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 inputed 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, RD-26.91/lakh population [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 AD2312; 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.[4] Kerala is now hyperendemic for Dengue with presence of multiple serotype, high rates of coinfection and local genomic evolution of viral strains.[5] The district of Thiruvananthapuram reports maximum number of cases in the state.[4]

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.[11] 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.

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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 (2601), but the relative DALY was highest for Idukki (204.3), which had only 6th rank in terms of incidence and 3rd rank in terms of mortality, because the population of Idukki is less.

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 2014 whereas in 2015 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

Sl.No	District *	Population	Dengue Case	Highest estimate	Lowest estimate	Incidence/1000-reported case	Rankincidence	Rank incidence category	Incidence/1000 highest estimate	Incidence/ 1000 lowest estimate
1	TVPM	3301427	1280	59719	8360.66	0.388	1	(red)	18.089	2.532
2	KLM	2635375	73	41869	5861.66	0.028	9	(yellow)	15.887	2.224
3	PTN	1197412	191	18108	2535.12	0.160	2	(red)	15.123	2.117
4	ALP	2127789	46	29785.6	4169.984	0.022	11	(yellow)	13.998	1.960
5	KTM	1974551	30	18072.6	2530.164	0.015	13	(green)	9.153	1.281
6	IDK	1108974	20	17396.6	2435.524	0.018	12	(green)	15.687	2.196
7	ERN	3282388	149	41512.6	5811.764	0.045	6	(yellow)	12.647	1.771
8	TSR	3121200	153	56572.2	7920.108	0.049	5	(yellow)	18.125	2.538
9	PKD	2809934	40	49926.4	6989.696	0.014	14	(green)	17.768	2.487
10	MLP	4112920	146	74823.2	10475.248	0.035	7	(yellow)	18.192	2.547
11	KZD	3086293	276	42306.6	5922.924	0.089	3	(red)	13.708	1.919
12	WYD	817420	44	27314.4	3824.016	0.054	4	(yellow)	33.415	4.678
13	KNR	2523003	55	46575.6	6520.584	0.022	10	(yellow)	18.460	2.584
14	KSD	1307375	45	24311.4	3403.596	0.034	8	(yellow)	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- Kasargode.

Table 2: Dengue deaths, mortality rate and DALYs in the districts in 2014 compared

District	Deaths	Mortality rate/1000	Rankmortality	Rank mortalitycategory	Absolute DALY based on reported case	Relative DALY (95 % 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	Rankincidence	Rank incidence category	Incidence/1000 highest estimate	Incidence/ 1000 lowest estimate
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	🟥	2312(1013-3391)	70.03(30.06-102.71)		3	🟥
KLM	3	0.001138	5	🟥	958(406-1411)	36.35(15.41-53.54)		6	🟥
PTN	0	0	14	🟩	23	1.92		10	🟩
IDK	3	0.002705	3	🟥	2266(961-3341)	204.33(86.66-301.27)		1	🟥
KTM	2	0.001013	6	🟥	844(357-1245)	42.74(18.08-63.05)		5	🟥
ALP	1	0.00047	8	🟨	400(176-588)	18.80(8.27-27.63)		7	🟨
ERN	0	0	13	🟩	10	0.30		2	🟩
TSR	0	0	12	🟩	11	0.35		11	🟩
PKD	0	0	11	🟩	7	0.25		14	🟩
MLP	2	0.000486	7	🟨	413(181-605)	10.04 (4.40-14.71)		8	🟨
KZD	5	0.00162	4	🟥	1376(597-2019)	44.58 (10.34-65.42)		4	🟥
WYD	0	0	10	🟩	26	3.18		9	🟩
KNR	0	0	9	🟩	8	0.32		12	🟩
KSD	4	0.00306	1	🟥	2601(1120-3810)	198.95(85.67-91.42)		13	🟥

