ORIGINAL ARTICLE

Causes of death: Findings from Longitudinal Aging Study of India (LASI), first wave: 2017-18

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Abstract

Background: As many deaths happen at household level, collecting information from the households can bridge the knowledge gap in causes of mortality. *Aim and Objectives*: The objectives of this study were to estimate the causes of death and to determine prevalence of deaths certified by medical professionals as reported by households in India. *Material and Methods:* We used household survey data of the Longitudinal Aging Study of India (LASI), first wave: 2017–18. We analysed the causes of death as reported by deceased person's household member and categorised them into 4 major causes and analysed the trends of the causes of death for four consecutive years, using descriptive statistics. *Results:* Out of 66,560 household interviewed across the country, 4440 (6.7 %) households reported death during the study period. We found that Non-Communicable Diseases (NCDs) were the leading causes of death (43.3%), followed by other causes like ill-defined conditions and symptoms/signs (35.8%), communicable diseases, maternal and neonatal (13%), and injuries (8.2%) related deaths. Overall, 61 % of the reported deaths were medically certified as reported by households. The highest certified deaths were reported by Lakshadweep (93%), Chandigarh (93%), and Kerala (90%), and lowest from Arunachal Pradesh (32%). *Conclusion:* Our study found NCDs to be the leading causes of deaths in India, among men and women both in rural and urban areas, followed by ill-defined conditions. Prevalence of death certified medically by medical professionals, varied across the country.

Keywords: cause of death, communicable, non-communicable diseases, injuries

Introduction

The proportion of disease burden due to Non-Communicable Diseases (NCDs), is growing in India, with large differences in epidemiological profile between states. In this context, country requires state specific evidence on the Causes of Death (CoD) to facilitate designing programs targeting specific diseases [1].

Therefore, knowing the CoD can assist in determining how to enhance health services, lower the number of avoidable deaths in the nation, and efficiently adapt to shifting epidemiological conditions. To address the CoD, the health systems need to act effectively. Numerous public health preventative initiatives can stop the nation's high rate of premature deaths. The cause-specific mortality data is required regularly by policy makers, administrators, researchers, and other health professionals for decision-making on resource allocation, monitoring of health indicators, and identifying the priorities for different schemes and other related activities in the area of public health [2].

At sub-national level, age, sex, and residence-wise cause-specific mortality information is vital for

monitoring the health trends in the community and for analysis on impact of ongoing health programs. Thus, mortality data by CoD for the entire nation is essential for decision-making in the health sector. In India, the Sample Registration System (SRS) is conducted on a half-yearly basis. SRS offers trustworthy information on birth and death rates in India, both at the national and state levels, but takes too long to provide data. Nearly 75% of the annual estimated (9.5 million) deaths take place at individuals residence, and most deaths are not medically verified to determine the CoD [3]. Only 22.5 percent of total registered deaths are medically certified [4]. Percentage of medically certified deaths to total deceased receiving any kind of medical attention at the time of terminal illness at the national level is 54.6 percent [2]. Despite the existence of multiple sources of mortality statistics in many ministries/departments of the government, neither the number of deaths nor the CoD reported annually are complete. Ideally, mortality statistics should be made available at shorter intervals (weekly) for small areas (wards) for epidemiological purposes to find any unusual rise in deaths for investigation of the causes so as to take public health action at an early stage [5]. The pandemic of corona virus disease 2019 (COVID-19) has highlighted the urgency of timely and accurate measurement of population mortality, requirement of quick collection of key data for informing policies and actions [6]. Apart from SRS, which is the regular survey, there are very limited nationwide studies to document the population deaths and their causes in India. There is need to explore other methods of rapid survey to understand CoD.

As many deaths happen at household level, collecting information from the households can bridge this knowledge gap on causes of mortality. This study was carried out with the objectives of estimating the deaths reported in different states in India, its causes and to determine the prevalence of deaths certified by medical professionals as reported by households.

Material and Methods

Data of the Longitudinal Aging Study of India (LASI), first wave: 2017–18 were used. This study was conducted by the International Institute for Population Sciences (IIPS), Mumbai, in collaboration with other international institutes like Harvard T.H. Chan School of Public Health (HSPH), University of Southern California (USC), and several other domestic and international institutions. The study was intended to give accurate estimates of all health outcomes and social and economic welfare status for older adults. This was a cross-sectional study conducted in 30 states and 6 union territories. The cluster sampling methodology was used; multistage stratified area probability was adopted for selecting clusters in rural and urban areas. To obtain reliable estimates of disease prevalence by state or union territory and by social and economic stratum, the survey considered the minimum necessary sample size of 1,000 individuals aged 45 years and above (including their spouses less than 45 years) for the smallest state. The sample was distributed proportionately to the size of the states and union territories and sample size for Delhi, Mumbai, Kolkata, and Chennai were raised proportionally. A total of 72,250 older adults were included in main survey.

