Estimating District Specific Dengue burden in Kerala using Disability Adjusted Life Years (DALY)

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Abstract
Introduction: Kerala is hyperendemic for dengue. Determining State and district specific DALY are crucial in prioritizing, implementing and evaluating actions, but are seldom done. The objective of this study was to compute and compare the DALY due to Dengue in the districts of Kerala for 2014 and 2015.

Methods: DALY was computed using the DALY package, accessible in the R statistical program. The parameters that were inputted are incidence/1000, mortality rate, mean age of mortality, disability weights, proportion of cases treated. Reported incidence/1000 and mortality rates were calculated using the reported cases and deaths from the state surveillance unit. Estimates of dengue incidence/1000 were made using the fever surveillance and sentinel surveillance data. DALY was computed based on reported and estimated dengue burden. Absolute DALY (AD) and Relative DALY (RD) with their 95% CI were computed.

Results: AD and RD was high for some districts and low for others. Thrissur, had the highest in 2014 (AD - 840, 95% CI: 11.50-39.60) and Kasargode (AD-2601; RD-198.95/lakh [95%CI: 85.67-291.42]) in 2015. Thiruvananthapuram recorded the second highest DALY consistently for both years (AD- 801; RD-24.26/lakh [95% CI: 11.27-35.04] and AD-2312; RD- 70.03[95% CI: 30.68-102.71]). Districts with highest incidence were not the same as those with highest DALY.

Conclusion: There is gross inequity in the burden of Dengue in the districts of Kerala. Estimated DALY in some districts are very much higher than the global estimates. Prioritization for action can be misleading if incidence is used as measure of burden.

Keywords: Dengue, DALY, Kerala, Districts, Burden of disease.

Introduction
Dengue is one of the most serious and fast emerging tropical mosquito borne disease. In Kerala cases of dengue with some deaths were reported in 1997 for the first time. The First epidemic occurred in 2003 with 3546 cases and 68 deaths. Thiruvananthapuram district was worst affected in this epidemic. In 2003, Kerala reported maximum deaths due to dengue in India. Over the years, the reported cases of dengue have been increasing. Kerala is now hyperendemic for Dengue with presence of multiple serotype, high rates of coinfection and local genomic evolution of viral strains. The district of Thiruvananthapuram reports maximum number of cases in the state.
In 1992, the World Health Organization (WHO), the World Bank, and Harvard School of Public Health cooperated to develop a new metric of disability-adjusted life years (DALY) to quantify the burden of disease and injury on human beings for the Global Burden of Disease Project (GBDP).\(^5,6\) It incorporates both disability and mortality. DALY enables comparison of disease burden across regions. We can also compare the disease burden due to different health conditions using DALY. Dengue related DALY has been calculated globally. However it has not been ascertained for the country and the state. Indian Council of Medical Research\(^7\) has brought in an initiative to determine state specific DALY, but dengue specific DALY has not has not been specified. This study is an attempt to calculate the district specific dengue burden using DALY in Kerala.

**Methods**

DALY was computed using The DALY package, accessible in the R statistical program.\(^8\) A Graphical User Interface (GUI) \(^9\) is available for calculating DALYs and performing uncertainty and sensitivity analyses. The age sex distribution of Kerala\(^10\) population was used. Life expectancy (LE) for Kerala (2011-2015) gives values only upto 85+, LE at 90 and 95 years were retained as in LE table of R and taken as 2.7 and 1.9 corrected to one digit. The reported cases of Dengue and deaths for the years 2014 and 2015 for the districts of Kerala was obtained from the state surveillance unit. The line list of cases with age and sex specific details were also obtained. Instead of using multiplication factor, we used the data from sentinel surveillance and fever surveillance to compute the highest (20% of fever cases; may be applicable to Thiruvananthapuram only during epidemic period) and lowest possible (2.8% of fever; applicable to the whole state) dengue estimates. These estimates of Dengue in Kerala have been published earlier by the same authors.\(^12\) The incidence/ 1000 and mortality /1000 population was calculated for the and the imputed in R for DALY calculation. The age sex specific incidence /1000 was calculated. The age sex profile of dengue cases, mean age of onset in each age group and mean age of mortality were computed in SPSS version 11. This data was used for DALY calculation for the corresponding years. We assumed that deaths due to Dengue may not be missed to reporting. Disability weights (DW) of GBD 1990 was used, since it has age specific values.

