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Direct estimates of disability-adjusted life years lost due to stroke : a cross-sectional observational study in a demographic surveillance site in rural Gadchiroli, India

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ABSTRACT

Objective To directly estimate disability-adjusted life years (DALYs) lost due to stroke in rural Gadchiroli, India and measure the contribution of mortality and disability to total DALYs lost.

Design Cross-sectional descriptive study using population census, vital registration and stroke prevalence data.

Setting A demographic surveillance site of 86 villages in Gadchiroli, a rural district in Maharashtra, India.

Participants Population counts and mortality information were drawn from a census and vital registration system covering a population of approximately 94 154 individuals; stroke prevalence information was based on a door-to-door evaluation of all 45 053 individuals from 39 of the 86 villages in the surveillance site.

Primary outcome measures Years of life lost (YLL), years lived with disability (YLD) and DALYs lost due to stroke.

Results There were 229 stroke deaths among the total population of 94 154 individuals and 175 stroke survivors among the subpopulation of 45 053 individuals. An estimated 2984 DALYs were lost due to stroke per 100 000 person-years with a higher burden among men compared with women (3142 vs 2821 DALYs). Over three-fourths (80%) of the total DALYs lost due to stroke were between ages 30 and 70 years. YLL accounted for 98.9% of total DALYs lost.

Conclusions There was a high burden of stroke in rural Gadchiroli with a significant burden at premature ages. These results reveal a substantial need for surveillance and improved preventive and curative services for stroke in rural India.

Strengths and limitations of this study

- ► The major strength of this study design is that it was based on census, verbal autopsy-based mortality surveillance and stroke prevalence data from a long-running demographic surveillance site.
- ► This allowed us to provide direct, unmodeled, estimates of disability-adjusted life years (DALYs) lost due to stroke.
- ► A limitation of this study was the lack of brain imaging and therefore inability to distinguish the contribution of ischaemic and haemorrhagic stroke to the total DALYs lost due to stroke.
- ► The study data are also from a single district of India and may not be representative of all of rural India.

INTRODUCTION

Stroke is the third leading cause of death and disability globally.[1] In 2017, stroke accounted for an estimated 11.0% of all deaths and 5.3% of all disability-adjusted life years (DALYs) lost.[1 2] Stroke in India has important global implications since an estimated 13.3% of global DALYs lost due to stroke occured in India. Within India, stroke was the sixth leading cause of DALYs lost in 2017 based on modelled estimates from the Global Burden of Disease (GBD) study.[1] The GBD study also found substantial variation across states, with the highest burden of stroke in the states of West Bengal, Assam, Odisha and Chhattisgarh, and substantially lower levels in Mizoram, Sikkim and Delhi.[3] Given that health policy decisions are often made at state levels, these results call attention to the importance of subnational stroke burden estimates for identifying which specific parts of the country need better preventive and curative stroke services.

One of the most important subnational distinctions in India is between urban and rural areas. Two-thirds of India's population—which is 12% of the world's population—lives in rural areas,[4] where health services are often not available, especially specialty care for individuals who have already experienced a stroke.[5] Compared with urban areas, patterns of non-communicable disease (NCD) risk factors also tend to be less pronounced in rural areas,[6 7] potentially leading to the belief that stroke and other NCDs are primarily a problem of urbanising city centres. Therefore, an important open question is whether strokeis an important public health problem in rural areas as well.

Existing studies find high stroke mortality among the 890 million individuals living in rural parts of India.[8–11] Using data from a rural surveillance site in Andhra Pradesh, Joshi *et al* found that stroke was a leading cause of death between the years 2003 and 2004; Kalkonde *et al* used data from rural Maharashtra and similarly concluded that stroke was the leading cause of death between 2011 and 2013.[8 11] Based on data from the Million Deaths Study, Ke *et al* found that stroke mortality rates were higher in rural, than in urban, India.[9] While these studies provided an important insight into the importance of stroke mortality in rural areas, policy efforts are generally focused on diseases that carry a large burden of avertable life years lost, the combination of morbidity and premature mortality due to stroke, which the previous studies did not estimate.

