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Chapter 2

The Burden of Dengue Illness and Its Economics Costs in the Americas: A Review on the Most Affected Countries

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Additional information is available at the end of the chapter

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Abstract

According to the Pan American Health Organization (PAHO) reports, the annual average number of dengue cases in the Americas has been 1,579,658 in the last 8 years (2010–2017), affecting the population's welfare. The high level in dengue cases does not only have an impact from an epidemiological perspective but also from an economical perspective as the treatment cost that must be borne. The aim of this chapter is to review the situation as reported in the American countries with the highest number of cases, focusing on the burden of the disease (measured in DALYs and number of cases) and its total treatment cost, which includes direct (medical and non-medical) costs and indirect costs. We calculate the total treatment cost per DALY for the epidemic year (2015). The results show that Mexico has the highest cost per DALY (US$ 17,703) followed by Brazil (US$ 11,218), Colombia (US$ 4,540), and the Dominican Republic (US$ 1,157). Additionally, after adjusting for total health expenditure, we found all the countries exhibit a similar share of total treatment cost over health expenditure (0.16% in average).

Keywords: dengue, disease outbreaks, epidemiologic measurements, disability adjusted life year, economics costs

1. Introduction

Dengue is a viral infection endemic to tropical regions, which is transmitted by *Aedes aegypti* and *Aedes albopictus* mosquitoes. It usually presents a cyclic behavior with peaks separated by

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3–5 years [1–3]. Even though this illness has been present for many years in tropical countries, the main prevention strategy is controlling the vector that carries the infection. Nowadays, vector control and prevention programs are the only strategies in the hands of public officials to handle and reduce dengue incidence.

In the 1970s, because of the vector control campaign against yellow fever, dengue was close to be eliminated, but then it showed a reinvasion that has been present to this day [4]. The constant presence of the illness (and the mosquitoes) is related with the suboptimal conditions of trash collection, piped water supplies and uncontrolled urban development [5]. Another possible cause is climate change [6]. Warming temperatures have expanded the endemic territories of the *A. aegypti* and *A. albopictus* mosquitoes allowing them to be present in larger areas [7], which added to the low efficacy of vector control strategies and create the perfect scenario for the number of dengue cases to rise. Unfortunately, the programs aimed to control the mosquito population have low success rates which are reflected in the consistent high number of dengue cases in the last decade.

In recent years, there has been enough interest from the pharmaceutical industry to develop a dengue vaccine that could act as a preventive strategy against the infection [8–10]. Nevertheless, most dengue vaccine strategies are still in their final stages before implementation [11].

Figure 1 shows the evolution of the reported dengue cases in the Americas for the period 2010–2017, from which it can be observed a drastic decline in the year 2017 after 2 years of high levels of dengue cases. Particularly, 2015 corresponds to the year with the highest number of cases in the region, which suggest it was an epidemic year. Given the cyclic behavior of the disease, the year 2017 could be interpreted as an interepidemic year.

The World Health Organization (WHO) recommends conducting an economic analysis for infectious disease to estimate the cost borne by the society, especially in low- and middle-income countries. These studies provide information to the governments that help them design policies and allocate public resources that achieve a positive impact on public health. The most common and recommended type of analysis is the cost-effectiveness analysis (CEA), which

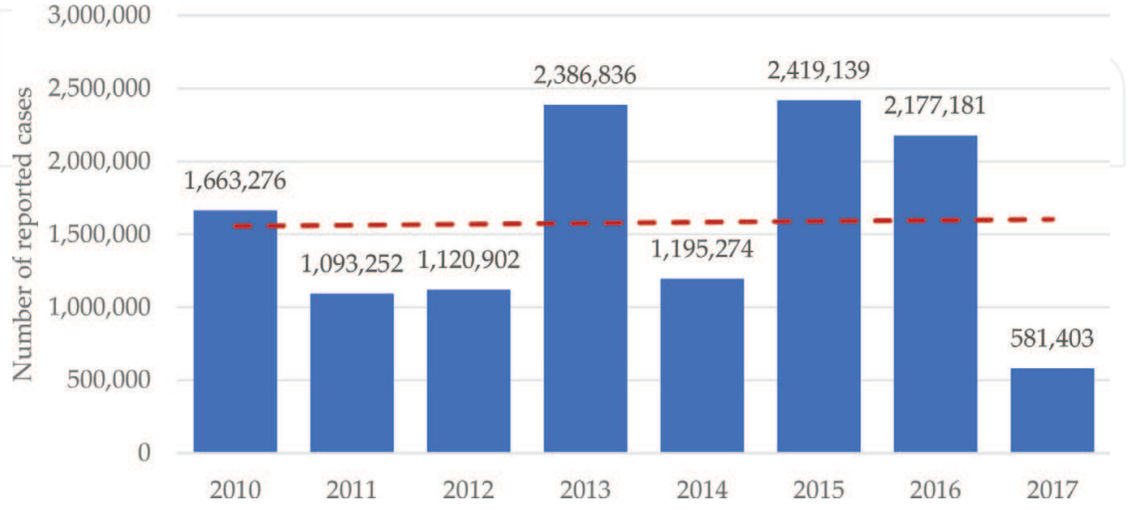


Figure 1. Evolution of reported dengue cases in the Americas (2010–2017). Source: PAHO.

compares different healthcare interventions estimating the economic costs and health gains (usually measured as Disability-Adjusted Life Years) of each intervention and hence identifies strategies with the potential of yielding the greatest health improvement for the least resources used [12]. The aforesaid type of analysis consists of two main elements, the burden estimation in the status quo scenario or current condition and the estimation in the intervention scenario. From this perspective, the analysis conducted in this chapter presents the burden estimation in the status quo scenario.

