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ECONOMIC EVALUATION

Burden of Disease and Economic Impact of Dengue and Severe Dengue in Colombia, 2011

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ABSTRACT

Objective: To assess the burden of dengue disease in Colombia and its associated costs. **Methods:** We estimated the burden of dengue and severe dengue in Colombia for the period 2011 to 2014 on the basis of a dynamic model calibrated against Colombian surveillance data. The model estimated the annual number of dengue and severe dengue cases for those receiving medical care and those who do not. We calculated the average cost of care per patient on the basis of a bottom-up costing of cases, and additional costs were estimated for activities of vector control and other community interventions. Economic information from a sample of local and departmental vector control programs was reviewed. **Results:** The dynamic model estimated that for 2011 and 2012 there would be 56,998 dengue cases requiring medical attention (22,799 ambulatory and 34,199 hospitalized), 1851 cases of severe dengue, and 205 deaths. The economic analysis, with 2011 data, showed that Colombia would spend between US $52.2 and US $61.0 million for dengue control activities and case management in an average year. Medical management costs would amount to US $16.9 million (CI 95% 15.2–18.5 million), while vector control activities and other community interventions would cost between US $37.08 and US $42.41 million. **Conclusions:** Dengue infection has an important impact on the health care system budget in Colombia. Most of the economic impact corresponds to community activities directed to prevent vector infestation (68.7%–71.0%), which are expensive and whose effectiveness is controversial.

Keywords: Colombia, costs and cost analysis, cost of illness, dengue, models.

Introduction

The World Health Organization (WHO) considers dengue infection as the second most important reemerging tropical disease, the major viral disease transmitted to humans by vectors, and a high priority for research [1]. WHO estimates that annually between 50 and 100 million infections and 20,000 deaths occur globally [2]. There are approximately 2.5 billion people living in areas at risk of transmission around the globe, 30% of the global population [2]. It is estimated that during epidemics, dengue may affect 80% to 90% of the susceptible individuals and lethality may exceed 5% [3]. The distribution of dengue and its vector has increased dramatically in the last 30 years, partly because of insufficient vector control, increased urbanization, and air travel [4,5].

In Colombia, dengue is an endemic-epidemic disease, with all four serotypes circulating around the country every year. During 2004 and 2006 in the Americas, Colombia had a high number of cases of hemorrhagic dengue (2261 and 6061, respectively) and deaths [6], and another outbreak was reported in 2010 with 5326 cases of severe dengue. In many tropical countries, generally dengue has a higher impact because of inadequate public health structure, lack of resources to combat the vector, and limited health care services for the treatment of patients [7].

The impact of dengue is reflected in the economic and social costs incurred [8]. The economic impact of dengue is difficult to assess nationwide for many reasons. One of the main difficulties is the underreporting of cases to surveillance systems [9], making it necessary to adjust national statistics using cohort studies or seroepidemiological data [10,11]. Another problem is the heterogeneity of costs. To obtain a complete estimate, direct medical costs need to be combined with indirect costs borne by the individual and society (school absenteeism and lost productivity) and with costs of vector control [12,13]. In addition, the cost estimate needs to be based on multiyear epidemic cycles because any single year is not representative due to the cyclical nature of dengue epidemics [14].

Conflicts of interest: The authors have indicated that they have no conflicts of interest with regard to the content of this article.

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At present, several tetravalent dengue vaccines are in phase I and II clinical trials and one candidate is in phase III trial [15,16]. Depending on the results of trials, a dengue vaccine could be licensed in the coming years, making it necessary to conduct economic studies to consider the inclusion of the vaccine in the Colombian Expanded Program on Immunization. The aims of this study were to assess the burden of dengue disease in Colombia and its associated costs from the health care system perspective.

Methods

We estimated the annual burden of dengue disease in Colombia for the years 2011 to 2014 on the basis of a dynamic transmission model designed with the best available evidence and validated with dengue occurrence data in Colombia. We estimated the average cost of care per patient with dengue and severe dengue on the basis of a microcosting of cases in some Colombian health institutions. In addition, the costs of the dengue community control activities (including vector control) were estimated by using information obtained from a sample of vector control programs at various administrative levels. The overall national dengue costs were estimated by extrapolating the costs per patient obtained from the clinical records review to the number of cases estimated obtained from the dynamic transmission model plus the extrapolation of the community control activities costs obtained from the sample of vector control programs to the rest of the country's vector control programs. Annual costs were estimated by using 2011 as the base year.

