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Caste, religion and regional differentials in life expectancy at birth in India

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Caste, religion and regional differentials in life expectancy at birth in India

Meena Kumari, International Institute for population Sciences (IIPS), Govandi station Road, Deonar, Mumbai-400088
Email:meenaiips@gmail.com
Prof. Sanjay Kumar Mohanty, Department of Fertility Studies, International Institute for population Sciences (IIPS) Mumbai-400088, India
Email: sanjayiips@yahoo.co.in

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Objective Though estimates of longevity are available for states of India by sex and place of residence, disaggregated estimates by social and economic characteristics are not available. In this study we have estimated the life expectancy at birth by caste, religion and in regions of India. **Design:** This study primarily used data from National Family Health Survey (NFHS-4), 2015-2016 and the Sample Registration System (SRS), 2011-2015 is used in estimation. The NFHS 4 is the largest ever demographic and health survey in India covering 601,509 households, 811,808 individual. **Measures:** The abridged life table is constructed to estimate the life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_{0}q_{70}$) by caste, religion and regions. **Results**: The life expectancy at birth was estimated at 66.4 years for schedule caste (SC), 67.2 years for scheduled tribe (ST), 68.1 years for OBC, and 70.4 years for others. The life expectancy at birth was higher among female compared to males across the social group in India. The life expectancy at birth was higher among Christian (71 years) followed by Muslim (68 years) and Hindu (68 years). The life expectancy ranges from 67–71 years across regions of India. With a difference of more than 4 years, the life expectancy was as low as 66.6 years in central regions compared to 70.9 years in West region. **Conclusion**: Many Health Policies promoting health system in India. But the improvements in health were not uniform throughout the country. Disparity by caste, religion, and sex in health remains large in India.

Strengths and Limitations of the study:

- ➢ This is the first ever study that provided the estimates of premature mortality and adult mortality by social characteristics of the society e.g. caste and religion in India.
- ➢ It also estimated the life expectancy at birth by caste and religions by different regions in India.
- ➢ Disease burden, disability among female and Cause of adult mortality and premature death in India were not explored in this study.

➢ However, the study could not analyse the estimates of life expectancy at birth, adult mortality and premature mortality for all Indian states separately due to the unavailability of appropriate number of sample.

➢ The NFHS was not powered to calculate mortality rate like SRS. To make it comparable with SRS and analyse the mortality data by different socio-economic characteristics we computed multiple calibration factors and link it with the datasets. So, we have not been able to provide the CIs for our estimates.

Introduction

Life expectancy at birth is one of the most frequently used summary measure of health of any population. Besides, it is used to quantify the health dimension of human development index [1]. Globally, the life expectancy at birth is converging among countries [2,3]. It is also converging across geographical regions within national boundary [3,4]. Besides life expectancy at birth, infant mortality rate, under-five mortality rate and utilisation of basic health services are converging [5–7]. The sex differential in life expectancy at birth has been narrowing down and the focus of research in both developed and developing countries [8–12]. Findings from large number of studies in developing countries suggests that female are disadvantages in health and health care [13]. Though life expectancy at birth has been rising in almost all societies but mortality differences exist within, as well as, between the population sub-group within national and regional boundaries [14–23]. This disparity in mortality is believed to have its roots in differential socioeconomic background of different social groups and has been increasing in India [24–26]. Urban inhabitants of the developing world generally enjoy improved medical care and means of life, better education, and other improved socio-economic facilities, which impact positively on health outcomes [27–30].

India with a population of 1.35 billion in 2018 is experiencing significant improvement in health indicators. The life expectancy at birth has increased from 58.7 years in 1990 to 68.30 years by 2015 (RGI). The state variations in life expectancy has been narrowing down over time. Although India has witnessed a spectacular improvement in mortality, the changes in mortality conditions across its states have been different [26]. There was a strong North-South gradient across the states, with great variations in the level and the pace of mortality reduction over time [31–33]. For instance, the life expectancy was higher in Kerala than Uttar Pradesh in India [34–37]. Similarly the adult mortality and premature deaths are high [33]. The national and state average in life expectancy conceals large variation among states and social groups in India.