As well as Latin-American and Caribbean countries, Asian countries have also been affected by dengue. Epidemiological studies conducted for Myanmar show that DALYs per million of inhabitants lost ranged between 90 and 97 in the 1990s [13], while in Thailand, the burden was estimated at 427 DALYs per million in the early 2000s. The latter allow us to have a frame of reference about the burden of dengue. Due to the increasing number of cases in Americas and Asia [14–16] and the economic cost that society must borne to treat (medical and out-of-pocket costs) and control the disease (prevention and promotion, surveillance and control activities), dengue continues to be a public health priority, especially in the regions previously mentioned. This chapter aims to present a recent picture of the treatment costs, generated by the disease and borne by the healthcare system and households, and its burden on the public health in relevant countries for each one of the main territories of the Americas.

The following sections contain: the explanation of the criteria used to select the group of countries for which the total economic cost and burden of the disease were calculated (Countries selection); the methodology used for estimating the DALY and the total economic cost, as well as the necessary adjustment in the cost figures (Materials and methods); the main results for the year 2015 (Results) and finally a brief discussion on the current levels of incidence of dengue as a comparison between 2015 and 2017 in terms of total costs and burden. By estimating the burden for 2015, which corresponds to the year with the highest number of reported dengue cases, according to PAHO, we can estimate the impact that dengue has on public health and health expenditure in an epidemic year. In contrast, having the results for 2017 not only shows a more recent level of the burden but also serve as a comparison of the disease's impact between epidemic and inter-epidemic years. It is worth noting that even though the figures used in this chapter correspond to official figures collected by PAHO, underreport in the information health systems is an element that could hide the real burden[1].

2. Countries selection

To select the countries reviewed, we consider two main elements. The total number of dengue cases in each country according to Pan American Health Organization (PAHO) reports and the availability of information regarding total and average economic costs (per patient). Additionally,

[1]Although it is challenging to estimate a robust level for underreport, attempts have been made. In Brazil the underreport expansion factor for total dengue cases have been estimated in 1.6, while in Nicaragua this estimation goes as high as 28. Additionally, the estimation for the underreport factor specific for severe dengue cases ranges from 1.4 to 3 [20].

we aimed for having a relevant[2] country for each one of the main territories of the Americas as described by PAHO: Central America and Mexico, Andean, Southern Cone, and the Caribbean[3] (**Map 1**). Given that dengue cases recorded in North America usually correspond to non-endemic cases, we exclude from this chapter the information related to the USA and Canada.

To obtain robust figures for each country and avoid making a selection based on a particular year, we used the aggregated figures, by adding the total number of reported cases and death for the period 2014–2017. Based on the total number of reported dengue cases and deaths, we



Map 1. Incidence per 100,000 inhabitants in Americas (2014–2017). Source: PAHO. 2017.

[2]We consider a country as relevant based on the burden of the disease in terms of reported dengue cases and dengue related deaths.

[3]As Caribbean territory we considered both Latin Caribbean and Non-Latin Caribbean.

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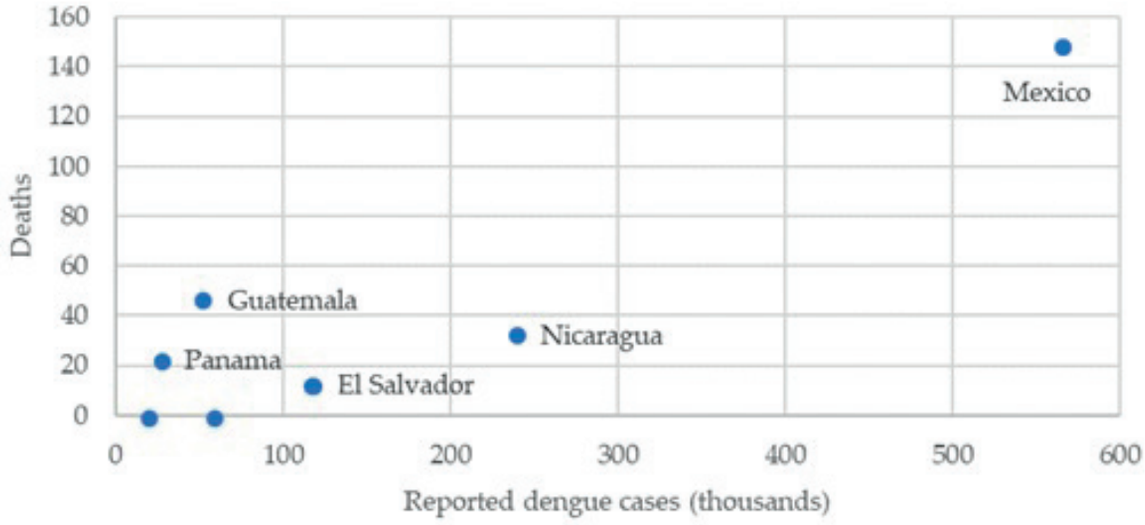


