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ARTICLE

Arboviruses in the context of large-events

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Human movement especially associated with major events can facilitate the transmission and spread of pathogens through importation by visitors in the host country or exportation of endemic pathogens to the countries of origin of visitors when returning home. The current scenario in Brazil is of a triple epidemic of Dengue, Chikungunya and Zika, including in the state of Rio de Janeiro, local headquarters of the Olympic Games which occurred in August, 2016. The complications arising from infections by Zika as microcephaly and Guillain-Barré syndrome, dengue and Chikugunya morbidity frames preoccupied participating countries as well as tourists who took part of the event. However, the possibility of introducing new non-current arboviruses in Brazil should be considered a risk factor, once the country has conditions to maintain and propagate new arboviruses, for both the vector and susceptible population, as occurred with the rapid dissemination of Chikungunya and Zika viruses.

Key words: Arbovirus, Tourism, Mega-event, Olympic Games, Brazil

Arboviruses comprise a major group of viruses (RNA genome) maintained in nature through cycles involving arthropod vectors (mosquitoes and ticks, mainly) and susceptible vertebrate hosts. *Flaviviridae*, *Togaviridae*, *Bunyaviridae* are the main families of arboviruses that cause disease in humans. *Flavivirus*, *Alphavirus* and *Orthobunyavirus* are genera considered of great public health concern and of most important threats in tropical regions due to the rapid climate change, deforestations, population migration, disorderly occupation of urban areas and precarious health conditions that favor the amplification and viral transmission (Figueiredo 2007, Cleton et al. 2012, Rust 2012, Dash et al. 2013).

The Arbovirus Catalogue available at the Centers for Disease Control and Prevention (CDC) estimates that 537 species of arboviruses have been identified. These are widely distributed in the world, mainly concentrated in countries of sub-tropical and tropical climates. About 150 of these species are associated with human disease and zoonosis (Gubler 2001, Cleton et al. 2012).

In Brazil, several arboviruses have been implicated as causative agents of human diseases. Grouped by family, we highlight , *Flaviviridae* (*Flavivirus*): Yellow Fever virus (YFV), Dengue virus 1 to 4 (DENV-1 to DENV-4), Encephalitis Saint Louis virus (SLEV), Rocio virus (ROCV), Zika virus (ZIKV); *Togaviridae* (*Alphavirus*): Mayaro virus (MAYV), Chikungunya virus (CHIKV); *Bunyaviridae* (*Orthobunyavirus*): Oropouche virus (OROV). However, other arbovi-

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ruses have been identified in mosquito vectors and other animal reservoirs (birds, monkey, equine, alligator and sheep, for example) indicating the presence of these viruses in nature, such as Ilheus virus (ILHV), Bussuquara virus (BSQV), Cacipacoré virus (CPCV), Iguape virus (IGUV), West Nile virus (WNV), Naranjal-like virus (NJLV), Culex flavivirus virus (CXFV), Eastern Equine Encephalitis virus (EEEV), Nhumirim virus (NHUV) (Box 1) (Lopes et al. 2014, Pauvolid-Correa et al. 2014, Nunes et al. 2015, Zanluca et al. 2015, Pauvolid-Correa et al. 2015a, 2015b).

Brazil offers ideal conditions for the maintenance of several arboviruses, such as its large territory and cities with large population clusters associated with environmental conditions favorable to the development of the mosquito. In the past decades the country has been the main tourist destination of many travelers from various countries, which has brought concern to health authorities. Many of these travelers can not only serve as input sources of new arboviruses into the country, but also as sources of arboviruses circulating in Brazil to their countries of origin if the vectors are present. Airplane travels contribute to the rapid introduction of viruses into different countries around the world (Nunes et al. 2014).

Box 1. Main arboviruses described in vector and/or vertebrate hosts in Brazil.