Caste and religion plays an important determinant of health; education, employment, social and economic outcomes in India. Caste and religion are often used as key social variables and given priority in national and state policies. The caste structure is also said to have associated with economic wellbeing of the household. For the benefit of welfare schemes in India, the population of India are classified into four caste groups namely schedule caste, schedule tribe,

other backward class and others. The ST population, accounting 8.6% of total population are most deprived population followed by SC population. A large number of studies has examined the caste differentials in health and health care in India and states and found poor health of SC and ST population [38–40]. However, studies suggest that the socio-economic inequality has been increasing over time [41–43]. The socio-economic inequality is associated with poor health outcome among sub-group of population in the country [44–47].

The sample registration system (SRS) provides regular estimates of life expectancy at birth and age specific death rate for major states, by sex and for rural and urban areas. However, such estimates are not available for social groups such as caste and religion and by economic groups. To our knowledge there were two studies that provided the estimates of life expectancy by social group/ economic groups. Mohanty and Ram (2010) estimated the life expectancy at birth among social group using NFHS-2 and NFHS-3 data and found that life expectancy at birth are similar among poor across caste groups [48] . Recently, [47] provides the estimates of life expectancy at birth across wealth quintile using NFHS 4 data and found that life expectancy at birth among poorest wealth quintile was 65.1 years lower than that of 72.7 years in richest wealth quintile. Earlier studies have identified the discrimination by quantifying whether differences in socioeconomic and health status in India. [49] explain lower caste children have worse height outcomes than higher caste in rural India [50]. Children's belonging to the STs, SCs and OBC can account for differences in health outcomes. [51] explain SC women's may be inequitably served by maternal health services and in some cases may face specific discrimination. Low health status are observed among poor, female, rural, and specific minority groups of Scheduled tribe and Scheduled castes [52]. In comparison to general caste, lower caste (OBC, SC/ST) women's were more likely to experience discrimination in rural western India [53]. Lower caste women reported a higher prevalence of poor health than higher caste [38,54]. At age 60, life expectancy, active life expectancy and inactive life expectancy estimates were significantly higher, by 2.3, 1.9 and 0.4 years, for older persons in the General castes group versus those in the SC/ST/OBC group respectively [46,55]. In case of regions the life expectancy were lower among central region than other regions other studies also support these findings [40,56].

The national average conceal large variations across population sub-group and by socio-economic characteristics. This is one of the few study that examine the mortality pattern and life expectancy ST, SC, OBC and Others, religion and by measures of life expectancy at birth are not often available across population sub-groups. It also examine the health inequalities within caste and regions and examine if these differences also followed a socioeconomic patterning.

Data Sources:

Data from National Family Health Survey (NFHS-4), 2015-16 and the Sample Registration System (SRS), 2011-2015 is used in estimation. The National Family Health Surveys (NFHSs) are the large-scale, multi-round survey, conducted in a representative sample of households throughout India. The first round of NFHS was conducted in 1992-93 and completed its fourth round in 2014-15. The NFHS 4 is the largest ever demographic and health survey in India that

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covered 601,509 households and 811,808 individual. The NFHS provides consistent and reliable estimates of fertility, mortality, family planning, child nutritional status, morbidity, utilization of maternal and child health care services, anaemia, utilization and quality of health and family planning services and other related indicators. NFHS-4 collects data at the national and district level and had the distinction of the largest ever population based health survey in the country.