Figure 2. Dengue cases and mortality in Central America and Mexico territory (2014–2017). Source: PAHO. 2017.

selected Mexico as the representative country of the Central America and Mexico territory (**Figure 2**). Mexico has the highest number of dengue deaths (149) as well as the highest number of reported dengue cases (564,498). Another benefit of reviewing the Mexican case is the availability of information regarding total and per patient economic cost through a micro-costing approach [17]. Similarly, for the Andean territory, we observed that the country with the highest number of reported dengue cases (337,018) and deaths (318) is Colombia (**Figure 3**). For this country, the cost for patient was calculated using a micro-costing approach that employed the administrative records of the national healthcare system and a household survey conducted by the authors [18].

In the Southern Cone territory (**Figure 4**), we observe Brazil as the country with the highest number of dengue cases (3,992,664) and deaths (2,048). The latter is particularly expected since

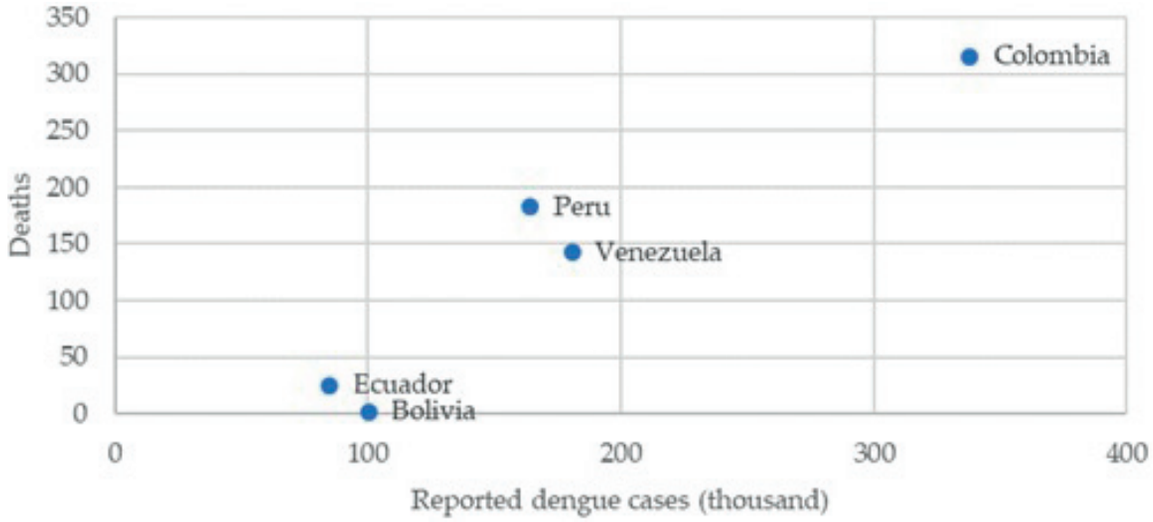


Figure 3. Dengue cases and mortality in Andean territory (2014–2017). Source: PAHO. 2017.

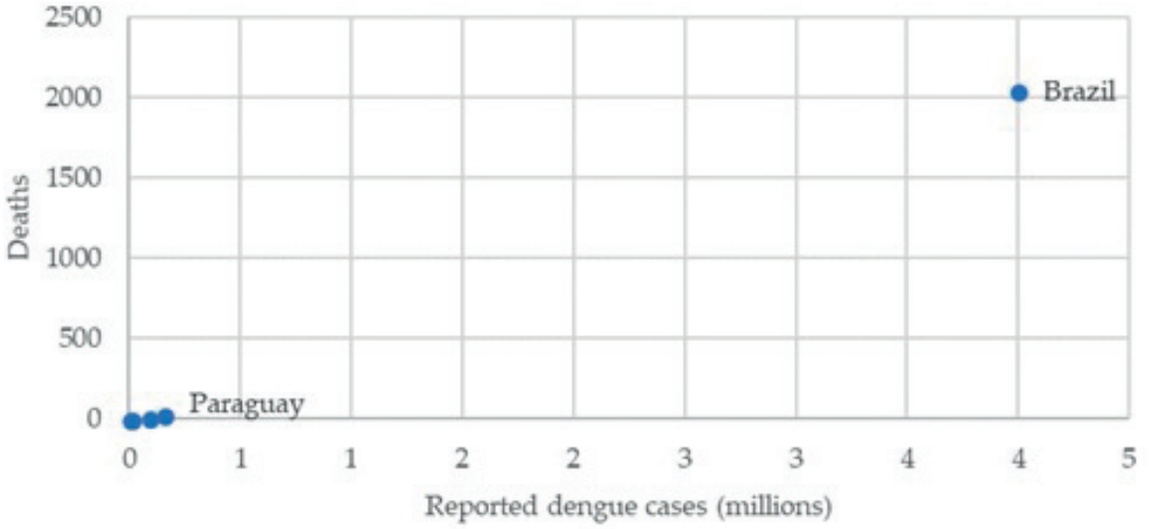


Figure 4. Dengue cases and mortality in Southern Cone territory (2014–2017). Source: PAHO. 2017.

not only Brazil has the largest population in the region (Southern Cone and Andean territory), but also the other countries in this territory are sub-tropical (Paraguay) and non-tropical (Chile, Argentina and Uruguay). The advantage of reviewing the Brazilian case is the large evidence of total and per patient economics costs which has been estimated using micro-costing, bottom-up approach from administrative records, household survey and interviews [19].