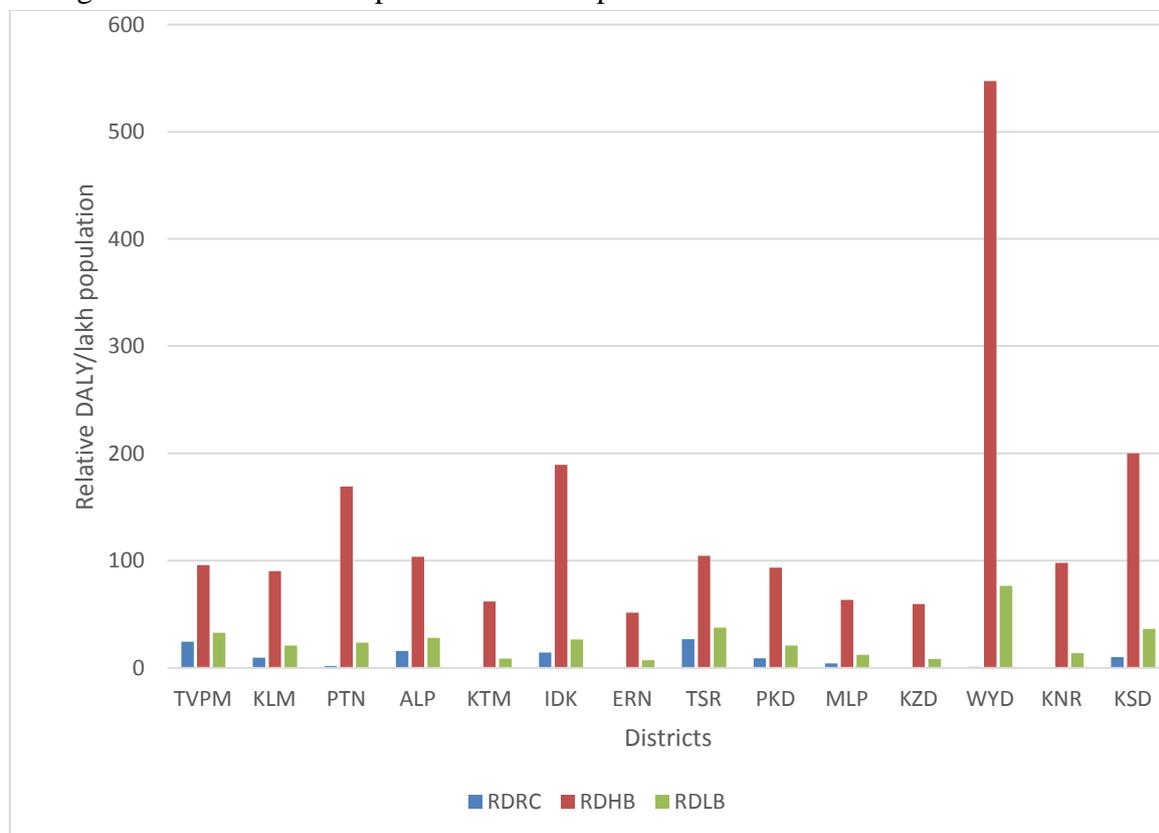**Figure 1:** Dengue DALY based on reported cases compared to estimated burden in 2014

