Cost analysis of dengue from a State in south India

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Background & objectives: Improved dengue cost estimates offer the potential to provide a baseline measure to determine the cost-effectiveness of interventions. The objective of this study was to estimate the cost of dengue prevention, treatment and fatalities in Kerala, India, over a period of one year.

Methods: The study was done in Kerala, a southern State in India. Costing of treatment was done from a family perspective. It was found by primary data collection in a sample of 83 dengue patients from Thiruvananthapuram district and estimated for Kerala using the reported number of cases in 2016. Costing of prevention was done from the government perspective for the entire State. In-depth interviews with State programme officers and experts in the field were conducted. The present value of lifetime earnings was used to value lives.

Results: The cost of treatment of dengue in the State was ₹137 milion (2.16 million US$). The cost of prevention in the State was ₹535 million (8.3 million US$). The cost of fatalities was the highest among costs at ₹1760 million (27.7 million US$). US$ 38 million was the least possible estimate of total cost of dengue. The total out-of-pocket spending (OOPS) of >60 yr was significantly ($P<0.05$) higher than other age groups. The total OOPS was significantly ($P<0.001$) higher in private sector compared to public.

Interpretation & conclusions: Although deaths due to dengue were few, the cost of fatalities was 12 times more than the cost of treatment and three times the cost of prevention. Focusing on mortality reduction and disease prevention in elderly would be beneficial.

Key words Cost - dengue deaths - Kerala - out-of-pocket spending - PVLE - treatment

Dengue is one of the most serious and fast emerging tropical mosquito-borne viral diseases. In India, the burden of dengue infection has been reported to be heterogeneous with high transmission in northern, western, and southern regions[1]. The overall seroprevalence of dengue infection was 48.7 per cent (95% CI 43.5-54.0)[1]. In Kerala, cases of dengue with some deaths were reported in 1997 for the first time[2].

The first epidemic occurred in 2003 with 3546 cases and 68 deaths, according to data from the Directorate of Health Services, Kerala[2]. Thiruvananthapuram district was worst affected in this epidemic. In 2003, Kerala reported maximum deaths due to dengue in India[2]. Over the years, the reported cases of dengue have been increasing[2]. Kerala became hyperendemic for dengue with presence of multiple serotypes, high

rates of coinfection and local genomic evolution of viral strains[3].

Economic estimates are used to argue that policies on dengue control and prevention should be given a high priority. The development of improved dengue cost estimates offers the potential to provide a baseline measure to determine the cost-effectiveness of dengue policies and programmes. Limited research has been done to estimate the costs of dengue according to a systematic review[4]. The studies reviewed indicated a variation in cost estimates for dengue due to differences in case classification, definition of cost categories, sampling, data sources and other methodological challenges. The findings of the literature were not of sufficient quantity and quality. It was not clear from these economic studies which form of treatment associated with dengue was being costed, what was included in the total cost estimates and how these estimates were calculated. Moreover, cost estimates from these studies were of heterogeneous quality, not generalizable to other populations and not representative of the total economic consequences of dengue[5]. The objective of this study was to estimate the cost of treatment of dengue from the family perspective, the cost of prevention from the government perspective and the cost of human fatalities due to dengue in Kerala State of India.

Material & Methods

The study was done in the State of Kerala, and the target was the Sate population. This study was conducted over a period of one year from January 2017 to December 2017. Human Ethics Committee (HEC) of the Government Medical College, Thiruvananthapuram, approved the study (IEC No.2/42/2014 dated February 14, 2014). Informed written consent was taken from all study participants.

