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Burden of chikungunya in India: estimates of disability adjusted life years (DALY) lost in 2006 epidemic

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Abstract

Background & objectives: During 2006, chikungunya emerged as a major ever known epidemic in India. Disability adjusted life years (DALY) is an appropriate summary measure of population health to express epidemiological burden of diseases. We estimated the burden due to suspected chikungunya using DALYs for the first time and compared between the states and also with the burden due to other vector-borne diseases in India. The economic burden was also assessed in terms of productivity loss.

Methods: Data on the reported cases of fever/suspected cases of chikungunya from different states during 2006 in India were used. Years lived with disability (YLD) were calculated for non-fatal cases to estimate DALY. Since the disability weight for chikungunya is not available, the weights available for rheumatic arthritis, comparable to the disease outcome of chikungunya were used for the estimation. The burden was estimated for both acute and chronic cases. It is considered that about 11.5% of cases were reported to have extended morbidity with persisting arthralgia. For acute disease, the average duration of illness was considered to be nine days and for chronic cases it was six months on an average. The productivity loss due to income foregone by the working class was calculated using minimum official wage.

Results: National burden of chikungunya was estimated to be 25,588 DALYs lost during 2006 epidemic, with an overall burden of 45.26 DALYs per million. It varied from 0.01 to 265.62 per million in different states. Karnataka alone contributed as high as 55% of the national burden. Persistent arthralgia was found to impose heavy burden, accounting for 69% of the total DALYs. The productivity loss in terms of income foregone was estimated to be a minimum of Rs. 391 million.

Interpretation & conclusion: The chikungunya epidemic in the year 2006 imposed heavy epidemiological burden and productivity loss to the community. The burden of chikungunya in terms of DALY was estimated for the first time. In view of re-emergence and spread of this infection in recent times it is warranted for derivation of disability weight for different health states of chikungunya to facilitate realistic estimates of DALYs. Quality epidemiological data from surveillance system to monitor vector-borne and zoonotic diseases would pave way for more realistic estimates of burden. The productivity loss in-terms of income foregone could be minimal as the estimation was made by using the minimum wage fixed by the government although the actual loss is expected to be higher.

Key words Burden – chikungunya – DALY – India

Introduction

Chikungunya is a mosquito-transmitted viral infection, affecting all in the community. It is caused by alphavirus belonging to the family Togaviridae[1,2]. It was first described in Tanzania in 1952[3] and has since been found in Africa, India, and other South-east Asian countries. The Asian isolate has been re-

ported to be different genomically from that of the African[4,5]. *Aedes aegypti*, a mosquito that breeds in domestic and peri-domestic containers and an aggressive daytime biter is the primary vector of chikungunya virus to humans in Asia[6]. *Aedes albopictus* which is prevalent in Asia is susceptible to chikungunya virus and may play a role in the transmission in this region[7,8]. Human is the only host serving as reservoir of infection and transmission is sustained by human-mosquito-human cycle through primates[9]. No sylvatic (forest) cycle has been reported in Asia as suggested in Africa. There is no evidence for transovarial (vertical) transmission[10]. But co-infection or dual infection with dengue has been reported[11,12]. Mother to child transmission has also been reported recently[13]. This disease is highly infectious and cases explode in geometric proportions. Since December 2005, chikungunya emerged in epidemic proportions in India and a total of 1.39 million suspected cases have been reported[14]. As many as 213 districts in 15 states were affected.

