National Burden Estimates of healthy life lost in India, 2017: an analysis using direct mortality data and indirect disability data

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Summary

Background Many countries, including India, seek locally constructed disease burden estimates comprising mortality and loss of health to aid priority setting for the prevention and treatment of diseases. We created the National Burden Estimates (NBE) to provide transparent and understandable disease burdens at the national and subnational levels, and to identify gaps in knowledge.

Methods To calculate the NBE for India, we combined 2017 UN death totals with national and subnational mortality rates for 2010–17 and causes of death from 211 166 verbal autopsy interviews in the Indian Million Death Study for 2010–14. We calculated years of life lost (YLLs) and years lived with disability (YLDs) for 2017 using published YLD–YLL ratios from WHO Global Health Estimates. We grouped causes of death into 45 groups, including ill-defined deaths, and summed YLLs and YLDs to calculate disability-adjusted life-years (DALYs) for these causes in eight age groups covering rural and urban areas and 21 major states of India.

Findings In 2017, there were about 9.7 million deaths and 486 million DALYs in India. About three quarters of deaths and DALYs occurred in rural areas. More than a third of national DALYs arose from communicable, maternal, perinatal, and nutritional disorders. DALY rates in rural areas were at least twice those of urban areas for perinatal and nutritional conditions, chronic respiratory diseases, diarrhoea, and fever of unknown origin. DALY rates for ischaemic heart disease were greater in urban areas. Injuries caused 11.4% of DALYs nationally. The top 15 conditions that accounted for the most DALYs were mostly those causing mortality (ischaemic heart disease, perinatal conditions, chronic respiratory diseases, diarrhoea, respiratory infections, cancer, stroke, road traffic accidents, tuberculosis, and liver and alcohol-related conditions), with disability mostly due to a few conditions (nutritional deficiencies, neuropsychiatric conditions, and other sensory loss, musculoskeletal disorders, and genitourinary diseases). Every condition that was common in one part of India was uncommon elsewhere, suggesting state-specific priorities for disease control.

Interpretation The NBE method quantifies disease burden using transparent, intuitive, and reproducible methods. It provides a simple, locally operable tool to aid policy makers in priority setting in India and other low-income and middle-income countries. The NBE underlines the need for many more countries to collect nationally representative cause of death data, paired with focused surveys of disability.

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Research in context

Evidence before this study
We searched MEDLINE, Plocine, CAB Global Health, and websites of WHO and the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) using the terms “burden of disease”, “DALY”, “India”, and “causes of death” for national studies in people of all ages in India, from Jan 1, 2010, to March 1, 2019, with no language restrictions. From 795 articles screened, we found that GBD and WHO published modelled annual national estimates of disability-adjusted life-years (DALYs) for more than five diseases in 2013, 2015, 2016, and 2017. Ischaemic heart disease was consistently the leading cause of DALYs in GBD estimates, but the rank of other causes varied by year. It was difficult to separate changes in model specifications from changes in actual disease burdens. We were unable to reproduce the GBD method for burdens in India.

Added value of this study
We have developed and implemented an indigenous, simple, and intuitive method to calculate deaths and disability at national and state levels in India. The National Burden Estimates (NBE) establishes the plausible distribution of the major causes of death and disability across the major states of India. In 2017, there were about 9·7 million deaths and 486 million DALYs in India. Non-communicable diseases comprised 46·6% of national DALYs, but a notably higher 55·0% in urban areas. Injuries comprised 11·4% of DALYs.

The conditions that accounted for the top 15 DALYs were led mainly by deaths in childhood and early adulthood. Together, these conditions accounted more than 70% of total DALYs—a proportion consistent with WHO and GBD results. The remarkable variation in years of life lost across India suggests that diseases common in one part of the country are relatively uncommon elsewhere, for reasons that are not well understood. Five conditions comprise much of the uncertainty in years lived with disability, and should be the focus of future research to derive better disability estimates. The NBE and GBD results for years of life lost and overall DALYs were moderately comparable, and the gaps identified in disability should help to improve future modelling and inform direct surveys of the major conditions causing disability.

