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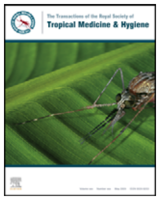

# Estimating the burden of disease and the economic cost attributable to chikungunya, Andhra Pradesh, India, 2005–2006

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ABSTRACT

To estimate the burden and cost of chikungunya in India, we searched for cases of fever and joint pain in the village of Mallela, Andhra Pradesh, and collected information on the demography, signs, symptoms, healthcare utilization and expenditure associated with the disease. We estimated the burden of the disease using disability-adjusted life years (DALYs). We estimated direct and indirect costs and made projections for the district and state using surveillance data corrected for under-reporting. On average, from December 2005 to April 2006, each of the 242 cases in the village led to a burden of 0.0272 DALYs (95% CI 0.0224–0.0319) and a cost of US$37.50 (95% CI 30.6–44.3). Overall, chikungunya in Mallela led to 6.57 DALYs and a loss of US$9100. Out-of-pocket direct medical costs accounted for 68% of the total. From January to December 2006 the burden for Kadapa district was 160 DALYs (cost: US$290 000). Over the same period the burden for Andhra Pradesh was 6600 DALYs (cost: US$12 400 000). While the burden was moderate, costs were high and mostly out of pocket.



## 1. Introduction

Chikungunya virus is transmitted through the bite of an infected *Aedes* mosquito. The disease presents with sudden onset of fever and joint pains, which are often incapacitating. The acute febrile phase can evolve towards a chronic phase, with persisting arthralgia that may last for several weeks. The disease is rarely fatal. There is no vaccine available; prevention and control depends entirely on vector control measures. Symptoms can be managed through effective oral medications, including painkillers (e.g. paracetamol) and non-steroidal anti-inflammatory drugs. Antibiotics and injections are unjustified, ineffective and costly. In addition, they may have side-effects.

Since 2005, chikungunya re-emerged around the Indian Ocean,[1] reaching several southern Indian states, and even Italy.[2] As the disease had been absent from India for 30 years it generated anxiety in the local and national press, and led to a number of questions. One key issue was the setting of priorities for the implementation of prevention and control measures. However, no studies were available, assessing either the disease or the economic burden of chikungunya, that would help decision-makers to efficiently allocate scarce resources. There is no universal health insurance in India, and healthcare expenditure is largely financed out of pocket.

In October 2005, in the Indian state of Andhra Pradesh, an increase in the number of patients presenting with

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fever and arthralgia was reported. By April 2006 the state reported more than 25 000 patients with symptoms compatible with chikungunya. The National Institute of Virology, Pune isolated the virus in blood specimens of patients and in *Aedes aegypti*.[3] In March 2006, as the disease was spreading in Andhra Pradesh, we conducted a field investigation in an affected village in the state (Mallela, Kadapa district) to estimate the burden of the disease in terms of disability-adjusted life years (DALYs), and the economic cost in terms of US dollars.

## 2. Methods

### 2.1. Data collection

#### 2.1.1. Village survey

We selected the village of Mallela in Kadapa district, as local health authorities reported a high number of chikungunya cases in the area. We conducted the field investigation on 28 and 29 April 2006. We defined a probable case of chikungunya as an acute onset of febrile illness with joint pain since 1 December 2005 among the residents of Mallela village (1965 inhabitants).[4] We searched for cases door to door, covering the entire village. After obtaining informed consent we interviewed all probable case-patients to collect information on demographic characteristics (age and gender), the episode of illness (symptoms and their duration, number of working days lost), healthcare utilization (visits to medical camps, health centres and hospitalization), treatment received (including injections – defined as procedures introducing a substance into the body by piercing the skin or a mucosal membrane) and income (daily wage). To estimate out-of-pocket expenditure we collected information regarding estimated expenses incurred in obtaining treatment, including transport to seek care at health facilities.