Estimating costs of treatment: Discounting is a mathematical procedure for adjusting future costs and outcomes of healthcare interventions to present value. In this study, discount rate was used only for costing fatalities and it was taken as three per cent. The cost of treatment from the family perspective was considered equivalent to the out-of-pocket spending (OOPS). Costs of treating patients include direct and indirect costs and both have been considered. Costs of treating patients as outpatient (OP) and inpatient (IP) in government and private sectors were included. Direct costs considered were consultation fees, costs of tests

performed and cost of medicines. For ambulatory cases, the number of OP visits was considered. Non-medical direct costs included individual and family transport costs. Indirect costs also included expenses for food, cost of reduced productivity, loss of schooling, caregivers' loss of productivity and services. Reduction of household services (cooking, cleaning and caring for children and elderly) was not taken. The cost of treatment was found on a sample from Thiruvananthapuram district and later projected for the entire State. Primary data collection was done by visiting the houses of 83 patients diagnosed to have dengue in Pangappara Primary Health Centre (PHC) area in Thiruvananthapuram in 2017. There were 157 reported cases of dengue in the area in 11 sub-centre areas. Seven sub-centres were selected randomly, and all cases reported from there were taken. Eighty three cases were thus obtained. The PHC had a mechanism by which any case of dengue was reported from the field irrespective of the system or sector in which they sought treatment. Therefore, identification of dengue cases from the reporting to the PHC was a representative sample. Pangappara was chosen because it represented both urban and rural areas of the State. The questionnaire was designed to include all the above-mentioned costs. Whenever possible, the bills and documents available with the patient were verified. Costs were converted into a common currency base and the exchange rates were used for comparison. The conversion used was 1 US\$=63.73 ₹ as on January 12, 2018 (at the time of the study). Unit cost of treatment from the family perspective was multiplied with the reported number of cases in the district and State to obtain the total cost of treatment.

Estimating costs of prevention and control: The cost components of prevention assessed were cost of material, activities for prevention and human resource (HR). It covered entomological and epidemiological surveillance, vector control, health education activities, epidemic preparedness and control. A literature review was done to identify the components to be costed. In-depth interviews with two State programme officers and two experts in the field of vector control were conducted using the themes identified. Budget and other financial documents for the year 2016-2017 were looked into (personal communication). The central and State allocation was considered.

Costing of human resource (HR): Costing of HR for prevention was done in three steps. First, the HR to be costed was identified from the in-depth interviews. The proportion of time spent for dengue prevention activities by the different categories of staff was also obtained as an expert opinion from these interviews and from a rapid assessment survey done among health workers and supervisors of Pangappara PHC area. They were asked to do a job analysis to find the time spent for dengue prevention and control. Health worker time spent in activities related to dengue prevention was identified by this method. The number of hours/week spent on vector control activities (source reduction, fogging, antilarval and other methods), vector survey, case reporting, health education and community mobilization was taken. Although the work hours were collected for epidemic and non-epidemic seasons, that of non-epidemic seasons alone was taken for analysis (because the occurrence of epidemic would vary across the State). Furthermore, this estimation would be the least possible. The scale of pay of the identified category of staff was taken from the website of the finance department. The number of each category of these staff was obtained from the administrative report of the Directorate of Health Services (personal communication). The proportionate time was multiplied by the salary for one month and then multiplied by 12 for the cost of these HRs for a year. The assumption was that the staff work for eight hours/day for 20 days/month, so as to constitute a total of 160 h of work/month. The hours of work spent for dengue prevention and control were taken as a proportion of this as obtained from the responses of interviews. Only the core category of staff involved in prevention was considered for analysis. The office staff, junior public health nurse and their supervisory staff, assistant surgeons and civil surgeons were excluded.

Costing fatalities using the human capital approach and present value of lifetime earnings (PVLE): The human capital approach to economic evaluation places a monetary value on loss of health as the lost value of economic productivity due to ill health, disability or premature mortality. The number of reported deaths in 2016 in Kerala due to dengue was 13. However, the age-sex distribution of deaths was not available for this year. The number of deaths in 2015 was 29, and this was used for costing fatalities. Only deaths which were confirmed due to dengue were taken along with their age-sex distribution. The present value of lifetime earnings (PVLE) was used to value lives lost[6].

Cost analysis framework suggested by the Pan American Health and Education Foundation, International Vaccine Access Centre and Dengue Vaccine Initiative has been used[5]. Primary data collection was done only for estimation of cost of treatment from the family perspective. All other information was obtained from secondary data.