Family	*Arbovirus*	*Regional distribution*	*References*
Flaviviridae	Cacipacore	North, Midwest	Figueiredo, 2000; Cruz et al., 2009; Batista et al., 2011; Batista et al., 2013; Casseb et al. 2014; Pauvolid-Corrêa et al., 2014.
	Dengue	North, Northeast, Midwest, Southeast, South	Osanai et al., 1983; Schatzmayr et al., 1986; Nogueira et al., 1990; 2001; 2007; De Castro et al., 2003; De Simone et al., 2004; Araújo et al., 2006; Feres et al., 2006; Araújo et al., 2009; Faria et al., 2010; 2016; Temporao et al., 2011; dos Santos et al., 2011; 2013; Castro et al., 2012; Macedo et al., 2013; Fares et al., 2015; Heinen et al., 2015a; Heringer et al., 2015; de Bruycker-Nogueira et al., 2015; 2016; SVS, 2016.
	Ilheus	North, Midwest	Iversson et al., 1993; Cruz et al., 2009; Pauvolid-Corrêa et al., 2013; 2014; Casseb et al., 2014.
	Rocio	North, Midwest, Southeast	Cruz et al., 2009; Casseb et al. 2014; Pauvolid-Corrêa et al., 2014; Silva et al., 2014.
	Saint-Louis Encephalitis	North, Midwest, Southeast, South	Rocco et al., 2005; Mondini et al., 2007; Cruz et al., 2009; Casseb et al., 2014; Pauvolid-Corrêa et al., 2010; 2014. Terzian et al., 2011; Rosa et al., 2013; Silva et al., 2014; Maia et al., 2014; Heinen et al., 2015b; Svoboda et al., 2014.
	West Nile	Northeast, Midwest	Pauvolid-Corrêa et al., 2011; 2014; Melandri et al., 2012; Ometto et al., 2013; Vieira et al., 2015b; 2015c.
	Yellow Fever	North, Midwest, Southeast, South	Araújo et al., 2002.; Filippis et al., 2001; 2004; de Filippis et al., 2002; Cruz et al., 2009; Chaves et al., 2009; Ribeiro et al., 2009; Lima et al., 2010; Souza et al., 2010; 2011; Almeida et al., 2012; 2014; Moreno et al., 2011; 2013; Câmara et al., 2013; Tranquilin et al., 2013; Mascheretti et al., 2013; Casseb et al., 2014; Romano et al., 2014; SVS, 2015.
	Zika	North, Northeast, Midwest, Southeast, South	Zanluca et al., 2015; Oliveira Melo et al., 2016; Cordeiro et al., 2016; Calvet et al., 2016; Brasil et al., 2016a; 2016b; Araújo et al., 2016; SVS, 2016.
Bunyaviridae	Oropouche	North, Northeast, Midwest, Southeast	Azevedo et al., 2007; Mourão et al., 2009; Bernardes-Terzian et al., 2009; Vasconcelos et al., 2009; 2011. Bastos et al., 2012; Cardoso et al., 2015.
Togaviridae	Chikungunya	North, Northeast, Midwest, Southeast, South	Albuquerque et al., 2012; Figueiredo & Figueiredo, 2014; Teixeira et al., 2015; Nunes et al., 2015. Conteville et al., 2016; SVS, 2016.
	Eastern Equine Encephalitis	North, Northeast, Midwest, Southeast; South	Iversson et al., 1993; Fernandéz et al., 2000; Pauvolid-Corrêa et al., 2010; Silva et al., 2011; de Novaes Oliveira et al., 2014;
	Mayaro	North, Midwest, Southeast* (*imported case of Mato Grosso do Sul)	Coimbra et al., 2007; Azevedo et al., 2009; Mourão et al., 2012; Figueiredo & Figueiredo, 2014. Vieira et al., 2015a; Pauvolid-Corrêa et al., 2015a; Serra et al., 2016.

In this context, epidemiological surveillance, use of diagnostic instruments able to identify and characterize infectious agents at an early stage, and implementation of control actions to ensure conditions that minimize the risk of infection in both the local population and visitors, are extremely important. In relation to control, it is important to consider that in cases of outbreaks, controlling of notified cases alone is not enough to stop pathogens from spreading. It is essential that surveillance units acting as sentinels for the early detection of newly introduced arboviruses are established.

During events, whether sporting, cultural, religious, ecological, and recreational or business, it is essential to consider the possibility of increased pathogen movement, since mobilization of human population tends to be stimulated (Nunes et al. 2014). This becomes even more worrying in mass events such as Rock in Rio, World Youth Day and sporting events such as the Soccer World Cup and the Summer Olympic Games, the latter being the largest and longest

sporting event, held in the Rio de Janeiro, Brazil, 2016.

With a high influx of people from many parts of world, a good portion of tourists do not limit their participation to Olympic events. Recreational activities such as ecotourism in the municipality of Rio de Janeiro and small trips to nearby municipalities can facilitate tourist contact with native viruses, as well as the spread of other non-occurring arboviruses in our region (Box 2). Tourists may serve as asymptomatic carriers of viruses or be still in the prodromal phase of the disease. Several publications involving mega events and arboviruses in Brazil have been published in recent years (Box 3). In the face of dengue epidemics over several decades, most of the publications until 2014 analyzed the spread of dengue viruses through exportation from country to country through tourism during big events. In 2015, the Chikungunya and Zika epidemics were established in Brazil, and some authors have hypothesized about possible viral pathways in Brazil related to the occurrence of major events in the country.