Since severity of disease was not given in the line list of cases reported, it was accounted in the duration of disease and disability weights. From a 5 year evaluation of dengue cases, it was seen that 90% of cases are not severe and only 10% is severe.\(^12\) The duration disease for classic dengue is 4 days (range; 2-6), moderate dengue is 10 days (range; 8-12) and 14 days for severe dengue (range; 10-18 days).\(^13\) We took duration of disease as 7 days, based on a weighted proportion of disease severity. Others have used a duration of 5 days\(^14\), 14 days for hospitalized patients and 4.5 days for ambulatory cases.\(^13\) Proportion of treated cases was taken as 90%, because in Kerala treatment seeking is high. After finding the absolute DALY, relative DALY /lakh population was computed for comparison. We categorised districts as high, intermediate and low risk based on incidence, mortality and DALY. This study was part of a larger study funded by WHO-TDR. Ethics committee clearance was obtained from WHO (protocol ID B40138 last approved on 27/4/2016) and institution (Govt. Medical College, Thiruvananthapuram- IEC No: 02/42/MCT dated 14/02/2014).

**Results**

The risk of dengue incidence, mortality and DALY across districts were different. Those districts with highest incidence were not the same as those with highest DALY. The incidence of dengue based on reported cases varied from 0.014 to 0.388/1000. In 2014 incidence of dengue was highest in Thiruvananthapuram district (TVPM).
and lowest in Palakkad (table 1). Mortality rate/1000 varied from zero to 0.0015. Mean age of mortality was 38 years. In 2014, mortality was highest in Thrissur and lowest in Pathanamthitta. Thrissur had the highest Relative DALY 26.91(11.50-39.60), although TVPM had the highest incidence. This is because mortality was higher in Thrissur than TVPM. The lowest DALY was for Kottayam (Table 2).

In 2015 the highest incidence was in Kasargode followed by Thiruvananthapuram. (Table 3). The values ranged from 0.05 in Kottayam to 0.364 in Kasargode. The highest mortality was also in Kasargode (0.003/1000). Mean age of mortality was 34.87. Absolute DALY was highest in Kasargode (26.91), although TVPM had the highest incidence. This is because mortality was higher in Thrissur than TVPM. The lowest DALY was for Kottayam (Table 2).

The relative DALY of three districts in 2015 were very high. (Idukki 204.33(86.66-301.27); Kasargode -RD-198.95/lakh [95%CI:85.67-291.42]; Thiruvananthapuram RD- 70.03[95% CI: 30.68-102.71]). At the same time there were districts with RD as low as 0.10 and 0.24/lakh. (Table 4).

Estimated burden is much higher than burden based on reported cases during both years (Figures 1 and 2)

The number of districts with high risk incidence, mortality and DALY increased in 2015 compared to 2014. In 2014 there were only two districts with relative DALY >20, whereas in 2015 there were 6 districts. Incidence/1000 of > 0.05 was seen only in four districts in 2015 whereas in 2014 all except two districts had high incidence. Similarly mortality/1000 was >0.001 in two districts only in 2014, which increased to 6 and mortality of (Figure 3).