Statistical analysis: Description of frequencies was given in percentages. Cost was described in mean [standard deviation (SD)] and median [interquartile range (IQR)]. Analysis was done using the Statistical Package of the Social Sciences (SPSS) trial version 24 (SPSS Inc., Chicago, IL, USA). Before testing for significance, the distribution of variable was tested for normality using the Kolmogorov-Smirnov test. Since distribution was not normal, Mann-Whitney U-test was used.

Results

Baseline description of the study participants: Interview of 83 patients (18, 32, 24 and 9 in the age groups <18, 18-39, 40-59, 60 yr and above) affected by dengue in 2017 was done in Pangappara PHC area. There were 65 (78.3%) adults and 18 (21.7%) children. There were 41 (49.4%) females and 42 (50.6%) males. Fifty three (63.9%) approached the private sector for treatment compared to 30 (36.1%) in the government sector. Seventy two (86.7%) of these patients were admitted for management. There could be an underestimation of mild cases which did not require hospitalization. This could be because the cases that were reported to the PHC were taken.

The median duration of illness was 14.00 days (IQR – 9.75-15.25); 83.75 per cent (70/83) had a duration of illness up to one week, and 16.25 per cent (13/83) had a duration of illness more than one week. This was not normally distributed ($P<0.001$). Half (42; 50.6%) of the patients had only one OP visit. Another quarter had two and the rest had three or more OP visits. Among the 72 patients with treatment, 22 (30.6%) took treatment from the government hospitals, while 50 (69.4%) took it from private hospitals. Forty seven per cent of the in patients stayed in the hospital for five days. Two patients had to take treatment for more than two weeks.

Out-of-pocket spending (OOPS): When the total OOPS was analyzed, it was found that one patient had a spending of ₹105,100. This patient had multiple comorbidities. Hence, this case was excluded for analyzing the OOPS. The variable was normally distributed (test of normality KS value – 0.145; P=0.107, Shapiro-Wilk – 0.908, P=0.013). The mean OOPS was ₹15315±12171. The split-up costs of the total OOPS for OP and IP treatment are presented in Table I. The total OOPS was significantly (P<0.001) higher (Fig. 1) in those who sought treatment from private sector. The median OOPS for OP treatment was ₹2125 (IQR – 1312.5-3412.5). The mean OOPS for treatment in the government sector was ₹2068 which was significantly lower than that in the private sector (P=0.01). The OOPS for IP treatment was not normally distributed (KS – 0.131, P=0.004). The median OOPS

for IP treatment was ₹12,900 (IQR – 4043.75-13,670). This was also significantly (P<0.001) higher in private sector. Among the spending, the highest expenditure was for laboratory followed by room rent and medicines.

The total OOPS was highest for elderly (>60 yr) and least for <18 yr (Fig. 2). The total OOPS of >60 yr was significantly higher than the other age groups (P=0.013). A higher percentage of elderly had taken treatment in private sector (88.9%) when compared to dengue patients in other age groups (60.8%). This difference was, however, not significant.

The OOPS was lower for females compared to males (Table II). This difference was, however, not
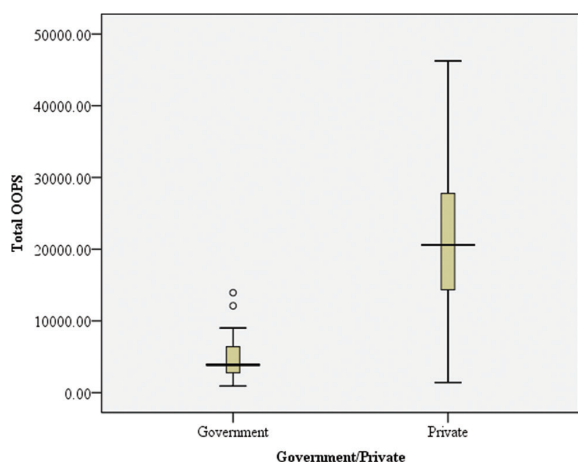