By using the households listing frame, the households were randomly selected from each of the Secondary Sampling Units (SSUs) i.e., villages in rural areas and Census Enumeration

Blocks (CEBs) in urban areas. Households were selected in two phases. In each SSU, 31 and 28 households were selected in urban and rural areas respectively, by using the systematic random sampling method. Four additional households were selected (urban and rural area) from all the households that had at least one-member aged 65 years or above. Each team of data collectors had 6 members, consisting of two male investigators, two female investigators, one health investigator and one field supervisor. The interviewers were recruited by the state field agencies, taking into consideration their educational qualifications, previous experience with large-scale surveys, and other relevant qualifications. To ensure the quality of data collection, each supervisor was given 10% of the completed households for validation. The survey data collectors received training in several survey manuals. The first was a mapping and listing manual (7 days, involving fieldwork in both rural and urban areas), which outlines the necessary procedures for identifying location and layout maps of the households in the survey area. The second was a survey interview manual, which included detailed instructions for conducting interviews, the purpose of each question, and how to ask each question and probe to get correct answer. Each state agency provided 35 days of training, which included five days of fieldwork for supervisors and interviewees. The detailed methodology is published in LASI report [7].

Information on number of deaths was collected from household members, if death would have happened two years preceding the survey. If the household had reported any deaths, the further questions on number of deaths, relationship with head of household, age, gender, month and year of death, CoD, and whether the death was medically certified were asked to the household members. For the analysis of this study, de-identified data was acquired from IIPS on request, thus no separate approval was obtained from Institutional Ethics Committee. The household level data to understand the CoD were analysed, which were not reported in the LASI report.

CoD were reported by deceased persons' household members. The drop-down list of causes and codes were given in the data collection tool. Whether death was certified by the medical professional, was collected by data collectors from the household members.

The data was reviewed for its quality and completeness. The proportion of missing values was 0.1%. After data cleaning and adjusting missing values, the descriptive statistics were applied. Statistical Package for Social Sciences (SPSS Inc. Chicago, USA) version 27 software was used to analyse the data. The data of deceased individuals were divided as per their age (below 45 years, 45 to 59 years, and 60 years and above age groups), gender (male and female), and place of residence (measured as rural and urban). For trend analysis, data for years 2015 to 2018 were used. Some deaths reported between the years 2019 to 2021 were considered for understanding the CoD but were excluded for trend analysis.

For analysis purpose CoD were grouped into four major categories:

(I) Death due to communicable diseases, maternal, perinatal, and nutritional conditions
(II) Death due to non-communicable diseases
(III) Death due to injuries
(IV) Symptoms, signs, and ill-defined conditions

Results

Out of 66,560 households interviewed, at national level 4440 (6.7%) households reported death during the study period. There were 17 states which reported more deaths than national level average, as shown in Figure 1. Households from Himachal Pradesh reported highest deaths (9.7%) followed by Madhya Pradesh (8.6%), Uttar Pradesh (8.6%) and Gujarat (8.4%). Nagaland (3.2%) reported lowest deaths and Bihar (6.7%) reported the same as that of national average (Figure 1).

Overall Non-Communicable Diseases (NCDs) were the major CoD both in rural and urban areas, as compared to other causes, accounting for 43.3% of all deaths. However, urban areas reported more deaths (49.9 % vs 40.1%) due to NCDs compared to rural areas. Deaths from communicable, maternal, perinatal, and nutritional conditions were more in rural areas compared to urban areas (14.3 % vs 9.6%). There were minor differences for CoD due injuries by place of residence (Figure 2). Overall, among the major categories of CoD, men had higher deaths due to NCDs (45.2 %vs 40.6 %) and injuries (9.8% vs 6.0%) as compared to women. Women had higher deaths due to ill-defined conditions compared to men (40.7% vs 32.3%). There were no gender differences for deaths due to communicable, maternal, perinatal, and nutritional conditions (12.7%) (Figure 3). The greatest number of deaths occurred among individuals aged 60 and above, and within this group, women made up 65.6% of the fatalities. However, deaths were more among men compared to women in age group less than 45 years and those between 45 to 59 years age (Figure 4). Across the age groups, NCDs were the most common cause of mortality (43.2%). The cardiovascular diseases (11.5%), malignancies (6.0%) and other neoplasms (6.4%), were the most common CoD due to NCDs. NCDs were more common in the age group of 45 to 59 years compared to other age groups (Table 1).