Finally, for the Caribbean territory, we found that, based on the information from PAHO, between 2014 and 2017, the country with the highest number of dengue cases (31,326) and deaths (209) is the Dominican Republic (**Figure 5**). In contrast to Brazil, Colombia and Mexico, no published study, which quantifies the cost of the disease per patient considering the same cost structure framework commonly found in the literature (direct and indirect costs), was

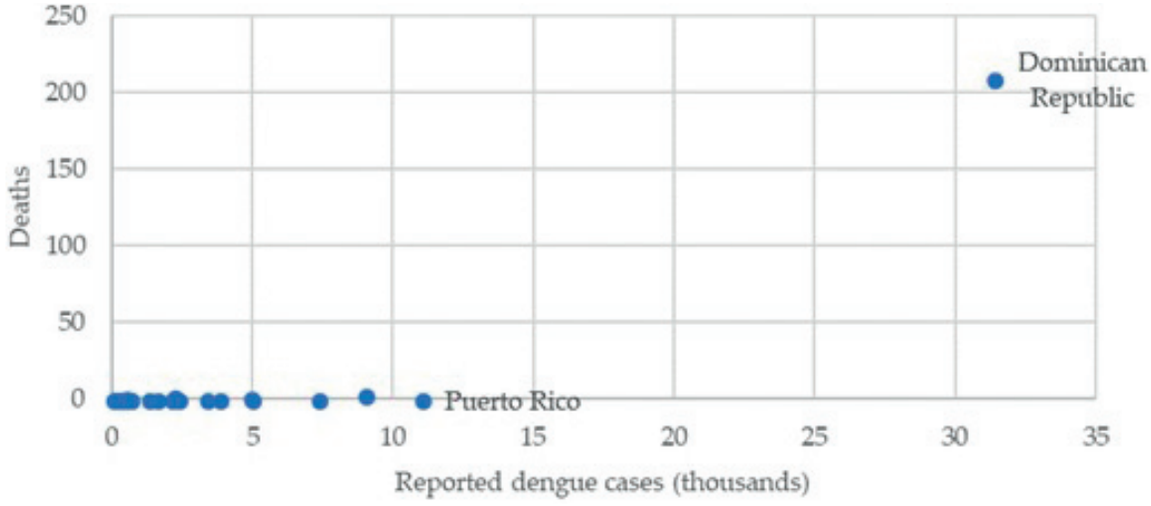


Figure 5. Dengue cases and mortality in the Caribbean territory (2014–2017). Source: PAHO. 2017.

found. Thus, we used the costs per patient estimated by Shepard [20] by extrapolating the results from other countries and considering the differences in purchasing power and income[4].

3. Materials and methods

To assess the economic cost of the disease, we used the results found for Brazil, Colombia, the Dominican Republic, and Mexico. To maintain cost structure homogeneity, we exploited the common methodological framework used in the literature, which is employed in the papers reviewed. There are three main cost categories used to quantify the economic burden of a disease: direct medical cost, direct non-medical cost, and indirect cost.

Direct medical cost comprises the cost borne by the healthcare unit (professional services, medical inputs, medical drugs, laboratory test). Additionally, direct non-medical cost corresponds to the value expended during a dengue episode and comprises food, lodging and travel expenses. Finally, indirect cost includes the productivity loss[5] (by patient and caregivers).

Even though the authors researched a common topic, there are some methodological differences that are worth noting to make a correct comparison between the results. In contrast to Mexico [17], Colombia [18] and Brazil [19] estimate the direct cost per patient grouping the medical and non-medical component in the same category, thus their figures could only be compared to the sum of medical and non-medical direct cost[6] from Mexico and Colombia.

Although the three studies present their results in dollars, nominal adjustment[7] was needed[8], for this we use the GDP deflator calculated by the World Bank for each country. Once the appropriate per patient is defined, the total number of reported dengue cases is required to estimate the total cost in each country; for this, we took the information reported by PAHO for

[4]More details about the methodology employed by the authors can be found in [20].

[5]Productivity loss corresponds to a monetary estimate of the days of work lost by the patient as well as caregivers.

[6]Direct non-medical costs include out-of-pocket expenses borne by the patient.

[7]Nominal adjustment accounts for price changes due to inflation between years. This adjustment allows for proper comparison between figures from different years.

