ELSEVIER
International Journal of Infectious Diseases
Volume 97, August 2020, Pages 81-89
IJID

Estimating the burden of arboviral diseases in Colombia between 2013 and 2016

Andrés Felipe Mora-Salamanca [a], Alexandra Porras-Ramírez [b, c, d, 1], Fernando Pío De la Hoz Restrepo [b, 2]
Show more

https://doi.org/10.1016/j.ijid.2020.05.051
Get rights and content

Highlights

- During 2013–2016, Colombia experienced dengue, chikungunya and zika epidemies.
- These arboviruses have been associated to several chronic complications.
- Almost 500,000 DALYs were lost due to arboviruses and their complications.
- In 2015, arboviruses exceeded the burden of HIV/AIDS and tuberculosis combined.
- Public health efforts must be made to mitigate new epidemics.

Abstract

Objective

During the 2013–2016 period, Dengue, Chikungunya, and Zika affected more than 1 million people in Colombia. These arboviruses and their chronic manifestations pose a public health challenge. Therefore, we estimated the burden of disease by Dengue, Chikungunya, and Zika in Colombia between 2013 and 2016.

Methods

An exploratory ecological study was carried out using the disability-adjusted life years (DALYs) as a unit of measure. The mortality databases of the National Administrative Department of Statistics (DANE) and the morbidity databases of the National Public Health Surveillance System (SIVIGILA) were used. Deaths and cases for each arbovirus were grouped and then adjusted to control biases. Subsequently, we performed a sensitivity analysis.

Results

In the 2013–2016 period, 491,629.2 DALYs were lost due to arboviruses in Colombia. By disease, 26.6% of the total DALYs were caused by Dengue, 71.3% by Chikungunya, and the remaining 2.2%, by Zika. The majority of DALYs (68.2%) were caused by chronic complications. Five out of 32 departments (Valle del Cauca, Tolima, Norte de Santander, Huila, and Bolívar) contributed 50.5% of total DALYs.

Conclusion

The burden of disease by arboviruses in the 2013–2016 period exceeded the burden of other infectious diseases such as HIV/AIDS and tuberculosis in Colombia. Public health efforts must be made to mitigate new epidemics of these arboviruses.

Previous article Next article

Keywords

Chikungunya fever; Colombia; Dengue; Disability-adjusted life years; Zika virus

Introduction

Arboviruses are the leading group of vector-borne diseases in Latin America. Dengue, the main arbovirus in the continent, has caused severe epidemics in recent years, and at the same time Chikungunya and Zika viruses were introduced into the Americas in 2013 and 2015, respectively (Fischer and Erin Staples, 2014, Gatherer and Kohl, 2016). As a consequence, more than 11 million cases of arboviruses were reported throughout the region during the 2013–2016 period (Pan American Health Organization (PAHO) and World Health Organization (WHO), 2018, Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019a, Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019b).

Colombia was one of the most affected countries by these viruses. According to the number of cases reported in the 2013–2016 period, Colombia was the third most affected country by the Dengue virus, just behind Brazil and Mexico (Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019a). Similarly, it ranked the second and third country in the region in terms of the number of Chikungunya (2014–2016), and Zika (2015–2016) cases reported, respectively (Pan American Health Organization (PAHO) and World Health Organization (WHO), 2018, Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019b). In total Colombia reported more than one million acute cases of arboviruses during the 2013–2016 peric

Arboviruses, apart from acute disease, have been associated with chronic complications. Dengue associated with a wide variety of chronic symptoms (depression, insomnia, fatigue, headache, arthralgias, among others) which have been grouped and named—without reaching any consens as: post-infectious fatigue syndrome in Dengue, post-Dengue chronic fatigue, persistent or chronic Dengue (Seet et al., 2007, Stanaway et al., 2016, Zeng et al., 2018). Chikungunya has been associated with inflammatory joint diseases such as chronic arthritis (Rodríguez-Morales et al., 2016) while Zika has associated with congenital syndromes and Guillain-Barré syndrome (GBS) (Parra et al., 2016, Rasmussen et al., 2016). Consequently, these disorders generate costs, deaths, and disability both in the short and long term.

Currently, research priorities on Dengue (which should extrapolate to Chikungunya and Zika) should aim at reducing severe Dengue rates and mortality, reducing virus transmission, preventing disease, and the application of public policies (World Health Organization (WHO), 2006, Farrar et al., 2007). According to the WHO, ``There is a contradiction between the high priority afforded to Dengue at political level and the low level of resources allocated to Dengue prevention and control program activities" (World Health Organization (WHO), 2006). Likewise, in 2012, the WHO set three main objectives: to reduce Dengue mortality by at least 50%, to reduce morbidity by at least 25% and to estimate the true burden of the disease (World Health Organization (WHO), 2012).

Although there have been multiple studies of Dengue burden of disease, the methodologies and parameters used have changed, as knowledge about this disease has increased (Beatty et al., 2011). On the other hand, the literature on the Chikungunya and Zika burden of disease is limited. For these reasons, the objective of this study was to estimate the burden of disease by Dengue, Chikungunya, and Zika in Colombia and its administrative subdivisions between 2013 and 2016.

Methodology

Type of study

Ecological exploratory study aimed at estimating the burden of disease by Dengue, Chikungunya, and Zika in Colombia during the 2013–2016 period.

Sources of information

Dengue, Chikungunya, and Zika mortality information was obtained from the National Administrative Department of Statistics (DANE) (Departamento Administrativo Nacional de Estadística (DANE)), and information from each acute arbovirus case was obtained from the National Public Health Surveillance System (SIVIGILA). Both databases recorded the information of each event (death or case) by sex, age, and department. Additionally, SIVIGILA reports whether the cases required hospitalization or outpatient management.

Dengue, Chikungunya, and Zika case definitions used by SIVIGILA were taken from public health protocols published by the Colombian National Institute of Health (Instituto Nacional de Salud (INS), 2016, Instituto Nacional de Salud (INS), 2017a, Instituto Nacional de Salud (INS), 2017b). Dengue case definitions are as follows: probable case, case confirmed by laboratory, and case confirmed by epidemiological contact (Instituto Nacional de Salud (INS), 2017b). In the 2013–2016 period, 53% (222,915 cases) of Dengue cases (with or without warning signs) were compatible with the probable case definition and 47% (200,022 cases) were confirmed cases (either by laboratory or epidemiological contact). Concerning severe cases, 25% (2041 cases) were probable cases, and the remaining 75% (6011 cases) were confirmed cases (either by laboratory or epidemiological contact) (Mercado Reyes and Instituto Nacional de Salud (INS), 2014, Mercado Reyes and Instituto Nacional de Salud (INS), 2015, Gómez and Instituto Nacional de Salud (INS), 2015, Gómez and Instituto Nacional de Salud (INS), 2016).

For Chikungunya, the definitions are as follows: suspected case, case confirmed by clinical diagnosis, and case confirmed by laboratory (Instituto Nacional de Salud (INS), 2017a). In the 2014–2016 period, 98.6% (480,524 cases) of Chikungunya cases were confirmed by clinical diagnosis, 1% (4984 cases) were confirmed by laboratory, and the remaining 0.4% (1694 cases) were suspected cases (Salas Botero and Instituto Nacional de Salud (INS), 2014, Salas Botero and Instituto Nacional de Salud (INS), 2015, Pinilla Farias and Instituto Nacional de Salud (INS), 2016). For Zika, all cases included in this study were confirmed either by clinical diagnosis or by laboratory.