#### 2.1.2. Cost identification

During the outbreak, public health authorities set up special medical camps to screen the population for symptoms, and provide healthcare (such medical camps for case-finding and treatment are a classical outbreak-response measure in India). In Kadapa district, medical camps were conducted in 46 villages. Typically, a camp provided medical care in the same locality for less than a week (range: 1–7 days). We selected one typical medical camp for which documentation was available. We interviewed medical staff and reviewed reports to estimate the cost of medical camps (including salaries, transport, equipment and supplies), by listing the resources used, and estimating quantities and unit costs. We estimated the average cost of a visit to a health centre, and the average daily cost of hospitalization in a tertiary hospital, using data extracted from the WHO country profile.[5]

### 2.2. Data analysis

#### 2.2.1. Disability-adjusted life years (DALYs)

We estimated the burden of chikungunya using DALYs, which estimate the amount of time, ability or activity lost by an individual from disability (years lost to disability) or death (years lost to death) resulting from a disease. This loss is then adjusted to account for age of onset, severity of disability and duration of disability. We estimated the DALYs for each probable case of chikungunya in Mallela using the formula:[6]

$$-\left[\frac{DCe^{-\beta a}}{(\beta - \mathrm{r})^2}\left[e^{-(\beta+\mathrm{r})(L)}(1+(\beta+r)(L+a)) - (1+(\beta+r)a)\right]\right]$$

$L$ represents the years lost to death or disability, and $D$ is the disease-specific disability weight. $C$ and $\beta$ are positive constants, $a$ is the age of the patient in years and $r$ is the social discount rate (Table 1).

In the absence of a standardized disability weight for chikungunya in *The Global Burden of Disease*,[7] we distinguished between the two phases in the clinical history of chikungunya: the acute phase, characterized by an acute episode of fever and joint pain, and the chronic phase, corresponding to the persistence of joint pain beyond the disappearance of fever. We assumed the disability weight for the acute phase of the disease to be 0.81 – equal to the disability weight used for dengue in Puerto Rico.[8] This assumed that the acute chikungunya symptoms incapacitated a person, leaving them unfit for almost all usual daily activities. For the chronic phase of the disease we assumed a disability weight of 0.2, corresponding to rheumatoid arthritis in *The Global Burden of Disease* (Table 1).[7] To allow direct comparison with the DALYs from other diseases, we choose values for $C$, $\beta$ and $r$ equal to those used in the *World Development Report*.[9]

#### 2.2.2. Economic cost

We expressed all economic costs in US dollars using the March 2006 exchange rate (US$1 = 42.9 Indian rupees). Direct costs met by public expenditure included the cost of diagnosis and treatment at medical camps and health centres, and the cost of hospitalization for severe case-patients. Direct costs also included out-of-pocket expenditure by affected households (e.g. transport costs to the health centres, private consultations, medicines).

Indirect costs included loss of income related to absence from work because of the disease, among patients aged over 15 years, and to mothers who stayed at home or the hospital to look after their children aged under 15 years. There were no vector-control measures during the outbreak in Mallela.

#### 2.2.3. Projections

First, we estimated the burden of disease and the economic cost per chikungunya case in Mallela village. We then projected these estimates to the district (Kadapa) and state (Andhra Pradesh) levels. At each level we used the number of chikungunya cases reported by the National Vector Borne Disease Control Programme[10] and adjusted it for the proportion of cases captured by the surveillance system (those who sought treatment in medical camps or public healthcare facilities). Based on a comparison of surveillance data with the results of a door-to-door survey in Mallela village, we estimated that the surveillance system captured 30% of all cases. We checked that the age- and gender-specific attack rates at the district and

**Table 1**
Parameters used to calculate disability-adjusted life years attributable to chikungunya in Mallela village, Andhra Pradesh, India, 2005–2006

| Parameter | Acute episode of fever and joint pain | | Episode of persistence of joint pain beyond fever | |
|---|---|---|---|---|
| | Value | Range | Value | Range |
| Age weighting | | | | |
| Constant (*C*) | 0.16243 | – | 0.16243 | – |
| Parameter (β) | 0.04 | – | 0.04 | – |
| Discount rate (*r*) | 0.03 | – | 0.03 | – |
| Disability weight (*D*) | 0.81 | 0.6–0.9[a] | 0.20 | 0.1–0.3[a] |
| Epidemiological parameters | | | | |
| Mean duration of illness (days)[b] | 10 | 1–90 | 19 | 11–28 |
| Mean age at onset (*a*; years)[b] | 39 | 1–80 | 49 | 35–73 |