One of the studies suggests that entrance of ZIKV in the country has possibly occurred during FIFA Confederations Cup in 2013 (Faria et al. 2016). However, another plausible possibility was that introduction of ZIKV occurred during the Va'a World Sprint Championship canoe race, held in 2014, when four participating Pacific countries (French Polynesia, New Caledonia, Cook Islands, and Easter Island) were facing a ZIKV epidemics (Musso 2015). It is noteworthy that in 2014 publication raised concern about the spread of Mayaro virus, a flavivirus circulating in the Midwest Region of Brazil (Slegers et al. 2014). In this scenario, in addition to the simultaneous movement of different arboviruses with a plurality and similarity of clinical manifestations, the lack of strict preventive measures, and specific therapy, little engagement in disclosure of educational measures and application of health measures, point to a vulnerability and the possibility that arboviruses endemic in certain regions could be rapidly identified in other regions of the world. Viral transmission by *Aedes aegypti*, a vector widely associated to human activities, present in large urban centers such as Rio de Janeiro, the availability of artificial oviposition sites and maintenance of the vector, viruses

Box 2. Arboviruses of medical importance related to travel without occurrence in Brazil.

Family	*Arbovirus*	*Vector*	*Geographic Distribution*
Flaviviridae	Alkhurma hemorrhagic fever	Tick	Western Asian
	Japanese encephalitis	Mosquito	South and South-East Asia,Oceania
	Kyasanur Forest disease	Tick	South-East and Western Asian
	Murray Valley	Mosquito	Oceania
	Powassan	Tick	North American
	Tick-borne encephalitis	Tick	Central, Northern and Eastern Europe, and Asia
Bunyaviridae	Bunyamwera	*Mosquito*	Sub-Saharan Africa
	Bwamba	*Mosquito*	Sub-Saharan Africa
	Crimean-Congo hemorrhagic fever	Tick	South-East and Eastern Europe, Africa, Asian
	Guaroa	*Mosquito*	Central and South America
	Ilesha	*Mosquito*	Sub-Saharan Africa
	Jamestown Canyon	*Mosquito*	North American
	La Cross	*Mosquito*	North America
	Ngari	*Mosquito*	Sub-Saharan Africa
	Rift Valley fever	*Mosquito*	Africa, Western Asia
	Sandfly fever	*Sandfly*	Southern Europe, Northern Africa, Asia
	Tahyna	*Mosquito*	Europe, Asia, Africa
	Tataguine	*Mosquito*	Sub-Saharan Africa
	Toscana	*Sandfly*	Southern Europe
Togaviridae	Barmah Forest	*Mosquito*	Australia
	O'Nyong-nyong	*Mosquito*	Sub-Saharan Africa
	Ross River	*Mosquito*	Oceania
	Sindbi	*Mosquito*	Northern Europe, Asia, Africa, Oceania

Font: Cleton et al., 2012; Pastula et al., 2016.

Box 3. Publications on arboviruses and large sport events in Brazil.

