Preliminary estimate of immediate cost of chikungunya and dengue to Gujarat, India

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Abstract

This study aims to provide a preliminary estimate of the immediate cost of chikungunya and dengue to household in the Indian state of Gujarat. Combining nine earlier studies and data from interviews, we analysed the costs of non-fatal illness and of intervention programmes; building a more comprehensive picture of the immediate cost of these \textit{Aedes aegypti} mosquito-borne diseases to Gujarat. The “RUHA matrix” was used to estimate the cost of illness by combining the shares of reported (R) and unreported (U) hospitalized (H) and ambulatory (A) cases of chikungunya and dengue with ambulatory and hospitalization costs per case and the number of reported cases. Using Monte Carlo sensitivity analysis, the immediate cost to households incurred on account of chikungunya and dengue to Gujarat was estimated to be 3.8 (range 1.6–9.1) billion Indian rupees (INR) per annum (US$ 90 million, range US$ 38 and US$ 217 million). It is hoped that this preliminary estimate will trigger more refined studies on cost of illness as well as cost-effectiveness of vaccines and other interventions to combat these neglected tropical diseases.

Keywords: Burden of illness; chikungunya; dengue; immediate cost; Monte Carlo analysis; RUHA matrix; Gujarat.

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Introduction

The number of dengue cases in the state of Gujarat, India, has followed an increasing trend since 2004. Several studies have estimated the costs of illness associated with dengue or chikungunya in different states of India, but the cost factors included tend to vary from study to study. In this paper, we make a preliminary estimate of the immediate cost of chikungunya and dengue to the state of Gujarat by combining available studies to include all major cost factors. Furthermore, we also analyse control costs to form a more comprehensive picture of the cost of these Aedes mosquito-borne diseases.

Materials and methods

The key components of the immediate cost of chikungunya and dengue to a society are: (i) cost of non-fatal illness; and (ii) cost of intervention programmes, which include vector control on Aedes mosquito, a fraction of the household insecticide market, and cost of research and development. Data on each cost parameter was collected from published and unpublished studies and from interviews with local authorities. Where direct data was not available, trends from other Asian countries were used. All cost estimates were inflation-adjusted to 2008 Indian rupees (INR). Costs in different countries were compared at the rate of 2008 US dollars (US$) and an exchange rate of 42 INR/US$ was used.

Cost of illness was estimated by combining reported cases, and costs per case with a RUHA matrix (defined below). Data on reported dengue cases for the years 2003–2008 was used to adjust for year-to-year variations caused by the cyclical nature of dengue.\(^{(1)}\) Chikungunya cases for 2006–08 were used to estimate the burden of an outbreak, which is assumed to occur cyclically.\(^{(2,3)}\) Costs per ambulatory and hospitalized case were obtained from published and unpublished studies, which were compared with and combined to ensure consistency in factors included in the costs. The shares of reported (R) and unreported (U) hospitalized (H) and ambulatory (A) cases were estimated based on published literature and local information, and used to construct a RUHA matrix. For this study, chikungunya and dengue were assumed to be identical from the point of view of disease control and management.

Monte Carlo sensitivity analysis was carried out (@Risk software version 5.0.1, Palisade Corporation, USA) to find out how uncertainties in each cost parameter affect the total cost to households of chikungunya and dengue. Sixty-five simulations, each with 10 000 iterations, were used, and for each iteration all parameters were independently drawn from Beta-PERT distribution. Beta-PERT was chosen because it places less emphasis on the direction of any possible skew compared to triangular distribution, but it is defined using the same parameters (minimum, most likely and maximum), which are easily understood and uncomplicated to estimate.\(^{(4)}\)

Results

Reported cases

The number of dengue cases in Gujarat reported by India’s National Vector Borne Disease Control Programme (NVBDPCP) has followed an increasing trend since 2004 (Figure 1). In the years 2003–2008 the number of reported dengue cases has varied from 117 to 1023 with an annual average of 493. There was a major outbreak of chikungunya in Gujarat in 2006 with 76 012 reported cases, which declined to 3223 and 246 cases in 2007.
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Figure 1: Dengue cases in Gujarat

![Graph showing dengue cases in Gujarat from 2003 to 2008.](image)

Source: NVBDCP, Government of India (since this article was written, the number of reported dengue cases have gone up to 2461 in 2009 and 2568 in 2010).

and 2008, respectively (Source: NVBDCP). These three years were taken to represent the burden of a chikungunya epidemic, and the annual cost of chikungunya was calculated by assuming that similar epidemic peaks followed by two-year tails occur every seven years (range 4–20 considered). Some discrepancies were noted between local and national data on reported cases, and these were taken into account in the Monte Carlo analysis.