[a] Used in sensitivity analysis.
[b] Values for Mallela village.

state levels were proportional to those observed in Mallela. We standardized the DALY estimate by age, using the 2001 census data. As the daily income reported in Mallela might not have been representative of the district and the state as whole, we used a rural daily wage reported in the literature,[11] and derived the urban wage from the state's per capita income and the urban proportion of the population. We distributed chikungunya cases between urban and rural areas in proportion to the relative sizes of the urban and rural populations given by the 2001 census.[11]

*2.2.4. Sensitivity analysis*

We performed a sensitivity analysis to assess the potential impact of changes in one or more of the estimated parameters. For the disability weights, we assumed ranges of 0.6–0.9 and 0.1–0.3 for the acute and chronic phases of the disease, respectively. For the projection to the district and state levels our lower estimate of incidence was the official number of cases reported by the National Vector Borne Disease Control Programme[10] (which did not take into account cases that were not reported). We constructed an upper estimate to take into account both the sensitivity of the surveillance system and the loss of information (case attrition) during data transmission. The latter was based on a comparison of the local and national data, indicating that, within a district, local reports included 2.5 times more cases than national reports. Finally, we ran the analysis with different wage levels, allowing daily wages to vary up to 50% around their baseline values.

## 3. Results

### 3.1. Disease burden

*3.1.1. DALYs attributable to chikungunya in Mallela village*

During the door-to-door survey we identified 242 patients who reported symptoms meeting the probable-case definition from 1 December 2005 to 29 March 2006 (attack rate in the village: 12.3%). Of 134 patients (55%) for whom a blood specimen was available, 90 (67%) tested positive for chikungunya-specific IgM at the National Institute of Virology, Pune. Of the 242 case-patients, 232 (96%) experienced the acute phase only. The mean duration of the acute and chronic phases was 10 and 19 days, respectively. The mean age of case-patients was 39 years (range: 1–80; Table 1). Twenty-four case-patients (10%) were aged 15 years or younger. The male:female ratio was 0.7.

In the model, each chikungunya case in Mallela village led to an average burden of 0.027 DALYs (95% CI 0.0224–0.0319; Table 2). Overall, the chikungunya burden in Mallela was 6.6 DALYs. The acute phase of the disease accounted for 6.5 DALYs (97% of the total).

*3.1.2. DALYs projections at the district and state levels*

From January to December 2006, using surveillance data adjusted for the proportion of cases captured in the public healthcare system, we estimated that 6040 chikungunya cases occurred in Kadapa district. Thus, the estimated burden of chikungunya in Kadapa district was 160 DALYs. Applying the same projection methods to the state level, the estimated burden of chikungunya in the state of Andhra Pradesh from January to December 2006 was 257 034 cases and 6600 DALYs (Table 3).

### 3.2. Economic burden

*3.2.1. Economic cost of chikungunya in Mallela*

We assessed one medical camp that cost US$193, during which 90 patients were managed (average cost per patient US$2.10). Among case-patients in Mallela, 73 (30%) visited a medical camp, 123 (51%) visited a health centre and 30 (12%) were hospitalized (mean duration of hospitalization: 5 days). In Mallela, direct medical costs were US$7760 (US$32 per patient, 95% CI 25.8–38.1), and accounted for 86% of the total costs. Of these, 79% were out-of-pocket expenditures. Seventeen per cent and 76% of adult male and female case-patients reported no regular income, respectively. The parameters used to calculate the direct and indirect economic costs of chikungunya in Mallela village are given in Table 4.