Population at risk

People living in risk areas for Dengue transmission in Colombia (people living in the urban, peri-urban and rural areas of municipalities with an altitude below 2100 m above sea level with entomological evidence or case reports) were defined as the population at risk for arboviral infection (Instituto Nacional de Salud (INS), 2017) We assumed that the population at risk for Dengue is the same for Chikungunya and Zika since they are transmitted by the same vectors.

Statistic analysis

Mortality

Given that mortality surveillance systems are imperfect because they cannot capture all deaths attributable to a disease, it was necessary to correct the number of deaths for each arbovirus to control biases. The most important bias in burden of disease studies is underreporting. Other biases described are miscoding and "garbage" codes (Murray et al., 1996). These biases were controlled by strategies such as: correction for the proportion of deaths with death certificates (Acosta Ramirez et al., 2008, Peñaloza et al., 2014), the Bennet–Horiuchi method (Bennett and Horiuchi, 1981) and expansion factors (Shepard et al., 2011).

Once the number of deaths for each arbovirus was adjusted, mortality rates were estimated per 1000 and per 100,000 inhabitants per year, by sex, age groups, and by sex and age groups at the national and departmental levels.

Morbidity

The different presentations of Dengue (Dengue without warning signs, Dengue with warning signs, Severe Dengue, and chronic post-Dengue fatigue), Chikungunya (acute phase and post-Chikungunya chronic arthritis) and Zika (acute phase, microcephaly, and GBS) were considered for the morbidity analysis.

Following the recommendations made by Beatty et al. (2011) concerning case counting, Dengue cases were discriminated in 3 groups: Outpatient Dengue, Hospitalized Dengue, and Severe Dengue. In accordance with this approach, we divided the number of acute cases of Chikungunya and Zika into two groups: outpatient and hospitalized.

Morbidity databases, as well as mortality databases, show underreporting. In order to correct underreporting, expansion factors (EF) were used. In the present study, we used the same EFs as Shepard et al. (2011), where they estimated the Dengue burden of disease in the Americas using two EFs. The first EF was used to correct the underreporting of hospitalized cases and the second EF to correct the number of outpatient cases (Table 1). These EFs were multiplied by the number of cases reported to the SIVIGILA system per year. The two EFs were used to correct the underreporting of cases for the three arboviruses under study.

The resulting Dengue and Chikungunya corrected cases were multiplied by the incidences of post-Dengue chronic fatigue and post-Chikungunya chronic arthritis described in previous studies (Rodríguez-Morales et al., 2016, Zeng et al., 2018) to approximate to the number of cases of these conditions in Colombia. We followed this procedure since there is no national database of these disorders.

With the corrected number of cases and the population at risk, incidences were estimated per 1000 and per 100,000 inhabitants by sex and age groups for every year under study, both at the national and departmental levels.

The burden of disease

The burden of disease was expressed in terms of disability-adjusted life years (DALYs). The methodology described by Murray et al. (1996) was used to calculate the DALYs. The DALYs are the result of the sum of the years of life lost (YLL), and the years lived with disability (YLD).

YLLs were calculated from the mortality rates for each arbovirus by year, sex, age group, and department. Among the existing four methods to calculate the YLLs, as well as Murray (1994), we chose the standard expected years of life lost method, where the expectation of life at each age is based on an ideal standard. The expectations used by the 2005 and 2010 colombian burden of disease studies are based on model life-table West Level 26 (Acosta Ramirez et al., 2008, Peñaloza et al., 2014). In order to achieve comparability of results between studies, we used the same model. This model conforms to the disparity in life expectancy between males and females in Colombia (Departamento Administrativo Nacional de Estadística (DANE), 2007a, 2007b). Other parameter values necessary for estimating YLLs are as follows: standard discount rate (value is 0.03), β standard age-weighting function (value is 0.04) and C standard age-weighting correction constant (value is 0.1658).

The parameters for the calculation of YLDs correspond to values defined in previous studies (Table 1). (Alfaro-Murillo et al., 2016, van den Berg et al., 2013, Chang et al., 2018, Cross et al., 2014, Honeycutt et al., 2003, Meltzer et al., 1998, Nembhard et al., 2001, Rodríguez-Morales et al., 2016, Rodriguez-Morales et al., 2015, Salomon et al., 2015, Sharp et al., 2016, Shepard et al., 2011, Zeng et al., 2018, World Health Organization (WHO), 2018b).

Table 1. Parameters for the estimation of disability-adjusted life years (DALYs) according to each scenario.

Arboviruses	Parameter	Conservative value	Medium value	Extreme value	Reference
All	**Expansion factor 1** **Central value – Rank**	1.4	2.3	3.3	Shepard et al. (2011)
	Expansion factor 2 **Central value – Rank**	4.5	9	18	Shepard et al. (2011)
Dengue	**Duration – Outpatient Dengue (days)** **Mean-Rank**	9.5	13.1	20	Zeng et al. (2018))
	Duration – Hospitalized Dengue (days) **Mean-Rank**	9	12.3	14.2	Zeng et al. (2018)
	Duration – Severe Dengue (days) **Mean-Rank**	10	14	18	Shepard et al. (2011)
	Duration – Post-Dengue chronic fatigue (days) **Median-CI 95%**	15	32	131	Zeng et al. (2018)
	Disability weight –Outpatient Dengue Mean-Rank	0.24	0.62	0.85	Zeng et al. (2018)
	Disability weight –Hospitalized Dengue **Mean-Rank**	0.49	0.71	0.9	Zeng et al. (2018)
	Disability weight – Severe Dengue **Base value-Rank**	0.6	0.81	0.92	Meltzer et al. (1998)
	Disability weight – Post-Dengue chronic fatigue **Estimate UI 95%**	0.148	0.219	0.308	Salomon et al. (2015); Zeng et al. (2018)
	Incidence – Post-Dengue chronic fatigue (%) **Median-CI 95%**	27	34	41	Zeng et al. (2018)
Chikungunya	**Duration – Outpatient Chikungunya (days)** **Median-Range**	2	6	21	Sharp et al. (2016)
	Duration - Hospitalized Chikungunya (days) **Median-Rank**	3	7	15	Sharp et al. (2016)
	Duration – Post-Chikungunya chronic arthritis (months) Median-Rank	3	20.12	72	Rodriguez-Morales et al. (2015)
	Disability weight – Outpatient Chikungunya	0.49	0.71	0.9	[a]
	Disability weight – Hospitalized Chikungunya	0.6	0.81	0.92	[b]
	Disability weight – Post-Chikungunya chronic arthritis in women **Mean-CI 95%**	0.194	0.275	0.366	Cross et al. (2014)
	Disability weight – Post-Chikungunya chronic arthritis in men **Mean-CI 95%**	0.149	0.213	0.286	Cross et al. (2014)
	Incidence – Post-Chikungunya chronic arthritis (%) CE-CI 95%	9.31	13.66	18	Rodríguez-Morales et al. (2016)
Zika	**Duration – Outpatient Zika (days)**	2	5	7	World Health Organization (WHO), 2018b
	Duration – Hospitalized Zika (days)	9	12.3	14.2	[c]
	Disability weight – Outpatient Zika	0.24	0.62	0.85	[d]
	Disability weight – Hospitalized Zika	0.49	0.71	0.9	[a]
Microcephaly	**The first-year survival rate (%)**	0.797	0.797	0.797	Nembhard et al. (2001)
	Mortality rate after the first year (%)	8	36.4	10.7	Honeycutt et al. (2003)
	Duration of the disease (years)	25	65	35	Honeycutt et al. (2003)
	Disability weight	0.16	0.16	0.16	Salomon et al. (2015)
SGB	**Mortality rate (%)**	3	3.9	5	van den Berg et al. (2013)
	Duration of the first phase of the disease (months)	6	6	6	Chang et al. (2018)
	Duration of the second phase of the disease (months)	0.75	6	18	Chang et al. (2018)
	Disability weight first phase	0.402	0.402	0.402	Alfaro-Murillo et al. (2016)
	Disability weight second phase	0.317	0.317	0.317	Alfaro-Murillo et al. (2016)

UI: uncertainty interval; CI: confidence interval; CE: combined effect.

a

Corresponds to the disability weight for hospitalized Dengue.

b

Corresponds to the disability weight for severe Dengue.

c

Corresponds to the duration of hospitalized Dengue.

d

Corresponds to the disability weight for outpatient Dengue.

