Clinical Characteristics and National Economic Cost of the 2005 Dengue Epidemic in Panama

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Abstract. In 2005, Panama experienced the largest dengue epidemic since 1993. We conducted both a prospective clinical and a national economic study. The full cost analysis measured costs of dengue cases and of dengue control efforts in the entire country. Costs are in 2005 US$. Ambulatory patients were 130 of the 136 participants, with 82% adults (18+) and 62% women. Duration of fever and illness averaged 6.1 (standard deviation [SD], 5.3) and 21.2 (SD 13.5) days, respectively. Loss in quality of life averaged 67% (SD 21) during the worst days of illness. An average ambulatory and hospitalized case cost $332 and $1,065, respectively. Although 5,489 cases were officially reported, the Ministry of Health (MOH) estimated 32,900 actual cases, implying a total cost of $11.8 million. Additionally, estimated government spending on dengue control efforts was $5 million. This dengue epidemic had a major disease impact and an economic cost of $16.9 million ($5.22 per capita).

INTRODUCTION

The control of Aedes aegypti and Anopheles spp., yellow fever, dengue and malaria vectors, started in 1905 by William C. Gorgas and was an important step in the building of the Panama Canal.1,2 Panama was declared Ae. aegypti-free in 1958.3 There were several re-infestation cases later, but these were successfully controlled. However, following the introduction of A. aegypti eggs and larvae from imported tires in 1985,4 Panama became infested again and still remains so, with the first autochthonous dengue cases detected in 1993.5,6 From 1993 through 2004 Panama registered 16,317 dengue fever (DF), 24 dengue hemorrhagic fever (DHF) cases, and three dengue-related deaths. By then, all four dengue serotypes had circulated, with either DEN-1 or DEN-2 being predominant. Dengue in Panama has affected primarily adults. Adults 18 years of age or older constituted more than 70% in each of the years from 2000 through 2005.7 In 2005, the country, with a population of 3.2 million, experienced the most severe epidemic since 1993 with 5,482 DF, 7 DHF, and 5 deaths.8 The reported number of dengue cases was 1.8 times that of the previous high epidemic in 1995. During 2005, dengue serotype DEN-1 (predominant) and DEN-2 circulated in the country.

We initiated a prospective study of dengue patients in late 2004. The study combined the data collected with surveillance information to analyze clinical and economic aspects of the 2005 dengue epidemic in the entire country. The economic analysis includes national estimations of cost of non-fatal and fatal dengue, as well as costs of dengue surveillance, laboratory, and mosquito vector control activities. To our knowledge, this is among the first studies on dengue in the Americas adopting this comprehensive approach as part of a multicountry initiative.8,9 As children and adults may have differences in clinical presentations and economic impact, including impacts on other household members, we compared child and adult cases.

METHODOLOGY

The study combines original data from the study population with administrative information for national estimates of dengue cases and costs. Study population. To describe the clinical characteristics and cost per case, we constructed the study population of patients who satisfied these four criteria. 1) Their blood samples were sent to the Gorgas Memorial Institute (GMI) as part of the national dengue surveillance system, and dengue was confirmed by serology or virology. 2) They sought care from ambulatory public health facilities run by the government in Panama Province from October 14, 2004 through September 8, 2005. Although our target sample size was 100 patients, given the unexpectedly high number of cases as a result of the epidemic, we were able to stretch our interviewing budget to enroll 162 patients. 3) The patient’s notification form sent to the national surveillance system had adequate contact information to locate the patient promptly. 4) The patient agreed to participate in the study.

