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

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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

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

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 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].

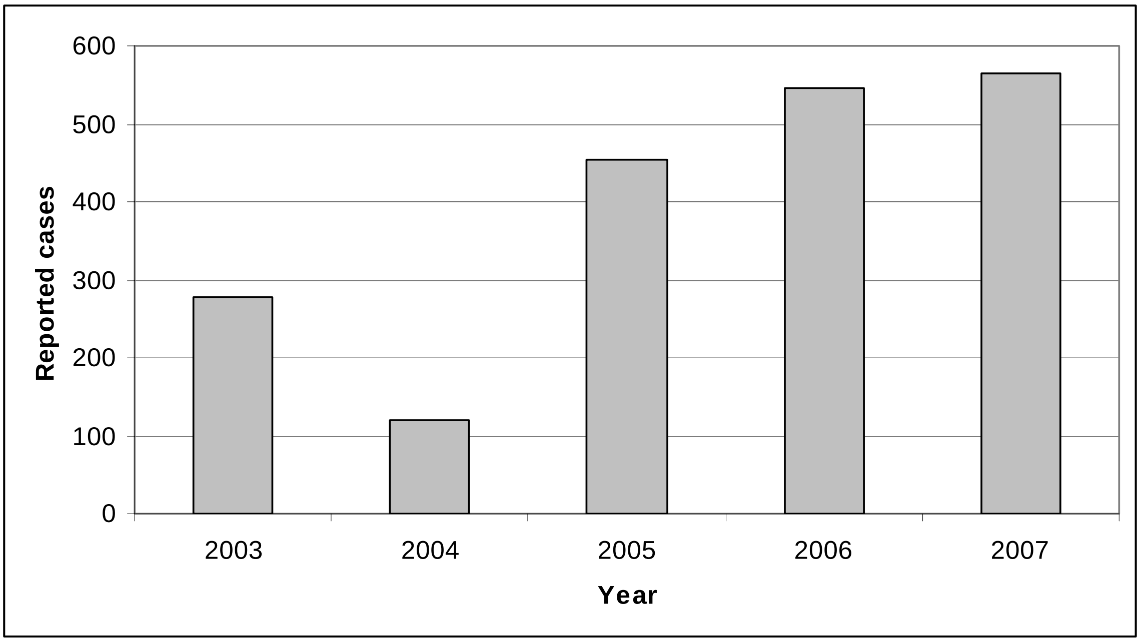
Results

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[1] (studies compared [6-9])

	Cost per case (INR)	Range (INR)	Reference[2]
Hospitalised			
Direct cost	9,790	3,300-155,640	[6-9],[8],[6]
Indirect cost	2,820	0-31,020	[6-9],[7],[6]
Sum	12,610		
Ambulatory			
Direct cost	1,070	40-9,500	[7-9],[8],[7]
Indirect cost	1,610	0-23,080	[7,9],[7],[7,9]
Sum	2,680		

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]. The

[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 2 RUHA matrix for Gujarat

	Reported	Unreported	Sum
Hospitalised	1%	14%	15%
Ambulatory	3%	82%	85%
Sum	4%	96%	100%

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

Method used	Most likely (INR million)	Range (Rs million)
1. Coils market taken as 30-50% of total market[3]	90	39-321
2. Insecticide (liquidator) cost estimated per day	127	42-253
3. Household insecticide market in Malaysia	68	40-105
Combined[4]	95	39-321

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.