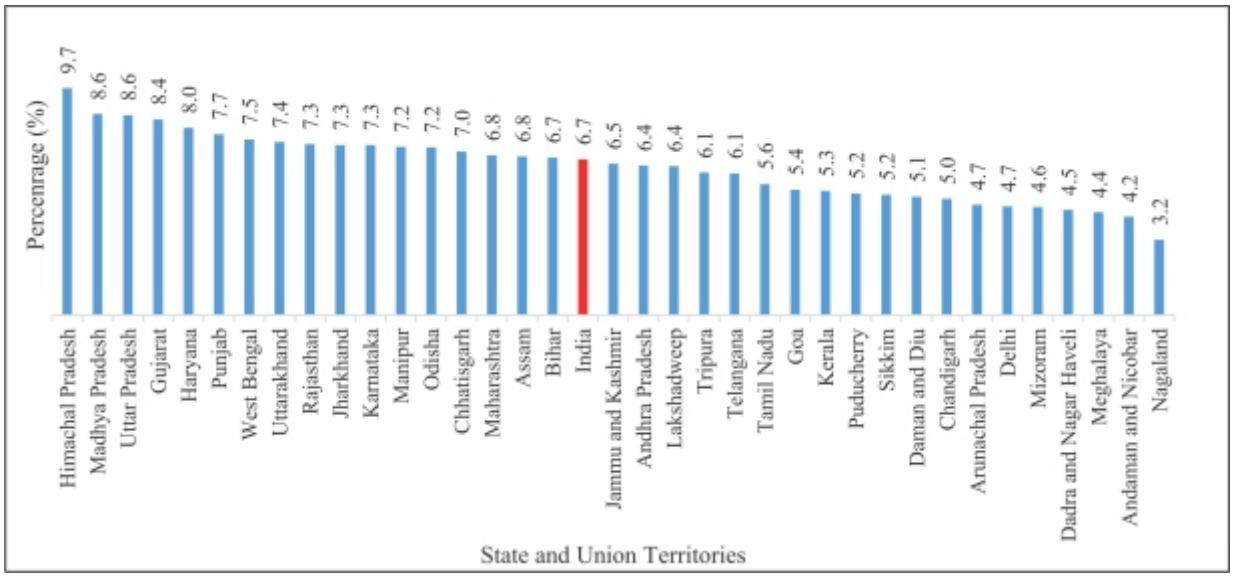

Figure 1: Percentage distribution of deaths to the total deaths by states in India 2015- 2018

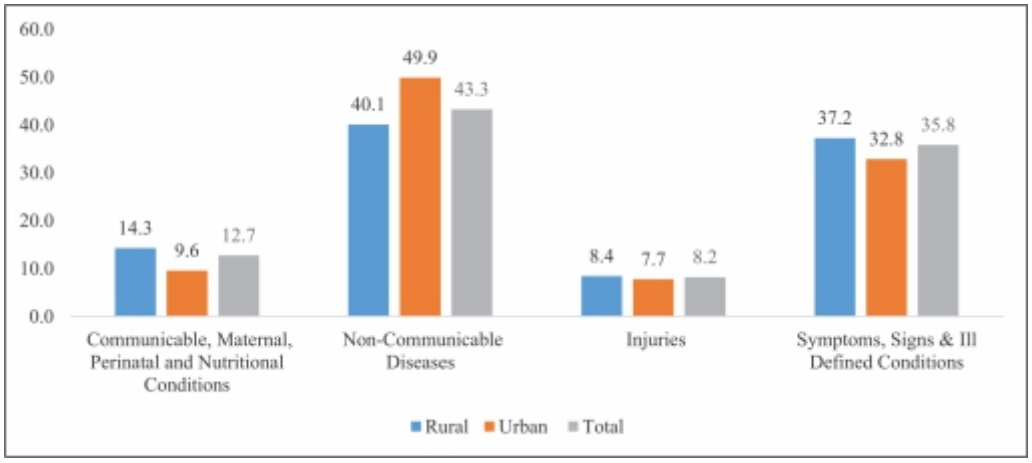

Figure 2: Percentage distribution of deaths, by major cause groups in India, by place of residence between 2015-2019