A total of 2200 working days were lost in Mallela because of chikungunya (8.9 days per case). The estimated indirect costs of the disease in the village were US$1300 (US$5.45 per case; 95% CI 3.67–7.27), accounting for 14% of the total costs. Overall, the estimated total economic cost of the disease in Mallela village was US$9100 (US$37.50 per case; 95% CI 30.6–44.3; Table 2). It was higher in males (US$43.90 per case) than in females (US$32.90 per case; $P = 0.06$), and for patients over 15 years of age (US$37.90

**Table 2**
Disability-adjusted life years (DALYs) and economic costs for chikungunya at village, district and state levels, standardized by age and share of rural population, 2005–2006

| | Mallela village | | Standardized value per case[a] | |
|---|---|---|---|---|
| | Total | Per case | Kadapa district | Andhra Pradesh |
| DALYs | | | | |
| Acute stage | 6.50 | 0.027 | 0.026 | 0.025 |
| Persistent joint pain | 0.11 | 0.011 | 0.013 | 0.011 |
| Total | 6.60 | 0.027 | 0.027 | 0.026 |
| Economic costs | | | | |
| Direct (US$) | 7800 | 32.0 | 32.0 | 32.0 |
| Indirect (US$) | 1300 | 5.5 | 16.0 | 17.0 |
| Total (US$) | 9100 | 37.5 | 48.0 | 49.0 |
| Productivity loss[b] | 2200 | 8.9 | 8.3 | 8.7 |

[a] Standardized by age (0–4, 5–14, 15–45, >45 years) for DALYs estimates, and by the share of rural population for indirect costs.
[b] In days of work.

**Table 3**
Sensitivity analysis for reported and projected cases of chikungunya, with disease burden in DALYs and economic costs in US$ at the district and state levels, 2006

| | Single factor | | | | | | | | | Combined | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Incidence | | | Disability weight[a] | | | Wage[b] | | | | |
| | Low | Medium | High | Low | Medium | High | Low | Medium | High | Low | High |
| Kadapa | | | | | | | | | | | |
| Cases | 1822 | 6040 | 15 386 | 6040 | 6040 | 6040 | 6040 | 6040 | 6040 | 1822 | 15 386 |
| DALYs | 49 | 160 | 410 | 120 | 160 | 180 | 160 | 160 | 160 | 36 | 460 |
| Costs US$ (000) | | | | | | | | | | | |
| Direct | 58 | 190 | 490 | 190 | 190 | 190 | 190 | 190 | 190 | 58 | 490 |
| Indirect | 30 | 100 | 250 | 100 | 100 | 100 | 70 | 100 | 120 | 21 | 330 |
| Total | 88 | 290 | 740 | 290 | 290 | 290 | 260 | 290 | 310 | 79 | 820 |
| Andhra Pradesh | | | | | | | | | | | |
| Cases | 77 535 | 257 034 | 654 717 | 257 034 | 257 034 | 257 034 | 257 034 | 257 034 | 257 034 | 77 535 | 654 717 |
| DALYs | 2000 | 6600 | 17 000 | 4900 | 6600 | 7400 | 6600 | 6600 | 6600 | 1500 | 19 000 |
| Costs US$ (000) | | | | | | | | | | | |
| Direct | 2500 | 8200 | 21 000 | 8200 | 8200 | 8200 | 8200 | 8200 | 8200 | 2500 | 21 000 |
| Indirect | 1300 | 4200 | 11 000 | 4200 | 4200 | 4200 | 3000 | 4200 | 5500 | 900 | 14 000 |
| Total | 3800 | 12 400 | 32 000 | 12 400 | 12 400 | 12 400 | 11 200 | 12 400 | 13 700 | 3400 | 35 000 |

[a] Disability weights [acute, chronic]: low = [0.6, 0.1]; medium = [0.81, 0.2]; high = [0.9, 0.3].
[b] Wages [rural, urban]: low = [0.58, 3.3]; medium = [1.2, 3.7]; high = [1.7, 4.2].

per case) compared with others (US$33.0 per case; $P = 0.33$). The cost of chikungunya was also higher among adult females reporting a regular income (US$41.60 per case) than among those reporting no regular income (US$28.0 per case; $P = 0.04$).

**Table 4**
Parameters used to calculate direct and indirect economic costs of chikungunya, Mallela village, Andhra Pradesh, India, 2005–2006

| | Estimated value | |
|---|---|---|
| | US$ | Indian rupees |
| Direct costs by sector | | |
| Public | | |
| Outpatient | | |
| Medical camp per patient | 2.10 | 90 |
| Health centre per patient | 2.19 | 94 |
| Hospitalization (day) | 6.53 | 279 |
| Private | | |
| Out-of-pocket expenses[a] | 25.20 | 1080 |
| Indirect costs | | |
| Daily wage for men[a] | 1.05 | 45 |
| Daily wage for women[a] | 0.26 | 11 |

[a] Mean value for Mallela village.