As batches of laboratory confirmation cases of dengue were obtained, patients were systematically selected for the study. Depending on the volume of the laboratory confirmed batches, we randomly selected one out of three through five candidates for interviews. For sera collected within two days of the onset of symptoms, the laboratory performed viral isolation using Vero cells. The cells were observed daily for 14 days before the immunofluorescent detection of viral antigens with polyclonal antisera. Identification of the specific virus type was performed with monoclonal antibodies. For sera collected after four days from onset of symptoms, the laboratory used a standard antibody capture MAC-ELISA to measure IgM antibodies. Dengue cases were considered laboratory confirmed if they satisfied at least one of the following criteria: 1) isolation of dengue virus, 2) positive IgM-enzyme-linked immunosorbent assay (ELISA) (if absorbance was twice the mean of the negative controls), and 3) a 4-fold increase in antibody titers in paired acute and convalescent sera.

Selected patients or legal surrogates (when a patient was a child) were then contacted over the phone and asked to participate in an in-person survey. Although over 95% of the
patients contacted agreed to participate, no systematic effort was made to collect information of non-participants.

Patients were interviewed by a trained health professional using a standardized survey instrument that included sections from the World Health Survey. All study participants or legal surrogates were interviewed once in person, either at the patient’s house or at work. Each interview lasted about 60 minutes.

**Patient survey.** Patients were interviewed about the impact of dengue on their health, use of medical services, schooling, work productivity, leisure time, out-of-pocket spending, and income lost. Clinical characteristics assessed included duration of fever and the illness, symptoms and signs of disease, perceived severity, and quality of life.

We used the health module of the World Health Survey to survey the patients on the impact of the dengue episode on eight health domains: pain and discomfort, mobility, interpersonal activities, sleep and energy, affect, self-care, cognition, and vision. The survey assessed each domain using one to three questions with a five-point response scale (none, mild, moderate, severe, and extreme). We assessed quality of life with the EuroQOL’s 100-point thermometer visual scale, where zero corresponds to death and 100 to perfect health.

Data were entered into a Microsoft Access database, using a double entry system for validation. Standard routines for cleaning, consistency checks, and analysis were performed. The study protocol and the data collection instruments were submitted and approved by the Institutional Review Boards of collaborating institutions and the funding agency.

**Cost analysis framework.** The objective of this analysis was to measure the national cost associated with the 2005 dengue epidemic by assessing and adding costs related to two categories of 1) dengue cases and 2) the national dengue control efforts (surveillance, laboratory, and vector control). For the first category, we used a combination of primary data (from patient surveys and macro-costing of health facilities), and national deaths reports to estimate the cost per dengue case by setting (ambulatory only or inpatient). We then estimated national aggregate costs based on officially reported cases and an expansion factor to adjust for under-reporting of cases. For the second category, we used secondary data and interviews with key public health officials.

(1) **Cost of dengue cases.** Dengue cases were classified as non-fatal (ambulatory or hospitalized) or fatal cases.

**Cost of non-fatal ambulatory and hospitalized cases.** We measured direct medical and non-medical costs, and indirect costs borne by households, medical providers, and employers. We calculated direct medical costs as the sum of the products of type and amount of services by setting (ambulatory or inpatient), and by provider (public or private) times their respective unit costs. Cost of private medical care was assumed to be equal to the patient’s out-of-pocket payments for those services. For public inpatient care, we used a macro-costing approach dividing the hospitals’ expenses by their weighted units (hospital days and ambulatory visits) to estimate the cost of a hospital day. For public ambulatory care, we assumed that the average unit cost of all public sector outpatient visits (which include health centers and dispensaries, as well as hospitals) was 15% of an average inpatient day. Direct non-medical costs included out-of-pocket payments for transportation, food, lodging, and miscellaneous expenses associated with seeking and obtaining medical care and/or household members visiting patients at the hospital.