Cost per case data

Costs per hospitalized and ambulatory case were derived from published and unpublished studies. The studies were compared to identify differences in cost factors included, and then combined to make cost estimates that include all main factors. The resulting minimum, most likely and maximum values for direct (including medical and non-medical) cost and indirect cost are shown in Table 1. The most likely values for costs per case in Gujarat sum up to US$ 300 and US$ 64 for hospitalized and ambulatory cases, respectively. These are generally consistent with those worked out by Suaya et al. in Malaysia (US$ 1259 and US$ 422, hospitalized and ambulatory, respectively) when taking into account Malaysia’s roughly five times higher GDP per capita.

RUHA matrix

The RUHA matrix in Table 2 shows the characteristics of chikungunya and dengue cases in Gujarat. It has been constructed from the following data:
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Table 1: Costs per hospitalized and ambulatory case (studies referred at 6–9)

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Cost per case (INR)a</th>
<th>Range (INR)a</th>
<th>Referencesb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hospitalized</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct cost</td>
<td>9790</td>
<td>3300 – 155 640</td>
<td>[6-9],[8],[6]</td>
</tr>
<tr>
<td>Indirect cost</td>
<td>2820</td>
<td>0 – 31 020</td>
<td>[6-9],[7],[6]</td>
</tr>
<tr>
<td>Total</td>
<td>12 610</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ambulatory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct cost</td>
<td>1070</td>
<td>40 – 9500</td>
<td>[7-9],[8],[7]</td>
</tr>
<tr>
<td>Indirect cost</td>
<td>1610</td>
<td>0 – 23 080</td>
<td>[7,9],[7],[7,9]</td>
</tr>
<tr>
<td>Total</td>
<td>2680</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INR denotes Indian Rupees.
aValues inflation adjusted to 2008 Indian Rupees.
bFor each item, references cited were used respectively for most likely, minimum, and maximum values.

Table 2: RUHA matrix for Gujarat

<table>
<thead>
<tr>
<th>Setting</th>
<th>Reported</th>
<th>Unreported</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalised</td>
<td>1%</td>
<td>14%</td>
<td>15%</td>
</tr>
<tr>
<td>Ambulatory</td>
<td>3%</td>
<td>82%</td>
<td>85%</td>
</tr>
<tr>
<td>Total</td>
<td>4%</td>
<td>96%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Authors’ estimates.

(1) A reporting rate of 4–10% (expansion factor 10–27) was recently used by Garg et al. to estimate the burden of dengue in India; this has been assumed to be applicable in Gujarat. A comparable reporting rate (3%) was found by attributing 1% of general fever cases (reported by Integrated Disease Surveillance System) to chikungunya or dengue. This percentage was based on data showing that at least 10% of tested cases are confirmed as chikungunya or dengue. The “confirmation rate” for general fever cases was taken as one tenth of this (i.e., 1%) to allow for smaller number of relevant symptoms.

(2) Garg et al. used a hospitalisation rate of 9–20% for dengue cases in India based on Thailand data. This range of rates agrees fairly well with chikungunya hospitalization rates of 6% and 13% found in studies in Ahmedabad city.

(3) The fraction of reported cases that are hospitalized was assumed to be 0.29 based on public sector case data in Ahmedabad in 2007.

Vector control costs

In 2007–2008, the NVBDCP spent INR 73 million on measures to prevent and control chikungunya and dengue in Gujarat. Additional spending by municipal corporations during that period was INR 44 million and INR 27 million in Ahmedabad and Surat,
respectively (assuming one third of Surat’s budget for the Vector-Borne Disease Control Programme is assigned for dengue). These public control cost estimates are conservative because they tend to focus on insecticides (possibly underestimating personnel costs) and because costs in districts other than Ahmedabad and Surat have not been estimated. This effect is partly cancelled out by using data from Malaysia\(^{(14)}\) to estimate expenditure in Gujarat to be 2% to 6% of government vector control spending. Expenditure on household insecticides to prevent these *Aedes* mosquitoborne diseases was estimated indirectly using three independent methods, which give fairly consistent results (see Table 3). The annual cost (taken as the average of the most likely values of the three methods) is INR 95 million (range INR 39–320 million).

