

Zika outbreak in 2016: understanding Brazilian social inequalities through urban spatial analysis and their consequences to health

Abstract

Despite mischief caused before, “Aedesegypti” has acquired an international important status in view of recent Zika outbreak in Brazil and consequently of the impressive numbers of Brazilian babies with microcephaly - approximately 2,106 cases in the last epidemiological week of October, 2016. In March 2016, the Brazilian Ministry of Health published the “Protocol” for the health care response to Zika-related microcephaly, but the number of cases has just increased. In the present case report we present the alarming numbers of microcephaly, mainly in Northeast and Southeast of country, and poor living conditions of cities. As we shall see, the “Aedesegypti” seems to have won the battle against citizens because they were cunning and have adapted quickly to deplorable urban conditions and to climate change. In contrast, the executive entities eventually put their prescriptions against imbalance health system in practice, just in some isolated cases. There is a distinct gap between government’s actions and population’s reality, which suggests that special attention to vulnerable populations should be priority, especially for those who are going to be born, because they represent the future of nation. Analyzing available information, we could conclude that given the situation, it would be regrettable to consider that citizens are mere spectators, dependent on previously defined actions, when in reality the society should occupy a prominent position in any process, demanding appropriated decisions in order to ensure the effectiveness of health and housing programs.

Keywords: contemporary, Brazilian cities, human settlement, disease vectors, “aedes” ecology, urban future

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Andrea Ferraz Young

Research and Development Coordination, National Center for Monitoring and Disaster Alerts (CEMADEN), Brazil

Correspondence: Andrea Ferraz Young, Research and Development Coordination, National Center for Monitoring and Disaster Alerts (CEMADEN), Ministry of Science and Technology, São José dos Campos, SP, Brazil, Email andfyoung@hotmail.com

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Introduction

Brazil has experienced one of the highest levels of Zika incidence transmitted by “Aedesegypti” with 2,106 of microcephaly cases confirmed in metropolitan areas where almost 80% of the population lives. In the last year, the World Health Organization (WHO) has raised alarm about the distribution and severity of microcephaly caused by Zika. Social and environmental determinants have a strong influence on a wide number of cases which include the government failures to manage important factors such as:

- I. Urban growth;
- II. Increased movement of humans and vectors (by travel and commerce drives);
- III. Land use change (with deforestation, agroindustry, ecological change, atmospheric and climate change).

The development of insecticide-resistance in mosquitoes.¹⁻⁵ Effects of climate change on health are also determinants that will affect most populations in urban areas.⁶ Especially, climate change has been associated with increased frequency and intensity of epidemic diseases, exacerbating the extent of impacts on the currently hazard-prone areas (IPCC, 2014).⁷ Urban growth combined with extreme events will cause a shift in the burden of disease.^{7,8} In recent decades, the extreme weather events have become more frequent and severe with increases in extreme heat, intense precipitation, and drought.⁹ The period of rain is becoming more irregular with intense rainfall events concentrated in a short period separated by warm dry periods (IPCC, 2014).⁷ However, no political action has effectively taken into account the impacts of biophysical environmental conditions

and the vulnerability of populations.¹⁰ Particularly, the absence of management in Brazilian cities refers to legal blameworthiness and lack of responsibility in each area of environmental law that in reality should include health and social economic equality compatible with sustainable goals. Such objectives are established by law and include measures to reduce the potential environmental exposure at local level.¹¹⁻¹³

This situation is exacerbated by broad disparities of income opportunities across spatial distribution of population.¹⁴⁻¹⁶ Low-income groups are often settled in segregated spaces disconnected from adequate urban infrastructure,^{14,17,18} and under these circumstances housing is frequently made of inappropriate building materials that do not provide minimum dwelling conditions.¹⁷ In general, the slums constitute the only affordable housing for the poorest, filling the gap between the demand and supply of residences. They are often polluted, located on hazardous and deteriorated. Socially, this scenario includes land tenure insecurity, informal income-generation strategies, limited access to credit (in the formal Real Estate market) and scanty formal jobs due to poor quality education, stigmatization, and discrimination combined with poor livelihood.^{17,19}

In this context, some important questions related to the future of Brazilian cities still call for an answer. For example, how the trajectory of Brazilian cities interferes on population health? The existent public policies are being put in practice to enhance the life at cities? What is the design-reality gap? It is marked that contemporary urban contexts can no longer be conceived without clear communication and social interaction. We need to re-establish the public space as a place of all, where we include cooperation, respect, and participation. Therefore, additional research is needed to better understand the

health risks and effective responses to this complex situation,¹⁰ which requires knowledge about social-ecological systems focusing on the interactions between biophysical and social systems.²⁰ The objective of this case report is to describe the situation through a socio-ecological perspective, presenting the numbers of microcephaly cases in urban areas of Brazil.

Case description

The emergence of zika

Several cases of microcephaly have been reported in Brazil since last year (2015-2016), when it was announced by World Health Organization (WHO) that one specific disease, apart from dengue and chikungunya, has been transmitted by “Aedes aegypti”, namely zika. Zika was just declared a global public health emergency after being linked to brain deformities in babies in November, 2015 - when it was reported 739 suspected cases. Zika was previously isolated in 1947 (in Uganda and Nigeria), investigated in 1968, and during studies conducted between 1971 and 1975.^{21,22} More recently, epidemics in the Pacific were revealed by World Health Organization, the first in Micronesia with 5,000 cases registered (2007), and the second one, extremely significant, with 55,000 patients in Polynesia (2013). In Malaysia, about 23,966 cases of dengue were reported,²³ in Africa (Gabon) 20,000 people were affected by dengue, chikungunya and zika,²⁴ and in America, the population is experiencing the major zika epidemic,²⁵ with 492,820 suspected cases reported from 45 countries through September 1, 2016.²² In February 2014, it was reported by the Ministry of Health of Chile, the first autochthonous case in the Americas. In February 2015, the number of cases reported by Ministry of Health of Brazil has already soared. In October 2015, the ministry of Brazil warned about an unusual increase in the number of cases of microcephaly reported in the State of Pernambuco, where 141 cases were identified in less than one year, versus only about 10 cases in past years.²²