Calculation of indirect costs consisted of assigning a monetary value to three major components: 1) days of school lost, 2) days of work for pay lost, and 3) other days lost by both the patient and any other household member who provided care to the patient during his illness. Because Panama funds primary education publicly, we assumed that the economic value of a day of school was equal to the cost of providing a day of public primary school ($US2.30). We then calculated the economic loss attributed to school days lost as the product of that daily cost times the number of school days lost. We used the higher of the reported daily loss or the Panama’s daily minimum wage ($US$11) to value a day of work lost to the worker or to the employer. We calculated the total economic costs of work days lost as the product of this average daily loss times the number of work days lost. To value “other” days (caregiver and patient days) lost other than for school or work in those members aged 15 or above, we used the country’s daily minimum wage times the number of “other” days lost. In addition, we calculated the household total days affected as the sum of school, work, and other days lost.

Finally, we estimated the total cost of an ambulatory and hospitalized dengue case as the sum of all their direct and indirect costs. Costs are expressed in 2005 US dollars ($US$). To compare children and adults, we divided participants by age for analysis, classifying those 18 years of age and above as adults.

**Cost of fatal dengue cases.** We estimated the cost of fatal dengue as the economic value of the years lost from premature deaths. First, for the five officially reported dengue deaths in 2005, we calculated their years of life lost as the sum of each of their discounted (at an annual rate of 3%) remaining life expectancies at their age of death based on life tables for Panama. Then, we multiplied the discounted years by the Panama GDP per capita for 2005.

**National cost of dengue cases.** We derived the cost of dengue by outcome (non-fatal versus fatal), type of case (ambulatory versus hospitalized), and location (Panama Province, rest of Panama, and entire country). Although the reporting of suspected dengue cases is mandatory in Panama, weak enforcement, the burden of reporting, and the lag of over 30 days between dengue testing and receipt of results from the national laboratory all contribute to under-reporting. On the basis of Panamanian data and international experience, the Ministry of Health (MOH) estimated that for every reported dengue case there were six actual dengue cases (i.e., expansion factor of six). Therefore, to address under-reporting of dengue, we estimated the actual number of cases by multiplying the officially reported number of cases times this expansion factor. To estimate the aggregate cost, we multiplied the estimated number of cases by the average cost by type derived above.

(2) **Cost of dengue surveillance, laboratory, and vector control activities.** We estimated utilization and costs for three major dengue-related activities of the MOH: dengue surveillance, laboratory, and vector control. Data sources were interviews with public health authorities and reviews of expenditure reports from the different divisions of the MOH in Panama Province. We estimated personnel, supplies, equipment, vehicles, and overhead costs by type of activity.
Dengue-related costs were based on the share of the total resources used in each division. For example, dengue vector control is part of a larger program that includes control of nuisance mosquitoes, ticks, and rodents. Therefore, we apportioned only those activities clearly related to dengue control such as periodic determination of Aedes mosquito infestation through inspection of premises, elimination or control of breeding sites, use of larviciding and adulticiding, enforcement, and education and community participation.

For capital items, such as equipment or vehicles, we used annualized costs based on their replacement value in 2005, useful life in years, and a real annual interest rate of 3%. Because we did not have access to information on maintenance and repair records, we estimated these annual costs at 20% of direct costs. We assumed per capita overhead (for use of space, office support, and general administration) were 20% of direct costs. We assumed per capita costs for the rest of Panama would be the same as those for Panama Province because the efforts operated similarly across the country.

Finally, to obtain aggregate regional and national estimates of total cost associated with dengue, we summed cost estimates for dengue cases and for surveillance, laboratory, and vector control activities.

Analytical approaches. We reported results for the study populations as unweighted means and standard deviations for continuous variables and frequencies for categorical variables. The t-tests and χ² tests, with alpha level of significance at 0.05, were performed for some analyses.

For national cost estimates, the level of under-reporting of dengue cases and its associated expansion factor was the most important area of uncertainty. We performed sensitivity analyses by varying the expansion factor from 1 (no expansion) to 10 as used by Meltzer and others.

RESULTS

Of the 162 participants recruited and interviewed, 136 were analyzed in this study. The remaining participants were excluded from the analysis to reduce recall bias because their interview occurred at least 60 days after the onset of their symptoms. Because of the small number of reported dengue hospitalizations, only six hospitalized patients (all treated in the public sector) were analyzed. For this reason, the description of the clinical characteristics of dengue and the cost per case is based primarily on ambulatory cases.