The burden due to illness can be expressed in many ways. Though the number of cases and incidence will indicate the magnitude and gravity of the problem for a given health state, it is essential to use a summary measure which considers all the health outcomes to compare across diseases with varied clinical outcomes. The disability adjusted life years (DALY)[15] is one such summary measure of population health which is being increasingly used in expressing the burden due to diseases. It is a measure of the loss of healthy days in a society due to mortality and morbidity. This summary measure can compare the burden across diseases, as well as across populations. It can also serve as a tool for resource allocation and cost-effective analysis. Precise information about diseases and injuries, their incidences, their consequences including non-fatal health outcomes, their causation and their trend is more than ever necessary to inform policy-making. The power of using a common metric for burden assessment and economic appraisal of intervention options warranted crafting of a measure for both purposes[16]. The Global Burden of Disease (GBD) study group as well as others (Dengue) have reported DALYs for a number of vector-borne diseases[17]. A large number of studies aimed at comparing the impact of intervention also used DALY[18]. However, now here, estimates of burden of chikungunya in terms of DALYs were made. This may be due to lack of epidemiological data and other input parameters. Therefore, data available on the suspected chikungunya cases during the 2006 epidemic in different states[14] were used to estimate the burden due to chikungunya in terms of DALY and the results are presented in this communication.

Material & Methods

Data base: The consolidated data base available from the National Vector Borne Disease Control Programme (NVBDCP) web site[14] for the year 2006 was used for estimating the burden. It gives state wise information on the number of districts affected, total number of reported fever/suspected cases of chikungunya, number of samples screened for chikungunya and confirmed cases. Chikungunya incidence was estimated based on the total population in the affected districts of the respective states wherever district wise information was available. Cases with less than one month of illness were considered as acute episodes and cases above one month duration of debilitating joint pain as persisting arthralgia.

Method of estimating DALY: Disability adjusted life years (DALYs), a summary measure of population health which combines time lived with disability and the time lost due to premature mortality was used to estimate the burden due to chikungunya in India. DALYs were estimated using the method adopted by Murray[19] for estimating the global burden of diseases[15,20]. The years of life lost (YLL) due to premature mortality and the years lived with disability (YLD) are the two components of DALY. Though mortality due to chikungunya has been reported[13,21,22], there was no data to support the cause of death due to chikungunya for the 2006 epidemic in India. Therefore, in the present estimation of DALY, YLL is zero and it reflects only YLD. Since, everybody in the community, irrespective of age and

gender is at the risk of infection and developing disease[23,24], estimates were made without considering the standard recommended age classes. Therefore, we did not consider age weighting for the estimation. Since, discount rate is shown to be an insignificant factor[25], we did not account for the future value of health. Consequently, the YLD was calculated as the product of the number of cases, disability weight and duration of illness. The DALY was corrected to the sero-positivity rate, and to ensure accuracy, the number of cases that had approached the private health care facilities were also taken into account to estimate the total number of chikungunya cases and DALY estimation because a large proportion of people (77.56%) (personal observation) could have utilized private health care facilities which may not have been reported under the current surveillance system.

The disability weight is a key component in YLD estimation. It represents the severity of an illness and can range from 0 to 1, where the value of 0 represents healthy life and 1 represents death. The Global Disease Burden study group[15] has derived disability weights for 107 health states which are the outcomes of different diseases[26], in addition to disability weights drawn independently for other health states[25]. However, no disability weight is available for a number of health states including chikungunya. Therefore, we used the disability weight (0.233), available for rheumatoid arthritis, the health outcome of which is comparable with the case definition of chikungunya[22,27,28]. This disease did not receive adequate attention for deriving disability weight as it was not common for decades. In case of non-availability of disability weight for a given health state, the disability weight of health state of other disease which are comparable to the health states of the disease in question are considered. For example, in a study on inherited disorders of haemoglobin[29], disability weights for anaemia caused by haemoglobin disorders were taken from other causes of anaemia for estimating the burden. DALYs for acute episodes and chronic cases (persistent arthralgia) were calculated separately and summed for total. It was reported that about 11.5% of the cases had extended morbidity with persistent arthralgia. The duration was reported to range from six months to three years[5]. A minimum duration of six months was used for calculating YLD for chronic cases and for acute disease, it was nine days.