A study developed by Fiocruz-Parana (in Brazil) using histochemistry confirmed the presence of the zika virus in the placenta, and similar situation has been reported by other local governments. In response to the situation, on 11 November, the Ministry of Health of Brazil declared a national public health emergency to give greater support to the investigations.²² In January 2016, twenty countries have confirmed autochthonous circulation of zika virus in the Americas, such as Brazil, Barbados, Bolivia, Chile (Easter Island), Colombia, Ecuador, El Salvador, Guatemala, Guiana, French Guiana, Haiti, Honduras, Martinique, Mexico, Panama, Paraguay, Puerto Rico, Saint Martin, Suriname, and Venezuela.²⁶

In February 2016, about 3,893 cases were reported in Brazil with 199 municipalities in state of dengue, chikungunya and zika outbreak risk, and other 665 municipalities in a state of alert.²⁶ Several pregnant women submitted to zika virus gave birth to babies with microcephaly (Table 1) due to the neurological and auto immune complications associated to zika virus²⁷ such as Guillain-Barré syndrome and congenital syndrome in newborns.²⁷ The Northeast (Figure 1) was the region with the highest prevalence of microcephaly at birth (223 cases), 40.4 cases per 10,000 live births according to the second epidemiologic week report.²⁸ Until October 29, 2016 (week 43), about 10,039 cases were reported according to the protocol settings surveillance (newborn, stillbirth, abortion or fetus). Of these, about 7,933 cases were investigated and 2,106 were confirmed (Table 1) for microcephaly and/or change in the central nervous system which suggests congenital infection. By region, the most significant

prevalence rates were 1,669 cases in Northeast, 232 cases in Southeast (Figure 2), 108 cases in Western, and 77 cases in North, but all over the country about 3,091 cases still being investigated.²⁸ In general terms, the situation has not improved, every day new cases were notified, and it seems that they were becoming unnoticed cases.

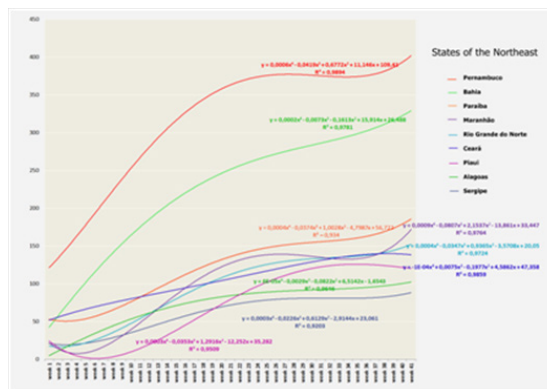


Figure 1 Microcephaly cases reported in the Northeast.

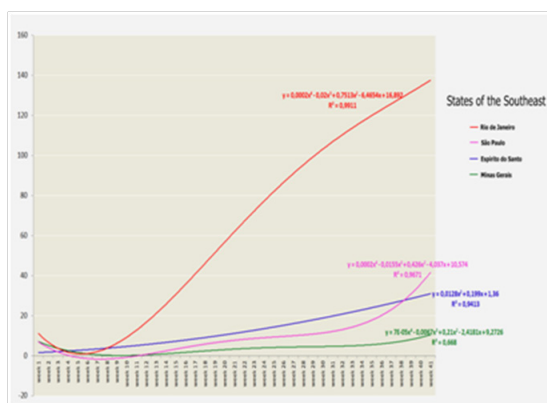


Figure 2 Microcephaly cases reported in the Southeast.

State/Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050			
Alagoas	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Bahia	200	250	280	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290
Bernambuco	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480
Paraná	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Rio Grande do Norte	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Rio de Janeiro	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Sergipe	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
North	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
South	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
West	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
South	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
TOTAL BRAZIL	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200		

Table 1 Distribution of microcephaly cases reported, investigated, and confirmed by Brazilian states between 2015-2016

Source: Ministry of Health (2016).

Discussion and evaluation

The role of the State, spatial segregation, and population health

Although the urban management and public health share a common vision on preventing urban disease outbreaks, there is

no clear correlation between them and their decisions, which has contributed to uncoordinated actions.^{29,30} For example, during the past decades, the Brazilian cities have suffered a significant socioeconomic transformation caused by pressures of globalization, industrial relocation (deconcentration), investments in technological development, changes in labor market, and accelerated urbanization, causing an expansion of metropolitan areas.³¹ From the beginning of 21st century, the country was number two of the emerging economies in the world, receiving high levels of foreign direct investment as a member of BRICs.³²

Despite this positive scenario of foreign investments, the housing shortage has not significantly change, especially for the poorest in large urban centers.³³ The income per capita of people living in subnormal agglomerates (e.g. favelas) was U\$ 104.20, which represented less than half of the minimum wage. In these subnormal areas, about half of the population over 16 years did not even have the full 1st degree.³⁴ Nowadays, we have 85% of the population living in urban areas; about 20% live in precarious conditions at slums.³⁵ The precariousness of employment is high, with almost 11% of the unemployed labor force and about 42.3% engaged in informal activities underpaid, with strong presence of unregistered workers and self-employed.³⁶ Brazilian cities have common problems related to inadequate urban management and lack of control over land use with abuse of Real Estate Market.³⁷ As the urban areas have spread in extension, density, and occupancy without control, the mosquito has invaded these habitats with striking speed and admirable capacity of adaptation. One outcome of this fact is the evolution of commensalism or “Aedes domestication”, which results in disastrous consequences like the preference for a stable blood source.³⁸ To aggravate the situation, the water supply is irregular in the majority of poorest neighborhoods; several houses are not even connected to the public water system. For this reason, there are more possible breeding areas (e.g. water tanks, cisterns) and chances of “Aedesegypti” survival in under-privileged homes.³⁹ The context of inadequate shelter, insufficient and unsafe water, and poor sanitation pose significant risk factors associated with outbreaks of disease.⁴⁰ The government claims that have invested in the housing sector, but in reality they invested significantly greater financial resources to the program “My Home My Life” than to the social housing programs (with a housing deficit nearly 5.8 million units). The program “My Home My Life” was created in July 2009 by Law 11,977 and actually it came to prioritize financial assistance to affordable housing for low-income households, but instead the program has favored families with income around 10 minimum wages, which correspond to the Brazilian middle class.³³

