A Preliminary Estimate of Immediate Cost of Chikungunya and Dengue to Gujarat, India

Dileep V. Mavalankar
Tapasvi I. Puwar
Dipti Govil
Tiina M. Murtola
S.S. Vasan

W.P. No. 2009-01-01
January 2009

The main objective of the working paper series of the IIMA is to help faculty members, research staff and doctoral students to speedily share their research findings with professional colleagues and test their research findings at the pre-publication stage. IIMA is committed to maintain academic freedom. The opinion(s), view(s) and conclusion(s) expressed in the working paper are those of the authors and not that of IIMA.
A Preliminary Estimate of Immediate Cost of Chikungunya and Dengue to Gujarat, India

Dr. Dileep V. Mavalankar (Corresponding author)
Professor, Public Systems Group, Indian Institute of Management
Vastrapur, Ahmedabad 380015, Email: dileep@iimahd.ernet.in

Dr. Tapasvi I. Puwar
Research Associate, Centre for Management of Health Services
Indian Institute of Management, Vastrapur, Ahmedabad 380015

Dr. Dipti Govil
Project Associate, Centre for Management of Health Services
Indian Institute of Management, Vastrapur, Ahmedabad 380015

Ms. Tiina M. Murtola
Exchange Intern, Centre for Management of Health Services
Indian Institute of Management, Vastrapur, Ahmedabad 380015

Dr. S.S. Vasan
Visitor, Centre for Management of Health Services
Indian Institute of Management, Vastrapur, Ahmedabad 380015

In collaboration with:
Dr. Robert W. Field, Dr. Hong-Fei Gong, Mrs. Ami Bhavsar-Vyas,
Dr. Jose A. Suaya, Dr. Marion Howard, Dr. Donald S. Shepard,
Dr. Vijay Kumar Kohli, Dr. P.B. Prajapati and Dr. Amarjit Singh

1University of Oxford, Department of Engineering Science, Parks Road, Oxford OX1 3PJ, UK
2Oxitec Limited, 71 Milton Park, Oxford OX14 4RX, UK
3Centre for Micro Finance, 8th Floor, West Wing, Fountain Plaza, Khaleel Shirazi Estate, 31/2A, Pantheon Road, Egmore, Chennai 600 008, India
4Brandeis University, Schneider Institutes for Health Policy, Heller School, MS035, Waltham, MA 02454-9110, USA
5Ahmedabad Municipal Corporation, Sardar Patel Bhavan, Danapith, Ahmedabad 380 001, India
6Government of Gujarat, Department of Health & Family Welfare, Commissionerate of Health, Medical Services & Medical Education, Dr. Jivraj Mehta Bhawan, Block No.5, Sector-10, Gandhinagar 382 010, India

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
Abstract

Background

In this working paper, a preliminary estimate of the immediate cost of chikungunya and dengue to the Indian state of Gujarat has been estimated by combining nine earlier studies on major cost factors such as costs of illness and control, and thus building a more comprehensive picture of the immediate cost of these Aedes mosquito-borne diseases to Gujarat.

Methods

Costs of illness and vector control comprise the immediate cost of chikungunya and dengue. In this working paper, cost of illness has been calculated using the RUHA matrix approach. Using the shares of reported (R) and unreported (U) hospitalised (H) and ambulatory (A) cases of chikungunya and dengue, a RUHA matrix has been constructed for the state of Gujarat. Cost of illness has been estimated by combining this matrix with ambulatory and hospitalisation costs per case and the number of reported cases. For this study, chikungunya and dengue were assumed to be identical from the point of view of disease control and management. Vector control cost includes state and municipal expenditure to prevent/control these diseases, a conservative fraction of the household insecticides market, and private sector cost. Comparisons with Asian countries have been used to estimate a parameter if direct data is unavailable. Monte-Carlo sensitivity analysis was carried out to find out how uncertainties in each cost parameter affected the total cost of chikungunya and dengue.

Findings

Using Monte-Carlo sensitivity analysis, the immediate cost of chikungunya and dengue to Gujarat has been estimated to be 3.7 (range 1.6-9.0) billion rupees per annum. This is a preliminary estimate; research is in progress to refine key parameters from the Monte-Carlo analysis such as ambulatory cost per case and reporting rate. The emotional and long-term burden of illness and deaths due to these diseases including impact on tourism, education, economic growth, per capita income, FDI, etc. are beyond the scope of this study. Extrapolating from Gujarat to the whole of India (after adjusting for the relative number of cases in each state and differences in state GSDP per capita), the immediate cost of chikungunya and dengue to the whole of India is approximately INR 61 billion (range INR 26-148 billion).