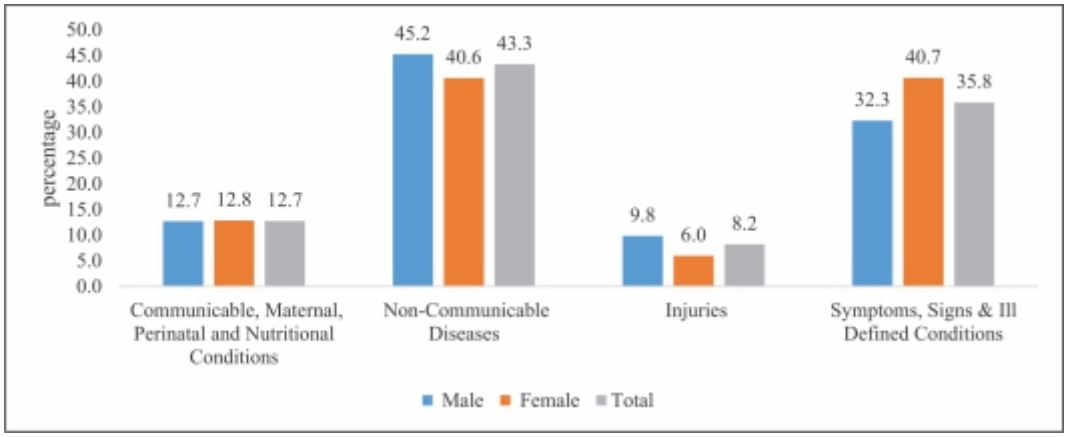

Figure 3: Percentage distribution of deaths, by major cause groups and gender in India: 2015-2019

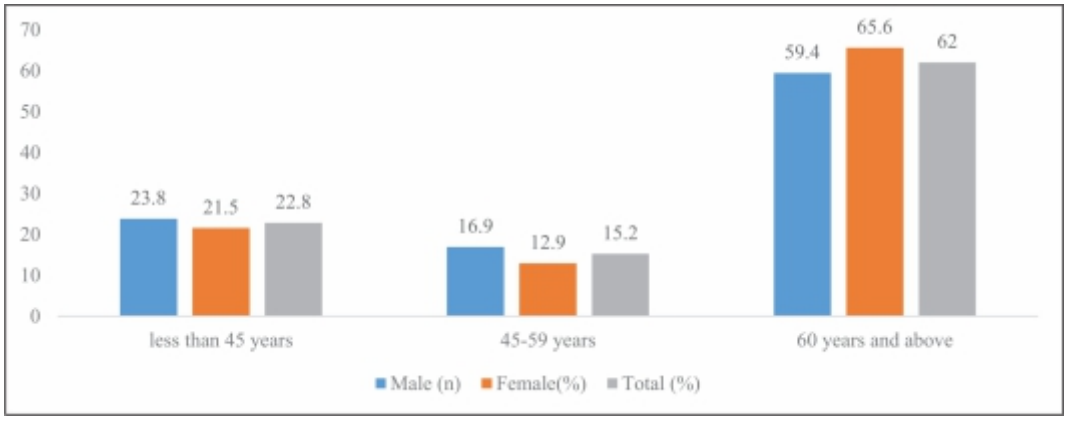

Figure 4: Percentage distribution of all causes of deaths, by gender and age in India: 2015-2019

Table 1: Percentage distribution of causes of deaths by age groups

Categories of cause of death	Number and proportion of deaths in different age groups							
	<45 years		45 to 59 years		≥60 years and above		All age group	
1. Communicable disease	n	(%)	n	(%)	n	(%)	n	(%)
Tuberculosis (lung, intestine, bones, brain)	22	2.1	25	3.6	51	1.8	98	2.2
HIV/AIDS	1	0.1	1	0.1	0	0.0	2	0.0
Diarrheal diseases	12	1.2	4	0.6	9	0.3	25	0.5
Malaria	12	1.2	7	1.0	5	0.2	24	0.5
Other infectious and parasitic diseases	26	2.5	12	1.7	35	1.2	73	1.6
Respiratory infections (Lungs and respiratory tract)	22	2.1	14	2.0	66	2.3	102	2.2
Unknown fever	32	3.1	15	2.2	44	1.6	91	2.0
Sub total	**127**	**12.4**	**78**	**11.3**	**210**	**7.4**	**415**	**9.1**
2. Maternal and neo-natal								
Maternal condition	36	3.5	1	0.1	0	0.0	37	0.8
Neonatal death	86	8.4	0	0.0	0	0.0	86	1.9
Nutritional deficiencies (excess or deficiency of nutrition)	19	1.9	1	0.1	11	0.4	31	0.7
Sub total	**141**	**13.7**	**2**	**0.3**	**11**	**0.4**	**154**	**3.4**
3. Non -communicable diseases								
Malignant and other neoplasms	48	4.7	72	10.5	154	5.5	274	6.0
Diabetes mellitus	19	1.9	26	3.8	96	3.4	141	3.1
Neuro- psychiatric conditions	32	3.1	36	5.2	88	3.1	156	3.4
Cardiovascular diseases (heart)	79	7.7	122	17.7	320	11.3	521	11.5
Chronic respiratory diseases (lungs)	28	2.7	30	4.4	149	5.3	207	4.6
Diseases of the digestive system (gastrointestinal)	29	2.8	24	3.5	64	2.3	117	2.6
Genitourinary diseases(genitals and urinary system)	10	1.0	13	1.9	37	1.3	60	1.3
Musculoskeletal diseases (muscles and bones)	7	0.7	11	1.6	26	0.9	44	1.0
Congenital anomalies (birth defects)	14	1.4	2	0.3	1	0.0	17	0.4
Other Non- communicable diseases	112	10.9	66	9.6	250	8.9	428	9.4
Sub Total	**378**	**36.8**	**402**	**58.4**	**1185**	**42.0**	**1965**	**43.2**

