Study on mortality and causes of death epidemiology in India and its states

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ABSTRACT

INTRODUCTION The study comprehensively examines and estimates India's mortality rates by investigating their cause of death (COD) according to the sociodemographic factors in India and its states.

METHODS This study is cross-sectional, drawing data from the Longitudinal Ageing Study in India (LASI, 2017–2018). Examining mortality and the cause of death (COD) in conjunction with various sociodemographic factors, unveils a nuanced understanding of this multifaceted landscape. To analyze the data, we have applied cross-tabulation and used chi-squared tests to check associations with significance set at $p<0.05$.

RESULTS On a national scale, the mortality rate surged to 7.7 per 1000 population in 2017–2018, exhibiting a notable escalation with advancing age. Across different states, great variation in the mortality rate prevails, ranging from 3 to 10 per 1000 population, with Himachal Pradesh recording the highest and Meghalaya the lowest rates. There has been a notable rise in mortality among older adults and the elderly. These regional disparities are mirrored in gender and geographical differentials, with males (8.8 per 1000 population) and rural areas (8 per 1000 population) reporting higher overall mortality rates compared to females (6.6 per 1000 population) and urban-regions (6.8 per 1000 population). The study shows the dominance of non-communicable diseases (NCDs) as the primary cause of death, accounting for a substantial 40% of mortality cases. Following closely are causes related to Senility (26%) and communicable, maternal, perinatal, and nutritional (CMPN) factors (15%). Noteworthy is the prevalence of NCD-related fatalities in urban settings (46%), contrasting with CMPN-related deaths, which are more pronounced in the younger age group.

CONCLUSIONS This analysis underscores the imperative for targeted healthcare interventions, given the pronounced regional and sociodemographic differentials. By shedding light on the prevalence of NCDs and other leading causes of deaths, it provides a roadmap for tailored public health policies aimed at mitigating mortality risks and enhancing overall health outcomes across India's diverse sociodemographic landscape.

INTRODUCTION

The 21st century has ushered in remarkable health transition trends characterized by significant shifts in fertility, mortality, morbidity, and overall health outcomes. Regions worldwide have experienced notable increases in life expectancy across all age groups. This era has seen unprecedented demographic changes, with most regions and nations undergoing rapid transformations[1]. One of the most striking global phenomena has been the substantial growth in the human population, with over four billion individuals added since 1950[2]. Global advancements in mortality over the last five decades have been uneven among countries. While there were initial signs of life expectancy convergence, recent years have seen a divergence in life spans worldwide[3]. This indicates a setback in efforts to narrow mortality gaps between different populations. The epidemiological transition, marked by a shift from infectious or communicable diseases (CD) to non-communicable diseases (NCDs), has led to improved mortality rates across all age groups, consequently delaying the age at which death occurs[4]. Concurrently, as a consequence of demographic and epidemiological transitions over the long-term, there

has been a decline in the frequency of births and deaths per family, accompanied by changes in morbidity patterns. These changes have been observed not only in developed nations but also progressively in developing countries[1].

Global mortality estimates are instrumental in assessing disease burden and risk factors worldwide, aiding policy decisions by international agencies, research groups, and governments. However, their utility in informing local decisions is limited due to the heterogeneous nature of morbidity and mortality patterns, both across regions globally and within individual countries. In order to address such events, there is a critical need to bolster the quality, availability, analysis, and utilization of local data and statistics. By strengthening local data infrastructure and analysis capabilities, countries can tailor health policies and interventions to their specific needs, ensuring efficient resource allocation and maximizing impact at the community level[5]. While mortality data in most developed and developing countries have been reliably collated, a significant challenge lies in the completeness and reliability of data regarding the cause of death[6]. Disparities in the coverage of civil death registration and cause documentation are stark, ranging from nearly 100% in the World Health Organization (WHO) European Region, to <10% in the WHO African Region[7]. This discrepancy underscores the on-going need for accurate and comprehensive statistics on mortality and causes of death, which are indispensable for informing the efficient accomplishment of programs and policies aimed at providing proper services to communities. Reliable information on causes of death is essential for designing targeted interventions and allocating resources effectively to address health challenges and improve outcomes across diverse populations of country.

India is the most populous country in the world, with more than 1.42 billion people[8]. There is always a challenge to collect reliable data and implement programs and policies. Many of India's states have a greater population than most European and American countries. Indian states have not only huge populations but also heterogeneity at various levels of caste, religion, culture, geographical region, socioeconomic factors, etc. India has >2000 cultural and religious groups and diverse lifestyles[9]. With the on-going demographic and epidemiological transition, India is also experiencing structural changes in the morbidity patterns and causes of death remarkably. After independence and up to the 1980s period, India was overwhelmed with the burden of infectious and parasitic diseases. However, since 1990, chronic diseases (NCDs) have been dominating the burden of communicable diseases. An existing study by Visaria[10] brought to light the situation of the dual burden of diseases in India. It revealed that the mortality trend of infectious diseases from 1969 to 1995 declined from 47% to 22%, and the share of NCDs increased from 35% to 55%[10].