Implications of all the available evidence
Much of Indian disease burden is avoidable. The NBE method is simple, locally operable, and widely replicable within India and in many other low-income and middle-income countries to track progress in human health.

to create a measure called National Burden Estimates (NBE), which combines nationally representative cause of death data from the Million Death Study (MDS) with UN demographic totals and WHO estimates of deaths and disability.5–11 We provide details on the methodology to encourage replication in other LMICs.

About a fifth of all deaths worldwide occur in India.10,11 The NBE was created in response to a request from India’s Ministry of Health and Family Welfare to the Indian Council of Medical Research (ICMR) to provide transparent and understandable disease burdens at the national and subnational levels, and to identify gaps in knowledge, particularly from disability.12

Methods

Data sources
To calculate our estimates, we used national-level population and mortality data for 2017 from the UN Population Division10 and state-level population and mortality data for 2010–17 from the Registrar General of India’s Sample Registration System,11,14 a continuous demographic surveillance system that reports state-level vital rates every year. For cause of death data, we used 2010–14 data from the MDS,9 to which we applied the classifications of specific disease groups used in the WHO Global Health Estimates (GHE) for 2016.9 We drew on the average of 2010–14 deaths, which are the latest available, for stability across age groups and cause of death categories.

Full details, including data limitations, of the UN demographic data, the Sample Registration System vital rates, and the WHO GHE have been published elsewhere.9–11 The methods, strengths, and limitations of the MDS and key results for various diseases have also been extensively reviewed and published.14–17 Briefly, in collaboration with the Registrar General of India, the MDS monitored approximately 14 million people in 2·4 million nationally representative households in India from 1998 to 2014.14 About 900 non-medical surveyors recorded the details of each death that occurred in these households during the preceding 6 months using a well validated verbal autopsy instrument, which is based on the 2012 WHO instrument and includes a half-page local language narrative. Each record is converted to an electronic form and randomly assigned to two of 400 trained physicians, who assign a cause according to the International Classification of Diseases, 10th revision (ICD-10). Disagreements in assignment undergo anonymous reconciliation, and persisting differences undergo adjudication by a third physician.

Subnational analyses focused on the 21 major states of India, comprising the 20 most populous states as defined by the Registrar General of India plus seven northeastern states which we grouped as one state.14 We included the recently created state of Telagana within Andhra Pradesh. These 21 states were home to more than 99% of India’s total population in 2017.

Causes of death
We grouped ICD-10 codes into 44 overarching categories (appendix pp 5–7), informed by public health goals, in consultation with ICMR’s Burden of Disease Technical
Advisory Group. These 44 categories were further grouped into three main disease categories: communicable, maternal, perinatal, and nutritional diseases (13 causes); non-communicable diseases (NCDs; 24 causes); and injuries (seven causes). We retained ill-defined deaths as an additional category. By contrast, the GBD realigns ill-defined deaths using unpublished algorithms whereas the GHE redistributes them to a published list of other specific causes. Ill-defined deaths are a check on the quality of a defined deaths using unpublished algorithms whereas the additional category. By contrast, the GBD reassigns ill-injuries (seven causes). We retained ill-defined deaths as non-communicable diseases (NCDs; 24 causes); and estimates, we used the same method, applying the national appendix (p 4).

The NBE method
Calculation of the NBE involves seven steps (figure 1). First, we obtained UN age-specific and sex-specific country population and death counts for 2017 and deaths and population by state and for rural and urban strata for 2010–17. Second, we summed the subnational deaths and adjusted these (usually upwards by small amounts) to match the UN national total for each age and sex stratum.

In the third step, we applied the cause of death proportions from the MDS for 2010–14, weighted by the sampling probability for rural and urban strata for each state, to these adjusted death totals to obtain age-specific and sex-specific numbers of deaths for each cause. We aggregated the death and population totals into eight age groups: 0–4 years, 5–14 years, 15–29 years, 30–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years or older. Fourth, we mapped the MDS classification of ICD-10 codes to the WHO GHE classification for India (appendix pp 5–7). For each condition in the GHE, we derived the years lived with disability (YLDs) and years of life lost (YLLs) and calculated the YLD–YLL ratio for the specified age groups (appendix p 8). The GHE assigns no deaths to major depression; hence, to calculate YLDs for depression, we applied the GHE proportion of YLDs due to depression to the estimated overall YLDs from neuropsychiatric conditions.