Sensitivity analysis

DALYs for each disease were calculated under three scenarios: conservative, medium, and extreme. The differences between these scenarios lie in the variability of 5 parameters: (1) EFs with an associated triangular distribution, (2) the incidence of post-Dengue chronic fatigue and post-Chikungunya chronic arthritis, (3) the duration of the diseases, both in their acute phase and in their chronic phase, (4) the disability weight of the acute and chronic phase of each of the diseases under study and (5) the mortality rate of GBS and microcephaly (Table 1).

Some parameters of Chikungunya and Zika are not described in the literature, so Dengue parameters were used to cover these gaps. Dengue was chosen as the model of these parameters since Dengue has similar symptoms to the other two arboviruses and is the principal differential diagnosis.

Results

After adjusting the number of cases, a total of 9,284,326 cases of arboviruses and their complications were estimated nationwide for the 2013–2016 period. The most affected year was 2015, with 4,484,386 cases, in comparison with 2014, when only 1,064,043 cases were estimated. By disease, 41% of the cases (n = 3,806,517) were caused by Dengue and its complications, 52.1% (n = 4,835,052) by Chikungunya and its complications, and the remaining 6.9% (n = 642,757) by Zika and its complications.

For mortality, a total of 1439 deaths were estimated nationwide in the 2013–2016 period. The highest number of deaths occurred in 2015 (427 deaths), while the lowest number occurred in 2014 (310 deaths). By Disease, 92.1% of the deaths (n = 1326) were caused by Dengue, 6.5% (n = 94) by Chikungunya, and the remaining 1.3% (n = 19) by Zika.

In the 2013–2016 period, 491,629.2 DALYs were estimated for arboviruses nationwide (Table 2). In terms of YLLs and YLDs, 6.5% of the total DALYs (31,760.3 YLLs) were years of life lost and 93.5% (459,868.9 YLDs) were years lived with disability. By disease, 26.6% of the DALYs were caused by Dengue and post-Dengue chronic fatigue, 71.3% by Chikungunya and post-Chikungunya chronic arthritis, and the remaining 2.2%, by Zika, microcephaly, and GBS. 31.8% (146,459.3 DALYs) of the total DALYs were caused by the acute phase of the diseases and 68.2% (313,409.6 DALYs) by chronic complications. In 2013, 1068 DALYs per million inhabitants were lost, 3131.2 DALYs per million inhabitants in 2014, 8255.6 DALYs per million inhabitants in 2015, and 1579.1 DALYs per million inhabitants in 2016.

Table 2. Disability-adjusted life years (DALYs) due to arboviruses and its complications in Colombia by sex and age groups in the 2013—2016 period.

	Period									
	2013		2014		2015			2016		
Age	Male	Female	Male	Female	Male	Female	Microcephaly	Male	Female	Microcephaly
0–4	1704.21	1614.92	2225.19	2236.81	2638.64	3801.39	112.60	1060.89	952.60	2960.60
5–14	6213.62	5833.15	10,634.50	10,043.90	18,521.57	22,164.70	–	4073.43	4085.10	–
15–29	6763.04	4978.91	15,639.57	21,707.03	39,055.99	61,122.07	–	8654.10	10,476.86	–
30–44	3201.42	2465.20	10,606.31	16,744.91	31,115.42	51,469.16	–	5579.19	8015.63	–
45–59	1472.24	1280.00	5158.22	8783.58	16,279.44	27,313.25	–	2839.91	4626.46	–
60–69	391.55	360.30	1308.25	2044.38	3877.64	6893.61	–	774.86	1025.44	–
70–79	179.37	138.41	536.74	722.75	1720.95	2540.58	–	316.85	405.56	–
≥ 80	57.86	52.84	182.00	233.05	599.50	807.20	–	103.30	130.48	–
Total	19,983.29	16,723.72	46,290.78	62,516.41	113,809.16	176,111.96	112.60	23,402.53	29,718.11	2960.60

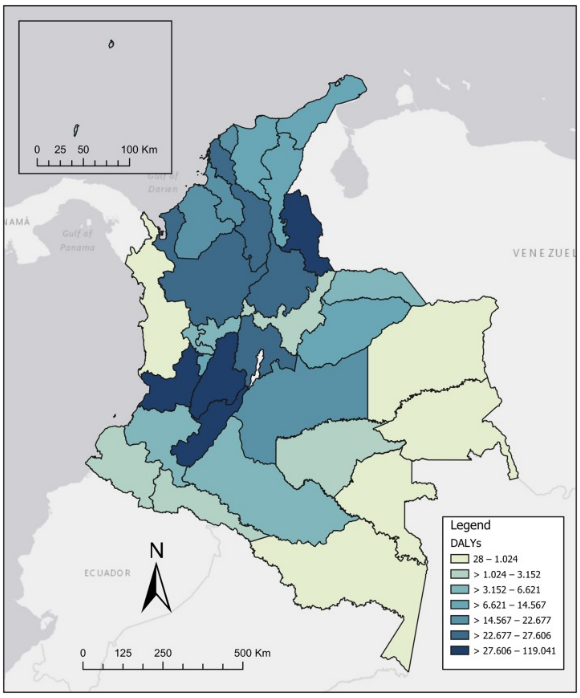
The year with the highest number of DALYs lost at the national level was 2015 (290,033.7 DALYs), when Colombia reached the peak of the Chikungunya epidemic, while the lowest was 2013 (36,707 DALYs), when only cases of Dengue were reported. Regarding DALYs and different age groups, the age range between 15 and 29 years contributed the most DALYs among all age groups, followed by the age group between 30 and 44 years, being women more affected than men (except in 2013) (Table 2).

At the departmental level, Valle del Cauca contributed 24.2% of the total DALYs for the 2013–2016 period, being the most affected department by arboviruses in Colombia. Five out of 32 deparments (Valle del Cauca, Tolima, Norte de Santander, Huila, and Bolívar) contributed 50.5% of the total DALYs. Twelve other departments, they each accounted for less than 1% of the total DALYs. In total, these departments (Cauca, Caldas, Putumayo, Nariño, Boyacá, Guaviare, San Andrés, Chocó, Amazonas, Vichada, Guainía, and Vaupés) contributed only 4.4% of the total DALYs (Table 3 and Fig. 1).

Table 3. Estimation under three scenarios of the disability-adjusted life years (DALYs) due to arboviruses and its complications at the departmental level in the 2013–2016 period.