[8]To nominally adjust the cost figures the GDP deflator was used for two different years (i, j).

$$GDP_{nominal,\,i} = \left(1 + \Delta\%_{real}^{i,j}\right) \times \left(1 + \Delta\%_{nominal}^{i,j}\right) \times GDP_{nominal,\,j}$$

$$GDP_{real,\,i} = \left(1 + \Delta\%_{real}^{i,j}\right) \times GDP_{real,\,j}$$

$$\Longrightarrow \frac{GDP_{nominal,\,i}}{GDP_{real,\,i}} = \left(1 + \Delta\%_{nominal}^{i,j}\right) \times \frac{GDP_{nominal,\,j}}{GDP_{real,\,j}}$$

$$\Longrightarrow \Delta\%_{nominal}^{i,j} = \frac{def_i}{def_j} - 1$$

$$def_i = \frac{GDP_{nominal,\,i}}{GDP_{real,\,i}}$$

the year 2015[9]. Considering potential lack of homogeneity among countries regarding laboratory confirmation practices and policies, we used total reported cases instead of laboratory confirmed cases for our analysis; we allow for this since reported dengue cases also received treatment and PAHO definition for reported cases only includes people "who has a fever or history of fever for 2-7 days duration, two or more symptoms of dengue and one serological test positive or epidemiological nexus with confirmed dengue case 14 days before onset of symptom." Even though using reported dengue cases, we are allowing for a potential overestimation of the economic burden, it is worth noting that by using DALY figures from WHO, we avoid this potential bias in the burden of the disease. It might also be noted that by using this approach, the results we found could be interpreted as an upper bound for the economic burden of the disease. To calculate the total treatment cost, we make the following assumption, and severe cases are considered to receive hospitalized treatment while nonsevere dengue cases[10] are considered to receive ambulatory treatment. From now on, we will refer only to ambulatory cases and hospitalized cases.

Total treatment cost was calculated for both ambulatory and hospitalized cases as presented in Eq. (1).

$$TC = AD \times PPC_{ambulatory} + HD \times PPC_{hospitalized} \tag{1}$$

where TC represents total cost, AD number of ambulatory dengue cases, HD number of hospitalized dengue cases, and PPC per patient cost.

$$PPC_i = DMC_i + DnMC_i + IC_i,$$
$$i \in \{ambulatory, hospitalized\} \tag{2}$$

where DMC represents direct medical cost, $DnMC$ direct non-medical cost and IMC indirect cost. In other words, the total cost of the disease is equal to the number of dengue cases times the cost per patient, for both ambulatory and hospitalized cases. The total treatment cost per patient corresponds to the sum of direct medical cost per patient, direct non-medical cost per patient and indirect cost per patient.

As estimates for the burden of the disease, measured as the number of Disability Adjusted Life Years (DALY)[11], we use the figures from the World Health Organization (WHO) for the year

[9] We considered the last published report that includes the information from the whole year. PAHO gathers epidemiological information from official reports made by the countries themselves. Thus, PAHO figures represent the official number of reported dengue cases, death and incidence. This mechanism has been working since 1980 and nowadays counts with systems of mandatory notification across the national territories.

[10] The number of ambulatory dengue cases is equal to the total number of reported cases minus the total number of hospitalized cases; both figures are used as reported by PAHO.

[11] According to WHO, one Disability Adjusted Life Years can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability and are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequence.

2015; we preferred DALYs as measurement of the disease's burden because it allows to express numerically the burden of the disease as years based on a set of standard weights [21].

Additionally, to estimate the number of DALYs for 2017, which is presented in the discussion section, we used the following approach. Using the DALY estimates of WHO for 2015 and the number of cases of dengue reported by PAHO, we calculated the ratio of DALY per reported dengue case, which we then used to calculate the burden of the disease for 2017.

$$rDALY = \# \frac{DALY_{2015-WHO}}{\#Cases_{2015-PAHO}} \tag{3}$$

$$DALY_{2017} = rDALY \times \#Cases_{2017-PAHO} \tag{4}$$

This approach relies on one underlying assumptions, mortality rates do not change dramatically from 2015 to 2017[12]. It is noteworthy that following this approach, we benefit from the WHO information about DALY estimation parameters, reduce bias (noise) from lack of specific data needed to estimate the burden of the disease[13] and get highly comparable estimations from a homogeneous methodology.

4. Results

After nominally adjusting the figures, the cost per patient found by the authors for Brazil, Colombia, the Dominican Republic, and Mexico are shown in **Table 1**. Since the authors used the same cost structure in their estimation process, we can separate the total cost into their main categories (direct medical and non-medical cost and indirect cost). The figures are presented in 2017 prices, which allows for comparison. **Table 1** shows the total cost per patient disaggregated.

In the four countries reviewed, Mexico is the one with the most expensive treatment cost per patient in ambulatory care, even when their indirect cost is the lowest. For ambulatory cases, in contrast to Brazil, Colombia, and the Dominican Republic, the direct medical cost in Mexico is larger than the direct non-medical cost and the indirect cost (even when combined). For hospitalized cases, Mexico keeps having the most expensive treatment cost per patient, with direct costs that more than double the direct costs of the other countries.

The latter shows that Mexico has the most expensive dengue treatment per patient, regardless of the type of care (ambulatory US$ 501 or hospitalized US$ 1,475). On the other hand, the less expensive treatment for ambulatory (US$ 189) and hospitalized (US$ 488) cases would be in Brazil.

[12] We do not find this assumption to be particularly strong.