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4. Injury								
Unintentional injuries: Motor vehicle accidents	75	7.3	27	3.9	35	1.2	137	3.0
Unintentional injuries: Other than motor vehicle accidents	22	2.1	15	2.2	32	1.1	69	1.5
Intentional Injuries : Suicide	31	3.0	6	0.9	3	0.1	40	0.9
Intentional injuries : Other than suicide	10	1.0	3	0.4	6	0.2	19	0.4
Injuries of undetermined intent	34	3.3	11	1.6	59	2.1	104	2.3
Sub total	172	16.7	62	9.0	135	4.8	369	**8.1**
5. Other causes								
Senility (related to old age)	29	2.8	25	3.6	1047	37.1	1101	24.2
Ill- defined/ All other symptoms, signs and abnormal clinical and laboratory findings	180	17.5	119	17.3	236	8.4	535	11.8
Sub total	**209**	**20.4**	**144**	**20.9**	**1283**	**45.4**	**1636**	**36.0**
Total of all causes	**1027**	100	**688**	**100**	**2824**	**100**	**4539**	**100**

The second leading CoD was senility related to old age 24.2% (overall) and more among deceased individuals in 60 years and above age group (37%). The unintentional injuries due to motor vehicle accidents (7.3%), intentional injuries due to suicide (3.0%) and injuries of undetermined intent (3.3%), were the leading CoD among deceased individuals less than 45 years of age compared with other age groups. Ill- defined or all other symptoms, signs and abnormal clinical and laboratory findings, were the leading CoD among deceased individuals less than 45 years of age (17.5%) and those in age group of 45 to 59 years (17.0 %). Tuberculosis (lung, intestine, bones, brain), other infectious and parasitic diseases and respiratory infections were the most common CoD due to communicable diseases. These causes were slightly higher in proportion (12.4%) among deceased individuals less than 45 years of age compared with other age groups. Among maternal and neo-natal CoD, neonatal death substantially contributed (8.4%) towards death in the age group lesser than 45 years.

NCDs were the most common CoD in both the gender. Cardiovascular Diseases (CVD) were the most common cause, however, the proportion of deaths due to CVD in men (13.8%) were more than women (8.4%). There were no apparent differences in both the genders in other CoD due to NCDs. Among communicable diseases, tuberculosis (affecting the lungs, intestines, bones, and brain) was the most frequent CoD. Men showed a slightly higher proportion of tuberculosis deaths (2.6%) compared to women (1.5%). Among maternal and neo-natal CoD, neonatal death and unknown deaths were higher among men compared to women. Deaths due to unintentional injuries, like motor vehicle accidents were higher in men (4%) compared to women (1.7%). Overall deaths were higher in men (10%) compared to women (6%) (Table 2).

Table 2: Percentage distribution of causes of death, by gender

Categories of cause of death	Male		Female		Total	
Communicable disease death	n	%	n	%	n	%
Tuberculosis (lung, intestine, bones, brain)	69	2.6	29	1.5	98	2.16
HIV/AIDS	1	0.0	1	0.1	2	0.04
Diarrheal diseases	11	0.4	14	0.7	25	0.55
Malaria	13	0.5	11	0.6	24	0.53
Other infectious and parasitic diseases	45	1.7	28	1.5	73	1.61
Respiratory infections (Lungs and respiratory tract)	61	2.3	41	2.1	102	2.25
Unknown fever	54	2.1	37	1.9	91	2.00
Sub- total	**254**	**9.7**	**161**	**8.4**	**415**	**9.13**
Non communicable disease death		0		0	0	0.00
Malignant and other neoplasms	148	5.6	127	6.6	275	6.05
Diabetes mellitus	76	2.9	65	3.4	141	3.10
Neuro- psychiatric conditions	96	3.7	61	3.2	157	3.46
Cardiovascular diseases (heart)	362	13.8	160	8.4	522	11.49
Chronic respiratory diseases (lungs)	124	4.7	83	4.3	207	4.56
Diseases of the digestive system (gastrointestinal)	73	2.8	44	2.3	117	2.58
Genitourinary diseases (genitals and urinary system)	39	1.5	22	1.1	61	1.34
Musculoskeletal diseases (muscles and bones)	18	0.7	26	1.4	44	0.97
Congenital anomalies (birth defects)	8	0.3	9	0.5	17	0.37
Other non- communicable diseases	247	9.4	181	9.5	428	9.42
Sub- total	1191	**45.3**	778	**40.6**	1969	**43.34**
Maternal and neo-natal condition						
Maternal causes	0	0.0	37	1.9	37	0.81
Neonatal death	54	2.1	32	1.7	86	1.89
Nutritional deficiencies (excess or deficiency of nutrition)	10	0.4	21	1.1	31	0.68
Sub total	**64**	**2.4**	**90**	**4.7**	**154**	**3.39**
Injuries						
Unintentional injuries: Motor vehicle accidents	104	4.0	33	1.7	137	3.02
Unintentional injuries: Other than motor vehicle accidents	42	1.6	27	1.4	69	1.52