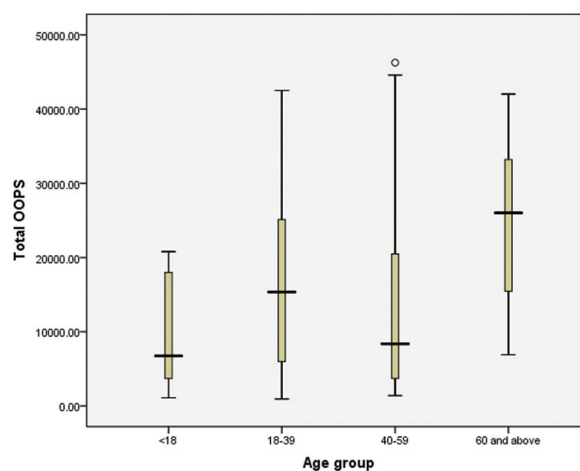Fig. 1. Out-of-pocket spending (OOPS) in government and private sectors compared.

Fig. 2. Out-of-pocket spending (OOPS) in the different age groups.

Table I. Components of out-of-pocket spending (₹) for outpatients and inpatients						
Components	Transport	Consultation	Laboratory	Medicine	Food	Others
Outpatient costs						
Mean±SD	703±531.4	583±299.4	1753±1119	1191±1174	906±554	566±709
Median (IQR)	650 (890)	550 (500)	1350 (2062)	675 (1950)	720 (600)	325 (612)
Minimum	200	200	400	200	200	150
Maximum	1480	1000	3250	3200	2000	2000
Inpatient costs						
Mean±SD	926±935	1585±820	6012±4745	3839±2532	5443±3999	2645±1699
Median (IQR)	500 (1000)	1400 (800)	4200 (3060)	3000 (2786)	4000 (4000)	2200 (964)
Minimum	100	600	1500	200	1600	100
Maximum	4000	4300	17,232	9931	16,000	8000
SD, standard deviation; IQR, interquartile range						

statistically significant (Mann-Whitney U – 648.5, P=0.075).

Work days lost: The median number of work days/school days lost for the patient was 14 (IQR – 10-30). Distribution was not normal (KS – 0.25, P=0.006). The median number of work days lost for the bystander was 7 (IQR – 5-13). All except two patients reported to have only one bystander. The median amount of money lost because of absence from work for the patient was ₹600/day (IQR – 432.5-1000). The median amount lost for bystander was ₹750/day (IQR – 500-1125).

Cost of treatment estimation from the family perspective projection to Kerala: The cost of treatment was projected for Kerala by multiplying the cost of treatment from the family perspective (OOPS) obtained in the study with the reported and estimated burden of dengue in the State for the year 2016. This is shown in Table III. The total cost of treatment from the family perspective for Kerala was ₹137.7 million, based on the reported cases alone. The cost of treatment for Thiruvananthapuram was ₹18.9 million.

Cost of preventive measures for dengue

Cost of materials and activities for dengue prevention: This included cost of entomological and epidemiological surveillance and vector control. It comprised the workforce cost, material cost and capital outlay cost. The capital outlay in the costing was not included. The material cost was based on the budget estimates for 2016 at the State level (personal communication). This included plan funds and non-plan funds. In the plan fund, there were funds allotted for material and supplies and activity. In the amount for material and supplies of the ₹25 million for vector-borne diseases, 16.03 million was for dengue alone. This amount was used for the purchase of insect growth regulators, technical malathion, materials for ultra low volume fogging, personal protective equipment, mosquito repellents, aerosol and laboratory materials. An amount of 14.5 million was allotted to activities related to vector-borne diseases, of which 6.7 million was for dengue (46%). The activities included dengue day observance, training, review meetings, fish hatcheries, mosquito proofing of fever wards and annual maintenance of machines, State entomology lab, maintenance of vehicles, mobility support and surveillance. In the non-plan fund, the total amount was 62.1 million. Of this, 0.23 million was for dengue (37%). The amount included fund for the apex referral laboratories, sentinel surveillance, monitoring and supervision, epidemic control, case management, vector control, health education, intersectoral coordination, training and reporting. Besides this, individual *panchayats* and other resident associations also invested in prevention of dengue, which was not considered here. Therefore, the spending on prevention of dengue for the year was taken as 0.46 million, excluding the cost of capital and HR.