In parallel, the “BolsaFamilia” (Basic Family Aid) is the benefit offered by Brazilian government to improve the living conditions of these people, but only families in conditions of extreme deprivation and poverty have access, which means that only those with per capita monthly income of U\$ 26.00 is entitled to this benefit (the scanty monthly installment of benefit is U\$ 26.86). <http://calendariobolsafamilia2016.org/bolsa-familia-valor/> For pregnant women, there is a benefit called Exchange Family to Pregnant Women and during the nine months of pregnancy the benefit is provided to the family of the child (the monthly installment of benefit offered to pregnant woman is U\$ 12.18) <http://calendariobolsafamilia2016.org/bolsa-familia-valor/> Because of government parsimony with poorest people, the majority of the low-income households have no access to public health services and hospitals (Young, 2016) and pregnant and lactating women continue to face compromised access to reproductive health (Baum et al., 2016). The health system situation

is characterized by the prevalence of health facilities that are no longer fully operational due to a lack of professionals and damage to facilities, equipment and supplies, exacerbating and increasing the chances of infection and complications (Young, 2016). To worsen the epidemic situation, unsafe abortion is a “public health reality in Brazil that can bring more uncertainties about related cases and their consequences”.⁴¹

Not so simple as it seems, the decision of changing the brain size parameters (i.e.criteria for head circumference) was changed by Ministry of Health on December 4, 2015) for compute the new microcephaly’s cases⁴² will not be able to contain the ferocity of the mosquito “Aedes”. Recently, Li et al.⁴³ have shown evidences that Zika virus (ZIKV) can also infect neural stem cells in the adult brain causing many damages. The analysis suggests that both adult as well as fetal neural stem cells are vulnerable to zika neuropathology. It is important to highlight that, a single mosquito survives 45 days and can contaminate 300 people. As we can notice, despite of health actions efforts and the fact that Zika virus (ZIKV) is considered a transient infection in adult humans without significant long-term effects, there may be serious consequences in the future.⁴³

Climate change and vector-borne diseases: an important reality to be considered

In recent decades, climate change has been linked to disease outbreaks^{44,45,10,7} because the climatic phenomena have potential to impact any health outcome that is seasonal.¹⁰ However, it could be precipitate to make a direct cause-effect relationship between possible climate variations and zika outbreaks. Although the Earth’s climate is significantly warmer than it was a century ago, there is no evidence that climate change has specifically favored infectious diseases.⁴⁵ In the case of “Aedesegypti”, the climate variability can produce positive and/or negative effects on the number of mosquito eggs or larvae depending on the severity and duration of weather events.⁴⁶ Over the past 30 years, the variability and frequency of droughts, storms, and cyclones have become critical issues among Brazilian experts. From a scientific perspective,⁴⁷⁻⁵⁰ the behavior of anomalies follows the standards identified in the mathematical prediction models with more intense and severe events of temperature and precipitation (e.g. extremely cold and heat; extremely dry and rainy). Basically, variables such as temperature, humidity, and precipitation influence the mosquito development in different stages.^{51,52} It is recognized that “Aedesegypti” uses a variety of strategies to exploit the advantages of timing and location depending on climate variability.⁵ When temperature raises nearly everything about “Aedesegypti” biology speeds up. The adult stage, for example, can range from two weeks to a month depending on environmental conditions^{53,54} Under moderate temperature fluctuations,⁵⁵ the hotter the air the longer the mosquito survives as an adult to take blood, develop eggs, and lay those eggs in an aquatic setting. Laid eggs can survive for more than a year in a dry weather conditions; however they hatch immediately once submerged in water (Kearney et al., 2009), making the control of mosquito extremely challenging. The warmer the water faster it will be the transitions from egg to adult. For this reason, the level of precipitation and temperature is a critical factor⁵¹ since it creates sources of water (puddles, reservoirs, and tanks), and maintains water tables of reservoirs.⁵⁶ Besides, the increasing soil moisture has important implications on the potential distribution of “Aedesegypti”, though malaria vector species in Africa have adapted to ecosystems ranging from humid forests to dry savannas.⁴⁴

An overview about regional climate phenomena

The 2015–2016 El Niño Southern Oscillation (ENSO) might have contributed to the emergence of Zika virus (ZIKV) in Latin America and the Caribbean,⁵⁷ primarily evidenced (i.e. evidence-based guidelines) at the beginning of the rainy season and higher temperatures,⁵⁸ following the same pattern of dengue epidemics that were associated with warm rainy El Niño phenomenon.^{45,59,27} Generally, the high temperatures in Brazil are concentrated in the areas close to the Equator, spreading and diluting over the Western, Northeast, Southeast and South regions, but lately the average temperature in the Brazilian territory shows a progressive warming trend, mainly through the 21st century.⁶⁰ Under the Representative Concentration Pathways (RCP 4.5) scenario, the whole country has surpassed the threshold of 2°C warming and the Western region exceeds 4°C, indicating that the territory is likely to warm more than the world average.⁶⁰ Most regional changes in precipitation are attributed either to internal variability of the atmospheric circulation as well to global warming (Marengo et al., 2013a) that are changing the spatial-temporal distribution of temperatures (Lambert et al., 2011; Stott et al., 2010). Recognized meteorological studies^{61,62} describe the pattern of rainfall in tropical Atlantic organized on monthly timescales into several convective zones. Basically, it depends on the development of intense convective activity over the continent in the North of the equator. The convergence of the winds associated to the meridional Hadley circulation produces a zone of intense convection recognized as inter tropical convergence zone (ITCZ). Basically, ITCZ appears as a mass of air (band of clouds) circulating the globe near the equator and its movement depends on the intensity of the northeast and southeast trade winds which is associated to sea level pressure (SLP) and sea surface temperature (SST) in the tropical North and South Atlantic.^{63,50}