In this study, we provide direct estimates of the disease burden of stroke—measured through DALYs lost—in a demographic surveillance site in rural India. We directly estimated DALYs lost using rare sources of local census, population-representative stroke prevalence and verbal autopsy-based cause of death data from the Gadchiroli demographic surveillance site in rural Maharashtra, India for the years 2011–2013. We measured both the overall burden of stroke and also determined how the burden varies across age and sex and whether the burden is primarily driven by stroke mortality or morbidity.

METHODS

Study setting

All data were from a rural demographic surveillance site of the Society for Education, Action and Research in Community Health (SEARCH), a non-governmental organisation working in the Gadchiroli district of Maharashtra, India since 1986. As of the last national census in 2011, Gadchiroli had a population of 1 072 942 individuals, the majority of whom live in rural areas (89%). More than one-third of individuals in the district (38.3%) are considered 'scheduled tribes', India's tribal demographic group.[12] Based on data collected by the Indian government, Gadchiroli falls in the bottom 101 of India's 718 districts in terms of development and is classified by the government as an 'aspirational district'.[13] SEARCH operates a demographic surveillance system in 86 villages in Gadchiroli with routine population censuses conducted every 10 years, 5 years after the national censuses. There is also a continuous enumeration of births and deaths that occur within the site with annual updating of the population register. As of 2011, the surveillance site had a population of 94 154 individuals. Data from census, mortality surveillance and studies on stroke mortality and prevalence were obtained directly from SEARCH.

Estimation of mortality due to stroke

The details of the method used to estimate stroke mortality have been previously published.[8] Briefly, all births and deaths within the surveillance site are reported at the village level by a resident community health worker (CHW) to the staff of SEARCH . The data on causes of death was collected prospectively between 1 April 2011 and 31 March 2013. Within 2–4 weeks of a reported death, trained surveyors collected information on the deceased using a well-validated verbal autopsy tool.[14] This information was then reviewed by two physicians who independently assigned cause of death; conflicting causes of death were reconciled between coders with a third coder adjudicating the cause of death if the two coders continued to disagree. Both physician coders agreed on the diagnosis of stroke in 92.6% of stroke deaths and adjudication by a third physician was needed in 7.4% of deaths.

Estimation of the prevalence of stroke survivors

The prevalence of stroke was estimated from a three-stage population-based screening of all 45 053 individuals living in 39 of the 86 site villages conducted between January and May 2014. Details of the sample size calculations, data collection method, participant recruitment and nonparticipation have been published previously.[15] Briefly, trained surveyors went house-to-house to screen for symptoms of stroke using a well-validated questionnaire which was used in prior population-based studies in India for estimating stroke prevalence.[16] The questionnaire was translated into the local language (Marathi) and was validated for the Gadchiroli population using a neurologist's clinical diagnosis as the gold standard. The questionnaire had a sensitivity of 86% and specificity of 99%.[15] The questionnaire had six questions: did anyone in the family ever have (a) weakness on one side of the body? (b) numbness on one side of the body? (c) drooping of one side of face? or (d) slurring of speech? If the respondent had any of these, they were asked whether these symptoms were (e) sudden in onset and (f) lasted >24 hours. If the respondent had one or more of the first four symptoms and if the symptoms were sudden in onset and lasted >24 hours, that individual was referred to the physician for further evaluation. Diagnosis of stroke was made by the study physician using WHO's clinical definition of stroke as a focal (or at times global) neurological impairment of sudden onset lasting >24 hours and of presumed vascular origin. Clinical diagnosis alone was used when no supporting documents were available irrespective of whether the patient had any residual neurodeficit at the time of evaluation by the physician. Doubtful cases were evaluated by the study neurologist (YK).

Estimation of population in 2012

We estimated the age-specific population for 2012 (the mid-period population for the 2011–2013 period over which mortality data were collected) based on censuses conducted in the Gadchiroli surveillance site in 2005 and

2015. To do so, we first calculated age-specific annual growth rates over the 10-year intercensal period and then applied these growth rates to the 2005 initial population to estimate age-specific counts of individuals in 2012.