The majority of the 130 confirmed dengue ambulatory patients were adults (82%), with an average age of 35 years and nearly three-quarters (76%) 25 years of age and above (Table 1). Females represented 62% of the overall cohort, and the majority of cases (86%) came from urban settings. Interviews occurred 39 (SD 9) days after the onset of symptoms, on average. Most of the participants (79%) reported good or very good health status before the illness (based on a five-point scale). There were no fatalities reported within the study cohort.

The most commonly reported symptoms by all ambulatory patients were fever (100%), headache (91%), muscle/joint pain (87%), skin rash (85%), and retro-orbital pain (76%). Of these symptoms, only muscle/joint pain was found to be significantly more common in adults than in children (P < 0.01).

<table>
<thead>
<tr>
<th>Item</th>
<th>Children</th>
<th>Adults</th>
<th>P value</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort (N)</td>
<td>23</td>
<td>107</td>
<td>–</td>
<td>130</td>
</tr>
<tr>
<td>Female</td>
<td>61%</td>
<td>63%</td>
<td>–</td>
<td>62%</td>
</tr>
<tr>
<td>Age (years):</td>
<td>Mean</td>
<td>12.3</td>
<td>40.0</td>
<td>35.1</td>
</tr>
<tr>
<td>(Standard deviation)</td>
<td></td>
<td>(3.6)</td>
<td>(11.7)</td>
<td>(15.1)</td>
</tr>
<tr>
<td>Urban residence</td>
<td>70%</td>
<td>90%</td>
<td>–</td>
<td>86%</td>
</tr>
<tr>
<td>Health status before illness</td>
<td>Good or very good</td>
<td>91%</td>
<td>77%</td>
<td>0.159</td>
</tr>
<tr>
<td>Prevalence of symptoms during illness</td>
<td>Fever</td>
<td>100%</td>
<td>100%</td>
<td>1.000</td>
</tr>
<tr>
<td>Headache</td>
<td>91%</td>
<td>91%</td>
<td>1.000</td>
<td>91%</td>
</tr>
<tr>
<td>Muscle or joint pain</td>
<td>70%</td>
<td>91%</td>
<td>0.006</td>
<td>87%</td>
</tr>
<tr>
<td>Skin rash</td>
<td>87%</td>
<td>84%</td>
<td>1.000</td>
<td>85%</td>
</tr>
<tr>
<td>Retro-orbital pain</td>
<td>70%</td>
<td>78%</td>
<td>0.414</td>
<td>76%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>61%</td>
<td>61%</td>
<td>0.991</td>
<td>61%</td>
</tr>
<tr>
<td>Sore throat and/or running nose</td>
<td>48%</td>
<td>47%</td>
<td>0.924</td>
<td>47%</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>43%</td>
<td>46%</td>
<td>0.840</td>
<td>45%</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>48%</td>
<td>35%</td>
<td>0.232</td>
<td>37%</td>
</tr>
<tr>
<td>Vomiting</td>
<td>39%</td>
<td>35%</td>
<td>0.679</td>
<td>35%</td>
</tr>
<tr>
<td>Bleeding</td>
<td>13%</td>
<td>18%</td>
<td>0.763</td>
<td>17%</td>
</tr>
<tr>
<td>Difficulty with schooling, job, or household activities</td>
<td>39%</td>
<td>63%</td>
<td>0.059</td>
<td>58%</td>
</tr>
</tbody>
</table>