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Intentional Injuries: Suicide	29	1.1	11	0.6	40	0.88
Intentional injuries: Other than suicide	13	0.5	6	0.3	19	0.42
Injuries of undetermined intent	67	2.5	37	1.9	104	2.29
Sub - total	**255**	**10**	**114**	**6**	**369**	**8.12**
Other causes		0		0	0	0.00
Senility (related to old age)	541	20.6	560	29.2	1101	24.24
lll- defined/ All other symptoms, signs and abnormal clinical and laboratory findings	313	11.9	222	11.6	535	11.78
Sub- total	**854**	**32.5**	**782**	**40.8**	**1636**	**36.0**
Grand Total	2618	100	1925	100	4543	100.0

A rising trend in deaths was seen from 2015 to 2018 due to tuberculosis (24 % to 38%), malaria (5 to 10%) and however, decline in deaths due to other infections and parasitic diseases was noticed (30 to 16%) during the study period (Figure 5). Among the NCDs, rising trend in CoD was seen for musculoskeletal disease from 19.5 to 23.5% and diabetes (5.3 to 9.3%) (Figure 6). The slight decline was seen in the deaths due to cardio-vascular disease (28.4% to 26.4%), malignant and other neoplasms (14.2 to 12.3%). Overall decline in trends in deaths due to injuries was seen, except for rising trends in unintentional injuries other than motor vehicle accidents (3.2 to 15.3%) (Figure 7). Rising trends of deaths due to old age (62.9 to 70.3%) was seen and decline in deaths due to ill- defined conditions was noted (37.1 to 29.7%) between 2015 to 2018 (Figure 8). Overall, 61 % of the reported deaths were medically certified in India, as reported by households. The highest certified deaths were reported by Laksha-dweep (93%), Chandigarh (93%), Kerala (90%) and lowest from Arunachal Pradesh (32%). Amongst major states, the highest level of CoD certified by a medical professional was reported in Tamil Nadu (78 %) followed by Telangana (64 %), and Jharkhand (36%) (Figure 9).