The ITCZ is the axis of confluence of the trade winds, where the trade winds from the north and south hemispheres meet. Trade winds are driven by subtropical high pressure areas over the oceans. The mechanism of the circulation of the monsoon and the seasonal migration of the Inter tropical convergence zone (ITCZ) affect the patterns of precipitation.⁶⁴ The main core of precipitation in South American occurs in the tropical region, following the ITCZ and local low-level jet structures, controlled by thermal gradients and topography, the main mechanisms of rainfall distribution in the continent.⁶⁵ Meantime, over the Atlantic, both the transient frontal system and mean low-level convergence lead to the formation of a diagonal band of precipitation maxima, known as the South Atlantic convergence zone (SACZ).^{66,67} This zone extends through the “southeastward from the great continental convective zone of tropical South America generated by moisture convergence between the South Atlantic high pressure and the continental thermal low pressure zones”^{63,7,23} and is an important mechanism of long-term climate variability in Amazonia.⁴⁸ The oceanic ITCZ and the SACZ are different systems, but the summer rainfall distribution over most of tropical South America is strongly induced by these two atmospheric convergence zones.^{67–70} A combination of factors related to the Sea Surface Temperature (SST) in the Pacific and Atlantic oceans can affect the dynamic of these two important meteorological systems. Both zones have a pronounced maritime component and present fundamental dynamical differences.⁶⁹ Convergence movements of the ocean-atmosphere system result in local warming of air temperatures and an increase in rainfall, basically when sea surface temperatures become anomalously warm.²⁷ The ITCZ lies over warmer surface waters, while the oceanic portion of the SACZ occurs predominantly over cooler surface waters.⁶⁹

Health risk and the “Aedes aegypti” ecology

The ecology of “Aedes aegypti” is complex and intricate, indicating a series of possible explanations for large numbers of mosquito under different latitudes. Experimental associations between climate and disease along with historical evidences have shown that vector diseases can be affected by latitudinal, altitudinal, seasonal, and inter annual variations in a nonlinear fashion.⁴⁵ High temperatures (e.g. equator and tropical zones), precipitation and humidity with availability of the preferred breeding habitats favorable to larval development at distinctive immature stages can lead to an increased number of emerging adult species.^{51,46} From the bio-ecological perspective, the presence of the vector mosquito “Aedes aegypti” and the quantity of breeding grounds and nurseries are extremely important^{71,72} because domestic water storage containers are appropriated sites for them.⁴⁵ Particularly, in dry periods, the irregularities or inexistence of water supply from the public sphere leads to store water in containers. In households less privileged, where the water supply is irregular, the frequent use of water storage containers such as tanks and improvised cisterns creates appropriate environmental conditions with a great number of breeding areas. Variations in climatic parameters affect the viruses and influence “Aedes” survivorship. Particularly, temperature affects the rate of development in different mosquito life stages.⁴⁵

Despite of the maximum temperature to the survival of pathogen has not been provided by IPCC (2001), the report highlights that 11.9°C is the minimum temperature required for disease transmission, and respectively 6–10°C is the minimum temperature for biological activity of mosquito. The temperature variability is extremely important because it affects the rate of mosquito larval development, vector size, geotropic cycle, and adult survival, as well as the incubation period of the virus in the vector.^{73,74} Experimental analysis achieved by Delatte⁷⁵ has shown the influence of temperature on immature development, survival, longevity, fecundity, and geotropic cycles of “Aedes”. Lambrechts et al. (2011) have shown that diurnal temperature range (DTR) affects the distribution and abundance of mosquito. They observed that large temperature fluctuations have reduced the probability of vector survival, but the mosquitoes have lived longer when the variation in the amplitude of daily temperature was moderate. At night, warm temperature favors the survival of “Aedes aegypti”, while cool at night is harmful to the mosquito activity.⁷⁶

Landscape and housing conditions

Indeed, as we mentioned, temperatures have risen during the last 30 years and the weather is hotter (IPCC, 2014), however “Aedes” outbreaks depends on a set of related factors. Environmental conditions strongly influence the distribution of Aedes aegypti and the risk prone areas arise as a combination of physical, socioeconomic, cultural, and institutional circumstances.^{77–79} Humans travel among different climatic regions more than they did decades ago, cities in tropical countries are becoming overcrowded with multiple deficiencies⁸⁰ full of poor and unhealthy settlements, creating nurseries for “Aedes aegypti” with a set of conditions caused by disregard of building standards and lack of urban management (WHO, 2010). Fundamentally, the landscape of mosquito can be represented by a set of unhealthy conditions associated to available standing water. Eggs are laid on damp surfaces in areas likely to temporarily flood, such as man-made containers (e.g. discarded bottles, tins, tires, discarded furniture, jars, pots, buckets, flower vases, plant saucers, tanks, etc).⁸¹ Normally, “Aedes aegypti” has preference for this kind of environment selecting them for laying its eggs.^{4,82} After hatching of the eggs, the

larvae feed on organic particulate matter in the water, such as algae and other microscopic organisms.⁴ With sufficient water supply and suitable temperature “*Aedes aegypti*” can remain in the larval stage for months. Of course, there are a number of other environmental aspects that can also influence the spatial distribution of host species, such as the topography (e.g. flat areas with standing water accumulation), the human settlement density (e.g. after taking a blood meal, female mosquitoes produce on average 100 to 200 eggs per batch), and other that can be equally important.

The female mosquito will not lay the set of eggs at a single site, but rather spread out over several sites, laying their eggs separately. Eggs will most often be placed at varying distances above the water line and it can take hours or days, depending on the availability of suitable substrates.⁸³ In Brazil, there is a considerable heterogeneity in the environmental conditions from neighborhood to neighborhood.⁸² The large number of vectors at lower elevations may be due to phenomenon of rapid and unplanned urbanization with presence of water-storage containers in shanty towns that represent opportunities to lay eggs.⁴⁶ Although unhealthy locations are most occupied by the poorest people, there are examples of high and middle income groups living close to informal settlements. In the last case, the decision to build in high-risk areas is a matter of available land, the wish to live in the most scenic areas, or just a matter of affordable price (with recognition or not of risks).⁷⁸ People and “*Aedes*” distribution are connected in many cities of Brazil (e.g. São Paulo, Rio de Janeiro, Recife, Salvador, São Luiz do Maranhão, Fortaleza), where we can find a significant amount of potable water containers and most of them have no appropriated protection.⁸² A significantly high percentage of Brazilian middle class have a private water supply system, but even in some middle class houses with running water, people use tanks to reserve the water during scarcity periods.⁸² In many cases, the tanks are reminiscent of a seasonal drought when the water supply is extremely precarious. Most informal settlements exhibit physical vulnerabilities due to their location and construction practices. Normally, these settlements are often placed on inappropriately and for habitation, most susceptible to flooding.^{83,84} Squatters and slums dwellers settle in deteriorated areas of inner-city or in areas where it is possible to survive inside of polarized urban spaces (of poor and rich). Often, the prone areas to contamination are the only option for livelihoods and survival of many people.⁷⁸