[13] Recalling the method used to estimate the total cost of the disease it is noteworthy that the latent risk of overestimation is not present in the estimation of the burden of the disease (DALY), as it is estimated by extrapolating the results of 2005 using the ratio of DALY per reported dengue case.

	Brazil	Colombia	The Dominican Republic	Mexico
Cost per ambulatory patient				
Direct medical	$70	$75	$75	$281
Direct non-medical		$33	$14	$102
Indirect	$119	$219	$136	$118
Total	$189	$327	$224	$501
Cost per hospitalized patient				
Direct medical	$258	$368	$366	$1,123
Direct non-medical		$59	$152	$193
Indirect	$230	$345	$366	$159
Total	$488	$771	$883	$1,475

Source: Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 1. Treatment cost per patient by country (nominally adjusted 2017 dollars).

Since the number of cases presented in **Table 2** is not corrected by country-specific population, they cannot be directly compared between themselves; nevertheless, we can observe that more than half the total number of de dengue cases in the Americas in 2015 are located in Brazil (69.1%) and although the population of Brazil is less than twice the population of Mexico, its number of dengue cases exceeds twice the number dengue cases of the latter. This exhibits a concerning situation for the public health in Brazil. Once we controlled for the population of each country, we found that in 2015, the lowest incidence rate corresponds to the Dominican Republic and the highest to Brazil. Although the Dominican Republic has the lowest incidence rate, its mortality rate is much higher than that of the other countries.

Once we have defined the total number of dengue cases for each country and its corresponding treatment cost, it is possible to calculate the total cost following Eqs. (1) and (2). **Table 3** exhibits the total treatment cost for the year 2015 (in 2017 prices). In absolute terms, the highest economic cost corresponds to Brazil, which, as was shown before, has the less expensive treatment cost per patient, hence the extent of the total cost is mainly due to the high incidence

	Brazil	Colombia	The Dominican Republic	Mexico
Number of cases				
Ambulatory dengue	1,647,439	95,023	15,194	214,129
Hospitalized dengue	1,569	1,421	1,854	5,464
Deaths	863	155	107	42
Incidence per 10.000 inhabitants	80.6	20.0	17.1	18.1
Mortality rate (%)	0.05	0.16	0.63	0.02

Source: PAHO. 2015. Week 52. IMF.

Table 2. Number of cases, death and epidemiological by country (2015).

	Brazil	Colombia	The Dominican Republic	Mexico
Total ambulatory (US Dollars)	310,672,689	31,052,056	3,411,045	107,351,329
Total hospitalized (US Dollars)	766,211	1,096,202	1,637,140	8,060,036
Total cost (US Dollars)	**311,438,900**	**32,148,258**	**5,048,184**	**115,411,366**
Total DALY	**49,500**	**16,200**	**9,600**	**12,100**
Population	204,469,667	48,202,951	9,980,185	121,006,250
DALY per million inhabitants	**242**	**336**	**962**	**100**

Source: PAHO. 2015. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 3. Total annual treatment cost and DALYs lost per million inhabitants by country (2015). 2017 dollars.

in the country. In terms of burden of the disease, measured as DALY, Brazil keep having the highest figures in absolute terms (49,500 DALYS), followed by Colombia (16,200 DALYS).

Having DALY in absolute terms does not allow for a proper comparison, therefore, we adjusted the results by dividing them by the country-specific population. Hence, we could express the burden of the disease as the number of DALY per million inhabitants, which is now perfectly comparable between countries. Now, Brazil is not the country with the highest burden relative to its population size, but the Dominican Republic (336 DALYS per million inhabitants), followed by Colombia, which remains in second place (962 DALYS per million inhabitants).

As well as adjusting the DALY by the population, it is also important to adjust the total treatment cost relative to some economic measure that allows to compare figures between countries in a proper manner. One alternative is to present the results as share of the total Gross Domestic Product (GDP) of each country, but this approach has two disadvantages. First, the resulting figures are too small, which by multiplying them by a factor makes the interpretation more difficult, and second, it does not consider GDP composition. Instead, we have used the total health expenditure estimated by the World Bank (WB) to adjust the total treatment cost. **Table 4** exhibits the total health expenditure by country in US billion dollars for 2015 (in 2017 prices).

Once adjusted, the total annual cost is very similar among countries. Notably, Colombia and Mexico spend nearly the same proportion (0.18%) of their health expenditure in dengue treatment, and Brazil has a lower share than the latter (0.16%). Given the country selection criteria used, one could assert that the average share of total cost caused by dengue treatment

	Brazil	Colombia	The Dominican Republic	Mexico
GDP (US Dollars billions)	2,142	297	67	1,093
Health expenditure (US Dollars billions)	191	18	4	64
Health expenditure (% of GDP)	8.9	6.2	6.2	5.9

Source: World Bank. IMF.

Table 4. Total health expenditure (2015). 2017 dollars.

in health expenditure in an epidemic year is 0.16% for the countries with the highest number of cases (**Table 5**). Although this result cannot be perfectly extrapolated to all the countries of the Americas, it could be interpreted as an upper bound for the size of the economic burden of dengue in the region.