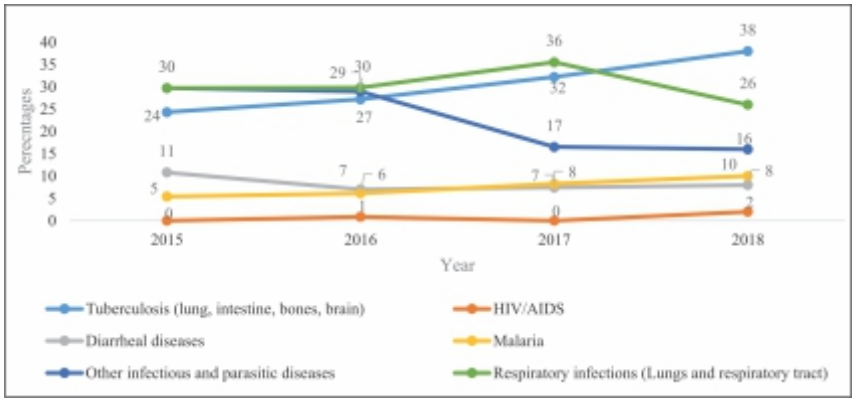

Figure 5: Trends in deaths due to communicable diseases 2015-2018

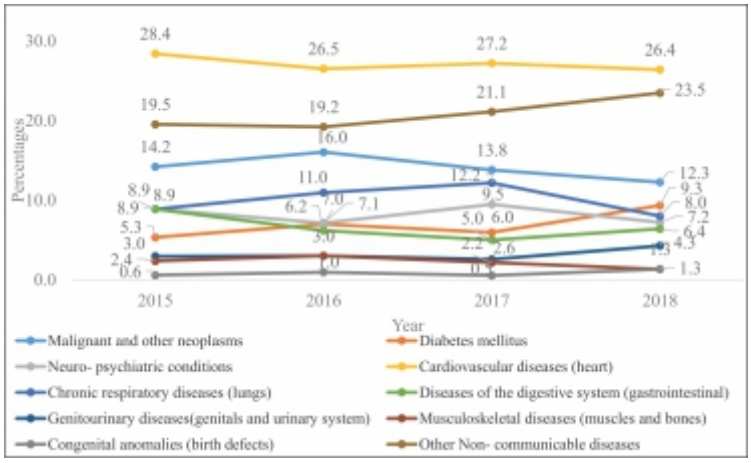

Figure 6: Trends in deaths due to non- communicable diseases in India: 2015-2018

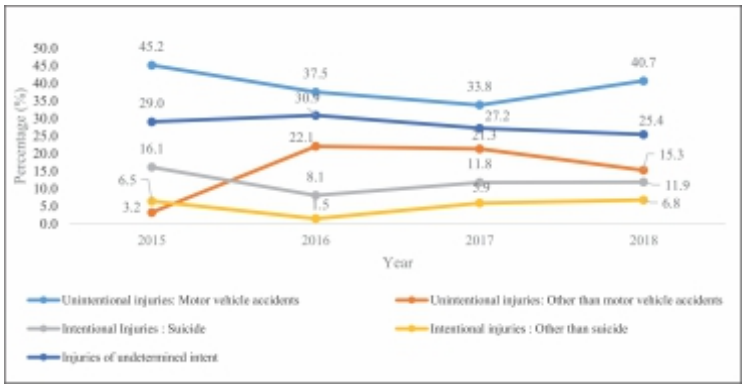

Figure 7: Trends in deaths due to injuries in India: 2015-2018

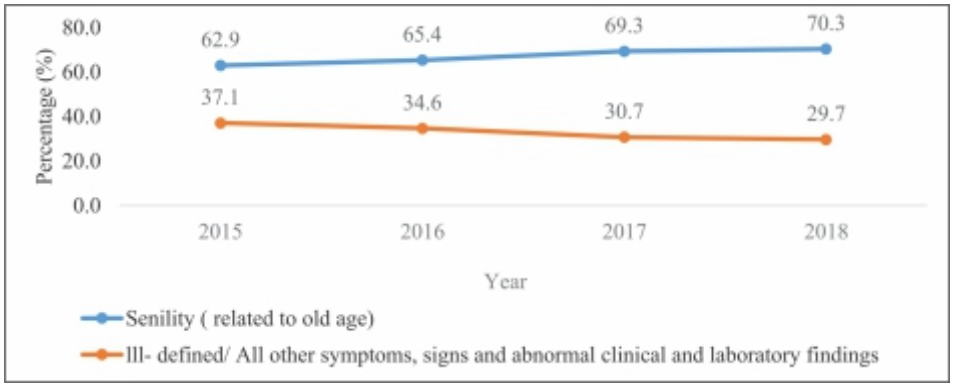

Figure 8: Trends in deaths due to old age and other ill- defined conditions in India: 2015-2018

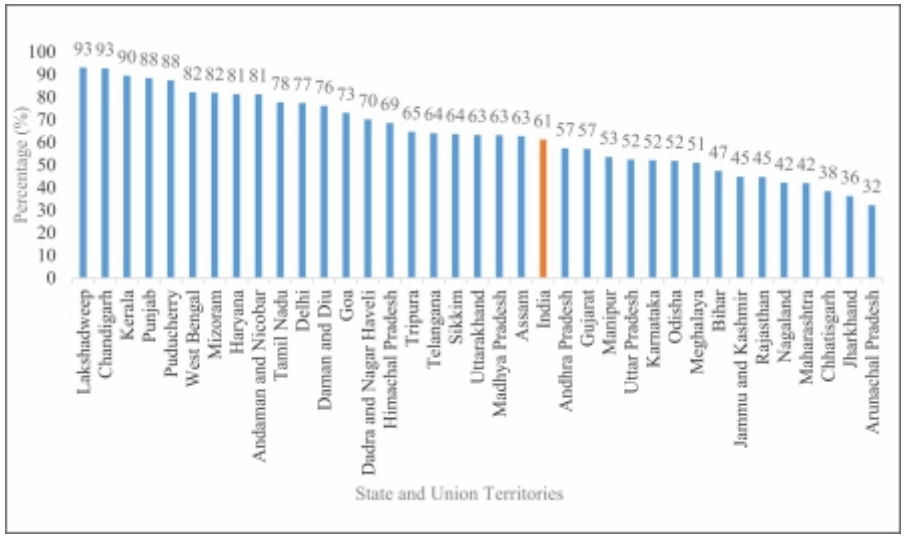

Figure 9: Percentage of medically certified causes of deaths as reported by households, in India: 2015-18