Costing human resource (HR) for dengue prevention and fatalities using human capital approach: The cost of HR for prevention of dengue was estimated at ₹4.9 million. There were 29 deaths in 2015. Using the PVLE, the cost of life lost was found to be 27.7 million US$ at three per cent discount (Table IV).

The estimated costs of dengue in Kerala are summarized in Table V. The total costs including the treatment, prevention and costs of fatalities have been estimated as 38.2 million US$.

Table II. Summary of out-of-pocket spending (OOPS in ₹) in females and males compared		
Total OOPS	Female (n=41)	Male (n=41)#
Mean±SD	12,639±10,870	17,992±12,927
Median (IQR)	7700 (14,900)	18,885 (20,500)
Minimum	1400	940
Maximum	42,000	46,200

#One excluded from analysis (due to multiple comorbidities and extreme values of cost). *SD, standard deviation; IQR, interquartile range*

Table III. Cost of treatment estimate (₹ in million) based on reported and estimated case of dengue in 2016							
Based on 2016	n	Cost government	Cost private	Cost treatment	Cost work days patient	Cost work days bystander	Total cost
Reported case	7210	5.35	16.98	22.34	60.56	37.85	137.74
Highest estimate	543,680	404.17	1280.48	1684.65	4566.91	2854.32	10386.35
Lowest estimate	76115	56.58	179.27	235.85	639.37	399.60	1454.09

Age group (yr)	Deaths	Females PVLE at 3% discount	Deaths	Males PVLE at 3% discount	Deaths	Total PVLE at 3% discount
<1	0	0.76	2	1.03	2	2.06
1-4	1	0.80	0	1.09	1	0.80
5-9	0	0.88	1	1.19	1	1.19
10-14	0	0.97	2	1.31	2	2.62
15-19	0	1.05	0	1.44	0	0.00
20-24	1	1.09	1	1.52	2	2.60
25-29	2	1.04	1	1.51	3	3.59
30-34	1	0.95	3	1.42	4	5.21
35-39	2	0.83	1	1.27	3	2.94
40-44	1	0.70	2	1.10	3	2.89
45-49	2	0.55	1	0.89	3	1.98
50-54	0	0.39	2	0.66	2	1.32
55-59	0	0.24	1	0.43	1	0.43
60-64	0	0.13	0	0.24	0	0.00
65-69	0	0.06	0	0.12	0	0.00
70-74	0	0.03	1	0.06	1	0.06
75-79	1	0.01	0	0.02	1	0.01
80-84	0	0.00	0	0.01	0	0.00
>85	0	0.00	0	0.00	0	0.00
Total	11		18		29	27.71

Table IV. Cost of fatalities due to dengue in US$ (in million)

US$ conversion 1 US $=63.73 ₹ (January 12, 2018). PVLE, present value of lifetime earning

Table V. Summary of costs for dengue/year

Cost of various components	₹	US$
Cost of treatment of a hospitalized case	14,857	233.12
Cost of treatment of an ambulatory case	2125	33.34
Total cost of treatment	137,700,000	2,160,677.86
Total cost of prevention excluding HR	45,725,000	717,479.99
Total HR cost for prevention	490,000,000	7,688,686.65
Total cost of fatalities	1,765,321,000	27,700,000.00
Total costs	2,438,746,000	38,266,844.50
Total costs	2438 million	38.2 million

US$ conversion 1 US $=63.73 ₹ (January 12, 2018). HR, human resource

Discussion

The total median cost of treatment was similar to the Gujarat study (Murtol T.M. 2010). These were also generally consistent with findings of Suaya *et al*[7] considering Malaysia's roughly five times higher gross domestic product (GDP) per capita. Our findings were consistent with other cost of illness Indian study where a hospitalized episode costed US$ 197.03 (₹12805) in public sector and US$ 248 (₹16120) in private sector[8]. In a study from Puducherry, the treatment cost was higher for males at ₹1247 (21 US$) than females at ₹873 (15 US$), similar to our finding[9].