Dynamic Model of Transmission

We designed a dynamic model of dengue transmission on the basis of a literature review to determine the types of models and parameters used. This model was fitted to the data of dengue occurrence in Colombia reported by the surveillance system (*Sistema Nacional de Vigilancia en Salud Pública*) for the period 1995 to epidemiological week 43 of 2011. Incidence, mortality, percentage of cases with severe dengue, and other epidemiological indicators of the occurrence of dengue and severe dengue in Colombia were estimated from the same source. Population and mortality indicators were obtained from the *Departamento Administrativo Nacional de Estadística* (*DANE*) for all years considered.

The model has three fundamental characteristics. It represents the circulation of two serotypes of the dengue virus, the human population was stratified into two age groups, and the human and mosquito populations interact.

The mosquito population was also modeled (Fig. 1A). It was divided into three epidemiological states: susceptible, infected by DEN-1, and infected by DEN-2. It was assumed that a mosquito does not becomes infected by both serotypes at the same time, and once infected by either serotype, it will be infected for the rest of its life, which is very short compared with human life. Also, it was assumed that the mosquito population remains constant, holding natality and mortality rate at the same value during the time of the study.

The human model has four states: susceptible, infected, recovered (immune), and dead (Fig. 1B). People progress through the states, with infection and immunity being serotype specific. Death can occur from any of the other three states. In the human population, two age ranges were considered: youth ($\leq$15 years old) and adult (>15 years old). In every age group, the size of the population susceptible to infection with either serotype was established. Individuals become infected after the bite by an infected mosquito. Infected individuals would progress to a recovered state, becoming immune to the associated serotype. They remain susceptible to the second serotype, however. The person may suffer a second infection with another serotype. Once the individual has recovered from both infections, total immunity to either circulating serotype is acquired. In any of the states considered, the individual might die because of dengue infection or another cause.

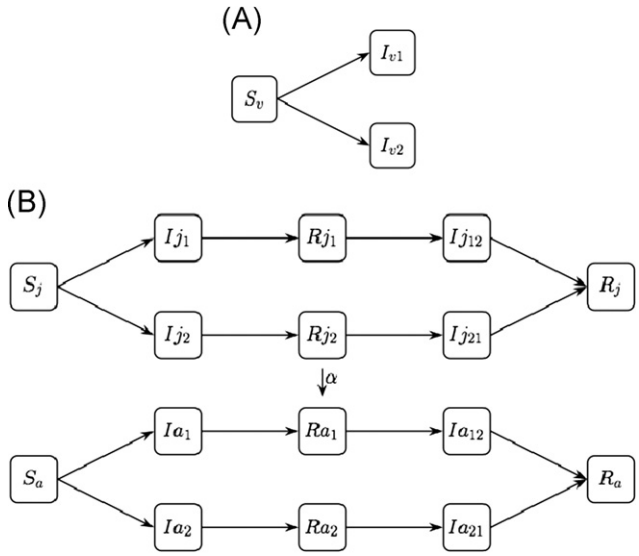

Fig. 1 – Dynamic transmission model to evaluate the occurrence of dengue in Colombia. (A) Mosquito population. (B) Human population.

Three ordinary differential equations represent the dynamics of the virus in the mosquito population, one for the susceptible state and two for the infected state. Each human subgroup (youths and adults) is described by differential equations that provide for eight states susceptible to both serotypes, serotype-infected (DEN-1 and -2), recovered from a serotype, reinfected by the other serotype, and recovered and immune to both serotypes (see Appendix in Supplemental Materials found at http://dx.doi.org/10.1016/j.vhri.2012.09.014).

The model produces epidemiological estimates of dengue occurrence that are used to predict the number of annual cases occurring in Colombia by department, by applying them to the population estimates from *DANE* for 2011 and later. Those figures were calibrated by using data reported by the *Sistema Nacional de Vigilancia en Salud Pública* for the last 17 years. Mortality data were adjusted by using *DANE* mortality reports. The burden of disease was estimated by clinical syndrome (dengue and severe dengue) and deaths due to dengue. The model formulated to explain the real behavior of the data required an optimization process (optimization algorithm) that minimizes the difference between the model outcomes, and the real dengue occurrence.

Costs Associated with Dengue

Direct medical costs

To derive the cost of medical care of dengue and severe dengue in Colombia, we took the perspective of the third-party payer (Colombian health care system). Bottom-up costing was performed from medical records of all patients diagnosed with dengue and severe dengue during the years 2009 and 2010, and recorded in the databases of the main public and private hospitals from two Colombian cities (Monteria and Neiva) with endemic disease.

The frequency of events by facility and the activities and procedures performed and medications dispensed to each patient were assessed. We excluded patients with incomplete medical records, without symptom onset date, or who did not specify the frequency of service use. The frequency of use of pharmacy, clinical laboratories, and imaging and average length