Questions on death of any members to the households in a three-year reference period was collected in NFHS4. A total of 74,945 deaths were recorded during survey. Along with death records, data on sex, place of residence, caste, religion and household's assets and amenities were collected. The caste data are generally collected by Scheduled Caste (SC), Scheduled Tribe (ST), Other Backward Class (OBC), and Others. Generally, the ST are considered to be socially and economically poorer followed by SC and OBC. Many central and state government welfare schemes are specifically designed for the welfare of the population. Similarly, data on religion were collected in seven groups. These are Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Other religion and persuasions and religion not stated. According to Census of India 2011, 79.80 % of the population in India were Hindus, 14.23 % were Muslims and 2.30 % Christians and 3.69% others. We have combined Sikh, Buddhist, Jain, Other Religion and Not Stated religion group owing to sample size constraints. Besides, the ASDR from SRS is used to compare the mortality rate across age group.

Methods:

The SRS data do not provide information on death by socio-economic status (SES). The advantages of using NFHS data is use of its death statistics by socio-economic characteristics. In the NFHS-4, 0.6 per cent (479) of 74,945 deaths were found missing for one or more socio-economic status (SES). The missing information on SES for age at death were adjusted and explained below.

The followings steps were used in computing the ASDR, life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_0q_{70}$) by caste and religion.

1. Adjustment of Missing Death cases: The cases with missing information on SES for age at death were inflated by 100/100-x for each age groups [47].

2. Computing Age Specific Death Rate (ASDR): To calculate annual death rates, the age-specific death, 74945 in total, was divided by 3 to make the death annually, assuming constant mortality rates across the 3 years prior to survey.

3. Adjustment of ASDR: The number of age-specific death was computed using the information from death reported in last three year prior to survey, at household level. 479 cases were found missing for some basic variables like age, sex and other SES characteristics. We have distributed 479 cases equally in each age group by using statistical method aforementioned in method used.

4. To make comparable death rates with the SRS, the death rates generated on NFHS data was adjusted with a calibration factor (C-factor), a factor to minimize the relative difference between death rates computed on different data source, for example, NFHS and SRS on household characteristics, for instance, caste, household poverty, religion and regions. The calibration factor was multiplied with the age-specific death rate compute using NFHS-4 data to make it equivalent with SRS rates [47]. Similarly,

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multiplying all subgroup of caste, religion and region with the appropriate C-Factor to derive mortality rates for each subgroups in NFHS data. In our calculation C-Factor was calculated by using NFHS and SRS data by sex in India.

5. The abridged life table is constructed to estimate the life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_0q_{70}$) by caste, religion and regions. The premature mortality is defined as any death under 70 years of age. The mathematical form of Premature ($_0q_{70}$) $= \frac{l_0}{l_{70}}$; and Mortality in working age ($_{15}q_{59}$) $= \frac{l_{15}}{l_{59}}$.

Finally, the age specific death rate was used to compute life expectancy at birth by sex, caste, religion and regions using the Chiang method. In Chiang method the $_na_x$ is estimated by average number of years lived in the x to x + n age interval by those dying in the interval [57,58]. Calibration factor is the ratio of response from detector to the analyte concentration. The purpose of this test is to characterize the calibration factor of the power sensor at each frequency parameter. The calibration factor created will be used as the correction for the power measured.

Patient and public involvement

Patients and the public were not involved. The paper uses secondary data available for public use.

Result

Figure 1 plot the ASDR was from SRS and NFHS in five-year age group. In general, the ASDR are close from both the sources and the ASDRs overlap in large number of age group. However, considering the SRS mortality as standard, we have used the calibration factor for mortality by five year age groups. The overall life expectancy at birth was estimated at 65.3 years from NFHS 4 compared to 68.3 years from SRS. **Table 1** presents the numerical value of ASDR from SRS and NFHS by five-year age group and the calibration factors. The life expectancy at birth was 68.3 years and 65.3 years from SRS and NFHS respectively–a difference of 1.05 years in India. **Figure 2** presents the life expectancy at various ages. The differences in life expectancy from these two sources suggests that, the life expectancy estimated from NFHS is slightly lower than that of SRS. Beyond age 45, the ASDR from NFHS 4 are lower than that of SRS. The result suggest that life-expectancy varies by different social characteristics, say caste, religion and regions in India.