Sensitivity analysis: Few assumptions were used in the calculation of DALY because of some uncertainties. They include: all those who suffered from chikungunya had reported to public health care facilities; all the suspected cases were due to chikungunya; the mean duration of illness (acute and persistent symptoms) represents the variation at population level; and disability weight of arthritis is valid for chikungunya. These uncertainties were subjected to sensitivity analysis with varying values reported from different studies. To account for unreported cases, the number of reported cases, i.e. 1.39 million, was multiplied by a set of factors. The multiplication factor for incorporating the proportion of cases that had reported to private health facilities [1.9 to 4.45 (personal observation)[24], duration of acute episode (1–30 days)[30], duration of persistent arthralgia (6 months to 3 years)][5,31,32], disability weight (0.233 to 0.81)[15,25] and the true positivity rate (2.7 to 100)[14] based on confirmatory tests for chikungunya were the parameters and values used in sensitivity analysis (Table 1). The difference in DALYs that was estimated using the lowest and highest values of the given parameter and the proportion to that of base model was used to examine the extent of its influence on DALY estimates. The change in DALY estimate in relation to that estimated from base model was compared between different parameters of uncertainties to identify the most influential parameter.

The burden of chikungunya was compared against the values reported by Global Burden of Disease group[17] for other vector-borne diseases in India after converting the total DALYs into DALYs per million population.

Productivity loss: The individuals affected with chikungunya remain incapacitated at least for a week, affecting their occupation and income. Loss of in-

Table 1. Basic model of DALY estimation with values for various input parameters

Parameter	Base value	Range	Source (Reference)
Multiplication factor	1	1.96–4.45	24
Disability weight	0.233	0.233–0.81	25, 26
Duration of illness (acute days)	9	1–30	24, 30
Duration of disability chronic (days)	6 months	6 months –3 year	5, 31
Proportion of persistent arthralgia	0.12	0.11–0.69	5, 34
Positivity rate (%) for chikungunya	100	2.7–100	14

come due to illness was calculated for those who were in the working age class. Since the primary data on income forgone for the individuals suffering from chikungunya were not available, the productivity loss in terms of income-forgone was estimated using the minimum official daily wage of Rs. 52.69 per individual as per the rate fixed by the government[33] and nine days as the average number of working days lost for both the genders. Therefore, the estimated productivity loss is considered minimal. Since the age distribution of the cases was not available, the population age distribution of the working age group between 15 and 59 years of age of the respective state was used to calculate the number of patients in the working age group. Productivity loss was calculated only for acute episodes for each state as the duration of persistent arthralgia is highly variable[5,34].

Results

Chikungunya affected at least 213 districts in 15 states in India during the year 2006. Fig. 1 shows the distribution of 168 districts for which details of chikungunya cases are available. For four states (Maharashtra, Tamil Nadu, Madhya Pradesh and Rajasthan), such district wise details were not available and the whole state population was considered as under risk. The total population at risk of infection was 565.41 million and the number of fever/suspected chikungunya cases were as high as 1.39 million and ranged between 35 (Lakshadweep) and 7,62,026 (Karnataka). The overall incidence per thousand population was calculated to be 2.46 and it ranged between 0.04 (NCT of Delhi) and 14.45 (Karnataka) (Table 2). The number of blood samples screened for chikungunya varied between 6 and 5421 from different states and the positivity rate ranged from 2.7 (Goa) to 100% (West Bengal and Lakshadweep). Out of the total 15,504 samples screened, 12.8% were positive for chikungunya. When corrected to the sero-positivity rate, out of 1.39 million at least 0.148 million cases were definitely due to chikungunya during 2006 epidemic.