Health domains severely to extremely affected during illness:
- Pain and discomfort: 52% (67%), 1.069, 65% (65%)
- Mobility: 43% (64%), 0.061, 61% (61%)
- Interpersonal activities: 39% (64%), 0.031, 59% (59%)
- Sleep and energy: 43% (63%), 0.090, 59% (59%)
- Affect: 26% (46%), 0.083, 42% (42%)
- Self care: 39% (36%), 0.743, 36% (35%)
- Cognition: 35% (34%), 0.917, 34% (33%)
- Vision: 9% (6%), 0.631, 6% (5%)

Impact on usual activities during illness:
- Difficulty with self-care: 39% (38%), 0.137, 3.6 (3.6)
- (Standard deviation)

Quality of life during illness:
- Mean, quality in %: 35.2 (32.9), 0.630, 33.3 (33.3)
- (Standard deviation)

Initial care seeking and treatment:
- Within 24 hours from onset: 39% (30%), 0.388, 32% (32%)
- Self-medicated: 70% (54%), 0.177, 57% (57%)
- Used antibiotics: 48% (46%), 0.859, 46% (46%)
- Used aspirin: 0% (8%), 0.360, 7% (7%)

* Based on a five-point scale with severe and extreme being the two worst outcomes.
† Assessment of quality of life was performed using a EuroQol instrument consisting of visual thermometer-like scale with 0 representing the worst and 100 the best imaginable health state.

Gastrointestinal symptoms, such as abdominal pain, diarrhea, and vomiting, were common (35–45%), with similar rates in children and in adults. Sore throat and/or running nose were equally common symptoms (47%). Only 17% of the patients were aware of bleeding manifestations. On average, a patient had 7.7 of the 13 symptoms covered in the survey.

The majority of the ambulatory patients reported serious difficulties with schooling, job, or household activities. The illness affected each of the eight health domains, with prevalence of severe to extreme impact (the two worst categories) ranging from 6% for vision to 65% for pain and discomfort. Sleep disorders and affect symptoms were also very common in both children and adults, but especially frequent among adults (63% and 46%, respectively). On average, 3.6 health domains were severely affected, with adults impacted more

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than children. Quality of life during the illness was seriously impaired in both children and adults and averaged only 33% of the equivalent of perfect health.

About one-third of the ambulatory patients with dengue sought medical attention within 24 hours from the onset of symptoms. Children received medication that was not prescribed by a medical practitioner more often than adults (70% versus 54%). The use of antibiotics was common in both age groups (46%). Despite aspirin’s risk of promoting bleeding, 8% of the adults had taken this drug during their illness (Table 1).

On average, an ambulatory case lasted 20 days, including 6 days of fever and 10 days feeling bad or very bad. Overall, children had an additional day of fever, but two fewer days of illness than adults (differences not significant) (Figure 1).

On average, each patient had 4.1 ambulatory visits, and 78% of them were obtained in public facilities (Table 2). The use of medical services was similar in children and adults ($P = 0.465$, not shown). On average, an ambulatory case had a direct medical cost of $63, not differing between children and adults ($P = 0.68$). Of this cost, prescriptions, supplies, and laboratory tests accounted for less than 10% (not shown). Direct non-medical costs, those related to transportation and food, amounted to $20 (SD 33) and were similar in both children and adults ($P = 0.34$).

Ambulatory dengue cases resulted in lost days of school, work, and other days for both the patient and close household members (Table 2). As expected, households of child patients had more days of school lost than households of adult patients (3.4 versus 0.5 days, $P < 0.01$). Most of the school days lost were borne by the patient himself (97%) and only 3% of the days were lost by other family members caring for the patient (not shown). When the patient was actually studying, he lost 3.2 days of school (not shown in tables). Furthermore, as expected, households of adult patients lost more days of working for pay than child households (5.3 versus 1.2 days, $P < 0.01$), and 84% and 16% of those days were lost by the patient and other household members, respectively (not shown). When the patient was actually working for pay, he lost 6.2 days of work (not shown in tables). Other days lost (those days other than school or working for pay) averaged 15 days per household. Therefore, for both child and adult cases, an average dengue case was associated with a loss of about 21 days for the entire household.