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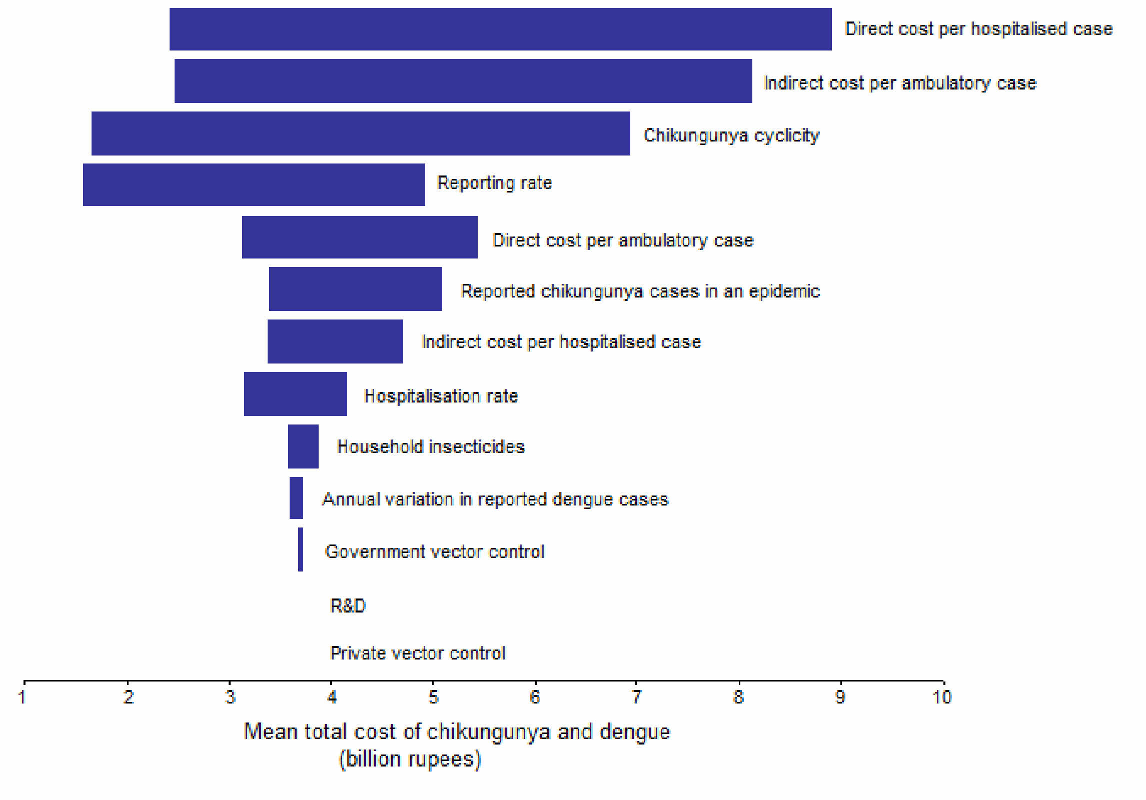
[3] Coils market data from Jyothy Laboratories 16. Jyothy Laboratories Ltd (2007) Annual Report 2006-07., coils market percentage based on data from Malaysia (Source: Malaysian CropLife & Public Health Association, Estimates of Household Insecticide Sales (2002 to 2006), Chooi Lam Khong, personal communication to Vasan SS, 2007)

[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



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

State	Reported cases 2006-08 (until 30 Jul 08) [21,22]			GSDP per capita 2005-06 (INR) [23]	Normalisation factor[5]	**Total cost of chikungunya and dengue (INR billion)**		
	Chik	Dengue	Total (chik+den)			**Min**	**Mean**	**Max**
A&N Islands	1549		1549	34853	0.02	0.0	0.1	0.2
Andhra Pradesh	77579	786	78365	26211	0.75	1.2	2.8	6.8
Bihar		4	4	7875	0.00	0.0	0.0	0.0
Chandigarh		281	281	86629	0.01	0.0	0.0	0.1
Delhi	763	3914	4677	61676	0.11	0.2	0.4	0.9
Goa	396	40	436	70112	0.01	0.0	0.0	0.1
Gujarat	*78781*	*1166*	*79947*	*34157*	*1.00*	*1.6*	*3.7*	*9.0*
Haryana	20	1203	1223	38832	0.02	0.0	0.1	0.2
J&K		24	24	20153[6]	0.00	0.0	0.0	0.0
Karnataka	804958	355	805313	27291	8.05	12.9	29.9	72.3
Kerala	117598	1663	119261	30668	1.34	2.1	5.0	12.0
Lakshadweep	5219		5219	33366[7]	0.06	0.1	0.2	0.6
Madhya Pradesh	60132	67	60199	15647	0.34	0.6	1.3	3.1
Maharashtra	272221	1368	273589	37081	3.72	6.0	13.8	33.4
Manipur		51	51	20326	0.00	0.0	0.0	0.0
Orissa	10526	5	10531	17639	0.07	0.1	0.3	0.7
Puducherry	542	288	830	48477	0.01	0.0	0.1	0.1
Punjab		1194	1194	36759	0.02	0.0	0.1	0.1
Rajastan	104	2347	2451	17863	0.02	0.0	0.1	0.1
Tamil Nadu	64850	1184	66034	29958	0.72	1.2	2.7	6.5
Uttar Pradesh	8	771	779	13262	0.00	0.0	0.0	0.0
West Bengal	19159	1336	20495	25223	0.19	0.3	0.7	1.7
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.

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