### Table 1: Dengue cases and Incidence in the districts in 2014 compared

| SLNo | District | Population | Dengue Case | Highest estimate | Lowest estimate | Incidence/1000 reported case | Rank incidence | Incidence/1000 highest estimate | Incidence/1000 lowest estimate |
|------|----------|------------|-------------|-----------------|----------------|-------------------------------|---------------|--------------------------------|-------------------------------|
| 1    | TVPM     | 3301427    | 1280        | 59719           | 8360.66        | 0.388                         | 1             | 18.089                         | 2.532                         |
| 2    | KLM      | 2653575    | 73          | 41869           | 5861.66        | 0.028                         | 9             | 15.887                         | 2.224                         |
| 3    | PTN      | 1197412    | 191         | 18108           | 2535.12        | 0.160                         | 2             | 15.123                         | 2.117                         |
| 4    | ALP      | 2127789    | 46          | 29785.6         | 4169.984       | 0.022                         | 11            | 13.998                         | 1.960                         |
| 5    | KTM      | 1974551    | 30          | 18072.6         | 2530.164       | 0.015                         | 13            | 9.153                          | 1.281                         |
| 6    | IDK      | 1108974    | 20          | 17396.6         | 2435.24        | 0.018                         | 12            | 15.687                         | 2.196                         |
| 7    | ERN      | 3282388    | 149         | 41512.6         | 5811.764       | 0.045                         | 6             | 12.647                         | 1.771                         |
| 8    | TSR      | 3121200    | 153         | 56572.2         | 7920.108       | 0.049                         | 5             | 18.125                         | 2.538                         |
| 9    | PKD      | 2809934    | 40          | 49926.4         | 6989.696       | 0.014                         | 14            | 17.768                         | 2.487                         |
| 10   | MLP      | 4112920    | 146         | 74823.2         | 10475.248      | 0.035                         | 7             | 18.192                         | 2.547                         |
| 11   | KZD      | 3086293    | 276         | 42306.6         | 5922.924       | 0.089                         | 3             | 13.708                         | 1.919                         |
| 12   | WYD      | 817420     | 44          | 27314.4         | 3824.016       | 0.054                         | 4             | 33.415                         | 4.678                         |
| 13   | KNR      | 2523003    | 55          | 46575.6         | 6520.584       | 0.022                         | 10            | 18.460                         | 2.584                         |
| 14   | KSD      | 1307375    | 45          | 24311.4         | 3403.596       | 0.034                         | 8             | 18.596                         | 2.603                         |

*TVPM – Thiruvananthapuram, KLM – Kollam, PTN- Pathanamthitta, ALP- Alappuzha, KTM- Kottayam, IDK – Idukki, ERN- Ernakulam, TSR- Thrissur, PKD – Palakkad, MLP- Malappuram, KZD- Kozhikkode, WYD – Wyanad, KNR- Kannour, KSD-Kasaragode.*
Table 2: Dengue deaths, mortality rate and DALYs in the districts in 2014 compared

| District | Deaths | Mortality rate/1000 | Rank | Mortality category | Absolute DALY based on reported case | Relative DALY (% CI) | Relative DALY rank category | Relative DALY rank |
|----------|--------|---------------------|------|-------------------|-------------------------------------|---------------------|-----------------------------|-------------------|
| TVPM     | 3      | 0.000909            | 3    |                   | 801 (372-1157)                      | 24.26 (11.27-35.04) | 2                           |                   |
| KLM      | 1      | 0.000379            | 5    |                   | 252 (106-371)                       | 9.56 (4.02-14.07)   | 6                           |                   |
| PTN      | 0      | 0                   | 14   |                   | 21                                  | 1.75 (1.75-1.75)    | 9                           |                   |
| ALP      | 1      | 0.00047             | 4    |                   | 336 (147-494)                       | 15.79 (6.91-23.21)  | 3                           |                   |
| KTM      | 0      | 0                   | 13   |                   | 2                                   | 0.10 (0.10-0.10)    | 14                          |                   |
| IDK      | 0      | 0                   | 12   |                   | 158                                 | 14.25 (14.25-14.25) | 4                           |                   |
| ERN      | 0      | 0                   | 11   |                   | 6                                   | 0.18 (0.18-0.18)    | 12                          |                   |
| TSR      | 4      | 0.001282            | 2    |                   | 840 (359-1236)                      | 26.91 (11.50-39.60) | 1                           |                   |
| PKD      | 1      | 0.000356            | 6    |                   | 251 (108-371)                       | 8.93 (3.84-13.20)   | 7                           |                   |
| MLP      | 1      | 0.000243            | 7    |                   | 171 (75-250)                        | 4.16 (1.82-6.07)    | 8                           |                   |
| KZD      | 0      | 0                   | 10   |                   | 12                                  | 0.39 (0.39-0.39)    | 11                          |                   |
| WYD      | 0      | 0                   | 9    |                   | 7                                   | 0.86 (0.86-0.86)    | 10                          |                   |
| KNR      | 0      | 0                   | 8    |                   | 3                                   | 0.11 (0.11-0.11)    | 13                          |                   |
| KSD      | 2      | 0.00153             | 1    |                   | 132 (59-193)                        | 10.10 (4.51-14.76)  | 5                           |                   |