There are not many studies on the work days lost due to dengue. The proportion of absenteeism due to dengue among illnesses in Thailand was 3, 7.1 and 1.4 per cent, respectively, in 1998, 1999 and 2000[10].

The cost on prevention in the Gujarat study was ₹144 million[11]. In their study, HR was not costed[11]. The cost of prevention without HR in our estimate was only ₹45 million.

A review of 17 publications on the cost of dengue showed a large range of variations from 0.2 million US$ in Venezuela to 135.2 million US$ in Brazil[12]. In another review of cost analyses of 21 papers, dengue annual overall costs ranged from US$ 13.5 million (in Nicaragua) to US$ 56 million (in Malaysia)[4]. The total dengue-related cost in our study was 38.2 million US$.

Cost estimation done in our study was likely to be an underestimation for the following reasons. Costs of treatment to the government such as HR costs, infrastructure and materials given free of cost to people were not considered. In terms of prevention cost to the family for purchasing insecticides, repellents and other preventive measures were not taken into account. Long-term illness due to the disease, impact on education, economic growth, per capita income, foreign direct investment, tourism *etc*., have not been considered[9,13-18]. The hospitalization rates used (5%) were one of the lowest. While estimating the cost of HR in prevention, non-epidemic season was taken. Only the core category of staff involved in dengue prevention was considered.

OOPS was higher for elderly. It could be due to the higher rates of hospitalization in private sector in elderly due to availability of health insurance. The higher spending in elderly could also be because of comorbidities and increased severity. Sample size was not calculated. The number of sites, settings (OP and IP), age groups, perspectives (private and public), classification (*e.g.* DF and DHF) were adequately characterized in the study. The PHC area selected had the characteristics of urban and rural areas of Kerala. However, since the cases reported to PHC were taken, mild cases might have been missed. Limitations inherent in the use of secondary data were minimized by selecting appropriate setting for quality data and using primary data wherever possible. Since the analysis was for one year, the seasonality changes were captured. However, long-term trends affecting cost were not considered. Sensitivity analysis was not done, but the estimates for the highest and lowest dengue burden were calculated.

Dengue in India have been on a rise[19]. There are wide variations between the States in the contribution to disease burden[20]. The focus of Indian studies has been on cost of illness[21]. The present study highlighted the need to invest in prevention to reduce costs. It has also been shown that targeting productive breeding sites may be a method to reduce costs and operational constraints[22].

In conclusion, the cost of treatment of dengue from the family perspective was estimated at ₹137 million (2.16 million US$) for Kerala. The cost of treatment was higher in private sector. The cost of treating elderly was significantly higher than the other age groups. The cost of fatalities was the highest among costs at ₹1760 million (27.7 million US$). Although deaths due to dengue were few, the cost of fatalities was 12 times more than the cost of treatment and three times the cost of prevention. This highlights the importance of focusing on mortality reduction. US$ 38 million was the least possible estimate of cost of dengue.

***Conflicts of Interest*:** None.

References

1. Murhekar MV, Kamaraj P, Kumar MS, Khan SA, Allam RR, Barde P, *et al*. Burden of dengue infection in India, 2017: a cross-sectional population based serosurvey. *Lancet Glob Health* 2019; *7* : e1065-73.

2. State Bulletin. Integrated disease surveillance project. *State surveillance unit, directorate of health services*. Thiruvananthapuram: Government of Kerala; 2010.

3. Anoop M, Aneesh I, Thomas M, Sairu P, Nabeel AK, Unnikrishnan R, *et al*. Genetic characterization of dengue virus serotypes causing concurrent infection in an outbreak in Ernakulam, Kerala, South India. *Indian J Exp Biol* 2010; *48* : 849-57.

4. Constenla D, Garcia C, Lefcourt N. Assessing the economics of dengue: results from a systematic review of the literature and expert survey. *Pharmacoeconomics* 2015; *33* : 1107-35.

5. Armien B, Arredondo J, Carabali M, Carrasquilla G, Castro R, Durand L, *et al*. *Costing dengue cases and outbreaks: A guide to current practices and procedures. pan American health and education foundation, international vaccine access centre, dengue vaccine initiative*. Baltimore: John Hopkins Bloomberg School of Public Health; 2012.