Calculation of DALYs

DALYs lost due to stroke were estimated as the sum of years of life lost (YLL) from stroke and years lived with disability (YLD) due to stroke. YLL due to stroke were estimated for the 2011–2013 period by multiplying the number of deaths from stroke at each age by the remaining life expectancy in the 2017 GBD reference life table at that age and then summing across all ages.[17]

To estimate YLD due to stroke, we first calculated the age-specific prevalence of stroke for 5-year age groups between the ages 0 and 85+ from the cross-sectional evaluation conducted in 2014. We then multiplied the age-specific stroke prevalence rates by the age-specific population counts in 2012 to estimate the expected number of individuals with stroke for the period. We then multiplied the number of expected cases of stroke by a disability weight of 0.07—drawn from the 2017 GBD disability weights for long-term stroke of moderate severity[18]—and summed across all ages.

Finally, DALYs were calculated as the sum of YLL and YLD expressed per 100 000 person-years lived. Based on the recommendations of the 2017 GBD study, we did not use age weights or other methods of discounting in estimating DALYs.[1] We also did not apply any inclusion or exclusion criteria to the input data.

Sensitivity analyses

Since our data did not allow us to assess the severity of disability due to stroke, we had to assign a single weight to all stroke survivors when calculating DALYs.[18] We conducted sensitivity analyses to determine how much influence this assignment of a single disability weight had on our conclusions. To do this, we re-estimated our main analyses using the minimum (0.019) and maximum (0.588) disability weights for stroke given as part of the 2017 GBD study.[18] We also used the Indian National Life Table for rural Maharashtra to determine how YLLs vary based on different survival assumptions (online supplementary file 1).

Ethical approval

The data used in this study were from previous studies to estimate stroke mortality and prevalence.[8,15]

Patient and public involvement

SEARCH has been working with people in these 86 villages for >30 years to monitor their health priorities, develop and test solutions and provide village-based treatments of selected ailments through its CHWs. The current and previous studies have identified stroke as a leading public health problem in these villages and SEARCH is testing a community-based intervention to reduce stroke deaths. For this study, patients and the public were not involved in the study design, data analysis or writing of the manuscript. CHWs of SEARCH were involved in the data collection.

Study checklist

We have provided the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) checklist and information on GATHER items as supplementary files (online supplementary file 2).

RESULTS

Table 1 presents stroke mortality rates, stroke deaths and YLL due to stroke. There were 229 stroke deaths between 2011 and 2013, corresponding to a stroke mortality rate of 125.3 per 100 000 person-years, 5545.4 absolute YLL and 3033.0 YLL per 100 000 person-years. YLL per 100 000 person-years were slightly higher for men compared with women (3148.4 for men compared with 2915.2 for women). The majority of stroke deaths occurred between ages 65 and 80 years, with the largest amount of YLL occurring among those aged 65–70 years. Stroke mortality rates and YLL per 100 000 person-years, however, were highest at ages above 75 years for both women and men.

Table 2 presents stroke prevalence rates, expected stroke cases and YLD due to stroke. Overall, there were 901.5 expected cases of stroke per 100 000 person-years between 2011 and 2013, corresponding to a stroke prevalence of 388.4 per 100 000 person-years, 63.1 absolute YLD and 34.5 YLD per 100 000 person-years. The morbidity burden of stroke was much higher for men: men had a stroke prevalence of 519.4, 42.8 YLD and 46.3 YLD per 100 000 person-years compared with a stroke prevalence of 255.1, 19.9 YLDs and 22.0 YLD per 100 000 person-years for women.

Figure 1 graphs DALYs due to stroke per 100 000 person-years by age group. Total DALYs lost due to stroke were 3068 per 100 000 person-years with a higher burden among men relative to women (3195 vs 2937 per 100 000 person-years). For both women and men, the rate of DALYs lost due to stroke increased steadily over age to a peak between ages 75 and 85 years. However, 80% of total DALYs lost due to stroke occurred prematurely between ages 30 and 70 years. The vast majority of DALYs for both women and men were due to YLL, with small contributions from YLD (0.7% for women, 1.5% for men).

Figure 2 compares the rate of DALYs lost due to stroke estimated in Gadchiroli with the national and global DALYs lost due to stroke from the GBD study.[3] The estimated rate of DALYs lost due to stroke in Gadchiroli is higher than all the states in the GBD study with the closest estimate in West Bengal (2821). Our estimate is closer to estimate for the neighbouring state of Chhattisgarh (2142) than the state of Maharashtra (1,341), where Gadchiroli is located.