Therefore, along with poverty conditions and inadequate settlements, the residents have become increasingly susceptible to “*Aedes aegypti*” outbreaks,⁷⁹ which make population particularly vulnerable to a chain of reactions such as the babies’ microcephaly and its consequences (Health Ministry, 2016). The physical exposure in squatter communities and poor settlements is accompanied by inadequate building materials and structures that are often built with non-permanent materials, such as plywood walls, roofs with cardboard, tin and wood material.⁷⁹ There is a wide range of unhealthy conditions associated, such as dark spaces without sun light, poor sanitation, crowding, and inadequate ventilation, making these places extremely hot and practically destitute of airing. A significant number of problems remain, such as absent of plumbing and sewage that normally are not affordable for households. Especially the walls, floors and ceilings of bathrooms are lined internally with un-plastered and un-lined materials that increase the humidity indoors, aiding reproduction of the “*Aedes*” mosquito. The most important factor for survival of adult mosquito inside the houses is the relative humidity, the best condition for this kind of mosquito, because it favors the processes of colonization and survival of these species.⁸⁵ A humid and warm ambient is pivotal to adult feeding behavior, reproduction,

survival period, the rate of larval development, and speed of virus replication.

The high humidity inside the houses provides the ideal environment for adult forms of “*Aedes*”.⁸⁵ Caprara et al. (2009) have mentioned that would be possible to infer that constructions with high level of indoor humidity can facilitate the presence of “*Aedes*” adult forms, even if the relative humidity indoors or outdoors has not been measured. Identically, the presence of trees may protect these breeding areas from sunlight, as well as water bowls for domesticated animals can improve the conditions for the multiplication of larvae and increase the number of potential breeding spots. The puddles formed during the rainy season in the yards may increase humidity, which may allow adult “*Aedes aegypti*” to survive longer. In Brazil, unprivileged homes have possibly much more breeding suitable for “*Aedes aegypti*” survival.. Hales (2002) analyzed the distribution of dengue fever on the basis of vapor pressure, which is a measure of humidity, showed that annual average vapor pressure was the most important individual predictor of “*Aedes*” distribution. Vapor pressure proved to be the single best natural predictor for the potential “*Aedes*” occurrence at any given place. In fact, this variable can explain almost 90% of the variability on its incidence around the world.

Conclusion

Let us try to address some specific points to summarize the importance of zika outbreaks in Brazil. Indeed, the main point of this discussion is focused on the recurrent contradiction of the socioeconomic expansion (e.g. of the last decades), which has changed the main Brazilian cities, obviously not contributing to an evolution of the country, but affecting the environmental conditions, contributing mainly to health inequities experienced by specific groups of population. One of the main reasons of social deficiencies is related to some patterns of urbanization expressed by poor housing, absence of sanitary conditions, and lacking of health care. Half of the Brazilian population does not have access to sewage and the National Plan for Basic Sanitation, which establishes the universalization of services throughout Brazil until 2033 with an estimated expenditure of US\$ 1,600 billion, and is not meeting the target.⁸⁶ Such of those circumstances, which imposes a marginal living in fragile environments, can be easily found in the great majority of Brazilian cities, visible to the naked eye in metropolitan regions like Rio de Janeiro (RJ), Recife (Pernambuco), Salvador (Bahia), Fortaleza (Ceara), between other.

Proper attention should be given to the fact that the vulnerability of the population and adaptive capacity vary from region to region, but normally the rapid spread of zika lied on the extension of urban areas with multiple deficiencies such as high population density, unplanned settlements, insufficient urban infrastructure, and lack of institutional capacity for dealing with burden of diseases in hazard-prone areas as well clarified by Gencer.^{78,79} This also can be evidenced by the latest cases of Brazilian yellow fever in 2017. Equally, greater clarity was provided by IPCC (2014) about climate impacts on diseases outbreaks. More than ever, drought, flooding, storms, and disease outbreaks constitute our reality. El Niño-Southern Oscillation (ENSO) is expected to have severe impact over the coming years, which may also lead to extreme drought situations and overwhelming storms. Consequently, altered patterns of rainfall and temperature may change the geographic distribution of “*Aedes*”. For this reason, it is so important to highlight that housing conditions are particularly linked with these multiple factors that affect “*Aedes aegypti*” ecology, showing the intrinsic relationship among each component of environment. It should be noted that life value must be examined from the point

of future view. Therefore, cities and local governments should offer opportunities to reverse the excessive concentration of population in precarious housing, upgrading interventions, and monitoring the climate conditions related to the evolution of diseases.^{87–92}

Environment involves factors that, for the most part, are beyond the control, because it is systemic and interconnected, with emergent properties that arise from a tangled network. It is important to observe how urban environment changes so that we can adapt our strategies appropriately. This principle highlights the statement that actions may have consequences for the individual as well as for others. In the case of microcephaly, changes in life expectancy will greatly influence individual life cycle and consequently important demographic aspects. For example, with lower birth rates or brain problems in newborns, younger generations are smaller relative to older generations. The average economic behavior varies systematically with age and health conditions. Actually, income, consumption and labor market have varied across age at different periods over the past half century.⁸⁶ Ignoring or denying the link between actions and their corresponding consequences will often make things worse. Therefore, the only way to achieve different consequences is to alter the actions. It represents great value to many economic segments because the benefits received are recognized as even greater than the “sacrifice” made. Concluding, there are no connections between government’s interventions and the veracity of health reports which suggests that special attention should be given to the provision of primary health care for the most vulnerable, reshaping the function of public sphere. The health system should be tangible for women in this situation, which means providing maternal and child health care, including treatment and prevention in areas of high impact (with Zika outbreak). Accordingly, specific actions should be taken to strengthen the epidemiological surveillance system into the health and housing sectors through an integrated management system. Improvements in public infrastructure and housing are pivotal. Public plans are needed to clarify what kinds of strategic objectives the national health organization would like to achieve and how this can be done in order to prevent the negligence in socio spatial terms and the outbreak prevalence.^{93–99}