With the aim of comparison, the insufficient longitudinal data for the study of epidemiological transition has received less attention to appropriately understand the significant shift of morbidity and mortality[11]. India has a government-led Civil Registration System (CRS) and Medical Certification of Causes of Death (MCCD) since 1969, mostly used as reliable data[12]; however, the problem is incompleteness at the national and sub-national levels. In recent years, India has increased the CRS deaths from 67% in 2010 to 92% in 2019, a significant increase, whereas India has not witnessed a substantial increase in the MCCD, which has increased from 17% in 2010 to only 21% in 2019[13,14].

The challenges highlighted in the previous sources of vital and COD data in India regard completeness, with data predominantly available only at the macro level, often limited to state or broader levels[13,14]. This poses a significant concern for policymakers who require more detailed insights into specific segments of the population that may be more vulnerable to certain health issues. Vital statistics or other sources often lack the ability to provide sociodemographic covariates for these population subsets, thus hindering the acquisition of crucial statistics necessary for informed decision-making and targeted strategy implementation. The dearth of comprehensive data poses a challenge in locating focused literature on existing studies. By acknowledging this gap, nevertheless, beyond the CRS and MCCD reports, there is a household survey such as the Longitudinal Aging Study in India (LASI). The LASI household data provide information on household deaths and the COD, according to the background covariates in India. Therefore, our study aims to estimate and understand the death rates and the COD distribution in India and its states, and to explore the sociodemographic determinants.

METHODS

According to the available data sources, the present study utilized secondary data from the first wave of the Longitudinal Aging Study in India (LASI, 2017–2018). In the LASI survey, information on various sociodemographic covariates of all individuals in 66613 households was collated at the household roster level, and further health and other information was collated for the individual (73396), aged ≥45 years, from the same household. The LASI is the only health and demographic survey that comprehensively provides the number of deaths in households and the COD in India. Data provide information on the number of deaths in the past two years from the date of the interview in the respondents' households with COD in the roster data. Over 4400 individual deaths were reported, with causes utilized for the study considered as the numerator. To obtain the denominator sample population (304487), roster household data were replicated according to the household size.

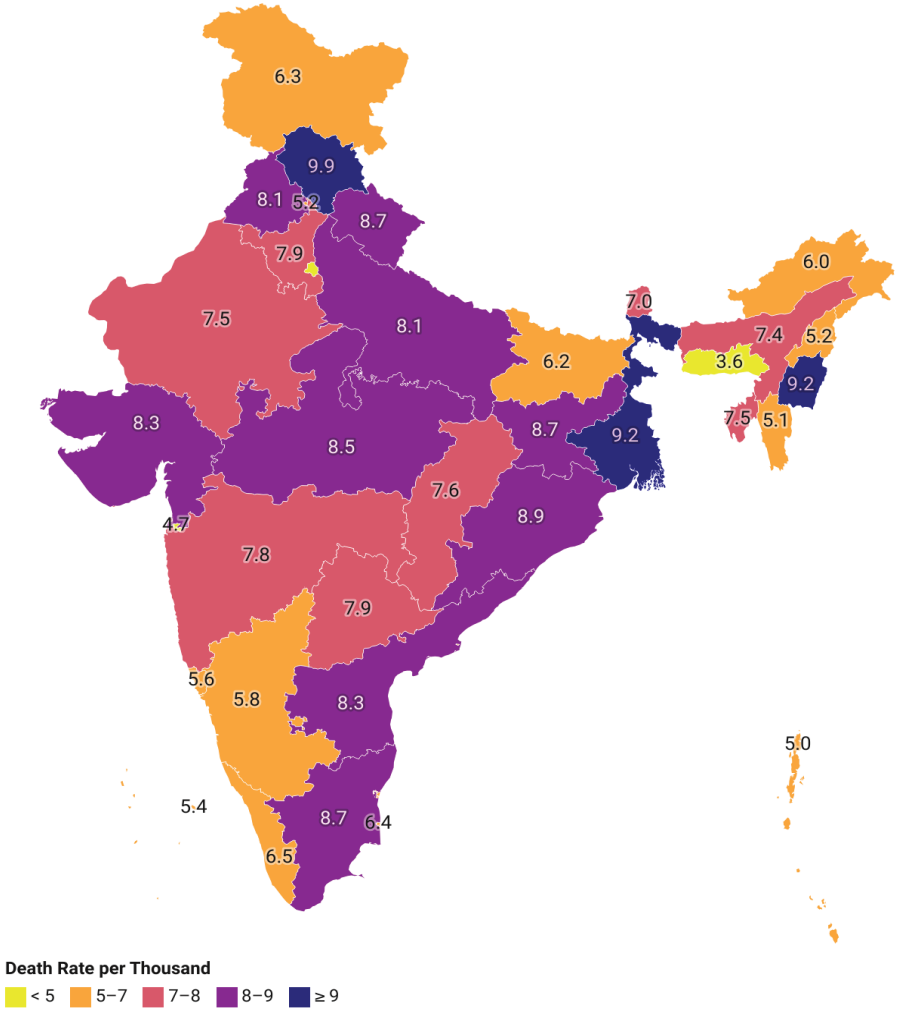
Variables

The present study has two important study variables: death rate and share of COD among all deaths. The death rate was defined as the number of deaths per 1000 population among