The indirect cost of an average ambulatory dengue case amounted to $249 for the entire cohort. However, the indirect cost incurred by children ($74) was significantly lower than that incurred by adults ($287) ($P < 0.001$). The total cost per case, the sum of direct medical costs, non-medical costs, and indirect costs, amounted to $332 for the entire cohort, and was about twice as high for adults ($368) as for children ($166) ($P < 0.01$). In the entire cohort, indirect costs averaged three-fourths of the total costs of a dengue case, ranging from 45% in children to 78% in adults.

About half of the ambulatory participants had difficulty affording the cost of medical care or transportation (details not shown). Out-of-pocket spending and income lost during the illness may explain why households used their savings (12%), or borrowed money from family members or friends (19%) or someone else (10%). About two-thirds of the patients’ households placed the economic impact of the dengue case in the two worst categories of a five-point scale (i.e., quite a lot or very substantial).

The total cost per hospitalized dengue case (based on the six patients) averaged $1,065 (SD 479) and consisted of $559 (SD 331) for direct medical cost, $184 (SD 154) for direct non-medical costs, and $322 (SD 258) for indirect costs.
non-medical cost, and $322 (SD 189) for indirect cost (details not shown).

Table 3 presents the costs of dengue surveillance, laboratory, and vector control activities incurred by the MOH only in Panama Province. The estimated annual cost was $2.5 million, equivalent to $1.56 per capita, comprised of personnel (71%), supplies (5%), equipment (4%), vehicles (3%), and overhead (17%).

Table 4 describes the cost of dengue in 2005 for two major categories (dengue cases and dengue control) and two regions (Panama province and the rest of Panama). The national aggregate cost totaled $16.9 million or $5.22 per capita, given the population of 3.2 million persons. Panama Province, containing 50% of the country’s population, accounted for 66% of the national cost. Most (70%) of national costs were dengue cases, of which non-fatal dengue cases cost $11.3 million.

The overwhelming (96%) share of costs of non-fatal dengue was a result of ambulatory cases, with hospitalized cases representing only 4%. Because fatal cases constituted only 0.1% of total dengue cases, they accounted for 5% of costs of all dengue cases. Dengue control constituted the remaining 30% of the total national cost.

The sensitivity analysis on under-reporting found that cost per capita varied from $2.31 (with no expansion factor) to $7.55 (with an expansion factor of 10).

**DISCUSSION**

**Age and sex distribution.** The similarities of the distribution by sex and age group of patients enrolled in this study to that of all the dengue cases confirmed under the national reporting system for 2005, maintained by the GMI, provide confidence in the representativeness of the sample. The national system reported 56% women and 76% adults. Our sample, which contained 62% women and 82% adults, did not differ significantly on either characteristic.

**Symptoms, quality of life, and health seeking behavior.** The rates of clinical manifestations of dengue such as fever, headache, muscular or joint pain, skin rash, bleeding, and retro-orbital pain, the duration of fever (6 days) were all similar to those described previously. The duration of illness (mean 21.2 days) was higher than those of prior studies, and may be explained by our longer recall period of up to 60 days; it allowed the full episode to be reported, but may have introduced recall bias. Although the rate of diarrhea in our study (45%) was higher than that of a previous study in the region (15%), our longer recall period provided a longer period of exposure. The fact that sore throat or running nose was present in almost half of our entire cohort of dengue confirmed cases (47%) suggests that these symptoms cannot rule out dengue. The low quality of life during a dengue case (33% of perfect health) may be explained by the large number of symptoms and health domains affected.

The use of antibiotics (which are not indicated for dengue and may promote resistance) by almost half the patients, some use of aspirin (which is usually contraindicated), and frequent self-medication all merit concern. Posters and leaflets to educate patients and training of medical providers on the rational use of antibiotics and management of dengue could be beneficial.