The total DALY estimated was 25,588 due to

Fig. 1: Districts reported with suspected cases of chikungunya in India during 2006

Table 2. Population at risk, reported cases and incidence of fever/suspected chikungunya cases during 2006 epidemic in India

State	Total number of districts	No. of districts affected	Total population	Total fever cases/suspected chikungunya fever cases	No. of samples screened	No. of confirmed cases	Positivity rate	Incidence (per 1000 population)
Andhra Pradesh	23	23	7,57,27,541	77,535	1224	248	20.3	1.02
Karnataka	27	27	5,27,33,958	7,62,026	5000	298	6	14.45
Maharashtra	35	34	9,67,52,247	2,68,333	5421	786	14.5	2.77
Tamil Nadu*	40	35	6,21,10,839	64,802	648	116	17.9	1.04
Madhya Pradesh	45	21	6,03,85,118	60,132	892	106	11.9	1
Gujarat	25	25	5,05,96,992	76,012	1155	225	19.5	1.5
Kerala	14	14	3,18,38,619	70,731	235	43	18.3	2.22
A & N Islands	2	2	3,56,265	4469	0	0	NA	12.54
NCT of Delhi	12	12	1,37,82,976	560	560	67	12	0.04
Rajasthan	32	1	20,09,516	102	44	24	54.5	0.05
Puducherry**	4	1	7,35,004	542	52	9	17.3	0.74
Goa	2	2	13,43,998	287	75	2	2.7	0.21
Orissa	30	13	3,68,04,660	6461	171	34	19.9	0.18
West Bengal	18	1	8,01,76,197	NA	21	21	100	NA
Lakshadweep		2	60,650	35	6	6	100	0.58
Total	309	213	56,54,14,580	13,92,027	15,504	1985	12.8	2.46

*Out of total 40 administrative districts; **Affected district population; *Source:* National Vector Borne Disease Control Programme (NVBDCP), Delhi (Available from: *http://www.nvbdcp.gov.in/chikun-cases.html*, accessed on 27 Nov 2006).

chikungunya in India. State-wise analysis showed that the maximum DALYs lost was in Karnataka 14,007, followed by Maharashtra (4932) (Table 3). Analysis of burden in relation to sequelae of this disease showed that acute episodes contributed only 7,909 DALYs (30.9%) and the persistent incapacitating arthralgia accounted for the rest (69.1%), indicating that major burden was imposed by the chronic arthralgia. When DALY estimates were made by computing the estimated number of confirmed cases (0.148 million), it was 2722. A large proportion of cases (77.56%) were seeking care from private health facilities, and hence, the number of cases reported from public health information system was underreported. When such underestimations were corrected and estimated, the DALYs were as high as 1,14,029.

Analysis of data on DALYs lost per million population showed that the estimates were highly variable (Table 3). It ranged between 0.005 (West Bengal) and 265.62 (Karnataka). Though the total DALY was only 82 in Andaman and Nicobar Islands, the DALY per million was as high as 230.68, ranking it next to Karnataka. Stratification of states in relation to DALYs lost per million population (Fig. 2) showed that Karnataka, Andaman and Nicobar Islands and Maharashtra were at the maximum risk of chikungunya.

Sensitivity analysis showed that since the proportion

of confirmed cases, choice of disability weight and the proportion of cases that have availed treatment from private health care sources were not known, DALY estimates were affected 9.4, 3.5 and 3.2 times, respectively. This indicated that these two parameters of uncertainties were the most influential ones. The other parameters such as duration of acute illness and duration of persistent arthralgia could influence the DALY estimates only 2.3 and 1.1 times respectively.

DALYs lost, per million population due to malaria, leishmaniasis, lymphatic filariasis, dengue and Japanese encephalitis for the year 1998 was 586, 1160, 2097, 359 and 67 respectively[17]. Current estimate of burden of chikungunya was 45.26 per million, the lowest among the vector-borne diseases. The total number of person days lost due to acute episodes of chikungunya in the working age class were estimated to be 7.4 million. Estimates of productivity loss in terms of income foregone showed that it varied from Rs. 5810 (West Bengal) to Rs. 214.4 million (Karnataka). The total productivity loss was to the tune of Rs. 391 million to the nation. The per capita loss was Rs. 0.68 in the affected community.