Figure 3 summarized the estimated ASDR by caste in India. The ASDR were higher among SC (0.0483) followed by OBC (0.0439), ST (0.0400) and then others (0.0378) at age below 1. Similarly at latter ages curve shows a zigzag pattern in each category. Contrastingly, at age 80 years and later, the ASDR was higher among for population belonging to others caste (0.1217) than SC (0.1205) in India. **Figure 4** presents the age-specific death rate by religion. The ASDR were higher among Muslim (0.0451) than others (0.0274) for age below 1. Among population between age group 1-4 and 45-49, the ASDR was higher for Hindu than that of Muslims. But at latter ages ASDR were higher among Muslim religion followed by Hindu, others and then Christian in India.

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Figure 5, shows higher ASDR in East region (0.0517) than West region (0.0248) for age below 1 year. Additionally, the death rate among children 1-9 years were higher in Southern than Northern region (0.0035 versus 0.0005). The death rate were almost similar for 10 to 35 then starts splitting and higher ASDR in Northeast for age group 35-39 years. The death rate for population of age group 65-69 were higher in East than West region (0.0353 versus 0.0241) in India. The iota variation were visible at age below 1 and 1-4 age group and it starts showing a fair gap among population of age-group 60-64 to 80-85.

The life expectancy at birth varies by four years across different caste groups in India (**Table 2).** The life expectancy at birth was estimated at 66.4 years for schedule caste, 67.2 years for scheduled tribe, and 68.1 years for OBC, and 70.4 years for others. Female had higher life expectancy at birth compared to males and this gap remains consistent by sex across the ethnic group in India. However, this gap decreases at the onset of elderly age (at age 60 years) and ranges from 1.2 to 2.8 years across the ethnic groups. The life expectancy at age 60 was 17 years for SC, 18.1 or ST, 17.8 years for OBC and 18.8 years for others. The result is consistent with other study in terms of life expectancy of women and men [8,9]. Women had higher life expectancy than men in across different caste categories in India.

Religion differentials in life expectancy suggests that the life expectancy at birth was higher among Christian (71 years) compared to Muslim (68 years) and Hindu (68 years) **(Table 3).** Table 3 also shows that the gap of life expectancy between male and female was as high as 5 years among Christian followed by others (4 years), Hindu (3 years) and Muslim (2 years) in India. The sex differential was found higher than 4 years among Christian followed by Hindu, Others and Muslim at the age of 20 years. The female life expectancy at birth was highest among Christians (73.8 years) followed by others (72.8 years) and Hindu (69.9 years) but it was lowest among Muslim in India **(Table 3).**

Table 4 presents the life expectancy at birth by region in India. The life expectancy ranges from 67–71 years across region. With a difference of more than 4 years, the life expectancy was as low as 66.6 years in central regions compared to 70.9 years in West region. However, life expectancy at age 1 was 72 years in North and 69 years in Northeast region – a difference of 3.1 years. Similarly, among male, life expectancy ranged from a low among Northeast (64.9 years) to high among West region (68.8 years) –a difference of 3.9 years. At age1, the gap in life expectancy by sex was as high as 6 year in South followed by West (4.4 years), North (4.3 years) and Northeast region (4.2 years). Below age 1, the gap in LE by sex was lower in East region. Similarly, female life expectancy at birth was higher among West region (73.2 years) and lower in East region (67.1 years), a difference of 6.1 years.