Table 3 presents the sensitivity of DALYs lost and the share of DALYs due to YLD to the choice of disability weight. When the maximum disability weight for stroke is used to estimate YLD, total DALYs per 100 000 increases

Table 1 Estimated age-specific and sex-specific stroke mortality, stroke deaths and years of life lost (YLL)* due to stroke between 2011 and 2013

	Men				Women				Total			
Age group	Stroke mortality rate (per 100 000)	Stroke deaths	YLL	YLL (per 100 000)	Stroke mortality rate (per 100 000)	Stroke deaths	YLL	YLL (per 100 000)	Stroke mortality rate (per 100 000)	Stroke deaths	YLL	YLL (per 100 000)
0–4	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0
4–9	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0
10–14	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0
15–19	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0
20–24	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0
25–29	12.0	1	63.2	754.9	0.0	0	0.0	0.0	6.2	1	63.2	394.4
30–34	0.0	0	0.0	0.0	29.3	2	116.4	1706.0	14.5	2	116.4	842.2
35–39	13.5	1	53.3	718.3	14.3	1	53.3	759.9	13.9	2	106.5	738.5
40–44	67.0	4	193.5	3241.9	0.0	0	0.0	0.0	33.3	4	193.5	1608.3
45–49	65.5	4	174.0	2848.5	85.1	5	217.5	3703.7	75.1	9	391.5	3267.7
50–54	200.4	9	348.3	7754.4	160.5	7	270.9	6211.0	180.7	16	619.2	6994.0
55–59	263.9	11	373.8	8968.4	138.3	5	169.9	4698.9	205.5	16	543.7	6985.0
60–64	302.1	8	234.5	8856.7	275.5	10	293.2	8075.9	286.7	18	527.7	8405.2
65–69	702.6	24	593.6	17 377.9	553.9	22	544.2	13 699.9	622.6	46	1137.8	15 400.5
70–74	850.0	17	345.5	17 272.8	1091.5	21	426.7	22 179.8	968.4	38	772.2	19 678.8
75–79	2252.3	20	321.9	36 248.8	2394.1	26	418.5	38 531.8	2330.3	46	740.3	37 504.8
80–84	3208.6	12	146.2	39 083.2	1181.1	6	73.1	14 386.9	2040.8	18	219.3	24 859.0
85+	2755.9	7	61.5	24 196.0	1898.7	6	52.7	16 670.3	2280.7	13	114.1	20 023.8
Total	127.7	118	2909.1	3148.4	122.7	111	2636.3	2915.2	125.3	229	5545.4	3033.0

*YLL were calculated using the 2017 Global Burden of Disease reference life table.

Table 2 Estimated age-specific and sex-specific stroke prevalence,* and years lived with disability (YLD)† due to stroke between 2011 and 2013