Interpretation

The annual cost of INR 3.7 billion (range INR 1.6-9.0 billion) translates to approximately INR 66 per capita (range INR 29-159), or US$ 1.6 (range US$ 0.7-3.8) per capita using an exchange rate 42 INR/US$. Comparable cost of dengue is US$ 5.3 in Malaysia and US$ 6.2 in Panama, while Brazil spends US$ 4.3 per capita on dengue prevention alone. The differences in these costs can be partially be explained by roughly five times higher GDP per capita in Malaysia, Panama and Brazil than in Gujarat. However, higher incidence of chikungunya increases the relative cost in Gujarat. As policy makers weigh investments in new technologies and expanded use of existing interventions to control neglected tropical diseases, the economic cost of illness is a major input into decision making. 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.

Key words: burden of illness; chikungunya; dengue; Gujarat; immediate cost; Monte-Carlo analysis; RUHA matrix
Introduction

The number of dengue cases in Gujarat, India, has followed an increasing trend since 2004 (Figure 1). Several studies have estimated costs of illness associated with dengue or chikungunya in different states of India, but cost factors included tend to vary from study to study. In this paper, we make a preliminary estimate for 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.

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 includes vector control on Aedes mosquito, a fraction of household insecticide market, and research and development cost. Data on each cost parameter was collected from published and unpublished studies and from interviews with local authorities. Where direct data was unavailable, trends from other Asian countries were used. All cost estimates were inflation adjusted to 2008 INR. Costs in different countries were compared in 2008 US$, and an exchange rate 42 INR/US$ was used.

Cost of illness was estimated by combing reported cases, and costs per case with a RUHA matrix (defined below). Data on reported dengue cases for the last five years (2003-07) was used as dengue tends to occur in 2-3 year cycles [1]. Chikungunya cases for 2006-08...
(up to 30 Jul 2008) were used to estimate the burden of an outbreak, which is assumed to occur cyclically [2,3]. Costs per ambulatory and hospitalised cases were obtained from published and unpublished studies, which were compared and combined to ensure consistency in factors included in the costs. The shares of reported (R) and unreported (U) hospitalised (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 of chikungunya and dengue. 65 simulations 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 National Vector Borne Disease Control Programme (NVBDCP) has followed an increasing trend since 2004 (Figure 1). In the last five years (2003-07) the reported dengue cases have varied from 117 to 570 with an annual average of 387. There was a major outbreak of chikungunya in Gujarat in
2006 with 75,419 reported cases, which winded down to 3,223 and 139 cases in 2007 and 2008 (until 30 Jul), respectively. 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 7 years (range 4-20 considered) [2,3]. Some discrepancies were noted between local and national data on reported cases, and these were taken into account in the Monte-Carlo analysis.

**Figure 1 Dengue cases in Gujarat (source: NVBDCP)**

Cost per case data
Costs per hospitalised and ambulatory case were worked out in 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 hospitalised and ambulatory cases, respectively. These compare fairly well with those worked out by Suaya et al. in Malaysia (US$ 1259 and US$ 422, hospitalised and ambulatory, respectively) [5] when taking into account Malaysia’s roughly five times higher GDP per capita.

Table 1 Costs per hospitalised and ambulatory case (studies compared [6-9])

<table>
<thead>
<tr>
<th></th>
<th>Cost per case (INR)</th>
<th>Range (INR)</th>
<th>Reference²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalised</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct cost</td>
<td>9,790</td>
<td>3,300-155,640</td>
<td>[6-9],[8],[6]</td>
</tr>
<tr>
<td>Indirect cost</td>
<td>2,820</td>
<td>0-31,020</td>
<td>[6-9],[7],[6]</td>
</tr>
<tr>
<td>Sum</td>
<td>12,610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambulatory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct cost</td>
<td>1,070</td>
<td>40-9,500</td>
<td>[7-9],[8],[7]</td>
</tr>
<tr>
<td>Indirect cost</td>
<td>1,610</td>
<td>0-23,080</td>
<td>[7,9],[7],[7,9]</td>
</tr>
<tr>
<td>Sum</td>
<td>2,680</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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:

i. Reporting rate of 4-10% (expansion factor 10-27) was recently used by Garg et al. to estimate the burden of dengue in India [8]; this has been assumed 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. The ratio of chikungunya/dengue to general fever was based on data showing that at least 10% of tested cases are confirmed as chikungunya or dengue [10,11].