Table 3: Dengue cases and Incidence in the districts in 2015 compared

| Sl.No | District | Population | Dengue Case | Highest estimate | Lowest estimate | Incidence/1000 reported case | Rank incidence | Incidence/1000 highest estimate | Rank incidence |
|-------|----------|------------|-------------|------------------|-----------------|-------------------------------|----------------|---------------------------------|----------------|
| 1     | TVPM     | 3301427    | 991         | 64862.4          | 9080.736        | 0.300                         | 2              | 19.647                          | 2.751          |
| 2     | KLM      | 2635375    | 245         | 45068.8          | 6309.632        | 0.093                         | 7              | 17.101                          | 2.394          |
| 3     | PTN      | 1197412    | 204         | 16174            | 2264.36         | 0.170                         | 5              | 13.507                          | 1.891          |
| 4     | IDK      | 2127789    | 127         | 17827.4          | 2495.836        | 0.115                         | 6              | 16.076                          | 2.251          |
| 5     | KTM      | 1974551    | 98          | 17232.2          | 2412.508        | 0.050                         | 14             | 8.727                           | 1.222          |
| 6     | ALP      | 1108974    | 157         | 26506            | 3710.84         | 0.074                         | 10             | 12.457                          | 1.744          |
| 7     | ERN      | 3282388    | 243         | 35762.6          | 5006.764        | 0.074                         | 9              | 10.895                          | 1.525          |
| 8     | TSR      | 3121200    | 253         | 54461            | 7624.54         | 0.081                         | 8              | 17.449                          | 2.443          |
| 9     | PKD      | 2809934    | 145         | 51321.2          | 7184.968        | 0.052                         | 13             | 18.264                          | 2.557          |
| 10    | MLP      | 4112920    | 275         | 72704.4          | 10178.616       | 0.067                         | 11             | 17.677                          | 2.475          |
| 11    | KZD      | 3086293    | 587         | 50608.4          | 7085.176        | 0.190                         | 4              | 16.398                          | 2.296          |
| 12    | WYD      | 817420     | 157         | 31104.2          | 4354.588        | 0.192                         | 3              | 38.052                          | 5.327          |
| 13    | KNR      | 2523003    | 156         | 45636            | 6389.04         | 0.062                         | 12             | 18.088                          | 2.532          |
| 14    | KSD      | 1307375    | 476         | 25337.6          | 3547.264        | 0.364                         | 1              | 19.381                          | 2.713          |
Table 4: Dengue deaths, mortality rate and DALYs in the districts in 2015 compared