	Men				Women				Total			
Age group	Stroke prevalence rate per 100 000	Expected stroke cases	YLD	YLD per 100 000	Stroke prevalence rate per 100 000	Expected stroke cases	YLD	YLD per 100 000	Stroke prevalence rate per 100 000	Expected stroke cases	YLD	YLD per 100 000
0–4	0.0	0.0	0.0	0.0	61.1	4.6	0.3	4.3	29.6	4.5	0.3	2.1
5–9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10–14	44.5	3.3	0.2	3.1	0.0	0.0	0.0	0.0	23.0	3.3	0.2	1.6
15–19	0.0	0.0	0.0	0.0	36.9	3.4	0.2	2.6	18.3	3.4	0.2	1.3
20–24	47.3	4.4	0.3	3.3	0.0	0.0	0.0	0.0	25.1	4.5	0.3	1.8
25–29	106.4	8.9	0.6	7.5	56.8	4.3	0.3	4.0	82.4	13.2	0.9	5.8
30–34	121.7	8.5	0.6	8.5	173.6	11.8	0.8	12.2	148.3	20.5	1.4	10.4
35–39	54.3	4.0	0.3	3.8	51.6	3.6	0.3	3.6	52.9	7.6	0.5	3.7
40–44	397.9	23.7	1.7	27.9	127.8	7.7	0.5	8.9	260.3	31.3	2.2	18.2
45–49	210.4	12.8	0.9	14.7	153.1	9.0	0.6	10.7	183.0	21.9	1.5	12.8
50–54	721.6	32.4	2.3	50.5	681.8	29.7	2.1	47.7	702.7	62.2	4.4	49.2
55–59	1522.2	63.4	4.4	106.6	634.5	22.9	1.6	44.4	1096.2	85.3	6.0	76.7
60–64	3270.2	86.6	6.1	228.9	1154.4	41.9	2.9	80.8	2119.3	133.1	9.3	148.4
65–69	4812.8	164.4	11.5	336.9	1068.7	42.4	3.0	74.8	2796.1	206.6	14.5	195.7
70–74	4000.0	80.0	5.6	280.0	3876.0	74.6	5.2	271.3	3934.9	154.4	10.8	275.4
75–79	6508.9	57.8	4.0	455.6	1485.1	16.1	1.1	104.0	3773.6	74.5	5.2	264.2
80–84	10 769.2	40.3	2.8	753.8	2381.0	12.1	0.8	166.7	6040.3	53.3	3.7	422.8
85+	8163.3	20.7	1.5	571.4	0.0	0.0	0.0	0.0	3846.2	21.9	1.5	269.2
Total	519.4	611.4	42.8	46.3	255.1	284.3	19.9	22.0	388.4	901.5	63.1	34.5

*Prevalence rate was calculated from a subsample of individuals surveyed in 2014 and then applied to the overall 2012 population counts to estimate expected cases of stroke.
†YLD are calculated using a disability weight of 0.07 for stroke.

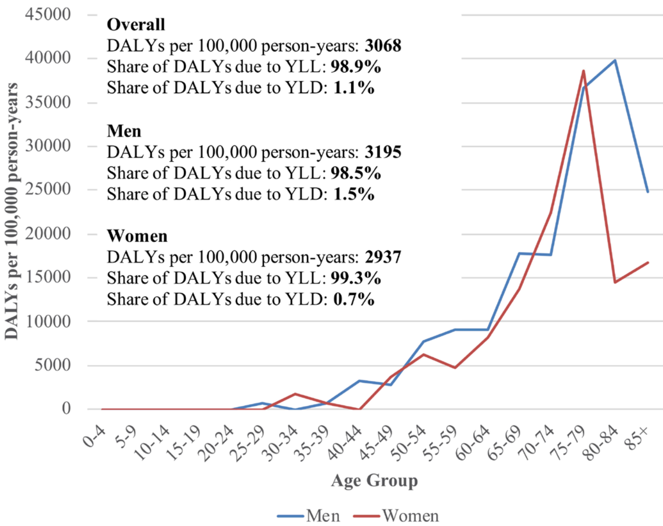

Figure 1 Age-specific rate of DALYs lost due to stroke per 100 000 person-years, 2011–2013, Gadchiroli, India. DALY, disability-adjusted life year; YLD, years lived with disability; YLL, years of life lost.

to 3323 (3537 for men and 3100 for women) and an 8.7% contribution from YLD. Using the minimum disability for stroke has a minor effect on our main estimates, reducing DALYs per 100 000 from 3068 to 3042 and the contribution of YLD from 1.1% to 0.3%.

All results are attached in spreadsheet form as per the GATHER checklist (online supplementary file 2).

DISCUSSION

We found a very high burden of DALYs lost due to stroke in the rural, Gadchiroli district, of Maharashtra, India. Importantly, the majority of DALYs lost occurred at relatively young ages between 30 and 70 years, revealing a large premature burden of stroke. We found a slightly higher burden among men compared with women, driven primarily by a greater number of YLL due to stroke among men. For both women and men, >98% of the total disease burden was due to YLL, indicating a high level of stroke mortality in Gadchiroli.