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Conflicts of interest

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References

1. Mayer JD. Geography, ecology and emerging infectious diseases. *Soc Sci Med.* 2000;50(7–8):937–952.
2. McMichael AJ. Environmental and social influences on emerging infectious diseases: past, present and future. *Philos Trans R Soc Lond B Biol Sci.* 2004;359(1447):1049–1058.
3. Harrus S, Baneth G. Drivers for the emergence and re-emergence of vector-borne protozoal and bacterial diseases. *Int J Parasitol.* 2005;35(11–12):1309–1318.
4. WHO. Hidden Cities: unmasking and overcoming health inequities in urban settings. World Health Organization Centre for Health Development (WHO Kobe Centre) Kobe, Japan, 2010. 145 p.
5. Reiter P. Climate Change and Mosquito-Borne Disease. *Environ Health Perspect.* 2001;109(1):141–161.
6. Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change. *The Lancet.* 2009;373(9676):1693–1733.
7. IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, RK Pachauri & LA Meyer (Eds.)]. IPCC, Geneva, Switzerland; 2014. 151 p.
8. Campbell T, Campbell A. Emerging disease burdens and the poor in cities of the developing World. *J Urban Health.* 2007;84(3):i54–i64.
9. Linnenluecke MKA, Griffiths, M Winn. Extreme weather events and the crucial importance of anticipatory adaptation and organizational resilience in responding to impacts. *Business Strategy and the Environment.* 2012;21(1):17–32.
10. Ebi K. Climate Change And Health Risks: Assessing And Responding To Them Through ‘Adaptive Management’. *Health Aff.* 2011;30(5):924–930.
11. Law 9,605/1998 – National guidelines on use of natural resources – Section III – Art. 54: About pollution and other environmental crimes which results or may result in damage to human health.
12. Law 10,257/2001 – National guidelines on urban policies. Chapter 1 – General guidelines IV – Issues: urban planning, development of cities, population distribution, and municipal economic activities. Objective: to avoid negative impacts on environment and to correct distortions of urban growth (at local territory and areas of influence).
13. Law 11,445/2007 – National guidelines on sewage – Chapter 1 – Fundamental principles VI – articulation of urban and regional policies.
14. Anderson MW. Cities inside out: Race, poverty, and exclusion at the urban fringe. *UCLA Law Review* 55:1095. UC Berkeley Public Law Research Paper No. 156006; 2008.
15. Taschner PS. A favela que virou cidade. In: *Cidade Illegal*. Ed. Marcio Moraes Valença; 2008:73–108.
16. Grostein MD. Periferias Metropolitanas em Nova Escala. Um ciclo da urbanização em São Paulo. *Revista Iberoamericana de Urbanismo*. riURB editores; 2015;12:33–52.
17. UN-Habitat. Accessibility of Housing – A Handbook of Inclusive Affordable Housing Solutions for Persons with Disabilities and Older Persons. United Nations Human Settlements Programme (UN-Habitat). Nairobi, Kenya; 2014. 100 p.
18. Acolin A, Chattaraj S, Wachter SM. Slums: How Informal Real Estate Markets Work. In: L. Birch, Shahana Chattaraj, Susan M Wachter, editors. Pennsylvania. USA: University of Pennsylvania Press; 2016. 272 p.
19. HABITAT III. New urban agenda. Draft outcome document for adoption in Quito, 2016. 24 p.
20. Spiegel J, Bennett S, Hattersley L, et al. Barriers and Bridges to Prevention and Control of Dengue: The Need for a Social-Ecological Approach. *Eco Health.* 2005;2(4):273–290.
21. Hayes EB. Zika Virus Outside Africa. *Emerg Infect Dis.* 2009;15(9):1397–1350.
22. PAN WHO. Provisional remarks on Zika virus infection in pregnant women: Document for health care professionals. Pan American Health Organization/World Health Organization. Montevideo (UR), 2016. 22 p.
23. Bryan P, Wai LT. Interrelation between Climate and Dengue in Malaysia. *Health.* 2015;7:672–678.
24. Grard G, Caron M, Mombo IM, et al. Zika virus in Gabon (Central Africa) – 2007: a new threat from *Aedes albopictus*. *PLoS Negl Trop Dis.* 2014;8(2):e2681.