Table 3. Total DALYs, DALYs lost per million population and productivity loss due to chikungunya during 2006 epidemic in India

State	Total DALYs lost	Productivity loss	DALYs lost per million population
Andhra Pradesh	1425	2,18,15,604	18.82
Karnataka	14,007	21,44,07,141	265.62
Maharashtra	4932	7,42,41,084	50.98
Tamil Nadu*	1191	1,94,48,521	19.18
Madhya Pradesh	1105	1,52,27,115	18.30
Gujarat	1397	2,13,87,086	27.61
Kerala	1300	2,08,96,259	40.84
A & N Islands	82	13,62,203	230.58
NCT of Delhi	10	1,62,816	0.75
Rajasthan	2	25,351	0.93
Puducherry**	10	1,65,208	13.55
Goa	5	90,173	3.93
Orissa	119	17,57,300	3.23
West Bengal	0	5810	0.00
Lakshadweep	1	9848	10.61
Total	25,588	39,10,01,519	45.26

*Out of total 40 administrative districts; **Affected district population.

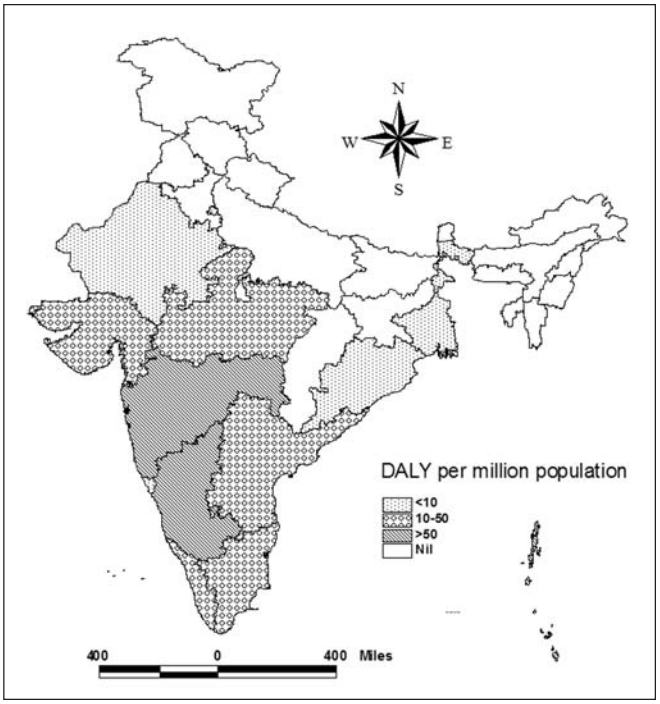

Fig. 2: Stratification of states in relation to DALYs due to chikungunya epidemic in 2006

Discussion

Chikungunya re-emerged in a massive scale with an estimated number of 1.39 million fever/suspected cases during 2006 in India, covering 213 districts in 15 states. About 565.42 million people were at the risk of infection. The number of cases affected with chikungunya would be more than that reported under current surveillance system in India due to the fact that a large proportion of the people consulted private health care which were not reported and thus lacked accuracy[35]. Wide variation in the proportion of laboratory confirmed cases suggest the issues related to diagnostic tools, procedure and quality con-

trol including the time delay in sample collection. Diagnosis related issues remain to be major challenges in arboviral diseases as reported in dengue[18]. Laboratory screening of every individual with suspected chikungunya is neither feasible nor necessary for treatment. Therefore, correction of suspected clinical cases to the proportion of laboratory confirmation is not expected to influence the burden estimates. However, the confirmation of cases is necessary from the public health point of view to initiate disease specific control measures at community level.

Several population based studies have assessed the burden of dengue in different endemic countries and the estimated DALYs lost ranged from 83.8 to 848 per million[25,36–40]. Our current estimate of DALY to express the epidemiological burden of chikungunya is first of its kind.