Discussion

Study finds NCDs are the major CoD in India, both in rural and urban areas and among men and women, while the second most common cause was ill-defined conditions. Among NCDs, cardiovascular diseases, other non-specific NCDs and malignancies were the major CoD, across all the age groups in India. These findings are concurrent with other studies [8-11]. The trend analysis showed slight decline in cardiovascular diseases, but rising trend for musculoskeletal diseases and diabetes. Among communicable diseases tuberculosis was the leading CoD. Declining trend of unintentional injuries related deaths due to motor vehicle accidents and suicide was noticed, but unintentional injuries due to causes other than motor vehicle had rising trend. CoD certified by a medical professional varied across the country, with Lakshadweep and Chandigarh having the highest number of certifications and Arunachal Pradesh the lowest. Overall deaths were more in rural areas, among men, and in individuals above 60 years. Similar findings were reported in hospital based studies and prospective cohort studies [12-14]. Results of our study are also comparable with other national level studies conducted in India [14-15]. The ranking for the major causes of the death in this study was similar to SRS. However, there are differences in proportion of leading CoD reported in this study and in SRS. The SRS reported higher proportion of deaths due to NCDs (56%), communicable, maternal, perinatal and nutritional conditions (21.5%), and injuries (10.4%) and reported less number of deaths due to ill-defined causes (12.2%) [16]. In our study we found a higher proportion of deaths in the ill-defined category (36.0%). This may be due to differences in the methodology adopted by SRS and LASI. In SRS, verbal autopsy was used and CoD were assigned by the trained physicians while in LASI study, the data collectors assigned the CoD based on drop down given in questionnaire. SRS also had 4 different forms to cover the different causes for different age groups. However, LASI

used one questionnaire for assessment of CoD. These differences are also due to differences in objectives of the study, with SRS being a more comprehensive survey for specific and reliable data on birth and death rates in India, both at the national and state levels. However, it takes time to publish its report. The LASI, survey, focused on health and social economic parameters to be measured among older population, along with small component of measure of mortality. In this study, neonatal deaths (8.4%) and unintentional injury due to road accidents (7.3%) substantially contributed to deaths in less than 45years age group, similar to the findings in other studies [17-19].

This study reported higher level of deaths certified by medical professionals compared to national report published by the government [2]. These might be due to differences in the Civil Registration System (CRS) for collecting the MCCD data and LASI. Under CRS the coverage of scheme in terms of percentage level of medical certification as well as the type of hospitals covered is not uniform across the States/UTs. Other studies also have found the reporting of MCCD to be at a sub-optimal level [20]. In LASI, data were gathered at the household level from relatives of deceased individuals, which resulted in a higher number of deaths being attributed to be certified by medical professionals rather deaths being reported by hospitals.

Globally the premature NCD mortality has significantly decreased from 22.9% in 2000 to 17.8% in 2019, which can be attributed to better prevention, diagnosis, and treatment [21]. Reduction in NCD related deaths were reported across the different WHO regions, except for South-East Asia Region, where an increase in premature NCD mortality was observed between 2015-2019 [22]. In this study we found, slight decline in cardiovascular diseases in India, but rising trend for other NCDs like musculoskeletal diseases and diabetes. These results are concordant with other studies in India [23-26].

The study highlights the importance of more effective prevention and treatment programs for cardio-vascular disease, musculo-skeletal disorders, cancer and diabetes to reduce its associated mortality due to NCDs. Similar recommendations were made in other studies [27-28]. However, tuberculosis and malaria are still a leading CoD due to communicable diseases among the younger population and slightly rising trend was seen during the study period. However, decline in tuberculosis and malaria deaths are reported in recent years [29-30]. The LASI study demonstrated that simple community based survey can be conducted, with the help of qualified trained data collectors using simple questionnaire. However, to minimize the number of deaths classified under ill-defined conditions, trained physicians can use the medical history and reports provided by household members to recode the ill-defined CoD cases. This approach can enhance data quality and improve understanding of the true CoD. This analysis provided information that using LASI questionnaire, it is feasible to conduct rapid mortality surveys especially during epidemics or pandemics, to understand the excess CoD in health emergencies.

There are a few limitations to this study. First, some families may have under-reported deaths because they were unwilling to recall or share the traumatic circumstances surrounding the individual's passing. Secondly, because the LASI study included only individuals aged 45 and above, it may have over-

looked deaths occurring in households with members younger than 45. As a result, the findings on CoD cannot be generalized to populations under 45 years of age. Another limitation of study is that causes were identified according to the treatment of terminal illness by seeing their medical prescription and other CoD reports, so the underlying CoD might have been missed for some cases.

Conclusion

Our study found NCDs to be the leading CoD in India, both in rural and urban areas, and among men and women, followed by ill-defined conditions. Prevalence of deaths certified by medical professionals as reported by households, varied across the country. Significant proportion of CoD collected by data collectors were in 'ill-defined' categories which highlights the need for training of data collectors.

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