### 3.2.2. *Projections of economic costs at the district and state levels*

Our projection suggested that, from January to December 2006, the estimated total economic cost of chikungunya was US$290 000 in Kadapa district and US$12 400 000 for the state of Andhra Pradesh (Table 3).

## 3.3. *Sensitivity analysis*

In Mallela, when the disability weight varied, the burden per chikungunya case ranged from 0.020 to 0.0304 DALYs. For the village, the total DALYs attributable to chikungunya ranged from 4.84 to 7.35. There was no variation according to the number of cases, as the door-to-door survey generated a reliable estimate of incidence.

In Kadapa district, when the disability weight varied, the DALYs estimate ranged from 120 to 180, but there was no impact on the economic cost. When the incidence varied, the DALYs estimate varied from 49 (low-incidence scenario) to 410 (high-incidence scenario). When rural and urban daily wages varied from US$0.60 to US$1.70 and US$3.30 to US$4.20 respectively, the total economic costs ranged from US$260 000 to US$310 000. Similarly, at the state level, the sensitivity analysis in terms of disability weight gave a burden estimate that ranged from 4900 to 7400 DALYs, whereas the lower and upper incidence scenarios using intermediate disability weights lead to estimates that ranged from 2000 to 17 000 DALYs. When the wages varied, the economic cost ranged from US$11 200 000 to US$13 700 000 (Table 3).

## 4. Discussion

Our study adds to another previously conducted on the burden of chikungunya in India.[12] The previous study reported comparable, although lower, estimates for DALYs and productivity loss. However, our work brought additional information. First, it relied on field survey data for key parameters, such as the duration of symptoms and the number of working days lost. Second, it took into account the actual, measured sensitivity of the surveillance system. Third, our estimates for economic costs included direct costs, with public and out-of-pocket expenditure. Since the latter constituted a large share of total cost, they were important to consider.

From January to December 2006 a total of 1 391 165 cases of chikungunya were reported throughout India.[10] If we assume the same proportion of capture of cases (sensitivity) by the surveillance system, and apply DALY estimates from Mallela village, the national burden of chikungunya would reach 120 000 DALYs in 2006. This would represent 1.2% of the 10 178 000 HIV/AIDS DALYs and 14% of the 844 000 malaria DALYs for the year 2002.[13] It would also be lower than the 226 000 DALYs of Japanese encephalitis and the 184 000 of dengue in 2002.[13] The lower burden is despite the higher disability weight we used for the acute phase of chikungunya than those assigned to dengue (0.21), malaria (0.191) and Japanese encephalitis (0.616) in the WHO *Global Burden of Disease Estimates*.[13]

A number of factors may explain this difference. First, the incidence of chikungunya in 2006 was lower than the incidence of malaria in India in 2002. Second, unlike the other three vector-borne diseases, death is extremely rare in chikungunya. As no deaths were reported in Mallela, our model assumed that no deaths occurred at district or state level. There have been deaths associated with chikungunya fever in the French Island of La Réunion, but they were rare (case-fatality rate: 0.05%), were associated with underlying conditions,[14] and occurred among older people, leading to few years lost to deaths in terms of DALY calculations. Third, the chronic phase only affected 4% of cases, was of limited duration (mean: 19 days), did not lead to major absenteeism and accounted for a small proportion of the DALY estimate.