The probability of death for adult and premature mortality were estimated by sex, region, and religion. The results were presented in table 5 and 6. **Table 5** findings shows that the level of adult mortality is higher for males than females in India. The individual belonging to SCs 0.14 has higher probability of adult death than individual belonging to others caste group 0.11. Similarly, by religion, the probability of death for Hindu 0.13 were higher than others 0.13 followed by Christians 0.11 and Muslims 0.12. By region, the probability of dying for adult

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death in northeast region was higher 0.15 in west 0.11 of India. Similar to adult mortality the **table 6** summarized that the premature mortality and it was higher for male than the female. By caste group, individual belonging to SC caste has higher probability of premature mortality than general caste 0.14 versus 0.11. The premature mortality was also analysed by religions and regions in India. The risk of premature mortality vary by religion. For instance, Muslims 0.30 had higher premature mortality than Christian 0.26. By region, the probability of premature mortality in Northeast region 0.34 was found to be higher followed by Central 0.33, East 0.32, South 0.29, West 0.26, and North region 0.26.

Prior studies suggests that caste and religion differential shows inequality in mortality across both population, subgroups and geographic areas in [44,59,60]. This study addressing ethnic disparities in health and provide evidence for the gap in life expectancy across different ethnic groups in India.

Discussion

Life expectancy at birth is widely used as a summary measure of health. Disaggregated estimates of life expectancy are limited in many developing countries including India. This is the first ever study that estimated the life expectancy at birth by social groups such as caste and religion in India. The followings are salient findings of this study.

First, we found remarkable variation in life expectancy at birth across caste and religion in India. The life expectancy at birth among SC was lowest followed by ST, OBC and others. The gap in life expectancy at birth others was 4 years. **Second,** the caste and religion differentials in life expectancy was not only observed at birth but also across ages. The gap in life expectancy among SC and others narrowed down at age 1-4 and continues decline up to age group 80-84. However in case of religion, we found higher life expectancy among Christians followed by Others, Muslims and then Hindu. The gap in life expectancy at birth between Christian and Hindu was 3 years. The life expectancy was as low in central regions compared West region at age below 1 year. **Third,** we found consistent sex differentials in life expectancy across caste and religion groups. The life expectancy at birth for women was higher for men in across the social group in both rural and urban and these findings are consistent in literature. **Fourth**, the adult mortality ($_{15}q_{59}$) were higher among SC than others and gap between SC and Others was 0.4. However in case of religion, the probability of adult death ($_{15}q_{59}$) were higher among Hindus than Muslims in India. In case of region the probability of death were higher among northeast than west region in India. **Fifth** premature mortality ($_0q_{70}$) were higher among SC than their counterpart from others caste group in India. However in case of religion the premature deaths ($_0q_{70}$) among Muslims were higher than Christians. By region, the premature mortality ($_0q_{70}$) in Northeast region were higher than North region in India.

EXPALNATION WHY SUCH RESULTS

We put forward the following explanation to our findings. The caste system, with its societal stratification and social restrictions, continues to have a major impact in India [61]. Caste and religion is inextricably linked to and is a proxy for socio-economic status in India. The poor socioeconomic status (SES) is significantly associated with poor health outcomes and low access to health-care facilities. Caste-based exclusion is related to lack of access to services

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offered by societies. Lower accessibility and poorer health statistics are observed among the lower castes in India. The ill health and disability has increased with increasing longevity. Similarly gender variation in health is consistent with other studies. At latter ages women reported marginally higher disability than [62]. The average year of disability free life expectancy among female was lower than male in India. It is well-established fact that life expectancy dividing gender is a well-organized result observed throughout the world and it has been explained by a combination of biological and behavioural factors [47]. Adult mortality risks could be a result of chronic infection or malnutrition in childhood. Most of the non-communicable diseases are non-curable but can be controlled with regular treatment. On other hand, while the risk of being affected by these life-style conditions is relatively lower among the poor, once affected, they cannot afford the continued high treatment costs and so they experience a premature death. Finding indicates significant differences in the population's health across different caste, religion and regions. The Hindu children have higher mortality than Muslim children's [63].

The reduction of premature mortality, a major public health focus, is one of the UN Sustainable Development Goals [64]. Mortality rate has decreased for most age groups from 2000 to 2016, especially for adolescents and young adults in many developed and developing regions but remains high among middle aged adult (ages 36-55) and older adult (55 years) but premature mortality and adult mortality is still higher among all ethnic groups globally [65,66].