all sample household individuals in India. After estimating the death rate for the last two years, the final death rate for the period 2017–2018 is considered half of the estimated death rate because the deaths were considered over the last two years. Furthermore, another interesting variable is the cause of death (COD) share among all reported deaths in households. There were a number of major causes of death (verbally reported) such as senility (related to old age), ill-defined/all other symptoms, cardiovascular diseases (CVDs), cancer, chronic respiratory diseases, diabetes mellitus, other NCDs, other infectious and parasitic diseases, tuberculosis, fever of unknown origin, genitourinary diseases, diarrheal diseases, malaria, diseases of the digestive system, neuropsychiatric conditions, injuries unintentional and intentional, respiratory infections, maternal conditions, neonatal deaths, nutritional deficiencies, musculoskeletal diseases, congenital anomalies, and HIV/AIDS etc. The multiple causes of death were categorized into five major disease streams: Communicable; Maternal, Perinatal and Nutritional (CMPN); Non-Communicable Diseases (NCDS); Injuries; Symptoms, Signs & Ill-Defined Condition (SSIDC); And Aenility (Related to Old Age).

The study also includes other sociodemographic and geographical explanatory covariates. Data on age at death were grouped into: newborn to young ages (0–14 years), youth to middle-aged adults (15–59 years), older adults (60–74 years), and oldest adults (≥75 years). Sex and residence have binary responses, male or female, and rural or urban, respectively. Socially representative Caste/Tribe attributes are separated into three categories: Caste (OBC/SC), Scheduled Tribe (ST), and other (no caste/no tribe). There are four sets of religions categorized: Hindu, Muslim, Christian, and Other. Lastly, six geographical regions, namely, the East, North-East, West, Central, North, and South, were considered. All Indian

Figure 1. Death rate (%) per 1000 population, across the states of India, LASI 2017–2018



CDR is estimated based on the dead person's information from the past two years of household data.

Map: Authors • Source: LASI • Created with Datawrapper

Table 1. Estimated death rate (%) per 1000 population according to age across the states of India, 2017–2018

State	0–14	15–59	60–74	≥75 years	All	95% CI		Sample
						Lower	Upper	
Andaman and Nicobar	2.4	1.9	23.1	35.9	5.0	3.5	6.4	4460
Andhra Pradesh	4.2	4.4	26.0	59.6	8.3	7.0	9.7	8604
Arunachal Pradesh	4.7	3.4	16.7	119.6	6.0	4.5	7.4	5132
Assam	1.5	4.6	25.7	93.3	7.4	6.2	8.6	10127
Bihar	2.7	3.1	15.3	81.1	6.2	5.4	7.0	17482
Chandigarh	2.7	2.8	17.8	37.0	5.2	3.8	6.7	4810
Chhattisgarh	2.8	3.7	26.8	120.3	7.6	6.3	8.8	8907
Dadra and Nagar Haveli	1.9	2.3	24.7	58.4	4.7	3.4	5.8	5899
Daman and Diu	4.2	5.5	18.7	36.8	7.4	5.7	9.0	4858
Delhi	2.0	1.7	35.4	56.3	4.9	3.7	6.1	6082
Goa	0.0	1.4	26.2	46.2	5.6	4.1	7.0	5132
Gujarat	3.9	3.1	29.0	81.8	8.3	7.1	9.5	10690
Haryana	2.9	4.5	25.3	78.6	7.9	6.6	9.1	9425
Himachal Pradesh	1.4	3.5	30.0	86.7	9.9	7.9	11.7	5134
Jammu and Kashmir	0.1	2.3	28.6	74.2	6.3	5.0	7.5	7816
Jharkhand	2.1	6.5	18.9	100.5	8.7	7.5	9.9	11320
Karnataka	6.9	1.9	22.4	27.2	5.8	4.7	6.9	9291
Kerala	0.6	3.4	15.9	48.9	6.5	5.3	7.8	7774
Lakshadweep	0.9	2.2	15.3	118.2	5.4	4.0	6.9	4870
Madhya Pradesh	3.7	3.3	26.8	89.8	8.5	7.4	9.6	13205
Maharashtra	1.9	2.8	25.8	77.3	7.8	6.8	8.8	15226
Manipur	4.7	4.6	22.7	71.9	9.2	7.4	11.0	5314
Meghalaya	1.2	2.9	8.8	57.6	3.6	2.5	4.7	5976
Mizoram	1.5	2.5	22.2	53.4	5.1	3.8	6.3	5821
Nagaland	1.7	1.2	6.3	81.0	5.2	3.7	6.7	4438
Odisha	3.0	4.2	19.3	102.3	8.9	7.5	10.2	9418
Pondicherry	2.5	2.7	19.1	53.9	6.4	4.8	8.0	4577
Punjab	6.1	4.4	18.9	58.5	8.1	6.7	9.4	8508
Rajasthan	3.3	2.7	27.0	91.5	7.5	6.4	8.6	10881
Sikkim	9.1	1.5	19.0	67.3	7.0	5.2	8.7	4335
Tamil Nadu	3.8	2.8	27.8	67.1	8.7	7.5	9.9	11360
Telangana	1.3	4.8	25.5	63.4	7.9	6.6	9.1	8905
Tripura	1.8	3.2	27.6	76.6	7.5	5.7	9.3	4346
Uttar Pradesh	3.8	4.1	30.5	93.3	8.1	7.3	8.9	25247
Uttarakhand	2.0	3.4	28.4	118.2	8.7	7.0	10.3	5788
West Bengal	1.7	4.3	30.7	87.4	9.2	8.0	10.3	13329
India	3.3	3.4	25.2	75.0	7.7	7.4	7.9	304487

Death rate estimated using information from LASI household data based on deaths in the past 2 years.

states were used for the state-level analysis.