**Aggregate cost.** The cost of $332 for an average confirmed dengue ambulatory case is substantial as viewed in the context of Panama’s economy. It represents the equivalent of 26 days of GDP per capita (annual GDP per capita of $4,630 prorated over 365 days).

The cost of dengue cases alone was $11.8 million or $3.66 per capita. For comparison, the gross cost of a dengue vaccine in Southeast Asia was $154 per 1,000 population. After incorporating savings from avoided medical care, the net cost was only $17 per 1,000 population per year, or $0.02 per capita. Similarly, an effective vector control program in Cambodia had a gross cost of $0.20 per capita, and a net cost from the public sector perspective of only $0.11 per capita. The annual total cost of dengue in Panama was estimated at $16.9 million, which is equivalent to the aggregate annual economic output (GDP per capita) of 3,600 people. By contrast, the budget of Panama’s leading public health institute, GMI, was only $3.5 million. Thus, if costs of dengue could be reduced, some of the savings could be reallocated to other health services.

**Impact on households.** Because the average household lost 1 day of school and 4.5 days of work for pay, the deleterious impacts on schooling and productivity were noticeable among patients actually studying (3.2 days) or working (6.2 days). In
other years, the school loss for children would have been even higher because during the study year (2005) there was a major national teacher’s strike without classes. As households faced higher income losses; it was not surprising that a large proportion of respondents reported using savings or borrowing money to pay for medicine, payments for non-medical items, and user fees for private sector consultations, laboratory tests and medication. The study did not include patients treated entirely in the private sector or patients treated outside of Panama Province.

**Limitations.** This study has a number of limitations. The patient interviews took place, on average, 39 days after the onset of symptoms, leaving some concerns about recall bias. Patients’ inclusion criteria required serological or dengue virus confirmation and laboratory results were not promptly obtained as a result of overload in the GMI because of the epidemic. However, the clinical findings in this study are consistent with those in other countries in the same multi-country initiative. Patients with recall periods above the mean ranged from 18.4 days, respectively, which may suggest some recall bias. However, neither difference was statistically significant (P = 0.10 and 0.21, respectively).

The study did not include patients treated entirely in the private sector or patients treated outside of Panama Province. We implicitly assumed that their costs per case were similar to those of study participants. Because Panama’s public sector includes not only the MOH but also the social security system,
which provides care to employed, their dependents, and retirees, and 72% of dengue cases are reported from Panama Province, our estimates should be reasonably representative.

Although the very few hospitalized dengue cases interviewed and analyzed creates uncertainty in the cost per hospitalized case, it has little impact on the magnitude of national cost of dengue cases, because only 1.4% of officially reported cases were hospitalized. Furthermore, our estimate of hospitalization costs was based on the national share, not on the portion in our study sample.

There were only five deaths from dengue illness reported nationally in 2005, and none of the participants in our study died. We did not directly analyze the direct medical and non-medical costs of fatal cases, but implicitly assumed they were comparable to those of non-fatal cases. Because fatal cases represented only 0.1% of reported cases, an alternative assumption would have made a trivial difference. We did, however, include the indirect costs based on years of life lost corresponding to actual ages of the patients who died.

Our national projections assume that the cost per case in this study would be nationally representative of unreported cases in Panama Province, and of all cases in the rest of Panama. We consider this assumption plausible because our participants resemble the national distribution in age and gender, were systematically obtained from the national laboratory from which 72% of the country’s confirmed dengue cases were reported, and come from the province from which 72% of the cases occurred. Finally, we did not have information on government spending on mass media campaigns, which were intense in the 2005 epidemic, or household expenditure on coils and mosquito repellents. Thus, our estimate of costs of dengue control efforts may be conservative.

In summary, this is the first study of the clinical, social, and economic impact of dengue in Panama, and one of the few in the Americas.22,28–30 It indicates the large economic cost of dengue. The potential benefit from prospective dengue vaccines and mosquito control innovations would be substantial.

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