Our estimate of DALYs due to stroke per 100 000 person-years was higher than the Indian state-specific estimates published in a recent GBD study.[3] As the GBD estimates are heavily modelled based on scarce data, extrapolated using multiple indirect sources of information, and are based on predictive models built with data from other contexts, it is possible that the GBD estimate of the burden of stroke in India could be an underestimate. However, higher estimates in our study could also be due to geographical differences within India and the lack of healthcare services in Gadchiroli. Furthermore, estimates for rural areas of India, where the majority of India's population lives and where there are significant challenges to healthcare delivery, are not available separately in the GBD study. Therefore, in this context our study provides a value addition and highlights the need to monitor the stroke burden in rural India. Beyond the GBD, our results are difficult to directly compare with other studies due to a paucity of DALY estimates from other parts of India, particularly rural India, and other low-income and middle-income countries. To our knowledge, there is only one other population-based study that has estimated DALYs lost due to stroke directly in India, and this study was based in an urban city centre. Banerjee *et al*[19] used data from city of Kolkata and estimated that

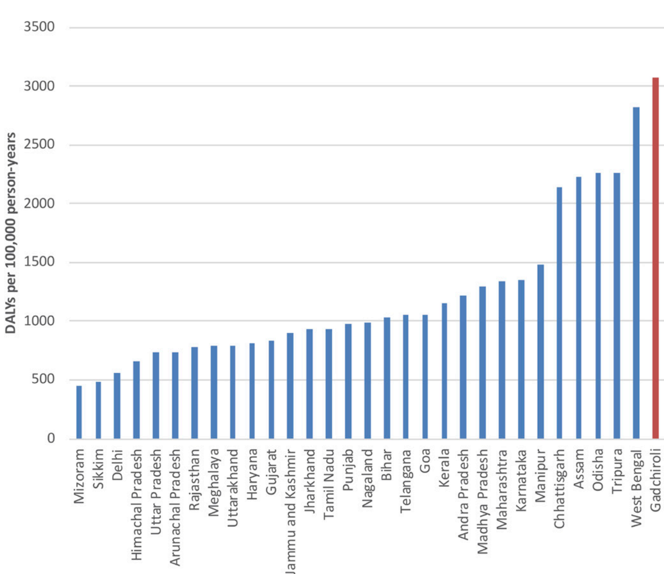

Figure 2 Comparison of total disability-adjusted life years (DALYs) lost due to stroke per 100 000 person-years in rural Gadchiroli to published state-level estimates from the 2016 Global Burden of Disease study.

Table 3 Sensitivity analyses of changes in estimates of a) DALYs per 100 000 and b) share of DALYs due to YLD to stroke disability weights

	Stroke disability weight used (0.07)*	Lowest stroke disability weight (0.019)†	Highest stroke disability weight (0.588)‡
Total	3068	3042	3323
Share due to YLD	1.1%	0.3%	8.7%
Men	3195	3161	3537
Share due to YLD	1.5%	0.4%	11.0%
Women	2937	2921	3100
Share due to YLD	0.7%	0.2%	6.0%

*This is the disability weight for long-term stroke survivors of moderate severity in the 2017 GBD list of disability weights.
†This is the lowest disability weight across stroke categories in the 2017 GBD list of disability weights.
‡This is the highest disability weight across stroke categories in the 2017 GBD list of disability weights.
DALY, disability-adjusted life year; GBD, Global Burden of Disease; YLD, years lived with disability.

795.6 DALYs per 100 000 person-years lived were lost due to stroke.[19] The large difference between our estimate is partly driven by the choice of life table used in the calculation of DALYs. Banerjee *et al* used Indian life tables to calculate DALYs where the life expectancies are lower compared with those in the 2017 GBD reference life tables. However, in sensitivity analyses using the rural Indian life tables, we estimated a substantially higher burden of DALYs lost due to stroke (1842 per 100 000 person-years lived), although the magnitude of this difference reduced substantially. Maredzea *et al* estimated DALYs lost due to stroke in rural South Africa using a prevalence-based method similar to ours.[20] Based on data from the Agincourt cohort in rural South Africa, the authors estimated that 2156 DALYs were lost due to stroke per 100 000 person-years—closer in magnitude to our estimate. Additionally, we found that the contribution of YLD to DALYs in our study was <2% (1.1%), compared with around 25% in the study by Banerjee *et al* and 8.7% in the study by Maredzea *et al*. This indicates that stroke mortality is potentially much higher in Gadchiroli compared with these other contexts. Our results are broadly consistent with a number of studies documenting a high incidence and mortality rate from stroke in specific Indian subpopulations.[8–11 21–24] Similarly, the high burden of stroke in Gadchiroli is consistent with recent nationally representative evidence that finds high levels of stroke mortality in eastern states, such as Chhattisgarh, that are geographically adjacent to Gadchiroli, and have similar levels of development and healthcare services.[9] Lack of access to healthcare and poor prevention and treatment of stroke are the likely important reasons for this pattern. As hypertension is the most important risk factor for stroke,[25 26] undetected, untreated and uncontrolled hypertension could be the driver of stroke in Gadchiroli.