### Table 3: Household insecticide market estimates

<table>
<thead>
<tr>
<th>Method used</th>
<th>Most likely(^b) (INR million)</th>
<th>Range(^b) (INR million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coils market taken as 30-50% of total market(^a)</td>
<td>90</td>
<td>39–321</td>
</tr>
<tr>
<td>Insecticide (liquidator) cost estimated per day</td>
<td>127</td>
<td>42–253</td>
</tr>
<tr>
<td>Household insecticide market in Malaysia</td>
<td>68</td>
<td>40–105</td>
</tr>
<tr>
<td>Combined</td>
<td>95</td>
<td>39–321</td>
</tr>
</tbody>
</table>

INR denotes Indian Rupees.


\(^b\) Most likely value is the average and range is the range of the three different approaches.

**Discussion**

**Cost of chikungunya and dengue to Gujarat**

Monte Carlo sensitivity analysis carried out on the cost incurred by households on chikungunya and dengue resulted in a mean annual cost of INR 3.8 billion (range INR 1.6–9.1 billion), equivalent to a mean of US$ 90 million and a range of US$ 38 to 217 million. About 88% of this cost was due to chikungunya illness, 5% was due to dengue illness, and the remaining 7% is the cost due to intervention activities. The total immediate cost translates to approximately INR 67 per capita (range INR 29–161), or US$ 1.60 (range US$ 0.70–3.80). Comparable estimates of the cost of dengue were US$ 5.3 per capita in Malaysia\(^{(14)}\) and US$ 6.2 per capita in Panama,\(^{(15)}\) while Brazil spends US$ 4.3 per capita on dengue prevention alone.\(^{(16,17)}\) The differences in these costs can be partially explained the fact that GDP per capita is five times higher in Malaysia, Panama and Brazil than in Gujarat. The high risk of chikungunya epidemics also increases the relative cost in Gujarat.

Most of the variation of the total cost to households is caused by uncertainties in direct cost of hospitalization, ambulatory costs, chikungunya cyclicity (frequency of chikungunya epidemics) and reporting rate (Figure 2). Further studies are in progress to refine the estimates of ambulatory costs and reporting rate, improving this preliminary cost estimate. These two parameters have been observed to have comparable effects outside Gujarat\(^{(7,14)}\) suggesting that improved understanding of them will help make more accurate economic cost estimates around Asia.
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Figure 2: Variation of total cost due to uncertainties in each parameter

This study considers only the immediate cost of these *Aedes* mosquito-borne diseases. Previous studies indicate that long-term illness and deaths are associated with these diseases, but the emotional and economic burden due to these is outside the scope of this study. These diseases can also have a long-term impact on education and economic growth, per capita income, foreign direct investment, tourism, etc. but these effects have not been taken into account in the cost estimates presented in this study. Furthermore, as this study was done from the household perspective, it does not include government subsidies to health centres, hospitals and other facilities that often pay for much of the original construction plus a share of the personnel and operating expenses. Another study in this issue of *Dengue Bulletin* also reports on the cost per case of dengue.

The resulting mean cost there (US$ 586) is dramatically higher than the mean from the present study ($28). The difference is due to several factors. The higher figure represented hospitalized cases, while the lower figure was mostly ambulatory cases. The higher figure is in the private sector and measures the full economic cost, while the lower value is simply the cost to households. It is hoped that this preliminary estimate will trigger more refined studies on cost of illness as well as cost-effectiveness of vaccines and other interventions to combat these neglected tropical diseases.

Acknowledgements

Funded in part by a grant to the Regents of the University of California from the Foundation.
for the National Institutes of Health through the Grand Challenges in Global Health initiative. The authors thank their colleagues, especially Ms Luise Birgelen and Ms Aikaterini Mandaltsi of Oxford University, Ms Clare Hurley of Brandeis University, and Rosemary Susan Lees of the University of Malaya, for their comments.

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