Figure 6 shows the normalized treatment cost[14] and burden for each country. We can observe that while the Dominican Republic is the country with the highest number of DALY adjusted by population, it has the lowest cost per each DALY lost because of the disease. In contrast, Mexico has the highest cost per DALY lost, but the lowest number of DALY adjusted by population.

Finally, **Table 6** exhibits the 2015 total economic cost per DALY adjusted for purchasing power parity (PPP). There appears to be high variance in the total treatment cost, with its ranges from $1,157 in the case of the Dominican Republic to $17,703 for Mexico. It is noteworthy that Mexico, in relative terms, always presents the highest treatment cost. This result is consistent whether we analyze the total treatment cost per patient, the share of total annual cost over the total health expenditure or the total treatment per DALY adjusted for PPP.

	Brazil	Colombia	The Dominican Republic	Mexico
Total ambulatory (%)	0.16	0.17	0.08	0.17
Total hospitalized (%)	0.00	0.01	0.04	0.01
Total cost (%)	**0.16**	**0.18**	**0.12**	**0.18**

Source: PAHO. 2015. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 5. Total annual treatment cost as share of the total health expenditure (2015).

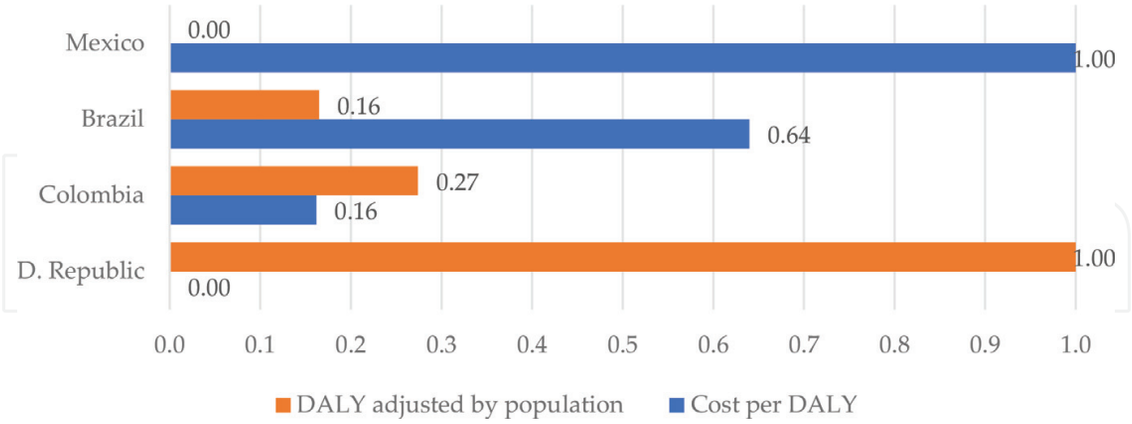


Figure 6. Normalized results. 2015. Source: PAHO. 2015. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

[14]Variable definition: level of current health expenditure expressed as a percentage of GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year. This indicator does not include capital health expenditures such as buildings, machinery, innovation and technology and stocks of vaccines for emergency or outbreaks.

	Brazil	Colombia	The Dominican Republic	Mexico
Total ambulatory (PPP Dollars)	$11,190.5	$4,385.6	$782.0	$16,466.4
Total hospitalized (PPP Dollars)	$27.6	$154.8	$375.3	$1,236.3
Total cost (PPP Dollars)	**$11,218.1**	**$4,540.4**	**$1,157.3**	**$17,702.7**

Source: PAHO. 2015. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 6. 2015 Total economic cost per DALY (2017 PPP dollars).

The variance in the results could be explained by the income gap between countries. If we consider the GDP per capital as proxy for the median income of each country, it makes sense that Mexico and Brazil have the highest cost per case and DALY since their GDP (US$ 9,033 and US$ 10,476 respectively) is close to 50% higher than the GDP per capita of Colombia and the Dominican Republic (US$ 6,161 and US$ 6,713 respectively).

5. Discussion

According to the review made by Shepard [22], who estimate the burden at a global scale for the year 2013, Latin-American and the Caribbean regions exhibit the highest treatment cost per case. From this perspective, our review presents the burden of the disease for the most affected countries, in terms of reported cases, of the region with the most expensive treatment cost. The latter is particularly relevant if we considered the estimates of the share of total treatment cost over the total health expenditure presented because our results could be interpreted as an upper bound for relative economic burden of dengue.

As mentioned before, in this section, we will discuss how the total treatment cost and the burden change in 2017, which we consider to be an inter-epidemic year given the low number of cases relative to previous years (2010–2017) (**Table 7**).

	Brazil	Colombia	The Dominican Republic	Mexico
Total ambulatory (US Dollars)	47,458,401	8,494,113	285,339	44,878,911
Total hospitalized (US Dollars)	184,593.94	220,629	77,707	553,169
Total treatment cost (US Dollars)	**47,642,995**	**8,714,742**	**363,046**	**45,432,079**
Total DALY	**7,599**	**2,481**	**259**	**7,554**
Population	207,680,999	49,293,878	10,172,243	123,517,856
DALY per 1 million inhabitants	**37**	**50**	**25**	**61**

Source: PAHO. 2017. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 7. 2017 Economic and DALY lost per million inhabitants by country (2017 dollars).