The major strength of our study is the direct estimation of DALYs based on mortality and prevalence data on stroke from a demographic surveillance site. Both the stroke prevalence and mortality data were conducted using validated instruments with rare cause of death data for a large population. Such a method provides estimates that more closely represent actual disease conditions than those obtained using indirect methods. We also used the new methods for DALY estimation recommended by the GBD 2017 study,[1] allowing for a consistent comparison of DALYs due to stroke across populations and time.

The study also has some limitations. We had to estimate the population in 2012 based on census data between 2005 and 2015, potentially leading to inaccurate measures of person-years lived. However, our estimates would only have substantial bias if there was a sudden in-migration or out-migration of individuals into the surveillance site which was not the case based on decadal growth rates. The mortality and prevalence data were from non-overlapping periods. The mortality data were from years 2011–2013 while the prevalence data were obtained in 2014. Therefore, we had to estimate the number of stroke survivors during the 2011–2013 period by applying the 2014 age-specific prevalence rates to the population counts for 2011–2013. However, since the study was conducted in the same population pool, we believe that the difference in the time period is unlikely to significantly affect the estimation of DALYs. We used a single disability weight of 0.07 for stroke disability. While the GBD study group proposes using different disability weights based on the level of disability due to stroke, we believe that given the smaller proportion of YLDs (1.1%) in the DALYs in our study, the method used in this estimation is unlikely to significantly affect the estimation of DALYs. Indeed, our sensitivity analyses reveal that even if all stroke survivors were assigned the most severe stroke disability weight from the 2017 GBD study, the absolute number of DALYs lost only increases slightly and the share of DALYs due YLDs is still <10%.

As brain imaging is not readily available in this region, we could not assess DALYs lost due to ischaemic and haemorrhagic strokes separately. In the Trivandrum stroke registry from the state of Kerala, 82% patients from rural areas had ischaemic stroke while the remainder had haemorrhagic stroke.[10] Relatively recent data from Ludhiana population-based stroke registry from rural Punjab found that 63% of strokes were ischaemic while 36% were haemorrhagic.[27] Patients with stroke from our study are likely to have a proportion of haemorrhagic strokes similar or higher than that reported by the Ludhiana stroke registry given high early mortality in our study area (46% of stroke deaths occurred within first month after onset of stroke symptoms).[8] Our study may not be completely representative of rural India since different rural regions of India might have different access to healthcare – which will affect the overall risk of having a stroke, disability and the mortality due to stroke. Lastly, causes of death were assigned based on verbal autopsies rather than medically certified causes of death. Therefore, there is a chance that stroke deaths were misclassified or missed. However, India does not have a comprehensive vital registration system, so verbal autopsies, which have high sensitivity (≥75%) and specificity (>90%) in diagnosing stroke,[28 29] provide the only source of information on causes of death in resource-poor setting like Gadchiroli.

Our study shows a high, underappreciated burden of stroke in a rural area of India and has important implications for health policy. It also highlights a need to monitor the stroke burden in rural areas of India where very little data are available and people remain vulnerable to preventable mortality. These efforts are essential to track progress towards the Sustainable Development Goals adopted in a United Nations General Assembly in 2015, which calls for a one-third reduction in premature mortality from NCDs by 2030.[30] At a systems level, identifying, testing and scaling different ways of delivering preventive and curative health services for stroke [26] in rural, resource-constrained environments in Gadchiroli and other parts of India will be essential.

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