---

1 Values inflation adjusted to 2008 rupees
2 For each item, references cited were used for most likely, minimum, and maximum values, respectively
“confirmation rate” for general fever cases was taken as one tenth of this to allow for smaller number of relevant symptoms.

ii. Garg et al. used a hospitalisation rate of 9-20% for dengue cases in India based on Thailand data [12]. This agrees fairly well with chikungunya hospitalisation rates of 6% and 13% found in studies in Ahmedabad city [7,13].

iii. The fraction of reported cases that are hospitalised was assumed 0.29 based on public sector case data in Ahmedabad in 2007 [10].

<table>
<thead>
<tr>
<th></th>
<th>Reported</th>
<th>Unreported</th>
<th>Sum</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>Sum</td>
<td>4%</td>
<td>96%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2 RUHA matrix for Gujarat

Vector control costs

In 2007-08 NVBDCP spent INR 73 million on measures to prevent and control chikungunya and dengue in Gujarat [11]. Additional spending by municipal corporations was INR 44 million and INR 27 million in Ahmedabad and Surat, respectively (assuming one third of Surat’s budget for Vector Borne Disease Control Programme is assigned for dengue) [14]. These public control cost estimates are conservative because they tend to focus on insecticides (possibly underestimating personnel costs) and because costs in other districts than Ahmedabad and Surat have not been estimated. This effect is partly cancelled out by using data from Malaysia [15] to estimate R&D expenditure in Gujarat to be 2-6% of government vector control spending. Expenditure on household insecticides to prevent these *Aedes* mosquito-borne diseases was estimated indirectly using three
independent methods, which give fairly consistent results (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 (INR million)</th>
<th>Range (Rs million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Coils market taken as 30-50% of total market³</td>
<td>90</td>
<td>39-321</td>
</tr>
<tr>
<td>2. Insecticide (liquidator) cost estimated per day</td>
<td>127</td>
<td>42-253</td>
</tr>
<tr>
<td>3. Household insecticide market in Malaysia</td>
<td>68</td>
<td>40-105</td>
</tr>
<tr>
<td>Combined⁴</td>
<td>95</td>
<td>39-321</td>
</tr>
</tbody>
</table>

### Discussion

**Cost of chikungunya and dengue to Gujarat**

Monte-Carlo sensitivity analysis carried out on the cost of chikungunya and dengue resulted in a mean annual cost of INR 3.7 billion (range INR 1.6-9.0 billion). 92% of this cost due to chikungunya illness, 3% due to dengue illness, and the remaining 5% is the cost due to intervention activities. The total immediate cost translates to approximately INR 66 per capita (range INR 29-159), or US$ 1.6 (range US$ 0.7-3.8). Comparable cost of dengue is US$ 5.3 in Malaysia [15] and US$ 6.2 in Panama [17], while Brazil spends US$ 4.3 per capita on dengue prevention alone [18,19]. The differences in these costs can be partially be explained by roughly five times higher GDP per capita in Malaysia, Panama and Brazil than in Gujarat. High risk of chikungunya epidemics increase the relative cost in Gujarat.

---


⁴ Most likely value is the average and range is the range of the three different approaches.
Most of the variation of the total cost is caused by uncertainties in direct cost of hospitalisation, ambulatory costs, chikungunya cyclicity (frequency of chikungunya epidemics) and reporting rate (Figure 2). Further studies are in progress to make more accurate the estimates of ambulatory costs and reporting rate, hence improving this preliminary cost estimate. These two parameters have been observed to have comparable effects outside Gujarat [8,15] suggesting that improved understanding of them will help making economic cost estimates around Asia.

**Figure 2 Variation of total cost due to uncertainties in each parameter**

![Image of Figure 2](image_url)

**Cost of chikungunya and dengue to India**

A rough estimate of the cost of chikungunya and dengue to the entire India was made based on the cost to Gujarat. The assumptions made were (i) that total chikungunya and dengue cases in 2006-08 represent the level of epidemic/endemic activity of these diseases in each state, and (ii) that the total cost per case (including cost of illness, control
and R&D) in each state is proportional to GSDP per capita. Table 4 shows the resulting costs for each state. The mean cost of dengue to India amounts to INR 61 billion (range INR 26-148 billion), which is a substantial fraction of total expenditure on health (1-7% [20]) and equivalent to INR 54 per capita (range INR 23-130). Five states contribute 89% of the cases and 90% of cost to India, indicating that future studies estimating the cost of chikungunya and dengue to India should pay particular attention to these states.