Fifth, we calculated the median age at death for each cause from the MDS, subtracted this from the WHO standard life expectancy of 92 years, and multiplied this by the number of deaths from step 3 to obtain YLLs. Thus, the YLLs for cause i for age group j are given by

\[ YLLs_{ij} = (92 - \text{median age at death}_i) \times \text{adjusted UN deaths}_{ij} \]

Sixth, we multiplied the YLLs by the GHE YLD–YLL ratios from step 4 to obtain YLDs. The final step summed YLLs and YLDs to obtain DALYs for each cause by age and sex. A worked example of the calculations for respiratory infection deaths at ages 5–14 years is shown in the appendix (p 4).

For subnational (rural or urban and state-specific) estimates, we used the same method, applying the national median age of deaths and 684 age-specific and sex-specific YLD–YLL ratios. We summed state-level vital rates to national totals in step 2, and applied the state-specific proportion of deaths in step 3. We compared state variation in DALY, YLL, and YLD rates after standardising for age using the World Standard Population 2000–25.

Statistical analysis
We applied chance-corrected mortality fraction accuracy to calculate the population-level concordance between the NBE and GBD, taking into account chance agreement. 100% concordance would mean identical cause of death distribution in the two comparisons. The major source of uncertainty in the NBE does not arise from random errors: the sample size for the MDS is very large and completeness of the sources of vital rates is high, as evaluated independently by the UN. Rather, uncertainty arises mostly from the misclassification of causes of death. The appendix (p 114) presents the uncertainty bounds based on dual or single physician agreement on the underlying cause of death. We used Stata version 15.1 for statistical analyses. The ICMR has developed a user-friendly estimation and visualisation tool. The Stata code and tools are available on written request to the first author.

Role of the funding source
The sponsors of the study had no role in the study design, data collection, or data interpretation. The corresponding authors had full access to the study data and had final responsibility for the decision to submit for publication.
In 2017, India had about 9·7 million deaths and 486 million DALYs, so the ratio of DALYs to deaths was about 50 to one (table). More than three quarters of deaths and DALYs occurred in rural areas, and males accounted for 54·3% of all DALYs. At all ages, the DALY rate per 100,000 population was 36·30, but rates were higher among rural residents and among males (table). DALY rates in rural areas were at least twice those of urban areas for perinatal and nutritional conditions, chronic respiratory diseases, diarrhoea, and fever of unknown origin. By contrast, DALY rates for ischaemic heart disease were considerably greater in urban areas (table). DALY rates showed a U-shaped relationship with age, starting high at ages 0–4 years, dropping to their lowest among children aged 5–14 years, and rising again to highest levels at 70–79 years. 35·7% of total national DALYs arose from communicable, maternal, perinatal, and nutritional causes, and this proportion was greater among females and rural residents (appendix pp 89–90). NCDs comprised 46·6% of DALYs overall, which increased to 55·0% in urban areas. Injuries comprised 11·4% of DALYs. Ill-defined causes comprised 3·3% of all DALYs before age 70 years but a higher proportion (27·9%) above age 70 years (appendix pp 89, 113). NCD and injury DALY rates were higher in males than females (table).

The top 15 conditions that accounted for the most DALYs at all ages arose mostly from YLLs—namely, ischaemic heart disease (9·6% of all DALYs), perinatal conditions (8·5%), chronic respiratory diseases (5·7%), diarrhoea (4·7%), respiratory infections (4·5%), cancer (4·0%), stroke (3·6%), road traffic injuries (3·3%), tuberculosis (3·1%), and liver and alcohol-related conditions (3·0%). DALYs for five conditions arose mostly from YLDs as opposed to YLLs: neuropsychiatric conditions including epilepsy (6·2% of all DALYs), nutritional deficiencies (6·0%), vision and other sensory loss (4·5%), musculoskeletal disorders (2·7%), and genitourinary diseases excluding renal failure (0·8%).