In the absence of cause of death (CoD) information, no death was attributed to chikungunya in India, though reports of chikungunya related deaths were reported elsewhere[13]. But the morbidity and disability caused due to chikungunya is enormous. The national burden was 45.26 DALYs lost per million population due to 2006 epidemic in India. Chikungunya imposed heavy burden in Karnataka, with 266 DALYs lost per million followed by Andaman and Nicobar Islands (231). Comparison of DALYs lost per million population among the vector borne diseases in India based on earlier estimates[17] showed that lymphatic filariasis remained to be a major public health concern. It imposes heavy burden by contributing about 49% of the total 4294 DALYs lost per million population in India due to vector borne disease. The diseases in the order of their contribution are leishmaniasis, malaria, dengue, JE and chikungunya. Though the number of cases and the attack rates were high (~38%)[32], the contribution of chikungunya in terms of DALY was the lowest. This is because of its restricted outbreak with about 565 million people exposed to the risk of infection but with no reporting of death attributable to chikungunya.

Though long-term arthralgia as extended morbidity was reported in only 11.5% of the cases, its contribution constitutes as high as 69% of the total 25,588 DALYs lost. It is mainly due to exceptionally longer duration[5,34] of this incapacitating symptom. It has greater implication on health care to provide long-term treatment for persistent arthralgia in addition to economic loss.

The surveillance data used in the present estimate have certain limitations. There was no age/gender details, not all the fever/suspected cases were confirmed with diagnostic tests, and considerable proportion of cases sought treatment from private health facilities which were unknown as reported in other cases[35,41]. The percentage of cases reporting to private health care facilities during the epidemic in Kerala was as high as 77.56% (personal observation). Lack of clear case definitions and/or lack of its uniform application and absence of uniform reporting system could result in lack of accuracy and poor reliability of surveillance data as reported earlier in chikungunya[35] and dengue[18]. This may be the consequence of not including this disease under "notifiable" diseases.

Assumptions and incorporation of parameters with uncertainties are inevitable in estimations. But it need not be a constraint. Proportion of confirmed fever/suspected chikungunya and under-reporting due to seeking of health care from private health facilities are the most influential parameters in DALY estimation. Provision of facilities for laboratory confirmation and inclusion of cases dealt within the private sector could reduce the uncertainties in these parameters so as to make more realistic estimates of DALY.

GBD study group[16] has derived age-specific disability weight for DALY estimates for 107 health states for different diseases[26]. There are a number of health states that require disability weight values, including chikungunya which presents two clear health states, viz. acute (early stage of the infection) and chronic (persistent arthralgia)[5,22,42]. Efforts are warranted to derive disability weight for the clinical states of chikungunya to facilitate realistic estimates of

DALYs.

Several reports that have emerged from the recent outbreaks of chikungunya around the world[32,35] will be useful for better understanding of the epidemiology of this infection. However, studies focusing on risk factors[43] are warranted to develop prediction models and develop situation-specific measures of epidemic preparedness. Vaccine is not currently available against chikungunya. Therefore, vector control remains a method of choice at least until a potential and cost-effective vaccine is available for large scale use. As the breeding of vector(s) is confined to domestic and peri-domestic environment, container management and source reduction may eliminate vector breeding. This can be encouraged through community participation with strong social mobilization and communication component[44] as it is primarily a man-made problem at household level as recommended for the control of dengue vectors[45,46]. Since the known vectors of chikungunya also transmit dengue[47], vector control efforts could offer protection against dengue also, which showed an increased incidence of dengue haemorrhagic fever and dengue shock syndrome in India[48]. Thermal fogging with appropriate insecticide should be resorted to contain the epidemic. Vaccine research needs to be encouraged as has been recommended and justified for dengue[25].

The current economic loss of Rs. 391 million due to 2006 epidemic of chikungunya in India can be considered as minimal as it used only minimum wage and did not consider persistent arthralgia due to high variability in its duration. The person days lost and income foregone justifies allocation of funds towards control/prevention of this disease. DALYs can also serve as a measure to assess cost-effectiveness of interventions against chikungunya but the number of parameters with uncertainties should be minimal for more realistic estimate. The important implication of this study is that surveillance covering all vector borne and zoonotic diseases needs to be strengthened for obtaining quality epidemiological data, apart from justifying preventive measures to save DALYs.

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