Department	DALYs conservative scenario	DALYs medium scenario	DALYs extreme scenario	Departmental contribution to the total DALYs (%)
Amazonas	310.53	666.32	3000.08	0.14
Antioquia	4454.36	27,055.02	219,625.9	5.50
Arauca	658.05	5399.6	53,663.43	1.10
Atlántico	3035.83	17,211.65	143,035.9	3.50
Bolívar	3541.94	27,606.93	277,876	5.62
Boyacá	421.66	2344.3	17,927.65	0.48
Caldas	632.26	3442.4	30,491.03	0.70
Caquetá	816.86	6621.97	66,789.22	1.35
Casanare	1131.56	14,567.13	150,559.3	2.96
Cauca	592.68	4019.16	38,785.42	0.82
Cesar	2472.83	7002.33	46,106.75	1.42
Chocó	210.4	1024.76	8894.13	0.21
Córdoba	2678.58	16,990.36	162,166.3	3.46
Cundinamarca	3945.35	24,326.19	221,142.2	4.95
Guainía	163.86	394.52	2246.42	0.08
Guajira	1554.57	9750.27	95,820.52	1.98
Guaviare	179.4	2157.1	21,744.15	0.44
Huila	3232.21	28,255.59	276,440.9	5.75
Magdalena	1769.37	11,565.99	111,334.9	2.35
Meta	3812.12	22,677.46	195,433.4	4.61
Nariño	642.78	2808.76	23,881.56	0.57
Norte de Santander	3990.99	30,564.07	291,290.1	6.22
Putumayo	588.76	3152.92	24,291.65	0.64
Quindío	1188.94	8020.83	70,639.19	1.63
Risaralda	906.89	6616.9	62,436.04	1.35
San Andres	74.12	1193.17	12,318.2	0.24
Santander	4442.56	25,582.02	199,435.8	5.20
Sucre	2547.71	18,390.29	180,260.6	3.74

Tolima	6358.01	42,606.45	403,012.3	8.67
Valle del Cauca	11,787.99	119,041.2	1,175,249	24.21
Vaupés	5.85	28.52	337.78	0.01
Vichada	101.17	539.43	4428.19	0.11
Colombia	68,264.73	491,629.2	4,598,006	100



Download : Download high-res image (626KB) Download : Download full-size image

Fig. 1. Total disability-adjusted life years (DALYs) due to arboviruses and its complications at the departmental level in the 2013–2016 period in Colombia. Valle del Cauca, Tolima, Norte de Santander, Huila, and Bolívar contributed 50.5% of the total DALYs.

The departmental trends are different for each virus, taking into account that Dengue has been present in Colombia for decades, while the Chikungunya virus was introduced in 2014 and the Zika virus in 2015. We added supplementary material to explain the departamental trends for each virus – annual variations in terms of DALYs for each arbovirus at the departmental level (Supplemental Figs. S1–S9).

In 2013 and 2014, Valle del Cauca was the leading department in terms of DALYs for Dengue. During 2014 and 2016, it was the second, preceded by Santander and Antioquia, respectively. After Valle del Cauca, DALYs for Dengue were distributed among the departments located in the Andean region, Meta, and to a lesser extent, the Caribbean region. The rest of the Orinoquia region (without Meta), the Amazon region, and San Andrés were the ones with fewer DALYs due to Dengue (Supplementary Figs. S1–S4).

During 2014, the region most affected by the Chikungunya epidemic was the Caribbean region along with Norte de Santander (Supplementary Fig. S5). In 2015, when the epidemic reached its peak, most DALYs were lost in Valle del Cauca, the Andean region, and Meta (Supplementary Fig. S6). Finally, during 2016, the end of the epidemic phase and the beginning of the endemic phase, once again, most DALYs were lost in Valle del Cauca and the Andean region (Supplementary Fig. S7).

Regarding the Zika virus, during 2015, there were two spotlights: the Caribbean region plus Norte de Santander, and, on the other hand, Valle del Cauca, Meta, Tolima, Huila, and Cundinamarca (Supplementary Fig. S8). In 2016, when the Zika epidemic reached its peak, most DALYs were lost in Valle del Cauca and the Andean region. In general, the DALYs lost in the Orinoquia and Amazon region were scarce (Supplementary Fig. S9).

In the conservative scenario was estimated that a minimum of 68,264.73 DALYs were lost in the 2013–2016 period at the national level, while in the extreme scenario was estimated that a maximum of 4,598,006 DALYs were lost in the same period (Table 3).

Discussion

The results presented here reiterate the importance in public health that arboviruses represent in Colombia. Since the highest number of DALYs were lost in the age group between 15 and 29 years, this translates into productivity lost (due to hospitalizations and complications such as post-Chikungunya chronic arthritis (Bloch, 2016) and GBS (Peixoto et al., 2019)) and school absenteeism (peaks of school absenteeism have been related to peaks of Dengue cases) (Lawpoolsri et al., 2014).

When comparing the estimated DALYs with those reported in the literature, our results should be compared against estimates from epidemic years, given that the period studied (2013–2016) was epidemic for the three arboviruses. For each arbovirus we compared our results against two previously published articles (Table 4). In general, the differences observed between previous studies and ours are explained by the heterogeneity of disability weights and the duration of the diseases used, both in their acute and chronic phases. Likewise, previous studies did not use weights by age, nor discount rate, chose the total population instead of the population at risk, and the number of deaths and cases was not adjusted (Cardona-Ospina et al., 2015a, Cardona-Ospina et al., 2015b). Particularly, Castro Rodríguez et al. (2016) underestimated the burden of disease for Dengue since they did not include the cases of post-Dengue chronic fatigue. Similarly, according to the WHO estimates, most DALYs are lost within the age range of 5 to 14 years (2015: 6.200 DALYs; 2016: 6.700 DALYs) (World Health Organization (WHO), 2018a), while we determined that the most affected age group were people from 15 to 29 years of age. The WHO used a discount rate value of 0%, and did not use age weights and, as a consequence, their results had an increase in absolute DALYs at younger ages.

Table 4. Summary of arboviral burden of disease studies.

Reference	Arbovirus	Study period; location; total cases estimated	Results	Parameters used for the estimation of disability-adjusted life years (DALYs)

Castro Rodríguez et al. (2016)	Dengue	2010–2012; Colombia; 2010: 153,165, 2011: 32,639, 2012: 57,238	2010: 1.198,73 DALYs per million inhabitants; 2011–2012: 83.88 DALYs per million inhabitants	Disability weight = 0.81 (0.6–0.92); duration: 15 days (10–21)
World Health Organization (WHO), 2018a	Dengue	2000–2016; World and country level; Colombia 2006–2016 Cases: 648,300 (448,100–892,200)	Colombia 2000: 9000 DALYs; 2010: 25,900 DALYs; 2015 and 2016: 25,600 DALYs	Disability weight: Dengue = 0.053; severe dengue = 0.210; moderate post-Dengue chronic fatigue = 0.051, severe = 0.133D uration: dengue = 6 days; severe dengue = 14 days; post-Dengue chronic fatigue = 6 months
Cardona-Ospina et al. (2015b)	Chikungunya	2014; Colombia; 106,592	427.96 DALYs per million inhabitants	Disability weight: acute phase = 0.172; post-Chikungunya chronic arthritis = 0.233; duration: post-Chikungunya chronic arthritis = 20.12 months
Cardona-Ospina et al. (2015a)	Chikungunya	2014; Sucre, Colombia; 14,741	3084.74 DALYs per million inhabitants	Disability weight post-Chikungunya chronic arthritis = 0.233; duration post-Chikungunya chronic arthritis = 20.12 months
Teich et al. (2017)	Zika	2016; Brazil; 215,319	0.005 DALYs; 1076.6 DALYs	Disability weight acute phase = 0.16; duration acute phase = 8 days
Alfaro-Murillo et al. (2016)	Zika	2016; Latin America and the Caribbean	Microcephaly: 29.95 DALYs per case; GBS: 1.25 DALYs per case.	Microcephaly: 79.7% probability of survival through the first year of life; disability weight = 0.16; duration = 35 years; GBS: 5% probability of death; 9% probability of severe motor impairment; disability weight = 0.402; duration = 6 months; 84% probability of moderate generalized musculoskeletal problems; disability weight = 0.344; duration = three weeks

In comparison with Alfaro-Murillo et al. (2016), their results are higher than those estimated here (2.75 DALYs per microcephaly case and 0.41 DALYs per GBS case). The differences are primarily explained by different values of the parameters used in the calculation of YLDs (Table 4). Also, we did not include deaths from microcephaly and GBS.