More than 70% of DALYs at all ages resulted from YLLs (346 million of 486 million years; figure 2), with YLLs dominating DALYS among the communicable, perinatal, maternal, and nutritional disorders and among injuries. By contrast, YLDs constituted 86·8% of DALYS for nutritional deficiencies. YLLs also dominated most of the NCDs, including all cancers and vascular and respiratory diseases. Among the NCDs, YLDs contributed more than DALYS for four conditions: genitourinary diseases excluding renal failure (0·8%), ischaemic heart disease (9·6%), chronic respiratory diseases, diarrhoea, and fever of unknown origin. By contrast, DALY rates for ischaemic heart disease were considerably greater in urban areas (table). DALY rates showed a U-shaped relationship with age, starting high at ages 0–4 years, dropping to their lowest among children aged 5–14 years, and rising again to highest levels at 70–79 years. 35·7% of total national DALYs arose from communicable, maternal, perinatal, and nutritional causes, and this proportion was greater among females and rural residents (appendix pp 89–90). NCDs comprised 46·6% of DALYs overall, which increased to 55·0% in urban areas. Injuries comprised 11·4% of DALYs. Ill-defined causes comprised 3·3% of all DALYs before age 70 years but a higher proportion (27·9%) above age 70 years (appendix pp 89, 113). NCD and injury DALY rates were higher in males than females (table).

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YLLs continued to dominate DALYS when we restricted analyses to below age 70 years, and for ages 30–69 years.

Results
We analysed 211,166 deaths from 2010 to 2014 in the MDS covering the whole of India (table). The full results for deaths, DALYS, YLLs, and YLDs by sex and age for each major state, and for rural and urban areas nationally, are provided in the appendix (pp 9–112). For ease of understanding, we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE tables, the only difference being that we present these results in formats identical to WHO GHE
(corresponding to the ages for the UN Sustainable Development Goals for NCDs; appendix p 117), and ages 15–59 years (corresponding to the ages in the current World Bank Human Capital Index,22 appendix p 118).

We observed a clear geographical distribution across states of YLLs and YLDs (appendix pp 11–14). We present differences in the age-standardised YLL rates per 100,000 population across the major states for selected causes that showed marked variation across states (figures 3, 4); we included smaller states and Union Territories in separate analyses of all remaining states (appendix pp 89–112). We defined the levels of each of the chosen diseases separately to highlight differences. Each is shown in descending order of YLL rates. Nearly every condition that is common in one state was far less common in another state, and hence must be mostly avoidable.

Among the infectious diseases, tuberculosis YLL rates were much higher in the north, particularly in Uttar Pradesh and Rajasthan, than in southern India (figure 3). Respiratory infection YLL rates were high in the northern and northeastern states. By contrast, diarrhoea YLL rates showed an east–west gradient, being much higher in Odisha, Jharkhand, Bihar, and Uttar Pradesh, and comparatively lower in western India. The high-burden states accounted for 52% of the absolute national total YLLs for tuberculosis, 41% for respiratory infections, and 15% for diarrhoea (figure 3).

Among NCDs, cancer YLLs were particularly high in northeastern states, Uttar Pradesh, Rajasthan, West Bengal, Haryana, Assam, Gujrat and Madhya Pradesh, and in the southern states of Kerala and Karnataka (figure 4), but the YLLs from specific causes of cancer varied even within those states with high cancer burden;21 these high-burden states accounted for 44% of national YLLs from cancer. Chronic respiratory YLL rates were high in Rajasthan and Uttar Pradesh, accounting together for 7% of national YLL totals. Liver and alcohol-related YLL rates were high in the northeastern states, Assam, Bihar, Karnataka, and Maharashtra, accounting for 18% of national YLLs. Suicide YLL rates were highest in the southern states, accounting for 15% of national totals.21 Road traffic injuries were high in the northern states of Uttar Pradesh, Punjab, Uttarakhand, Haryana and Himachal Pradesh, accounting for 33% of national totals. Drowning YLL rates were highest in the central states of Madhya Pradesh and Chhattisgarh and in Assam in the northeast, accounting for 11% of national totals.