25. Zanluca C, de Melo VCA, Mosimann ALP, et al. First report of autochthonous transmission of Zika virus in Brazil. *Mem Inst Oswaldo Cruz*. 2015;110(4):569–572.
26. Ministry of Health. Proteja da sua casa do mosquito da dengue antes de sair de férias. Blog da Saúde; 2015.
27. Stewart-Ibarra AM, Lowe R. Climate and non-climate drivers of dengue epidemics in southern coastal Ecuador. *Am J Trop Med Hyg*. 2013;88(5):971–981.
28. Ministry of Health. Boletim Epidemiológico. Monitoramento dos casos de microcefalia no Brasil – Semanas Epidemiológicas no período de 2015–2016. Secretaria de Vigilância em Saúde – Ministério da Saúde; 2016.
29. Corburn J. Confronting the challenges in reconnecting urban planning and public health. *Am J Public Health*. 2004;94(4):541–546.
30. Corburn J. *Toward the healthy city. People, places, and the politics of urban planning*. The MIT Press Cambridge, Massachusetts London, England; 2009. 380 p.
31. Cassiolato JE, Lastres HMM, Maciel ML. Systems of innovation and development: Evidence from Brazil. *New horizons in the economics of innovation*. Edward Elgar. Cheltenham (UK); Northampton (USA); 2003. 645 p.
32. Hauge GMH, Magnusson MT. Globalization in Brazil: How has globalization affected the economic political and social conditions in Brazil? Copenhagen Business School, 2011. 97 p.
33. National Confederation of Municipalities. Política Nacional de Habitação: o atual cenário das políticas do setor habitacional e suas implicações para os municípios brasileiros. National Housing Policy: the current situation of the housing sector policies and their implications for municipalities. Technical Studies of National Confederation of Municipalities. Brasília (Brazil); 2010;3:139–152.
34. PNAD. Pesquisa nacional por amostra de domicílios. Um panorama da saúde no Brasil. Acesso e utilização dos serviços, condições de saúde e fatores de risco e proteção à saúde. Ministério do Planejamento, Orçamento e Gestão Instituto Brasileiro de Geografia e Estatística – IBGE Diretoria de Pesquisas Coordenação de Trabalho e Rendimento, 2008. 245 p.
35. Lisboa C. O mosquito que desafia o Brasil. *Revista Desafio do Desenvolvimento*. IPEA – Ano. 2015;12(87):29–43.
36. Moraes MP. Condições de vida e moradia nos assentamentos precários brasileiros. *Desafios do Desenvolvimento*. Revista de Informações e Debates do Instituto de Pesquisa Econômica Aplicada, Brazil; 2016.
37. Maringoni G, Raquel Rolnik: Estamos implantando instrumentos legais que permitem às empresas avançar sobre o espaço público das cidades. *Revista Desafios do Desenvolvimento*. IPEA – Ano. 2015;12(87):11–17.
38. Powell JR, Tabachnick WJ. History of domestication and spread of *Aedes aegypti* – A Review. *Mem Inst Oswaldo Cruz*. 2013;108(Suppl D):11–17.
39. Caprara A, Lima J, W de O, et al. Irregular water supply, household usage and dengue: a bio-social study in the Brazilian Northeast. *Cad Saude Pública*. 2009;25 (Sup1):S125–S136.
40. WHO. Summary of health priorities and WHO projects in interagency humanitarian response plans. Department for Emergency Risk Management and Humanitarian Response (ERM); 2016. 68 p.
41. Baum P, Fiastro A, Kunselman S, et al. Ensuring a rights-based health sector response to women affected by Zika. *Cad. Saude Pública*, Rio de Janeiro; 2016;32(5):1–4.
42. G1 News. News reporter Gabriel Luiz – Saúde muda critérios e considera menos bebês com microcefalia. 2015.
43. Li H, Saucedo-Cuevas L, Regla-Nava JA, et al. Zika Virus Infects Neural Progenitors in the Adult Mouse Brain and Alters Proliferation. *Cell Stem*. 2016;19(3):593–598.
44. Githeko AK, Lindsay SW, Confalonieri UE, et al. Climate change and vector-borne diseases: a regional analysis. *Bulletin of the World Health Organization*, NO 78 (9). World Health Organization; 2000:1136–1147.
45. Lafferty KD. The ecology of climate change and infectious diseases. *Ecology*. 2009;90(4):888–900.
46. Dhimal M, Gautam I, Joshi HD, et al. Risk Factors for the Presence of Chikungunya and Dengue Vectors (*Aedes aegypti* and *Aedes albopictus*), Their Altitudinal Distribution and Climatic Determinants of Their Abundance in Central Nepal. *PLoS Negl Trop Dis*. 2015;9(3):e0003545.
47. Nobre P, Almeida RA de, Malagutti M, et al. Coupled Ocean–Atmosphere Variations over the South Atlantic Ocean. *Journal of Climate*. *American Meteorological Society*. 2012;25:6349–6358.
48. Marengo JA, Alves LM, Soares WR, et al. Two Contrasting Severe Seasonal Extremes in Tropical South America in 2012: Flood in Amazonia and Drought in Northeast Brazil. *Journal of Climate*. *American Meteorological Society*. 2013;26:9137–9154.
49. Marengo JA, Valverde MC, Obregon GO. Observed and projected changes in rainfall extremes in the Metropolitan Area of São Paulo. *Inter-Research CR*. 2013;57(1):61–72.
50. Espinoza JC, Marengo JA, Ronchail J, et al. The extreme 2014 flood in south-western Amazon basin: the role of tropical–subtropical South Atlantic SST gradient. *Environmental Research Letters*. 2014;9(12):124007.
51. Hopp MJ, Foley JA. Worldwide fluctuations in dengue fever cases related to climate variability. *Climate Research*. 2003;25(1):85–94.
52. Johansson MA, Dominici F, Glass GE. Local and Global Effects of Climate on Dengue Transmission in Puerto Rico. *PLoS Negl Trop Dis*. 2009;3(2):e382.
53. Waldock J, Chandra NL, Lelieveld J, et al. The role of environmental variables on *Aedes albopictus* biology and chikungunya epidemiology. *Pathogens and Global Health*. 2013;107(5):224–241.
54. Arias JH, Martinez HJ, Sepulveda IS, et al. Predator–Prey model for analysis of *Aedes aegypti* population dynamics in Cali, Colombia. *International Journal of Pure and Applied Mathematics*. 2015;105(4):561–597.
55. Lambrechts L, Paaijmansb KP, Fansiria T, et al. Impact of daily temperature fluctuations on dengue virus transmission by *Aedes aegypti*. *PNAS*. 2011;108(18):7460–7465.
56. Kearney M, Porter WP, Williams C, et al. Integrating biophysical models and evolutionary theory to predict climatic impacts on species’ ranges: the dengue mosquito *Aedes aegypti* in Australia. *Functional Ecology*. 2009;23(3):528–538.
57. Paz S, Semenza JC. El Niño and climate change – contributing factors in the dispersal of Zika virus in the Americas? 2016;387:745.
58. Muñoz AG, Thomson MC, Goddard L, et al. Analyzing climate variations at multiple timescales can guide Zika virus response measures. *Giga Science*. 2016;5(1):41.
59. Stewart-Ibarra AM. A social-ecological systems approach to dengue–chikungunya–zika in urban coastal Ecuador. UGEC Viewpoint. 2016.
60. Costa D, Hacon S, Siqueira ASP, et al. Municipal temperature and heat wave predictions as a tool for integrated socio-environmental impact analysis in Brazil. *American Journal of Climate Change*. 2015;4:385–396.
61. Hastenrath S, Heller L. Dynamics of climatic hazards in northeast Brazil. *Issue Quarterly Journal of the Royal Meteorological Society*. 1977;103(435):77–92.
62. Hastenrath S, Lamb P. On the dynamics and climatology of surface flow over the equatorial oceans. *Tellus*. 1978;30(5):436–448.