Using the aforementioned variables, we explored sociodemographic determinants for mortality patterns and COD according to the major categories of diseases, which were unable to be estimated using CRS or MCCD reported macro data even at the India level. Therefore, the present study first estimated the death rate and share of COD due to different causes such as CMPN, NCDs, injuries, SSIDC and senility at the national and sub-national levels in India. Moreover, we have examined basic determinants such as age, sex, residence, caste, religion, and region for death rate and COD stratification.

Statistical analysis

We used cross-tabulation for descriptive statistics, and to check associations we used the chi-squared test with 5% level of significance ($p<0.05$). The statistical analyses were performed using STATA 15.0 software.

RESULTS

Figure 1 and Table 1 illustrate the estimated mortality rates across Indian states categorized by overall and age groups. At the national level, the death rate stands at 7.7 per 1000 population, showing a significant increase from 3.2 in the young age group (0–14 years), 3.4 in the working middle-aged group (15–59 years), 25.2 in older adults (60–74 years), to nearly 75 per 1000 population in the oldest age group (≥75 years) in India, 2017–2018. Figure 1 reveals a range of death rates from 3 to 10 per 1000 population across the states. The highest death rate was reported in Himachal Pradesh (9.9), followed by Manipur, West Bengal, Odisha, etc. However, the lowest was reported in Meghalaya (3.6), Dadara Nagar Haveli, Delhi and others.

The mortality rates varied significantly across different age groups and states. At the state level, the age pattern of the death rate showed almost a 'J' shape. In the early stages of life (0–14), Sikkim reported the highest death rate at 9 per 1000 population, followed by Karnataka at 7 and Punjab at 6. For the middle-aged (15–69 years), Jharkhand had the highest mortality rate, reaching 6.5. As age advanced, the mortality rate surged notably among older adults (60–74 years) and the elderly (≥75years) across all states, compared to the younger age groups. Delhi recorded the highest mortality rate in those aged 60–74 years, with 35 deaths per 1000 population, while Chhattisgarh had 120 deaths per 1000 population in those aged ≥75 years.

Furthermore, the variability in mortality patterns per 1000 population, as delineated by sociodemographic factors, is illustrated in Table 2. The data indicate significant disparities, with a notable contrast in death rates between males (8.8) and females (6.6) per 1000 population in 2017–2018. Similarly, substantial differences are evident between rural (8) and urban (6.8) areas. Analysis by caste reveals slightly higher mortality rates among OBC/SC or ST communities compared to the general category. Moreover, significant variations are observed across religious groups, with Hindu (8), Christian (7), and Muslim (6) populations displaying distinct mortality rates. Geographically, the mortality pattern varies across regions, with Central, West, and East regions exhibiting rates of 8 per 1000 population, followed by the North (7.4) and North-East and South (7) regions.

Figure 2 demonstrates an overview of the distribution of various causes of death at national levels. NCDs, CVDs,

Table 2. Estimated death rate (%) per 1000 population across sociodemographic characteristics, 2017–2018

Characteristics	Death rate	95% CI		Sample
		Lower	Upper	
Age (years)***				
0–14	3.3	3.0	3.5	80535
15–59	3.4	3.2	3.6	186622
60–74	25.2	23.9	26.4	29883
≥75	75.0	70.9	79.0	7401
Sex* **				
Male	8.8	8.5	9.1	152801
Female	6.6	6.3	6.8	151648
Place of residence* **				
Rural	8.1	7.8	8.4	195807
Urban	6.8	6.4	7.1	108680
Caste/tribe**				
Caste (OBC/SC)	7.6	7.3	7.8	251573
Tribe (ST)	7.6	7.0	8.2	41227
No caste/tribe	6.6	5.5	7.7	10072
Religion* **				
Hindu	8.1	7.8	8.3	214672
Muslim	5.8	5.3	6.3	45080
Christian	7.0	6.3	7.7	30003
Other	7.6	6.6	8.6	14732
Region* **				
East	7.9	7.3	8.4	51549
North-East	7.0	6.4	7.5	45489
West	7.9	7.3	8.5	41805
Central	8.2	7.6	8.7	47359
North	7.4	6.9	7.8	58444
South	7.1	6.6	7.5	59841
India	7.7	7.4	7.9	304487

Chi-squared significance: *p<0.05, **p<0.01, ***p<0.001.

diabetes, cancer and other NCDs constitute the largest share, accounting for approximately 40% of all deaths. CVDs alone contributed 11% of the COD share. Following closely are deaths attributed to old age-related conditions, specifically senility, comprising 26% of the total. Communicable, maternal, perinatal, and nutritional (CMPN) causes account for 15% of deaths, symptoms, signs & ill-defined conditions (SSIDC) around 12%, and injuries (intentional and unintentional) contribute approximately 8% of total deaths.