GBD estimates, which we derived from GBD data,1 and NBE DALY results correlated moderately (figure 5). Compared with the NBE, GBD underestimated absolute totals of nutritional conditions for males, overestimated most NCDs for both sexes, and, surprisingly, underestimated road traffic injury deaths among males. There were differences in both directions for specific conditions, with some overestimates and some underestimates when comparing NBE and GBD estimates. The contribution of YLDs to overall DALYs in the NBE is similar to that in the GHE and GBD, at around 30% (appendix p 116). The most notable discrepancies between NBE, GHE, and GBD were for YLDs for just a few conditions (appendix pp 115–116).

There is no reference standard for disability, only the modelled estimates from the GBD, which WHO also uses.26 We examined our NBE estimates of major depression, which causes much disability but little mortality. At ages 30–59 years, major depression caused 4·1 million YLDs, approximately 40% of all YLDs attributable to neuropsychiatric conditions. Based on GBD median disability weights,26 this would constitute about 10 million people in India with prevalent depression. This prevalence is close to the estimate of 13 million adults of these ages reporting major depression in a recent multisite survey of mental health.27

If we take NBE to be the comparison standard, the GBD yields similar YLD rates for vision loss, underestimates YLD rates for nutritional and other genitourinary diseases, and overestimates YLD rates for neuropsychiatric conditions and musculoskeletal disorders. Had we substituted our NBE rates with the GBD rates, then the total from these conditions would have been 96 million YLDs versus 87 million YLDs in the NBE. This change would add less than 2% to total DALYs.
Discussion
We have developed and implemented an indigenous, transparent, and reproducible method to calculate deaths and disability at national and state levels in India, using a combination of the UN mortality totals for India,\textsuperscript{11} disability–mortality ratios published by WHO for many years,\textsuperscript{12} and, most importantly, nationally representative cause of death data from the MDS.\textsuperscript{14–18} The NBE establishes the plausible distribution of the major causes of death and disability across the major states of India, showing that the largest burdens of disease occur in rural areas, especially from communicable, maternal, perinatal, and nutritional causes, and a large burden of NCDs exists in urban areas. Importantly, premature deaths, expressed as YLLs, account for more than 70% of the total DALYs.

The MDS mortality data have been incorporated recently into GBD analyses, but GBD data and the modelling techniques are not in the public domain and hence have not been reproduced in other studies. Unsurprisingly, this has led to discrepant results between GBD and country-led estimates, even for high-income countries with complete mortality data.\textsuperscript{26–28} In India, for example, the availability of MDS data from 2001 onwards should have decreased GBD’s reliance on modelled inputs. However, it is not possible to determine how these data were used because changes in model specifications and variable data inputs are not public,\textsuperscript{7,9,29} leading to an inability to understand trends or to compare them with estimates using other methods, such as NBE. For example, in the GBD estimates for India, premature birth ranked as the second leading cause of death at all ages in 2015 but seventh in 2016 and fifth in 2017.\textsuperscript{6}

The NBE method avoids so-called black boxes of complex econometric models that have uncertain validity,\textsuperscript{7} even for countries with high-quality mortality data.\textsuperscript{27,28} The NBE will allow the Indian Government to reliably monitor progress in the major states, including the impact on mortality of the new Ayushman Bharat national health insurance programme intended to cover about 500 million Indians.\textsuperscript{30}

We observed remarkable variation in YLLs across India, showing that each disease that is common in one part of the country is relatively uncommon elsewhere. This disease variation contributes particularly to marked differences in adult mortality, where differences in life expectancy between districts can exceed a full decade.\textsuperscript{11} This variation in disease rates across India indicates the existence of differences in underlying social, behavioural, or biological risk factors, suggesting important avoidable causes that await discovery. Much more remains to be understood about the novel genomic, proteomic, and other biochemical

![Tuberculosis (375,000 deaths)](image)