Table 4 Estimating the cost of chikungunya and dengue to India based on the cost to Gujarat

<table>
<thead>
<tr>
<th>State</th>
<th>Reported cases 2006-08 (until 30 Jul 08) [21,22]</th>
<th>GSDP per capita 2005-06 (INR billion)</th>
<th>Normalisation factor</th>
<th>Total cost of chikungunya and dengue (INR billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chik</td>
<td>Dengue</td>
<td>Total (chik+den)</td>
<td>Min</td>
</tr>
<tr>
<td>A&amp;N Islands</td>
<td>1549</td>
<td>1549</td>
<td>34853</td>
<td>0.02</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>77579</td>
<td>78365</td>
<td>26211</td>
<td>0.75</td>
</tr>
<tr>
<td>Bihar</td>
<td>4</td>
<td>4</td>
<td>7875</td>
<td>0.00</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>281</td>
<td>281</td>
<td>86629</td>
<td>0.01</td>
</tr>
<tr>
<td>Delhi</td>
<td>763</td>
<td>3914</td>
<td>61676</td>
<td>0.11</td>
</tr>
<tr>
<td>Goa</td>
<td>396</td>
<td>40</td>
<td>70112</td>
<td>0.01</td>
</tr>
<tr>
<td>Gujarat</td>
<td>78781</td>
<td>79947</td>
<td>34157</td>
<td>1.00</td>
</tr>
<tr>
<td>Haryana</td>
<td>20</td>
<td>1203</td>
<td>38832</td>
<td>0.02</td>
</tr>
<tr>
<td>J&amp;K</td>
<td>24</td>
<td>24</td>
<td>20153</td>
<td>0.00</td>
</tr>
<tr>
<td>Karnataka</td>
<td>804958</td>
<td>805313</td>
<td>27291</td>
<td>8.05</td>
</tr>
<tr>
<td>Kerala</td>
<td>117598</td>
<td>119261</td>
<td>30668</td>
<td>1.34</td>
</tr>
<tr>
<td>Lakshadweep</td>
<td>5219</td>
<td>5219</td>
<td>33366</td>
<td>0.06</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>60132</td>
<td>60199</td>
<td>15647</td>
<td>0.34</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>272221</td>
<td>273589</td>
<td>37081</td>
<td>3.72</td>
</tr>
<tr>
<td>Manipur</td>
<td>51</td>
<td>51</td>
<td>20326</td>
<td>0.00</td>
</tr>
<tr>
<td>Orissa</td>
<td>10526</td>
<td>10531</td>
<td>17639</td>
<td>0.07</td>
</tr>
<tr>
<td>Puducherry</td>
<td>542</td>
<td>830</td>
<td>48477</td>
<td>0.01</td>
</tr>
<tr>
<td>Punjab</td>
<td>1194</td>
<td>1194</td>
<td>36759</td>
<td>0.02</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>104</td>
<td>2347</td>
<td>2451</td>
<td>0.02</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>64850</td>
<td>66034</td>
<td>29958</td>
<td>0.72</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>8</td>
<td>771</td>
<td>13262</td>
<td>0.00</td>
</tr>
<tr>
<td>West Bengal</td>
<td>19159</td>
<td>20495</td>
<td>25223</td>
<td>0.19</td>
</tr>
</tbody>
</table>

TOTAL (INR billion) | 26.4 | 61.2 | 148.0

5 Calculated for State-n as (ratio of total cases in State-n to total cases in Gujarat) x (ratio of GSDP per capita in State-n to GSDP per capita in Gujarat)
6 GSDP per capita for 2005-06 was not available, so 2004-05 figure was adjusted to inflation
7 No data available, so average GSDP per capita of all chikungunya/dengue endemic states was used
This study considers only the immediate cost of these *Aedes* mosquito-borne diseases. The emotional and economic burden of long-term illness and deaths due to these diseases is outside the scope of this study. These diseases can also have long-term impact on education and economic growth [24,25], per capita income [26,27], foreign direct investment [28,29], tourism [30], etc., but these effects have not been taken into account in the cost estimates presented in this paper. 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.

**References**