Table 3 presents the state level; the prevalence of major COD, CMPN is most pronounced in Karnataka (30%), followed by Uttar Pradesh (24%), Bihar (22%), Nagaland, Telangana, and Madhya Pradesh, and other states. Similarly, the incidence of NCD fatalities is notably high in Meghalaya (78%), Sikkim (76%), Mizoram (71%), West Bengal, and Delhi, nearly reaching 70%. Analysis reveals that approximately 15 Indian states account for half of all deaths attributable to NCDs, with the share of NCD-related deaths ranging from 21% to 78% across states. Regarding deaths associated with injuries, Telangana (13%), Arunachal Pradesh (12%), Goa (11%), Maharashtra, and other states report higher incidences. Furthermore, deaths attributed to SSIDC are more prevalent in Pondicherry and Gujarat, accounting for around 22%, followed by Jharkhand, Uttarakhand, Tamil Nadu, and other states. Additionally, deaths due to natural ageing, i.e. senility, also constitute a significant proportion, ranging from 4% to 45% across the Indian states. The highest share of senility-related deaths is reported in Lakshadweep and Tamil Nadu (45%), followed by Pondicherry, Jharkhand, Maharashtra, Chhattisgarh, and other states, while the lowest incidence is observed in Nagaland (4%), Meghalaya, and other regions.

Table 4 presents a comprehensive analysis of the distribution of causes of death according to sociodemographic characteristics. Regarding age-wise patterns, the data reveal that among newborns to the younger age group (0–14 years), communicable, maternal, perinatal, and nutritional (CMPN) causes accounted for nearly 57% of deaths, followed by non-communicable diseases (NCDs) at 19%, symptoms, signs & ill-defined conditions (SSIDC) at 18%, and 3% attributed to injuries and senility. Conversely, in the working adult age group (15–59 years), NCD-related deaths constituted over half of all deaths (51%), while CMPN causes were only 14%. Among older adults aged 60–74 years, NCDs remained predominant at 46%, followed by senility at 28%. In the oldest age group (aged ≥75 years), senility accounted for 54% of deaths, with NCDs contributing 28%. Sex-wise distribution of

Figure 2. COD share (%) among reported deaths in India, LASI 2017–2018

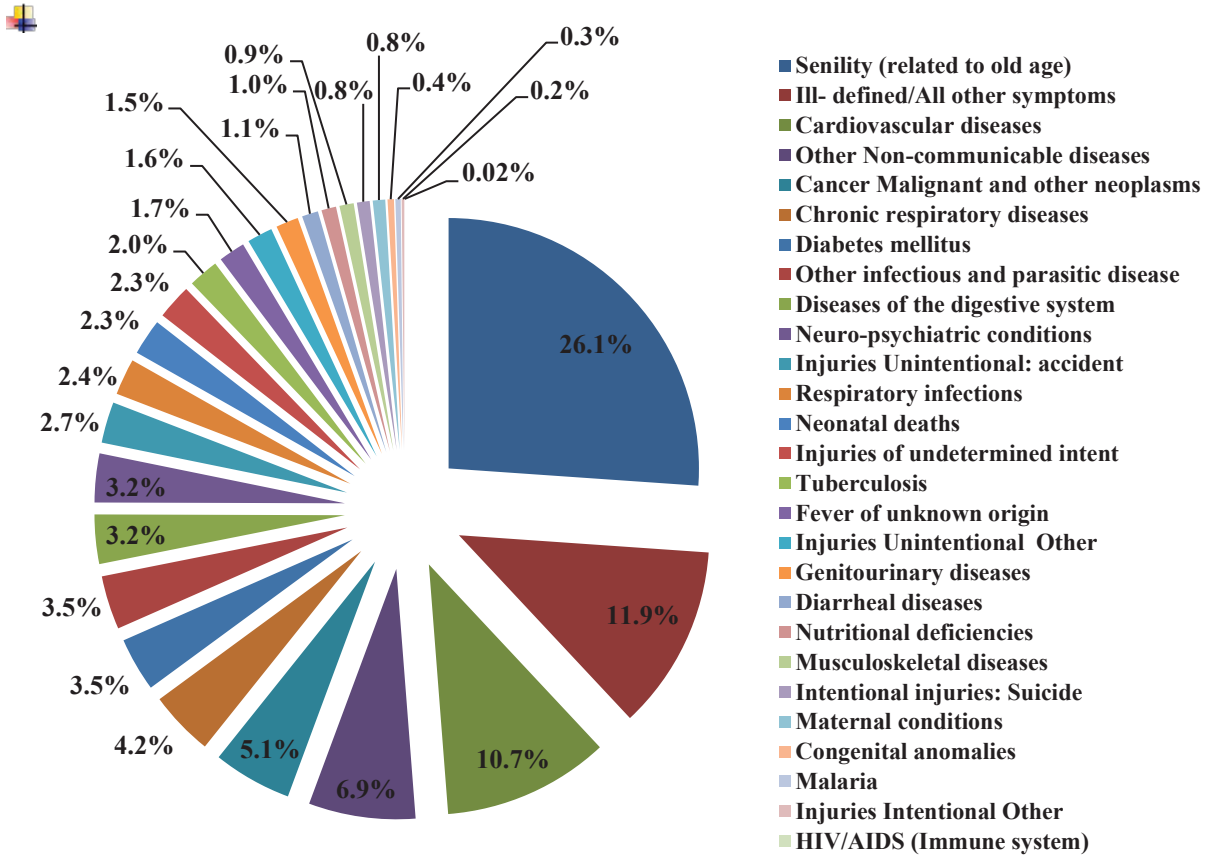


Figure created using LASI wave-1 data. Most leading causes of death in India have been considered.