![Respiratory infections (342,000 deaths)](image)

![Diarrhoea (519,000 deaths)](image)

Figure 3: Variation in YLLs using age-standardised rates for selected communicable causes of death across the major states of India, 2017

Northeastern states include Tripura, Meghalaya, Manipur, Nagaland, Arunachal Pradesh, Mizoram, and Sikkim. YLLs—years of life lost. AP—Andhra Pradesh. AS=Assam. BR=Bihar. CG=Chhattisgarh. DL=Delhi. GJ=Gujarat. HP=Himachal Pradesh. HR=Haryana. JH=Jharkhand. JK=Jammu and Kashmir. KA=Karnataka. KL=Kerala. MH=Maharashtra. MP=Madhya Pradesh. OD=Odisha. PB=Punjab. RJ=Rajasthan. TN=Tamil Nadu. UK=Uttarakhand. UP=Uttar Pradesh. WB=West Bengal.
Figure 4: Variation in YLLs using age-standardised rates for selected non-communicable diseases and injuries across the major states of India, 2017.

Northeastern states include Tripura, Meghalaya, Manipur, Nagaland, Arunachal Pradesh, Mizoram, and Sikkim.

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Cancers (544 000 deaths)

Chronic respiratory (833 000 deaths)

Liver and alcohol related (273 000 deaths)

Suicide (199 000 deaths)

Road traffic injuries (275 000 deaths)

Drowning (62 000 deaths)
To calculate concordance in cause of death distribution between NBE and GBD, we excluded the causes of unknown origin and ill-defined or cause unknown due to the lack of comparable categories between the NBE and GBD. DALYs—disability-adjusted life years. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study. NBE=National Burden Estimates. PC=population-level concordance. ARI=respiratory infections. DRH=diphtheria. HEP=hepatitis. INF=other infectious and parasitic. MAL=malaria. MAT=maternal. MEN=meningitis and encephalitis. NUTR=nutritional deficiencies. PERI=perinatal conditions. SUI=suicide. STR=stroke. DRO=drowning. FALL=falls. INJ=all other injuries. MSK=musculoskeletal disorders. NEU=neuropsychiatric conditions. REN=renal failure. RHD=rheumatic heart diseases. GTU=genitourinary diseases. IHD=ischaemic heart disease. L&A=liver and alcohol-related conditions. DIA=diabetes and other endocrine. DIG=digestive. EPI=epilepsy. GTO=gastro-oesophageal diseases. GTO=genitourinary diseases. IHD=ischaemic heart disease. L&A=liver and alcohol-related conditions. MSK=musculoskeletal disorders. NEU=neuropsychiatric conditions. REN=renal failure. RHD=rheumatic heart diseases. SENS=vision and other sensory loss. STR=stroke. DRO=drowning. FALL=falls. INJ=all other injuries. IPV=interpersonal violence. RTI=road traffic injuries. SUI=suicide. VEN=venomous deaths.

YLLs alone can be a robust measure to monitor disease burden, particularly trends over time. Indeed, the inconsistent results between NBE and GBD for disability point to measurement error in disability. This error often exceeds any change in health outcomes that governments might want to monitor. For example, in seeking a 10% annual improvement in health outcomes in children, it is not possible to assess accurately the outcome of a child health programme if the measurement error exceeds 10%. As death is a discernible, objective outcome, focusing analyses of trends on mortality should reduce measurement error and allow reliable monitoring of the impact of disease control programmes. An argument can be made that rather than a composite metric such as DALYs, priority setting could focus on the major causes of mortality for children and adolescents (eg, age ≤19 years) and for adults in middle and older age, and separately consider the major causes of disability at all ages. This would have the specific benefit of tying better survey methods to each of these three outcomes.

Nonetheless, governments commonly demand some reasonable measurement of disability. Most of the GBD and GHE disability data use disability weights that relate a preference of disability relative to mortality, and then apply these to estimated incidence and duration for various diseases. These disability weights come from a multicountry (including India) but non-representative household survey that asked 18–65 year olds to self-report their health states. Aside from the obvious biases in household survey that asked 18–65 year olds to self-report their health states, there are other limitations to such disability surveys should accompany expanded cause of death studies. This error exceeds 10%. As death is a discernible, objective outcome, focusing analyses of trends on mortality should reduce measurement error and allow reliable monitoring of the impact of disease control programmes.