| District | Deaths | Mortality rate/1000 | Rank mortality | Rank mortality category | Absolute DALY based on reported case | Relative DALY | Relative DALY rank | Relative DALY rank category |
|----------|--------|---------------------|----------------|------------------------|--------------------------------------|--------------|-------------------|-----------------------------|
| TVPM     | 9      | 0.002726            | 2              | 2                     | 2312(1013-3391)                      | 70.03(30.06-102.71) | 3 |  |
| KLM      | 3      | 0.001138            | 5              | 3                     | 958(406-1411)                        | 36.35(15.41-53.54)  | 6 |  |
| PTN      | 0      | 0                   | 14             | 23                    | 23                                   | 1.92         | 10 |  |
| IDK      | 3      | 0.002705            | 3              | 23                    | 2266(961-3341)                       | 204.33(86.66-301.27) | 1 |  |
| KTM      | 2      | 0.001013            | 6              | 8                     | 844(357-1245)                        | 42.74(18.08-63.05)  | 5 |  |
| ALP      | 1      | 0.00047             | 8              | 10                    | 400(176-588)                         | 18.80(8.27-27.63)  | 7 |  |
| ERM      | 0      | 0                   | 13             | 11                    | 7                                    | 0.35         | 11 |  |
| TSR      | 0      | 0                   | 12             | 7                     | 7                                    | 0.25         | 14 |  |
| PKD      | 0      | 0                   | 11             | 8                     | 8                                    | 0.32         | 12 |  |
| MLP      | 2      | 0.000486            | 7              | 26                    | 413(181-605)                         | 10.04(4.40-14.71)  | 8 |  |
| KZD      | 5      | 0.00162             | 4              | 13                    | 1376(597-2019)                       | 44.58(10.34-65.42)  | 4 |  |
| WYD      | 0      | 0                   | 10             | 26                    | 26                                   | 3.18         | 9 |  |
| KNR      | 0      | 0                   | 9              | 8                     | 8                                    | 0.32         | 12 |  |
| KSD      | 4      | 0.00306             | 1              | 2601(1120-3810)        | 198.95(85.67-91.42)                  | 13 |  |

Figure 1: Dengue DALY based on reported cases compared to estimated burden in 2014
Figure 2: Dengue DALY based on reported cases compared to estimated burden in 2015

![Graph showing Dengue DALY based on reported cases compared to estimated burden in 2015.](image)

Figure 3: District wise dengue burden for the years 2014 and 2015

A. District wise Dengue related DALY in 2014
B. District wise Dengue related DALY in 2015
C. District wise Dengue Incidence in 2014
D. District wise Dengue Incidence in 2015
E. District wise Dengue mortality in 2014
F. District wise Dengue mortality 2015
Discussion
The relative DALY according to Global burden of disease due to dengue in 2013 was 15.8/lakh.\textsuperscript{15} It increased to 25.5/ lakh in 2015.\textsuperscript{16} The same trend is seen in our study. The DALY of some districts in 2014 is comparable to the global burden. In 2015, however we find the DALY has escalated up to more than 8 times the global burden in two districts. The South East Asian burden is 19.5/lakh. The state DALY has been computed by us and reported in a separate publication as 7.22/lakh (6.62-7.72). Some districts have very low dengue burden. Thus there is a gross heterogeneity in the distribution of dengue burden across the state.

Dengue burden is higher in all district in 2015 compared to 2014, except Thrissur and Palakkad. Although this is not a sufficient period to determine trend the increase is at par with the increase in dengue seen throughout India. Over the period 1998–2009, 82 327 dengue cases (incidence: 6.34 per million population) were reported. During a more recent period (2010–2014), 213 607 cases (incidence: 34.81 per million population) of dengue fever were observed. Thus, the number of dengue cases during the past 5 years has increased markedly, by a factor of ~ 2.6, with respect to the 1998–2009 period.\textsuperscript{17}

Use of incidence alone may be misleading for prioritising among the districts for action. If we were to use incidence alone, the highest priority would be given to Thiruvananthapuram. However, DALY estimation, which considers mortality, age at mortality, population and many other indicators besides incidence would place Thrissur district to receive the highest priority in 2014.

Conclusions
There is gross heterogeneity across the districts of Kerala in dengue burden. Some districts have much higher burden than the global burden. Prioritising for action can be misleading if we use the incidence alone for burden estimation. Similarly dengue and other disease burden needs to be estimated at the district level, which can be considered as the smallest unit of planning. Strengthening surveillance system will add to the reliability of such burden estimations. We recommend the use of DALY for better understanding of distribution of disease and policy prioritization at district level.

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