In the same way that it is possible to compare our results against previous periods or international studies, DALYs can be compared against other infectious diseases. When combining the DALYs lost by the three arbovirosis and comparing them against the WHO estimates, we found that, in 2015, the arboviral burden exceeded the sum of the DALYs lost by tuberculosis, HIV/AIDS, and other sexually transmitted diseases (290,000 DALYs compared with 285,500 DALYs). In 2016, arboviral burden was 56,081 DALYs, being slightly higher than tuberculosis burden (55,300 DALYs) (World Health Organization (WHO), 2018a). Therefore, arboviruses were the leading cause of DALYs among infectious diseases during 2015 and the third cause during 2016 in Colombia. Such was the arboviral burden of disease in Colombia that it was the seventh leading cause of DALYs lost among all health conditions and diseases in 2015 (Table 5).

Table 5. The 10 leading causes of disability-adjusted life years (DALYs) in Colombia in 2015.

Health Conditions & Diseases	DALYs (1000)[a]
Interpersonal violence	1311.5
Ischemic heart disease	1047.2
Road injuries	602.6
Stroke	438.9
Diabetes mellitus	398.0
Low respiratory infections	337.5
Arboviruses	290.0[b]
Other causes of hearing loss	283.3
Cervical and lumbar pain	266.3
Complications of premature birth	260.6

a

Values estimated by the WHO. Source: Global Health Estimates 2016: Disease burden by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018.

b

Combined burden of Dengue, Chikungunya and Zika in Colombia in 2015.

The limitations of this study can be summarized in 4 points. First, the databases present underreporting. This was minimized using expansion factors (Shepard et al., 2011); however, this method cannot guarantee that the study lacks underreporting. In addition, different EFs have been published to correct the underreporting of Dengue in Colombia (Shepard et al., 2011, Sarti et al., 2016). We used Shepard et al. (2011) EFs, which were published in 2011. Nonetheless, those EFs arised from a study published in 2004, but whose data are older, dating back to 1995 and 1997 (Camacho et al., 2004). Despite Shepard et al. (2011) EFs are outdated, it is necessary to implement correction factors, since surveillance systems are unable to detect all cases.

Second, the entire spectrum of chronic manifestations of Chikungunya and Zika was not taken into account. Chronic post-Chikungunya arthritis accounts for about 50% of all post-Chikungunya chronic inflammatory rheumatism (Rodríguez-Morales et al., 2016). Furthermore, congenital and neurological alterations have been associated with Chikungunya virus (Gérardin et al., 2008, Barrios-Corrales et al., 2015, Solomon et al., 2018). Similarly, GBS and microcephaly only represent a fraction of the entire spectrum of clinical manifestations associated with Zika (Moore et al., 2017, Muñoz et al., 2017). As a result, the burden of disease due to chronic manifestations caused by Chikungunya and Zika is being underestimated. There are no databases of chronic manifestations of these diseases in Colombia, and new clinical manifestations of both diseases are still documented (Costa Monteiro et al., 2018, Merle et al., 2018).

Third, hospitalized cases and deaths associated with each virus are not necessarily a consequence of the infection, but may be related to pre-existing medical conditions of each patient. However, one cannot ignore that the infection contributed to a patient's hospitalization or death. Therefore, this limitation can lead to a possible overestimation of the burden of disease.

Fourth, microcephaly deaths and GBS deaths were not included in the DALYs calculation. The exclusion of these deaths underestimate Zika's total DALYs. They were not included because there is no a reliable database of deaths from these causes. Similarly, the number of cases of microcephaly and GBS were not corrected by underreporting, resulting in underestimation of the burden of disease. They were not corrected by underreporting since there are no expansion factors reported previously for these two clinical conditions.

The main strength of this study was to present the total and per arbovirus burden of disease at the national and departmental levels, by sex and age group, following the recommendations of previous studies (Beatty et al., 2011) and including the chronic manifestations associated with the three arboviruses. Moreover, the disability weight of post-Chikungunya chronic arthritis was differentiated by sex since the evidence shows that rheumatoid arthritis is more disabling in women (Cross et al., 2014). Finally, it is one of the first studies to calculate the Zika burden of disease, taking into account both the acute phase and chronic manifestations of the infection.

This study highlights the importance of the introduction of new viruses in America, especially in Colombia. Other arboviruses, such as mayaro and oropuche, have been proposed as new threats that, if not addressed, could reach the epidemic scale of Chikungunya or Zika (Hotez and Murray, 2017, Rodríguez-Morales et al., 2017, Romero-Alvarez and Escobar, 2018). Likewise, there is a great diversity of African arboviruses that could potentially be introduced into the Americas and trigger the next epidemic (Braack et al., 2018). Therefore, public policies established at the national and departmental levels must be improved to detect, prevent, and mitigate the impact of established and emerging arboviruses in Colombia.

Authors contribution

Andrés Felipe Mora-Salamanca, MSc: He did the literature search, designed the study, performed data analysis, and elaborated the discussion.

Alexandra Porras-Ramírez, Ph.D.: She designed the study, performed data analysis, and elaborated the discussion.

Fernando Pío de la Hoz Restrepo, Ph.D.: He performed data analysis, elaborated the discussion, and made corrections.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare no conflicts of interest

Financial support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

The authors thank the Colombian National Institute of Health (Instituto Nacional de Salud) for providing the 2013-2016 Dengue, Chikungunya and Zika virus databases.

Appendix A. Supplementary data

The following are Supplementary data to this article:

Download : **Download Acrobat PDF file (33MB)**

References

Acosta Ramirez et al., 2008 N. Acosta Ramirez, R.E. Peñaloza, J. Garcia Rodriguez
Carga de Enfermedad en Colombia 2005: Resultados Alcanzados [Internet]
Available from: http://www.javeriana.edu.co/cendex/GPES/informes/PresentacionCarga_Informe.pdf
Pontificia Universidad Javeriana (2008)
Google Scholar

Alfaro-Murillo et al., 2016 J.A. Alfaro-Murillo, A.S. Parpia, M.C. Fitzpatrick, J.A. Tamagnan, J. Medlock, M.L. Ndeffo-Mbah, *et al.*
A cost-effectiveness tool for informing policies on zika virus control
PLoS Negl Trop Dis, 10 (5) (2016), pp. 1-14
Google Scholar

Barrios-Corrales et al., 2015 M. Barrios-Corrales, A. Menco-Ramos, A.J. Rodríguez-Morales, T. Molinares-Palacios, A. Gonzalez-Vergara, L. Alba-Silvera, *et al.*
Congenital chikungunya virus infection in Sincelejo, Colombia: a case series
J Trop Pediatr, 61 (5) (2015), pp. 386-392
Google Scholar