Table 3. Share (%) of major causes of deaths among overall deaths across the states of India, LASI Wave-1, 2017–2018

State	CMPN	NCDs	Injuries	SSIDC	Senility
Andaman and Nicobar	9.5	54.1	9.76	21.36	5.34
Andhra Pradesh	11.53	54.8	9.96	6.3	17.45
Arunachal Pradesh	12.98	48.4	12.17	0.57	25.9
Assam	7.43	46.7	7.83	20.26	17.77
Bihar	21.81	21.8	7.02	20.07	29.34
Chandigarh	5.41	62.1	7.77	12.29	12.43
Chhattisgarh	13.51	21.6	7.93	18.14	38.79
Dadra and Nagar Haveli	10.09	41.9	9.33	17.06	21.65
Daman and Diu	16.36	50.8	7.05	17.47	8.29
Delhi	3.57	69.6	4.12	11.68	10.99
Goa	9.55	62.0	10.86	5.28	12.26
Gujarat	7.24	36.9	8.39	21.7	25.73
Haryana	11.47	61.3	10.23	6	11.03
Himachal Pradesh	6.1	49.8	8.83	16.22	19.05
Jammu and Kashmir	5.59	66.1	5.65	1.69	20.94
Jharkhand	6.54	22.7	5.17	20.99	44.58
Karnataka	29.64	49.3	5.17	1.39	14.51
Kerala	8.36	48.1	10.01	13.94	19.61
Lakshadweep	3.25	46.7	3.6	1.27	45.17
Madhya Pradesh	19.04	26.0	5.9	12.41	36.7
Maharashtra	10.48	35.1	10.23	2.52	41.72
Manipur	13.42	63.6	3.67	13.24	6.08
Meghalaya	8.63	77.7	6.53	1.97	5.17
Mizoram	7.23	70.9	2.65	0	19.2
Nagaland	21.62	68.4	3.34	2.85	3.82
Odisha	15.13	30.3	3.97	13.44	37.19
Puducherry	2.22	26.4	4.48	21.93	44.93
Punjab	9.81	65.1	3.6	15.74	5.78
Rajasthan	15.71	49.2	8.97	8.78	17.35
Sikkim	1.72	76.4	5.56	5.22	11.13
Tamil Nadu	5.41	21.3	7.91	20.44	44.98
Telangana	20.9	32.8	13.03	7.29	25.98
Tripura	18.28	47.5	5.81	10	18.45
Uttar Pradesh	23.59	32.2	8.45	14.94	20.83
Uttarakhand	10.14	33.6	5.97	20.8	29.47
West Bengal	5.96	69.7	6.12	4.54	13.73
India	14.95	39.56	7.53	11.93	26.1

Cause of death estimated using information from LASI household based on deaths in the past 2 years. CMPN: communicable, maternal, perinatal, and nutritional. NCDS: non-communicable diseases. SSIDC: symptoms, signs and ill-defined condition.

COD revealed slight variations in patterns, with notable differences in senility-related deaths between males (23%) and females (30%). NCD-related deaths were the most common cause among both males (40%) and females (38%) compared to other categories.

Analysis by place of residence indicated disparities between rural and urban areas, with NCD-related deaths higher in urban (46%) compared to rural (37%) areas. Among social caste or tribe strata, there was a slight burden of CMPN deaths ranging from 12% in Scheduled Tribes (ST) to 13% in Other Backward Classes (OBC) and Scheduled Castes (SC).

NCD-related deaths were considerably higher (53%) in the 'Other' category compared to OBC/SC and ST, while senility-related deaths were higher in OBC/SC (27%) compared to 'Other' (18%). Religion-based analysis revealed the highest CMPN-related deaths among Hindus (15%), while the highest NCD-related deaths were observed in the 'Other' category (53%), apart from Hindus (38%), Muslims (44%), and Christians (49%). Injuries and SSIDC deaths showed marginal differences across religious groups. Regional disparities in COD burden were notable, with the Central region reporting the highest proportion of CMPN-related deaths (21%). NCD-related deaths were highest in the North

Table 4. Share (%) of major causes of death among reported death according to sociodemographic characteristics, LASI, 2017–2018

Characteristics	CMPN	NCDs	Injuries	SSIDC	Senility	Sample
Age (years)***						
0–14	56.7	18.7	3.5	17.6	3.5	419
15–59	13.9	50.7	14.8	16.6	4.0	1241
60–74	8.8	46.1	4.8	11.9	28.3	1506
≥75	6.5	28.8	5.5	5.1	54.1	1235
Sex* **						
Male	15.5	40.19	9.36	11.91	23.05	2574
Female	14.22	38.56	5.09	11.96	30.16	1830
Place of residence* **						
Rural	15.07	36.66	8	13.22	27.05	2965
Urban	14.66	46.42	6.39	8.75	23.79	1440
Caste/tribe* **						
Caste (OBC/SC)	13.46	39.91	7.59	12.07	26.98	3796
Tribe (ST)	11.84	41.94	9.33	15.69	21.19	464
Other (No caste/tribe)	11.85	52.79	8.46	9	17.9	124
Religion* **						
Hindu	15.4	38.1	7.39	12.34	26.77	3306
Muslim	14.3	43.66	8.63	8.82	24.6	562
Christian	10.98	48.7	4.4	14.59	21.33	322
Other	8.6	52.74	9.71	10.76	18.19	215
Region* **						
East	12.33	41.19	5.9	13.36	27.24	786
North-East	9.39	50.63	7.29	16.14	16.54	546
West	9.28	35.9	9.55	9.65	35.63	585
Central	21.41	29.45	7.62	14.4	27.13	778
North	11.37	55.93	7.48	10.23	14.99	842
South	16.95	40.31	7.96	9.37	25.41	868
India	14.95	39.56	7.53	11.93	26.1	4405