On average, in the village we studied, a chikungunya case cost the government sector US$6.78 for care at medical camps or health centres, or for hospitalization. By contrast, the patient, or their family, spent on average US$25.20 and experienced an average productivity loss equivalent to US$5.47. Economic losses attributable to chikungunya were therefore largely borne by affected households. Sixty-seven per cent of all costs were out-of-pocket expenditure. These financial losses should be considered in the light of the average daily wage in Mallela, which was US$1.05 for men and US$0.257 for women. Overall, the estimated total cost per chikungunya case in Mallela village was slightly lower than the total economic loss attributable to a dengue patient requiring hospitalization in Thailand (US$37.50 vs. US$44).[15]

We do not have a breakdown of out-of-pocket expenditure, and thus cannot say what proportion was unnecessary. However, more than a third of all case-patients in Mallela village used antibiotics as part of their treatment.[16] Antibiotics are ineffective against chikungunya, and can only facilitate antimicrobial resistance. No specific education campaign on the use of antibiotics was run in the village, but there was a slight decline in the proportion of case-patients treated with antibiotics over time (from 65% in the first 2 weeks of the outbreak to 30% in the last 2 weeks; National Institute of Epidemiology, unpublished data). The proportion of patients who took antibiotics was 45% among those who visited a health camp or a public sector healthcare facility; against 34% among those who sought care elsewhere (National Institute of Epidemiology, unpublished data). In addition, in Mallela, 96% of suspected case-patients received at least one injection during their treatment.[15] Injections are costlier, no more effective than oral painkillers,[17] and may lead to infections associated with unsafe practices. Thus, irrational use of medicines may have led to the majority of the economic burden of the disease. Alternative use of these resources (opportunity cost) could have improved the welfare of the patients and their families.

Our analysis suffered from three main limitations. First, our study is based on the experience of one village, which might not be representative of all the affected areas in Andhra Pradesh and India. To address this limitation, in our projections at the district and state levels we adjusted surveillance data for the number of reported cases, the age structure of the population, and the urban/rural wage. However, in the absence of available data suggesting otherwise, we used Mallela data for the duration of symptoms and the direct economic cost per case. The spending pattern in Mallela might not be representative of other rural areas of Andhra Pradesh, let alone urban areas.

Second, we used surveillance data to estimate the number of cases in Kadapa district and Andhra Pradesh. This may have led us to underestimate the incidence because, at the time of the outbreak, chikungunya was not on the list of diseases that must be reported through the national system. While we adjusted for under reporting, uncertainty remained. We attempted to deal with that uncertainty using various incidence scenarios. Under the worst-case scenario, the national burden estimate would be 337 000 DALYs in 2006. Even in this scenario, chikungunya would still represent less than half the burden of malaria, but would exceed the burden of dengue and Japanese encephalitis estimated in 2002. This level of incidence might not be sustained beyond the first years of re-emergence of the disease in a susceptible population (the reported incidence of chikungunya decreased in 2007 in India). Overall, the uncertainty in the incidence estimate and its impact on the burden estimate in our sensitivity analysis emphasize the need for a good surveillance system to generate quality data to promptly identify and manage emerging and re-emerging diseases.

Third, we conducted our survey shortly after the peak of the outbreak. Thus, it might have been too soon to estimate the proportion of case-patients with long-term joint pain. However, 96% of the patients had a self-limited illness, and the majority of the burden was secondary to the acute phase. Thus, it is unlikely that a long-term follow-up would have yielded a substantially different burden estimate.

The DALY burden of chikungunya may be considered moderate when compared with other public health problems, particularly vector-borne diseases. However, it should be considered and managed as one of the additional burdens contributed by the presence of *Aedes* mosquitoes. Thus, chikungunya prevention and control should be addressed within the broader picture of dengue control efforts. From an economic point of view, our analysis suggests that the costs secondary to chikungunya were substantial for the poor, were mostly borne out of pocket and were driven by healthcare providers. Thus, an active communication strategy targeting health professionals, aimed at promoting the rational use of medicines, is needed to avoid the poor population spending substantial resources on unnecessary medications that could even be harmful. Overall, our recommendations in the area of improving surveillance, integrating the control of *Aedes* mosquitoes and rational use of medicines illustrate that prevention and control of emerging and re-emerging infectious diseases should occur through long-term healthcare system strengthening.

**Authors' contributions:** All authors designed the study protocol; YH, VR, RR, PM and MM carried out the survey; TS and YH carried out the analysis and interpretation of the data. YH and TS drafted and revised the manuscript. All authors read and approved the final manuscript. TS is guarantor of the paper.

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**Conflicts of interest:** None declared.

**Ethical approval:** Not required; the field survey was conducted as part of an emergency response to an outbreak, and is covered by normal practice.

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