63. Grodsky SA, Carton JA. The intertropical convergence zone in the South Atlantic and the equatorial cold tongue. *Journal of Climate. American Meteorological Society.* 2003;16:723–733.
64. Liu, C, Zipser EJ. Global distribution of convection penetrating the tropical tropopause. *J Geophys Research.* 2005;110(23).
65. Amador JA. The Intra Americas Seas Low–Level Jet (IALLJ): Overview and future research”. In: Gimeno L, Garcia R, Trigo R, editors. Trends and directions in climate research. New York: Annals of the New York Academy of Sciences; 2008.
66. Liebmann B, Allured D. Daily Precipitation Grids for South America. *Bulletin of the American Meteorological Society.* 2005;86:1567–1570.
67. Carvalho LMV, Jones C, Liebmann B. The South Atlantic Convergence Zone: persistence, intensity, form, extreme precipitation and relationships with intraseasonal activity. *J Climate.* 2004;17:88–108.
68. Nogués–Paegle J, Mo KC. Alternating wet and dry conditions over the South America during summer. *Mon Wea Rev.* 1997;125:279–291.
69. Chiang JCH, Vimont DJ. Analogous Pacific and Atlantic meridional modes of tropical atmosphere–ocean variability. *J Climate.* 2004;17:4143–4158.
70. Satyamurty P, da Costa CPW, Manzi AO. Moisture source for the amazon Basin: a study of contrasting years, *Theor. Appl Climatol.* 2013;111(1–2):195–209.
71. Nobre P, Marengo JA, Cavalcanti IFA, et al. Seasonal to decadal predictability and prediction of South American climate. *J Climate.* 2006;19:5988–6004.
72. Lenzi MF, Coura LC, Grault CE, et al. Estudo do dengue em área urbana favelizada do Rio de Janeiro: considerações iniciais. *Cad Saúde Pública.* 2000;16(3):851–856.
73. Focks D, Haile DG, Daniels E, et al. Dynamic life table model for *Aedes aegypti* (L) (Diptera: Culicidae). Analysis of the literature and model development. *J Med Entomol.* 1993;30(6):1003–1017.
74. Focks DA, Haile DG, Daniels E, et al. Dynamic life table model for *Aedes aegypti* (Diptera: Culicidae). Simulation results and validation. *Journal of Medical Entomology.* 1993;30:1018–1028.
75. Delatte H, Gimonneau G, Triboire A, et al. Influence of temperature on immature development, survival, longevity, fecundity, and gonotrophic cycles of *Aedes albopictus*, vector of chikungunya and dengue in the Indian Ocean. *J Med Entomol.* 2009;46(1):33–41.
76. Kumar S, Kumar R. Environment change: broaden of diseases. *Int J Curr Microbiol App Sci.* 2013;2(5):60–66.
77. Gencer EA. The impact of globalization on disaster risk trends: a macro and urban scale analysis. Background paper prepared for the global assessment report on disaster risk reduction. United Nations Office for Disaster Risk Reduction. Geneva, Switzerland; 2012. 45 p.
78. Gencer EA. The interplay between urban development, vulnerability, and Risk Management. A case study in Istanbul Metropolitan Area. Springer; 2013;XIII:111.
79. Gencer EA. An overview of urban vulnerability to natural disasters and climate change in central America & the Caribbean Region. FEEM Working Paper No. 78; 2013.
80. Tauil PL. Urbanização e ecologia do dengue. *Cad. Saúde Pública, Rio de Janeiro;* 2001;17:99–102.
81. Focks DA, Alexander N. Multicountry study of *Aedes aegypti* pupal productivity survey methodology: findings and recommendations. World Health Organization on behalf of the Special Programme for Research and Training in Tropical Diseases; 2006. 56 p.
82. Da Silva VC, Scherer PO, Falcão SS, et al. Diversity of oviposition containers and buildings where *Aedes albopictus* and *Aedes aegypti* can be found. *Rev Saude Publica.* 2006;40(6):1106–1111.
83. Okal MN, Lindh JM, Torr JS, et al. Analysing the oviposition behavior of malaria mosquitoes: design considerations for improving two–choice egg count experiments 2015;14(250):2–17.
84. UN–Habitat. The Challenge of slums. Global report on human settlements 2003. United Nations Human Settlements Program. London, UK: Earthscan Publications Ltd; 2003. 345 p.
85. Thu HM, Aye KM, Thein S. The effect of temperature and humidity on dengue virus propagation in *Aedes aegypti* mosquitos. *Southeast Asian J Tropical Med Public Health.* 1998;29(2):280–284.
86. Institute of Medicine (US). Committee on the long–run macroeconomic effects of the aging U.S. Population. Aging and the Macroeconomy: Long–Term Implications of an Older Population. Washington (DC): National Academies Press (US); Demographic Trends; 2012.
87. Hales S, de Wet N, Maindonald J, et al. Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. 2002;360(9336):830–834.
88. Barrera R, Amador M, Clark GG. Use of the pupal survey technique for measuring *Aedes aegypti* (Diptera: Culicidae) productivity in Puerto Rico. *Am J Trop Med Hyg.* 2006;74(2):290–302.
89. Chang P, Saravanan R, Ji L, et al. The effect of local sea surface temperatures on atmospheric circulation over the tropical Atlantic sector. *J Climate.* 2000;13:2195–2216.
90. Health Ministry. Epidemiologic Bulletin. Secretaria de Vigilância em Saúde. 2016;47:1.
91. IPCC. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK; 2001:1–32.
92. Kodama YM. Large–scale common features of sub–tropical precipitation zones (the Baiu Frontal Zone, the SPCZ, and the SACZ). Part II: Conditions of the circulations for generating the STCZs. *J Meteor Soc Japan.* 1993;71:581–610.
93. Lambert E, Colin D MacLeod CD, et al. Quantifying likely cetacean range shifts in response to global climatic change: implications for conservation strategies in a changing world. *Endangered Species Research.* 2011;15:205–222.
94. Lardeaux F, Riviere F, Sechans Y, et al. Control of the aedes vectors of the dengue viruses and wuchereriabancrofti: the French polynesian experience. *Annals of Tropical Medicine & Parasitology.* 2002;96(2):S105–S116.
95. Marengo JA, Alves LM, Espinoza JC, et al. Regional climates tropical South America east of the Andes (in ‘state of the climate in 2013’) *Bull. Am Meteorol Soc.* 2014;95:S170–171.
96. Instituto Trata Brasil. Ociosidade das Redes de Esgoto – 2015. Sewage Network Idleness, 2015 – Report based on National Sanitation Information System (SNIS) from Ministry of Cities. Org. Instituto Trata Brasil and Basic Sewage Coordination from National Organization of Lawyers (OAB), USA; 2015.
97. Padmanabha H, Soto E, Mosquera M, et al. Ecological links between water storage behaviors and *aedes aegypti* production: implications for dengue vector control in variable climates. *Eco Health Springer–Verlag.* 2010;7(1):78–90.
98. Stott PA, Gillett NP, Hegerl GC, et al. Detection and attribution of climate change: a regional perspective. John Wiley & Sons. 2010;1(2):192–211.
99. Young JA. Rio de Janeiro is in the middle of a major public health crisis. Americas Vice News Paper; 2016.