Title	*Author*	*Year*
Zika is not a reason for missing the Olympic Games in Rio de Janeiro: response to the open letter of Dr Attaran and colleagues to Dr Margaret Chan, Director - General, WHO, on the Zika threat to the Olympic and Paralympic Games.	Codeço et al.	2016
Travelers to the FIFA world cup 2014 in Brazil: Health risks related to mass gatherings/sports events and implications for the Summer Olympic Games in Rio de Janeiro in 2016	Eberhardt et al.	
The risk of dengue for non-immune foreign visitors to the 2016 summer olympic games in Rio de Janeiro, Brazil	Ximenes et al.	
Rapid Spread of Zika Virus in The Americas - Implications for Public Health Preparedness for Mass Gatherings at the 2016 Brazil Olympic Games.	Pertersen et al.	
Potential exposure to Zika virus for foreign tourists during the 2016 Carnival and Olympic Games in Rio de Janeiro, Brazil	Burattini et al.	
A crucial time for public health preparedness: Zika virus and the 2016 Olympics, Umrah, and Hajj	Elachola et al.	
Countdown to the 2016 Olympic Games: A travel medicine checklist	Patel et al.	
Entry routes for Zika virus in Brazil after 2014 world cup: New possibilities	Salvador & Fujita.	2015
Dengue transmission during the 2014 FIFA World Cup in Brazil	Aguiar et al.	
Dengue, chikungunya and Zika and mass gatherings: What happened in Brazil, 2014	Gautred & Simon.	
Recommendations for Chilean travelers to the FIFA World Cup 2014 in Brazil	Perret & Weitzel.	2014
Travel to Brazil: analysis of data from the Boston Area Travel Medicine Network (BATMN) and relevance to travelers attending world cup and olympics.	Iliaki et al.	
The 2014 FIFA World Cup: communicable disease risks and advice for visitors to Brazil--a review from the Latin American Society for Travel Medicine (SLAMVI).	Gallego et al.	
Risk of symptomatic dengue for foreign visitors to the 2014 FIFA World Cup in Brazil	Massad et al.	
Risk of Dengue for Tourists and Teams during the World Cup 2014 in Brazil	van Panhuis et al.	
Persisting arthralgia due to Mayaro virus infection in a traveler from Brazil: Is there a risk for attendants to the 2014 FIFA World Cup?	Slegers et al.	
Illness in travelers returned from Brazil: the GeoSentinel experience and implications for the 2014 FIFA World Cup and the 2016 Summer Olympics.	Wilson et al.	
Health risks among travelers to Brazil: implications for the 2014 FIFA World Cup and 2016 Olympic Games	Wilson & Chen.	
Football fans and fevers: dengue and the World Cup in Brazil.	Harley & Viennet.	
Dengue outlook for the World Cup in Brazil: an early warning model framework driven by real-time seasonal climate forecasts.	Lowe et al.	
Dengue outlook for the World Cup in Brazil.	Massad et al.	

and human interaction is facilitated (Forattini 2002).

Tauil (2001) has highlighted population growth, migration, air travel, inadequate urbanization, poor functioning of health systems and population density as key factors to define standard viral transmission. Concern increases when a country is experiencing a triple epidemic (Dengue, Chikungunya and Zika), especially in Rio de Janeiro (RJ). The probable dengue cases in the country exceed 1 million (approximately 50% in the Southeast Region, being 47,000 of RJ), about 120,000 Zika occurrences (about 46,000 in the Southeast, 32,000 of RJ) and 64,000 of Chikungunya (about 4,000 in the Southeast, being 1,000 of RJ) (SVS 2016). As dengue epidemic, the intense expansion of reported cases of CHIKV and ZIKV infections, this latter associated with microcephaly and Guillain--Barré syndrome (Oliveira-Melo et al. 2016, Brazil et al. 2016), emerged as a major public health

problem, not only in Brazil but all over the world (Stahl et al. 2013, Vieira-Machado et al. 2014, Martelli et al. 2015, Cardona-Ospina et al. 2015).

Concern regarding infection of tourists with ZIKV has been demonstrated, especially in pregnant women, due to the possible neurological disorders occurring in the fetus. However, during the Olympic Games when we observed a large concentration of athletes, we believe that CHIKV infection is of greatest concern due to the morbidity associated to this disease. Symptoms of the infection were described by several authors as highly debilitating, since some individuals suffer intense pain, with persistent arthralgia and arthritis for months or even years (Borgherini et al. 2008, Lwande et al. 2015, Vijayan & Sukumaran 2016, Zeana et al. 2016). Given this fact, athletes who may be infected with CHIKV are at risk of having their athletic activities interrupted for undetermined period of time.

CONCLUSION

Several factors are related to the increasing number of cases of arboviral diseases in the world, including: (i) continued growth of the population, (ii) disorganized urbanization, (iii) failure in the control of arthropods such as mosquitoes and ticks, with expansion territorial vectors, (iv) increased travel, particularly by air, to the transport of people and goods; (v) deforestation and (vi) climate and environmental changes.

According to the WHO the incidence of dengue has increased 30 times in the last 50 years, with geographic expansion to new countries. An estimated of 50 to 100 million infections occur every year. The growing number of Dengue, Zika and Chikungunya cases in different Brazilian states, as well as Mayaro cases in states of the Midwest region of the country, confirms the potential simultaneous outbreak of these arboviruses; against which there are no effective antiviral drugs or vaccines available yet. As a result, there was an increasing risk that a large number of people can get infected by one of these arboviruses during the Olympic Games.

Finally, while the main concern is related to tourists at risk of acquiring the infection in Brazil, it is essential to consider the possibility of introducing new arboviruses associated with mosquitoes such as Japanese encephalitis (JBE) and Murray Valley (MVE) as well as those associated with ticks such as tick borne encephalitis (TBE) and the Kyasanur forest disease (KFD). contain a possible spread of an infectious disease.

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