Beatty et al., 2011 M.E. Beatty, P. Beutels, M.I. Meltzer, D.S. Shepard, J. Hombach, R. Hutubessy, *et al.*
Health economics of dengue: a systematic literature review and expert panel "s assessment
Am J Trop Med Hyg, 84 (3) (2011), pp. 473-488
CrossRef View Record in Scopus Google Scholar

Bennett and Horiuchi, 1981 N.G. Bennett, S. Horiuchi
Estimating the completeness of death registration in a closed population author
Popul Index, 47 (2) (1981), pp. 207-221
CrossRef View Record in Scopus Google Scholar

van den Berg et al., 2013 B. van den Berg, C. Bunschoten, P.A. van Doorn, B.C. Jacobs
Mortality in Guillain-Barre syndrome
Neurology [Internet], 80 (Apr (18)) (2013), pp. 1650-1654, 10.1212/WNL.0b013e3182904fcc
CrossRef View Record in Scopus Google Scholar

Bloch, 2016 D. Bloch
The cost and burden of Chikungunya in the Americas [Internet]. Public Health theses
Available from: http://elischolar.library.yale.edu/ysphtdl/1022
Yale University (2016)
Google Scholar

Braack et al., 2018 L. Braack, A.P. Gouveia De Almeida, A.J. Cornel, R. Swanepoel, C. De Jager
Mosquito-borne arboviruses of African origin: review of key viruses and vectors
Parasites Vectors, 11 (1) (2018)
Google Scholar

Camacho et al., 2004 T. Camacho, F. de la Hoz, V. Cardenas, C. Sanchez, L. de Calderon, L. Perez, *et al.*
Incomplete surveillance of a dengue-2 epidemic in Ibague, Colombia, 1995–1997
Biomedica, 24 (1) (2004), pp. 174-182
CrossRef View Record in Scopus Google Scholar

Cardona-Ospina et al., 2015a J.A. Cardona-Ospina, A.J. Rodriguez-Morales, W.E. Villamil-Gómez
The burden of Chikungunya in one coastal department of Colombia (Sucre): estimates of the disability adjusted life years (DALY) lost in the 2014 epidemic
J Infect Public Health, 8 (6) (2015), pp. 644-646
Article Download PDF View Record in Scopus Google Scholar

Cardona-Ospina et al., 2015b J.A. Cardona-Ospina, W.E. Villamil-Gómez, C.E. Jimenez-Canizales, D.M. Castañeda-Hernández, A.J. Rodríguez-Morales
Estimating the burden of disease and the economic cost attributable to chikungunya, Colombia, 2014
Trans R Soc Trop Med Hyg, 109 (12) (2015), pp. 793-802
CrossRef View Record in Scopus Google Scholar

Castro Rodríguez et al., 2016 R. Castro Rodríguez, G. Carrasquilla, A. Porras, K. Galera-Gelvez, J.G.L. Yescas, J.A. Rueda-Gallardo

The burden of dengue and the financial cost to Colombia, 2010-2012
Am J Trop Med Hyg, 94 (5) (2016), pp. 1065-1072
CrossRef Google Scholar

Chang et al., 2018 A.Y. Chang, R. Lynch, K. Martins, L. Encinales, A. Cadena Bonfanti, N. Pacheco, *et al.*
Long-term clinical outcomes of Zika-associated Guillain-Barré syndrome
Emerg Microbes Infect [Internet], 7 (1) (2018), pp. 4-7, 10.1038/s41426-018-0151-9
View Record in Scopus Google Scholar

Costa Monteiro et al., 2018 L.M. Costa Monteiro, G.N. De Oliveira Cruz, J.M. Fontes, T.R.D. Saad Salles, M.C. Bastos Boechat, A.C. Monteiro, *et al.*
Neurogenic bladder findings in patients with congenital zika syndrome: a novel condition
PLOS ONE, 13 (3) (2018), pp. 1-11
Google Scholar

Cross et al., 2014 M. Cross, E. Smith, D. Hoy, L. Carmona, F. Wolfe, T. Vos, *et al.*
The global burden of rheumatoid arthritis: estimates from the Global Burden of Disease 2010 study
Ann Rheum Dis, 73 (7) (2014), pp. 1316-1322
CrossRef View Record in Scopus Google Scholar

Departamento Administrativo Nacional de Estadística (DANE), 2007a Departamento Administrativo Nacional de Estadística (DANE)
Microdatos – DANE: Estadísticas Vitales 2012–2016 [Internet]
[Cited 2019 May 15]. Available from:
http://microdatos.dane.gov.co/index.php/catalog/MICRODATOS#_r=1557972246716&collection=&country=&dtype=&from=2012&page=1&ps=&sid=&sk=vitales&sort_by=rank&sort_order=desc&to=2016&topic=&view=s&vk=
(2007)
Google Scholar

Departamento Administrativo Nacional de Estadística (DANE), 2007b Departamento Administrativo Nacional de Estadística (DANE)
PROYECCIONES DE POBLACI–N 2005–2020. Colombia. Tablas abreviadas de mortalidad nacionales y departamentales 1985–2020. Proyecciones de población 2005–2020 [Internet]
(2007), pp. 4-22
Available from:
https://www.dane.gov.co/files/investigaciones/poblacion/proyepobla06_20/8Tablasvida1985_2020.pdf%0Ahttp://www.dane.gov.co/files/investigaciones/poblacion/proyepobla06
Google Scholar

Farrar et al., 2007 J. Farrar, D. Focks, D. Gubler, R. Barrera, M.G. Guzman, C. Simmons, *et al.*
Editorial: towards a global dengue research agenda
Trop Med Int Heal, 12 (6) (2007), pp. 695-699
CrossRef View Record in Scopus Google Scholar

Fischer and Erin Staples, 2014 M. Fischer, J. Erin Staples
Chikungunya virus spreads in the Americas – Caribbean and South America, 2013–2014
Morb Mortal Wkly Rep, 63 (22) (2014), pp. 500-501
View Record in Scopus Google Scholar

Gatherer and Kohl, 2016 D. Gatherer, A. Kohl
Zika virus: a previously slow pandemic spreads rapidly through the Americas
J Gen Virol, 97 (2) (2016), pp. 269-273
CrossRef View Record in Scopus Google Scholar

Gérardin et al., 2008 P. Gérardin, G. Barau, A. Michault, M. Bintner, H. Randrianaivo, G. Choker, *et al.*
Multidisciplinary prospective study of mother-to-child chikungunya virus infections on the island of La Réunion
PLoS Med, 5 (3) (2008), pp. 0413-0423
View Record in Scopus Google Scholar

Gómez and Instituto Nacional de Salud (INS), 2015 S. Gómez
Instituto Nacional de Salud (INS); Informe del evento dengue, Colombia, hasta el décimo tercer periodo epidemiológico, 2015. [Internet]. Vigilancia y control en Salud Pública
Available from: http://www.ins.gov.co/buscador-eventos/Paginas/Info-Evento.aspx
(2015)
Google Scholar

Gómez and Instituto Nacional de Salud (INS), 2016 S. Gómez, Instituto Nacional de Salud (INS)
Informe del evento dengue, Colombia, hasta el décimo tercer periodo epidemiológico, 2016 [Internet]. Vigilancia y control en Salud Pública
Available from: http://www.ins.gov.co/buscador-eventos/Paginas/Info-Evento.aspx
(2016)
Google Scholar

Honeycutt et al., 2003 A.A. Honeycutt, S.D. Grosse, L.J. Dunlap, D.E. Schendel, H. Chen, E. Brann, *et al.*
Economic costs of mental retardation, cerebral palsy, hearing loss, and vision impairment
Using survey data to study disability: results from the National Health Survey on Disability [Internet], Elsevier Ltd. (2003), pp. 207-228
Available from: https://www.emeraldinsight.com/10.1016/S1479-3547(03)03011-2
View Record in Scopus Google Scholar