Despite the obvious biases in household survey that asked 18–65 year olds to self-report their health states, there are other limitations to such disability surveys should accompany expanded cause of death studies.

**Figure 5:** Comparison of the absolute total of DALYs in India in the GBD model-based estimates to the NBE by condition, 2017

To calculate concordance in cause of death distribution between NBE and GBD, we excluded the causes of unknown origin and ill-defined or cause unknown due to the lack of comparable categories between the NBE and GBD. DALYs—disability-adjusted life years. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study. NBE=National Burden Estimates. PC=population-level concordance. ARI=respiratory infections. DRH=diphtheria. HEP=hepatitis. INF=other infectious and parasitic. MAL=malaria. MAT=maternal. MEN=meningitis and encephalitis. NUTR=nutritional deficiencies. PERI=perinatal conditions. SUI=suicide. STR=stroke. DRO=drowning. FALL=falls. INJ=all other injuries. MSK=musculoskeletal disorders. NEU=neuropsychiatric conditions. REN=renal failure. RHD=rheumatic heart diseases. GTU=genitourinary diseases. IHD=ischaemic heart disease. L&A=liver and alcohol-related conditions. MSK=musculoskeletal disorders. NEU=neuropsychiatric conditions. REN=renal failure. RHD=rheumatic heart diseases. SENS=vision and other sensory loss. STR=stroke. DRO=drowning. FALL=falls. INJ=all other injuries. IPV=interpersonal violence. RTI=road traffic injuries. SUI=suicide. VEN=venomous deaths.
Our results are subject to uncertainties in the key demographic inputs, such as the age-specific totals of deaths. The Indian census and Sample Registration System data provide a reasonably robust time series of death rates by age, sex, and location, and we grouped results for 5 years to reduce temporal fluctuations. We used 2010–14 cause of death rates, the latest available, applied to 2017 UN death totals, probably resulting in modest overestimates of the rapidly declining burden of some childhood and infectious conditions.15,16,20 Moreover, autopsies, and generally low rates of misclassification in reproducibility of the dual physician-coded verbal autopsies, and generally low rates of misclassification in children and young and middle-age adults.15,16,20 Moreover, the uncertainty in diagnosis on verbal autopsy is not likely to affect the relative ranking of diseases.

The NBE method is replicable in other LMICs, as well as in the districts of India. A benefit of the method is that it draws mostly on well established and respected WHO and UN demographic inputs, which are available widely.21 Although GBD estimates for India have drawn on MDS data in recent years, this is not the case for many other countries as they do not have nationally representative cause of death data.7,29 Earlier assessments in Africa have found GBD results to be more plausible when local cause of death data were available.4 As an interim solution, LMICs without nationally representative cause of death data could use results from similar settings (such as Mozambique’s 2007 post-census mortality survey77 in Africa, or from the MDS in Asia). Another option is to use pooled regional cause of death data from the INDEPTH network, despite these not being nationally representative.4 However, the main priority for countries is to implement nationwide representative mortality studies.7,15,20 Well validated cause of death data will decrease reliance on modelled data and improve burden estimates.38

Decentralised and improved burden estimates would complement the expanding use of local cost-effectiveness and poverty analyses.1 The NBE could help countries to address data and reporting needs relevant to the WHO and UN goals for universal health coverage. Countries require open-source, locally operable, transparent, and believable data paired with simple, transparent and reproducible tools to track progress towards the 2030 UN Sustainable Development Goals.1,15,39

Contributors
GRM and PJ conceived the idea for the study and developed the study design. GRM, SAF, PS, PY, LW, and WS contributed to the data analysis. SAF and GRM did the literature review. GRM and PJ wrote the initial draft, and all authors were involved in commenting on subsequent revisions.

Declaration of interests
We declare no competing interests.

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