CMPN: communicable, maternal, perinatal, and nutritional. NCDS: non-communicable diseases. SSIDC: symptoms, signs and ill-defined condition. Senility means age-related diseases. Chi-squared significance: *p<0.05, **p<0.01, ***p<0.001.

region (56%), followed by North-East (51%), East (41%), South (40%), West (36%), and lowest in the Central region (29%). Injuries-related deaths were consistently lower across all regions, ranging from 6% to 9%.

DISCUSSION

This study is a comprehensive effort to analyze death and causes of death in India in recent times. This study delves into the sociodemographic determinants of death rates and the distribution of COD in India, both nationally and at the sub-national level. Its uniqueness lies in exploring mortality patterns and COD not only at the state level but also across different demographic and social groups. While there were a few data sources and reports available in the public sphere, their completeness and reliability remain a concern[6]. Moreover, the existing studies on death and COD data primarily provide macro-level insights, limiting the exploration at micro-level stratification for demographic or social backgrounds of people in India[13,15].

The present study revealed that the death pattern has a significant increase with age, lowest at the younger ages and highest among the oldest ages, almost a 'J' pattern in India, which follows the similar multi-county phenomenon observed half a decade ago and current times[16,17]. Significant variation in death rates exists across the states of India, ranging from three to ten deaths per 1000 population. Himachal Pradesh reported the highest death rate, while Meghalaya had the lowest. Notably, specific age groups showed variations: Sikkim had the highest death rate among early ages, Jharkhand among working ages, Delhi among older adults (60–75 years), and Chhattisgarh among the oldest adults (≥75years) in 2017–2018. However, when comparing our study estimates to the Sample Registration System (SRS) 2017 and 2018 report estimates, some discrepancies emerged[18,19]. This disparity could stem from differences in the operational definition of the death rate and process of collection and analysis used between SRS and this study. Both are valid estimates based on their usability, and the present study confirmed our estimates with the LASI household-based death rate[20]. Present studies primarily focus on exploring the background covariates changes with various factors and COD share distribution, rather than not just death rate estimates.

This study revealed that as per the overall death estimates, the male death rate was considerably higher than for women in India. Likewise, the pattern of sex-differential was found in a million nationally surveyed deaths study[21] and systematic multi-country adult mortality study[22] , and it reflects the life expectancy at birth and survival ultimately higher among women[23] than men. Similarly, our study showed that the overall death rate among the rural population was at a higher level than that of urban people. This is expected, as we experience mortality in the rural region at the early and later ages of life to be higher than in urban regions due to better health, education, awareness and other life-oriented services in urban areas[24,25], which again implies less in life expectancy in rural parts than urban. Mortality in the deprived section of the population belonging to SC, ST and OBC is considerably higher than for 'Other' (no-caste or no-tribe individuals). It shows there are ample programs and policies. However, there is still room to reduce inequality by providing better health and welfare services for better survival patterns among the deprived social groups[26,27]. Furthermore, the study demonstrated a significant gap in the overall death rate between Hindus at a higher level and Muslims at a lower, which is a consistent finding with existing child and adult mortality risk[28] and life expectancy level comparison in religion in India[29], nevertheless there is a further gap in literature for the whole population to understand why the mortality is higher in Hindus than its counterparts.

Apart from the deaths background distribution, the present study has mainly focused on the distribution of causes of death across different states and demographic groups. In the current landscape of public health, non-communicable diseases (NCDs) are a major concern. This work found that health conditions such as CVD, diabetes, cancer, digestive diseases and other NCDs are major causes of death, and collectively account for nearly half of all deaths. Across the Indian states, NCD-related fatalities range from two to almost eight out of ten individuals. Other research has highlighted the transition of diseases over time due to demographic and epidemiological shifts, with chronic diseases now posing the greatest burden on the healthcare system[30]. Given the increasing burden of NCDs, it is essential to not only implement NCD prevention and control program policies but also ensure public health preparedness at both primary and secondary healthcare levels in India[31]. Due to the diverse geographical and developmental stages of Indian states, the burden of mortality encompasses not only non-communicable diseases (NCDs) but also communicable, maternal, perinatal, and nutrition (CMPN) related deaths, creating a dual burden of mortality. This phenomenon is most pronounced in states like Uttar Pradesh, Bihar, Nagaland, Karnataka, Telangana, Tripura, and others. However, across all states, deaths due to NCDs outnumber those attributed to CMPN causes, a trend consistent with findings from collaborative studies conducted by ICMR under the supervision of the Ministry of Health and Family Welfare[32]. Among the existing literature, few studies on COD focused on senility (old age-related deaths). Among every ten fatalities, death due to senility contributes around two to four across the states, which may be high with increasing life expectancy or the ageing phenomenon[33].