To estimate the total number of DALY for the year 2017, we calculated the ratio between dengue cases and DALY for 2015 with the WHO and PAHO figures and extrapolate the results as discussed in section "Materials and methods." Population has been updated too, to correspond to the year 2017. DALY adjusted for population present a dramatic decline of 76.53% in average due to the decrease in total number of dengue cases. Additionally, the total treatment cost of the disease decreased 77.8% in average (from 2015 to 2017), being Dominica Republic the country with the highest reduction rate (92.8%). It is worth saying that the change in the figures is closely tied to the change in the number of dengue cases since the cost per patient remained the same (**Table 8**).[15]

As result of the decline in the number dengue cases in 2017, the share of the total costs decreased to almost a fifth of the share in 2015 (**Figure 7**).

	Brazil	Colombia	The Dominican Republic	Mexico
GDP (US Dollars billions)	2,081	307	75	1,142
Health expenditure (% of GDP)	8.9	6.2	6.2	5.9
Health expenditure (US Dollars billions)	185	19	5	67
Total ambulatory (%)	0.03%	0.04%	0.01%	0.07%
Total hospitalized (%)	0.00%	0.00%	0.00%	0.00%
Total cost (%)	**0.03%**	**0.05%**	**0.01%**	**0.07%**

Source: PAHO. 2017. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

Table 8. Total health expenditure and 2017 total economic cost as share of the total health expenditure (2017 dollars).

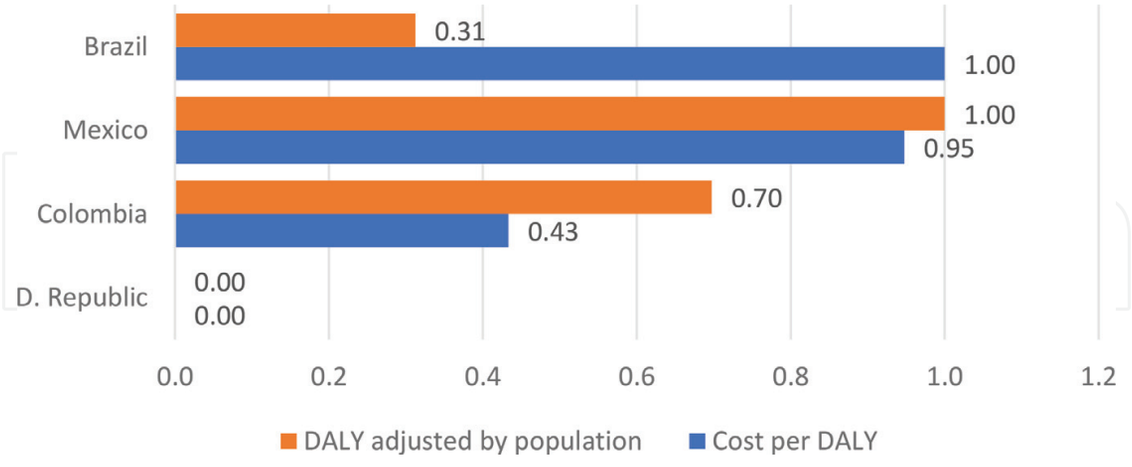


Figure 7. Normalized results. 2017. Source: PAHO. 2017. Week 52. Martelli, et al. (2015) [19], Castro, et al. (2015) [18], Undurraga, et al. (2014) [17], Shepard, et al. (2011) [20]. Prices 2017.

[15] Cost per patient do not vary since they are expressed in 2017 dollar are correspond to the figures obtained in the respective studies reviewed.

Normalized results for 2017 show that, in contrast to 2015, the Dominican Republic exhibits both the lowest total treatment cost per DALY and DALY per million of inhabitants, which suggest an improvement for the Caribbean country, especially considering the noneconomic burden. On the other hand, Mexico went from having the lowest number of DALY adjusted for population to having one of the highest.

One important limitation about this review and potentially other burden analyses is the accuracy of the epidemiological information. As the number of total dengue cases, severe and non-severe, corresponds to reported cases, one cannot assume that they correspond to the effective number of cases. Reported (or febrile) cases can overestimate the total actual burden of the disease. On the other hand, one should consider that by using laboratory confirmed cases, bias in the other direction is introduced, since not only that figure would be affected by laboratory confirmation policies and practices but also by underreport. After reviewing the latter, we decided to use reported cases and allow for potential overestimation in the economic burden. Thus, our results should be considered as upper bound estimates of the economic burden[16] and not completely accurate figures.

The results found have three interesting implications for further studies and reviews. Economic burden of dengue should follow a structured costing framing, which allows for proper comparison between results and better estimation of treatment cost per case. The data and sources used in this chapter could serve as inputs in future cost-effectiveness analysis (CEA); once economic cost per cases has been covered, the remaining element to conduct a CEA would be the approximate reduction in dengue cases due to the use of a prevention technology. Finally, the similar results in terms of relative economic burden suggest that 0.16%[17] could be interpreted as an upper bound of the total treatment cost of dengue as share of total health expenditure.

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[16] Burden measured as DALY is not affected by overestimation since WHO figures are used.

[17] 0.16% is the mean share for the four countries reviewed during a period of high incidence in the region with the most expensive treatment cost per case.

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