Hotez and Murray, 2017 P.J. Hotez, K.O. Murray
Dengue, West Nile virus, chikungunya, Zika–and now Mayaro?
PLoS Negl Trop Dis., 11 (8) (2017), Article e0005462
CrossRef Google Scholar

Instituto Nacional de Salud (INS), 2017 Instituto Nacional de Salud (INS)
Evento Dengue – Información Epidemiológica – Informes de Evento [Internet]
[Cited 2019 May 15]. Available from: https://www.ins.gov.co/buscador-eventos/SitePages/Evento.aspx?Event=4
(2017)
Google Scholar

Instituto Nacional de Salud (INS), 2016 Instituto Nacional de Salud (INS)
Protocolo de Vigilancia en Salud Pública. Enfermedad por Virus Zika [Internet]. Vol. PRO-R02.05. Bogotá
Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Fichas-y-Protocolos.aspx
(2016), pp. 1-27
Google Scholar

Instituto Nacional de Salud (INS), 2017a Instituto Nacional de Salud (INS)
Protocolo de Vigilancia en Salud Pública. Chikungunya [Internet]. Vol. FOR-R02.00
Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Fichas-y-Protocolos.aspx
(2017), pp. 1-17
Google Scholar

Instituto Nacional de Salud (INS), 2017b Instituto Nacional de Salud (INS)
Protocolo de Vigilancia en Salud Pública. Dengue [Internet]. Vol. FOR-R02.00
Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Fichas-y-Protocolos.aspx
(2017), pp. 1-19
Google Scholar

Lawpoolsri et al., 2014 S. Lawpoolsri, A. Khamsiriwatchara, W. Liulark, K. Taweeseneepitch, A. Sangvichean, W. Thongprarong, *et al.*
Real-time monitoring of school absenteeism to enhance disease surveillance: a pilot study of a mobile electronic reporting system
JMIR mHealth uHealth., 2 (2) (2014), pp. 1-15
Google Scholar

Meltzer et al., 1998 M.I. Meltzer, J.G. Rigau-Pérez, G.G. Clark, P. Reiter, D.J. Gubler
Using disability-adjusted life years to assess the economic impact of dengue in Puerto Rico: 1984–1994
Am J Trop Med Hyg, 59 (2) (1998), pp. 265-271
CrossRef View Record in Scopus Google Scholar

Mercado Reyes and Instituto Nacional de Salud (INS), 2014 M. Mercado Reyes
Informe evento Dengue 2013
Vigilancia y control en Salud Pública (2014)
Google Scholar

Mercado Reyes and Instituto Nacional de Salud (INS), 2015 M. Mercado Reyes
Informe final dengue, Colombia, 2014
Vigilancia y control en Salud Pública (2015)
Google Scholar

Merle et al., 2018 H. Merle, A. Donnio, A. Jean-Charles, J. Guyomarch, R. Hage, F. Najioullah, *et al.*
Ocular manifestations of emerging arboviruses: Dengue fever, Chikungunya, Zika virus, West Nile virus, and yellow fever
J Fr Ophtalmol [Internet], 41 (7) (2018), pp. 659-668, 10.1016/j.jfo.2018.05.002
Article Download PDF View Record in Scopus Google Scholar

Moore et al., 2017 C.A. Moore, J.E. Staples, W.B. Dobyns, A. Pessoa, C.V. Ventura, E.B. Da Fonseca, *et al.*
Characterizing the pattern of anomalies in congenital zika syndrome for pediatric clinicians
JAMA Pediatr, 171 (3) (2017), pp. 288-295
CrossRef View Record in Scopus Google Scholar

Muñoz et al., 2017 L.S. Muñoz, B. Parra, C.A. Pardo
Neurological implications of Zika virus infection in adults
J Infect Dis [Internet], 216 (Suppl 10) (2017), pp. S897-S905
Available from: http://academic.oup.com/jid/advance-article/doi/10.1093/infdis/jix512/4676001
View Record in Scopus Google Scholar

Murray, 1994 C.J.L. Murray
Quantifying the burden of disease: the technical basis for disability-adjusted life years
Bull World Health Organ, 72 (3) (1994), pp. 429-445
View Record in Scopus Google Scholar

Murray CJL et al., 1996 Lopez A.D. Murray CJL, C. Mathers, World Health Organization (WHO)
The global burden of disease: a comprehensive assessment of mortality and disability from deceases, injuries and risk factors in 1990 and projected to 2020 [Internet], Vol. 1, Harvard University Press (1996)
Available from: https://apps.who.int/iris/handle/10665/41864

Nembhard et al., 2001 W.N. Nembhard, D. Kim Waller, L.E. Sever, M.A. Canfield
Patterns of first-year survival among infants with selected congenital anomalies in Texas, 1995–1997
Teratology, 64 (5) (2001), pp. 267-275
View Record in Scopus Google Scholar

Pan American Health Organization (PAHO) and World Health Organization (WHO), 2018 Pan American Health Organization (PAHO), World Health Organization (WHO)
Epidemic diseases – Chikungunya in the Americas. New cases of Chikungunya in the Americas, 2013-2017 per year and country [Internet]
[Cited 2019 March 3]. Available from: http://ais.paho.org/phip/viz/ed_chikungunya_amro.asp
(2018)
Google Scholar

Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019a Pan American Health Organization (PAHO), World Health Organization (WHO)
PAHO/WHO data – Dengue cases. Dengue fever in the Americas. Number of reported cases by country or territory [Internet]
[Cited 2019 March 3]. Available from: http://www.paho.org/data/index.php/en/mnu-topics/indicadores-dengue-en/dengue-nacional-en/252-dengue-pais-ano-en.html?start=2
(2019)
Google Scholar

Pan American Health Organization (PAHO) and World Health Organization (WHO), 2019b Pan American Health Organization (PAHO), World Health Organization (WHO)
PAHO/WHO data – weekly report. Cases of Zika Virus disease by country or territory. Cumulative cases [Internet]
[Cited 2019 March 3]. Available from: http://www.paho.org/data/index.php/en/?option=com_content&view=article&id=524:zika-weekly-en&Itemid=352
(2019)
Google Scholar

Parra et al., 2016 B. Parra, J. Lizarazo, J.A. Jiménez-Arango, A.F. Zea-Vera, G. González-Manrique, J. Vargas, *et al.*
Guillain–Barré syndrome associated with Zika virus infection in Colombia
N Engl J Med [Internet], 375 (16) (2016), pp. 1513-1523, 10.1056/NEJMoa1605564
CrossRef View Record in Scopus Google Scholar

Peixoto et al., 2019 H.M. Peixoto, G.A.S. Romero, W.N. De Araújo, M.R. Fernandes de Oliveira
Guillain–Barré syndrome associated with Zika virus infection in Brazil: a cost-of-illness study
Trans R Soc Trop Med Hyg, 113 (5) (2019), pp. 252-258
CrossRef View Record in Scopus Google Scholar

Peñaloza et al., 2014 R. Peñaloza, N. Salamanca, J. Rodriguez, J. Rodriguez, A. Beltrán
Estimacion de la carga de enfermedad para Colombia, 2010. [Internet]
Available from:
https://www.javeriana.edu.co/documents/12789/4434885/Carga+de+Enfermedad+Colombia+2010.pdf/e0dbfe7b-40a2-49cb-848e-bd67bf7bc62e
Editorial Pontificia Universidad Javeriana (2014)
Google Scholar