Understanding the assessment of causes of death through various background factors is crucial. We found that more than half of deaths were attributed to communicable, maternal, perinatal, and nutritional (CMPN) causes in newborns to younger individuals below fifteen years old, whereas NCDs were predominant among working-age older adults in India. This highlights the on-going epidemiological

transition, where the burden of NCDs is becoming more dominant in contemporary times. As a result, India still grapples with the dual burden of CMPN and NCDs, which are prevalent across different phases of life. Literature and recent studies over the decade have also warned about this dual burden, indicating a modest epidemiological transition observed through age-specific morbidity patterns[34,35]. Among the oldest adults, a significant portion of deaths are attributed to natural causes related to old age. Regarding sex differentials, males experience a considerably higher mortality share due to NCDs, CMPN, and injuries compared to females. This finding aligns with the outcomes of other studies conducted in India[36]. However, the scenario is inverted when it comes to deaths attributed to senility, which are higher in women, possibly due to their longer life expectancy compared to men[22]. Additionally, mortality rates due to symptoms and ill-defined diseases (SSIDC) are nearly the same in both sexes.

The study found that there was not a significant gap between CMPN diseases in urban and rural areas. However, there were considerable deaths due to non-communicable diseases (NCDs), with higher rates recorded in urban India compared to rural areas. Conversely, deaths from injuries, SSIDC, and senility are significantly higher in rural India. This underscores that NCDs are more prevalent in urbanized or developed areas, while other diseases are more common in underdeveloped regions, reflecting sociodemographic and economic disparities. Nevertheless, the literature indicates the pace of NCD progression due to the rapid epidemiological transition in rural India[23]. In addition to considering gender and residence, this study also showed the importance of examining the impact of social caste, tribe, religion and region on the distribution of causes of mortality. These background features play an important role in determining the share of various types of deaths within different sociodemographic and geographical groups.

Limitations

This research delves into the determinants of death and COD, exploring sociodemographic and geographical aspects due to a lack of reliable and incomplete data sources. However, it is essential to acknowledge certain limitations. Our study is based on the LASI household where at least one member is aged ≥45 years. We assumed that almost every family of India has at least one person aged ≥45 years, and this part of data limitations. Given the cross-sectional nature of the data, the study primarily establishes associations rather than delving into causal analyses. Furthermore, the reliance on reported mortalities and COD of a person in the past two years by the household member introduces the possibility of underestimation or overestimation of prevalence, influenced by various factors. Lastly, the study does not incorporate other potential risk factors, such as the dead person's physical, mental, and drinking or smoking behaviors or nutrition. Recognizing these limitations opens avenues for further research and the identification of gaps in the existing understanding of mortality and cause of death dynamics in India.

Future research

Future research should focus on addressing the identified disparities in mortality and causes of death across various sociodemographic and geographical factors. Efforts should be made to enhance data collection methods to ensure the reliability and completeness of mortality data, particularly in rural areas and among marginalized communities. Governments should consider implementing mandatory COD reporting protocols nationwide to ensure accurate and comprehensive data collection following the death of an individual. Additionally, interventions aimed at reducing the burden of non-communicable diseases (NCDs) should be prioritized, alongside targeted strategies to improve access to healthcare and address sociodemographic inequalities.

Furthermore, primary healthcare centers should be equipped to address the dual burden of mortality NCDs, CMPN and better healthcare for the aged person providing comprehensive health services tailored to the needs of the local population. Regular death and COD studies should be conducted to continually assess and understand the burden of deaths, with data collection integrated into major household and health-related surveys to ensure comprehensive information gathering. By fulfilling these recommendations, officials can better identify and address the underlying factors contributing to mortality disparities and work towards achieving equitable health outcomes for all segments of the population.

CONCLUSIONS

This comprehensive study highlights the intricate landscape of mortality and causes of death in India and its states, and the sociodemographic determinants. The study unveiled disparities across age groups, genders, residence types, and social categories. Death patterns have an almost 'J' shape and vary across the states. While non-communicable diseases (NCDs) pose a significant challenge, a dual burden of mortality persists, with communicable, maternal, perinatal, and nutritional (CMPN) related deaths prevalent, particularly in certain states. Gender disparities in mortality rates mirror broader health inequities, highlighting the need for targeted interventions. Rural–urban divides underscore the importance of enhancing healthcare access and quality in rural areas. Moreover, the study underscores the pivotal roles of social factors such as caste, tribe, religion, and region, in shaping mortality patterns and causes of death, necessitating tailored strategies to address disparities among marginalized groups. Overall, this study provides valuable insights to inform targeted public health interventions to the deprived or more prone sections of the population, aimed at achieving equitable health outcomes across India's diverse population.

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DATA AVAILABILITY
The data on which this article is based are from the LASI Wave-1 data. All data were de-identified. The de-identified version of the LASI Wave-1 data is publicly available to the researchers and policymakers upon formal request to the International Institute For Population Sciences at LASI_DataRequestForm_0.pdf (iipsindia.ac.in) or at International Institute for Population Sciences (IIPS) (iipsindia.ac.in). Other information for the LASI data set are available at: LASI Wave-I |International Institute for Population Sciences (IIPS) (iipsindia.ac.in).

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