6. Wendy M, Rice SD, Hai-Yen P. *Valuing human life: Estimating the present value of lifetime earnings, 2000*. UC San Francisco: Economic Studies and Related Methods; 2004. Available from: *https://escholarship.org/uc/item/82d0550k*, accessed on May 31, 2018.

7. Suaya JA, Shepard DS, Siqueira JB, Martelli CT, Lum LC, Tan LH, *et al*. Cost of dengue cases in eight countries in the Americas and Asia: A prospective study. *Am J Trop Med Hyg* 2009; *80* : 846-55.

8. Shepard DS, Halasa YA, Tyagi BK, Adhish SV, Nandan D, Karthiga KS, *et al*. Economic and disease burden of dengue illness in India. *Am J Trop Med Hyg* 2014; *91* : 1235-42.

9. Vinothkumar PS, Prasad KN, Basavaraj MI, Gnanamani G. Descriptive study on treatment cost for fever during outbreak of dengue fever in Pondicherry. *Int J Sci Res Publ* 2013; *3* : 1-3.

10. Endy TP, Chunsuttiwat S, Nisalak A, Libraty DH, Green S, Rothman AL, *et al*. Epidemiology of inapparent and symptomatic acute dengue virus infection: A prospective study of primary school children in Kamphaeng Phet, Thailand. *Am J Epidemiol* 2002; *156* : 40-51.

11. Murtol TM, Vasan SS, Puwar TI, Govil D, Field WR, Hong-Fei G, *et al*. Preliminary estimate of immediate cost of chikungunya and dengue to Gujarat, India. *Dengue Bulletin* 2010; *34* : 32-9.

12. Stahl HC, Butenschoen VM, Tran HT, Gozzer E, Skewes R, Mahendradhata Y, *et al*. Cost of dengue outbreaks: literature review and country case studies. *BMC Public Health* 2013; *13* : 1048.

13. Krishnamurthy V. Chikungunya arthritis. *Indian J Rheumatol* 2008; *3* : 91-2.

14. Mavalankar D, Shastri P, Bandyopadhyay T, Parmar J, Ramani K. Increased mortality rate associated with chikungunya epidemic, Ahmedabad, India. *Emerg Infect Dis* 2008; *14* : 412-5.

15. Bloom DE, Canning D, Moore M, Song Y. Epidemics and Economics. Program on the Global Demography of Aging Working Paper No. 9. Harvard Initiative for Global Health; 2006. Available from: *https://.harvard.edu/pgda/Working%20 Papers/2006/BLOOM_CANNINGWP9.2006.pdf*, accessed on October 22, 2019.

16. Bloom DE, Canning D, Sevilla J. The effect of health on economic growth: A production function approach. *World Develop* 2004; *32* : 1-13.

17. Barro R, Sala-I-Martin X. *Economic growth*. New York: McGraw-Hill; 1995.

18. Bhagava A, Jamison DT, Lau LJ, Murray CJ. Modeling the effects of health on economic growth. *J Health Econom* 2001; *20* : 423-40.

19. Mutheneni SR, Morse AP, Caminade C, Upadhyayula SM. Dengue burden in India: Recent trends and importance of climatic parameters. *Emerg Microbes Infect* 2017; *6* : e70.

20. Indian Council of Medical Research, Public Health Foundation of India and Institute for Health Metrics and Evaluation. *India: Health of the Nation's States - The India State-Level Disease Burden Initiative*. New Delhi: ICMR, PHFI, and IHME; 2017.

21. Hariharan D, Das MK, Shepard DS, Arora NK. Economic burden of dengue illness in India from 2013 to 2016: A systematic analysis. *Int J Infect Dis* 2019; *84S* : S68-73.

22. Tun-Lin W, Lenhart A, Nam VS, Rebollar-Téllez E, Morrison AC, Barbazan P, *et al*. Reducing costs and operational constraints of dengue vector control by targeting productive breeding places: A multi-country non-inferiority cluster randomized trial. *Trop Med Int Health* 2009; *14* : 1143-53.

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