Pinilla Farias and Instituto Nacional de Salud (INS), 2016 A. Pinilla Farias, Instituto Nacional de Salud (INS)
Informe del evento Chikungunya periodo epidemiológico XIII, Colombia 2016 [Internet]
Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Info-Evento.aspx
Vigilancia y control en Salud Pública (2016)
Google Scholar

Rasmussen et al., 2016 S.A. Rasmussen, D.J. Jamieson, M.A. Honein, L.R. Petersen
Zika virus and birth defects – reviewing the evidence for causality
N Engl J Med [Internet], 374 (20) (2016), pp. 1981-1987, 10.1056/NEJMsr1604338
View Record in Scopus Google Scholar

Rodríguez-Morales et al., 2016 A.J. Rodríguez-Morales, J.A. Cardona-Ospina, S. Fernanda Urbano-Garzón, J. Sebastian Hurtado-Zapata
Prevalence of post-chikungunya infection chronic inflammatory arthritis: a systematic review and meta-analysis
Arthritis Care Res (Hoboken) [Internet], 68 (12) (2016), pp. 1849-1858, 10.1002/acr.22900
CrossRef View Record in Scopus Google Scholar

Rodriguez-Morales et al., 2015 A.J. Rodriguez-Morales, J.A. Cardona-Ospina, W. Villamil-Gómez, A.E. Paniz-Mondolfi
How many patients with post-chikungunya chronic inflammatory rheumatism can we expect in the new endemic areas of Latin America?
Rheumatol Int, 35 (12) (2015), pp. 2091-2094
CrossRef View Record in Scopus Google Scholar

Rodríguez-Morales et al., 2017 A.J. Rodríguez-Morales, A.E. Paniz-Mondolfi, W.E. Villamil-Gómez, J.C. Navarro
Mayaro, Oropouche and Venezuelan Equine Encephalitis viruses: following in the footsteps of Zika?
Travel Med Infect Dis, 15 (2017), pp. 72-73
Article Download PDF View Record in Scopus Google Scholar

Romero-Alvarez and Escobar, 2018 D. Romero-Alvarez, L.E. Escobar
Oropouche fever, an emergent disease from the Americas
Microbes Infect [Internet], 20 (3) (2018), pp. 135-146, 10.1016/j.micinf.2017.11.013
Article Download PDF View Record in Scopus Google Scholar

Salas Botero and Instituto Nacional de Salud (INS), 2014 D. Salas Botero, Instituto Nacional de Salud (INS)
Informe Final del Evento Chikungunya, Colombia 2014 [Internet]

Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Info-Evento.aspx
Vigilancia y control en Salud Pública (2014)
Google Scholar

Salas Botero and Instituto Nacional de Salud (INS), 2015 D. Salas Botero, Instituto Nacional de Salud (INS)
Informe final del evento Chikunguña, Colombia, 2015. [Internet]
Available from: https://www.ins.gov.co/buscador-eventos/Paginas/Info-Evento.aspx
Vigilancia y control en Salud Pública (2015)
Google Scholar

Salomon et al., 2015 J.A. Salomon, J.A. Haagsma, A. Davis, C.M. de Noordhout, S. Polinder, A.H. Havelaar, *et al.*
Disability weights for the Global Burden of Disease 2013 study
Lancet Glob Heal, 3 (11) (2015), pp. e712-23
View Record in Scopus Google Scholar

Sarti et al., 2016 E. Sarti, M. L 'Azou, M. Mercado, P. Kuri, J.B. Siqueira, E. Solis, *et al.*
A comparative study on active and passive epidemiological surveillance for dengue in five countries of Latin America
Int J Infect Dis, 44 (2016), pp. 44-49
Article Download PDF View Record in Scopus Google Scholar

Seet et al., 2007 R.C.S. Seet, A.M.L. Quek, E.C.H. Lim
Post-infectious fatigue syndrome in dengue infection
J Clin Virol, 38 (1) (2007), pp. 1-6
Article Download PDF View Record in Scopus Google Scholar

Sharp et al., 2016 T.M. Sharp, K.R. Ryff, L. Alvarado, W.J. Shieh, S.R. Zaki, H.S. Margolis, *et al.*
Surveillance for chikungunya and dengue during the first year of chikungunya virus circulation in puerto rico
J Infect Dis, 214 (Suppl 5) (2016), pp. S475-81
CrossRef View Record in Scopus Google Scholar

Shepard et al., 2011 D.S. Shepard, L. Coudeville, Y.A. Halasa, B. Zambrano, G.H. Dayan
Economic impact of dengue illness in the Americas
Am J Trop Med Hyg, 84 (2) (2011), pp. 200-207
CrossRef View Record in Scopus Google Scholar

Solomon et al., 2018 T. Solomon, P. Gerardin, M.L.B. Ferreira, C.A.A. de Brito, R. Mehta, C.N. Soares
The neurological complications of chikungunya virus: a systematic review
Rev Med Virol, 28 (3) (2018), p. e1978
Google Scholar

Stanaway et al., 2016 J.D. Stanaway, D.S. Shepard, E.A. Undurraga, Y.A. Halasa, L.E. Coffeng, O.J. Brady, *et al.*
The global burden of dengue: an analysis from the Global Burden of Disease Study 2013
Lancet Infect Dis, 16 (6) (2016), pp. 712-723
Article Download PDF View Record in Scopus Google Scholar

Teich et al., 2017 V. Teich, R. Arinelli, L. Fahham
Aedes aegypti e sociedade: o impacto econômico das arboviroses no Brasil
J Bras Econ da Saúde [Internet], 9 (3) (2017), pp. 267-276
Available from: http://www.jbes.com.br/images/v9n3/267.pdf
CrossRef View Record in Scopus Google Scholar

World Health Organization (WHO), 2006 World Health Organization (WHO)
Report of the Scientific Working Group meeting on dengue, Geneva, 1–5 October 2006. [Internet]
Available from: https://apps.who.int/iris/handle/10665/69787
(2006)
Google Scholar

World Health Organization (WHO), 2012 World Health Organization (WHO)
Global Strategy for Dengue Prevention and Control 2012–2020 [Internet]
Available from: https://www.who.int/denguecontrol/9789241504034/en/
World Health Organization (2012)
Google Scholar

World Health Organization (WHO), 2018a World Health Organization (WHO)
Global health estimates 2016: disease burden by cause, age, sex, by country and by region, 2000–2016. [Internet]
World Health Organization, Geneva (2018)
Available from: https://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html
Google Scholar

World Health Organization (WHO), 2018b World Health Organization (WHO)
Zika Virus [Internet]
[Cited 2019 March 3]. Available from: https://www.who.int/news-room/fact-sheets/detail/zika-virus
(2018)
Google Scholar

Zeng et al., 2018 W. Zeng, Y.A. Halasa-Rappel, L. Durand, L. Coudeville, D.S. Shepard
Impact of a nonfatal dengue episode on disability-adjusted life years: a systematic analysis
Am J Trop Med Hyg, 99 (6) (2018), pp. 1458-1465
CrossRef View Record in Scopus Google Scholar

[1] Address: Universidad El Bosque, Edificio Fundadores, Piso 5, Oficina de Epidemiología, Carrera 9 No. 131 A 02, Bogotá, Colombia.

[2] Address: Universidad Nacional de Colombia – Sede Bogotá, Edificio 471, Departamento de Salud Pública, Carrera 30 No. 45 03, Bogotá, Colombia.

View Abstract