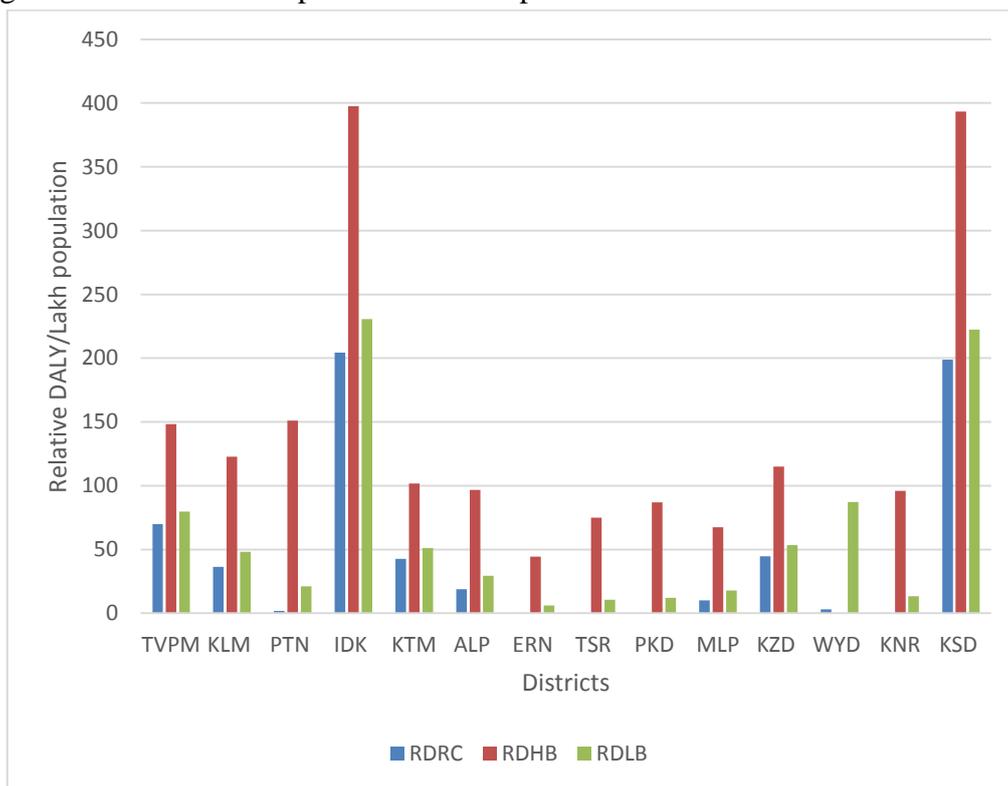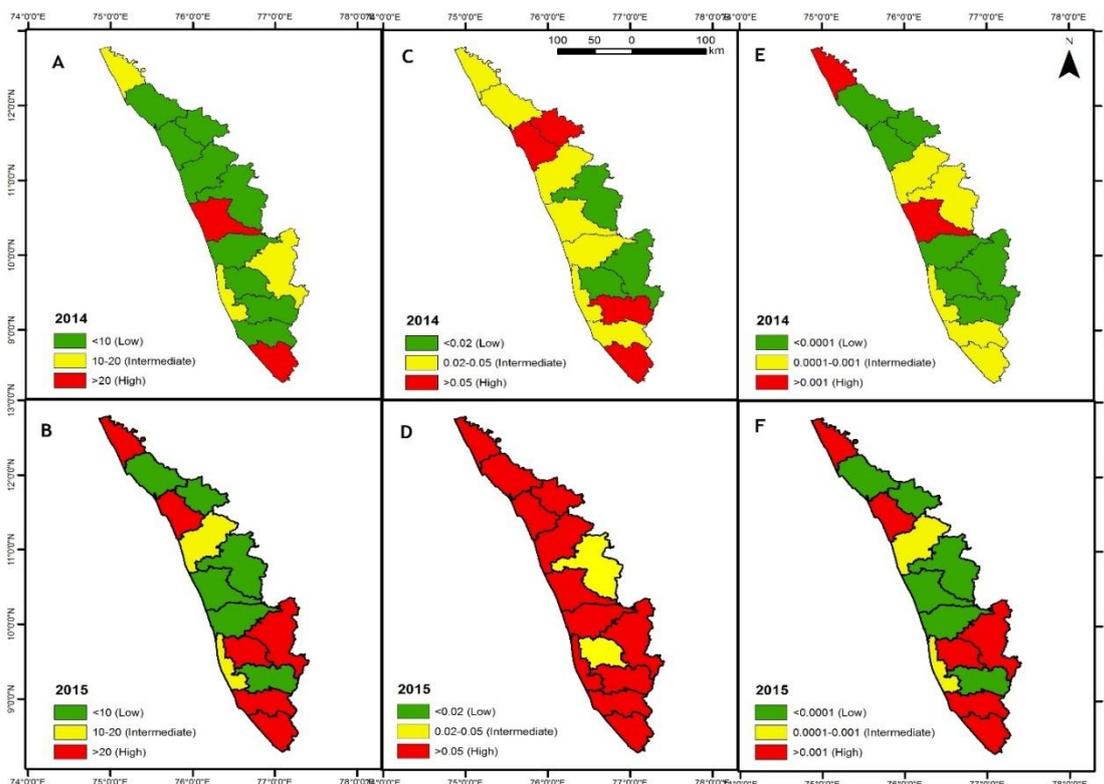**Figure 2:** Dengue DALY based on reported cases compared to estimated burden in 2015

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.[15] It increased to 25.5/ lakh in 2015.[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 upto 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.[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.

Limitations and Strengths

This study is the first of its kind to determine district specific dengue burden using DALY. It has relied on the state surveillance system for data on reported cases of dengue and estimation of dengue burden, besides our own personal studies. Therefore any inaccuracies in the disease reporting may also be reflected in this calculation.

Since we have calculated DALY based on reported cases and estimated cases also, any underreporting would have been taken care of.

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.

Acknowledgements

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