Conclusion:

The findings suggest that the mortality differentials are significant across caste, religion and regions in India. Though, female life expectancy at birth is higher for female, they might be suffering from higher morbidity. The premature mortality is high across caste and religion groups. Prioritising reduction of premature mortality including infant and under-five mortality among SC and ST is recommended.

Figure 1: Age specific death rate from NFHS-4 and SRS, 2011-2015, in India.

Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15 in India.

Figure 3: Adjusted Age Specific death rate across caste groups in India 2015-16.

Figure 4: Age Specific death rate by Religions in India.

Figure 5: Age Specific death rate across Regions of India 2015-16.

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Table 1: ASDR by five year age group and estimated life expectancy from NFHS 4 and SRS in India, 2015-16

Age group	ASDR_NFHS	ASDR_SRS	Calibration Factors	Life expectancy NFHS_2015	Life expectancy SRS_2015	Calibration Factors
0-1	0.0485	0.0429	0.8846	65.3	68.3	1.05
1-5	0.0055	0.0022	0.4021	67.5	70.3	1.04
5-10	0.0049	0.0008	0.1677	65.0	66.9	1.03
10-15	0.0008	0.0007	0.8716	61.5	62.2	1.01
15-20	0.0014	0.0011	0.7546	56.8	57.4	1.01
20-25	0.0018	0.0015	0.8058	52.2	52.7	1.01
25-30	0.0021	0.0017	0.7782	47.6	48.1	1.01
30-35	0.0036	0.0020	0.5686	43.1	43.5	1.01
35-40	0.0032	0.0027	0.8663	38.8	38.9	1.00
40-45	0.0045	0.0038	0.8263	34.4	34.4	1.00
45-50	0.0060	0.0054	0.8924	30.1	30.0	0.99
50-55	0.0083	0.0086	1.0365	26.0	25.7	0.99
55-60	0.0147	0.0127	0.8627	22.0	21.7	0.99
60-65	0.0188	0.0196	1.0422	18.5	18.0	0.97
65-70	0.0311	0.0303	0.9720	15.1	14.6	0.97
70-75	0.0418	0.0465	1.1126	12.2	11.5	0.95
75-80	0.0821	0.0700	0.8529	9.4	8.9	0.94
80-85	0.0856	0.1142	1.3347	8.0	6.6	0.82
85+	0.1664	0.2058	1.2370	6.0	4.9	0.81

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Table: 2. **L**ife expectancy by caste and Sex in India, 2015-16.

Age interval	SC			ST			OBC			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	66.4	64.4	68.6	67.2	64.7	70.1	68.1	66.7	69.7	70.4	69.2	71.7
1-4	68.7	66.7	70.9	68.9	66.6	71.6	70.2	68.6	71.9	72.1	70.7	73.6
5-9	65.3	63.1	67.7	65.7	63.3	68.5	66.8	65.1	68.7	68.6	67.1	70.2
10-14	60.5	58.4	63.0	60.9	58.5	63.7	62.1	60.3	64.0	63.8	62.4	65.5
15-19	55.8	53.6	58.2	56.2	53.8	59.0	57.3	55.5	59.2	59.0	57.5	60.6
20-24	51.1	49.0	53.5	51.6	49.1	54.4	52.6	50.8	54.5	54.3	52.7	55.9
25-29	46.5	44.4	48.9	47.1	44.6	49.9	47.9	46.2	49.8	49.6	48.1	51.3
30-34	41.9	39.9	44.3	42.6	40.1	45.3	43.3	41.6	45.2	44.9	43.4	46.5
35-39	37.4	35.4	39.7	38.1	35.8	40.7	38.7	37.1	40.5	40.2	38.8	41.8
40-44	32.9	31.1	35.1	33.7	31.6	36.2	34.2	32.7	35.9	35.6	34.4	37.0
45-49	28.7	27.0	30.6	29.5	27.4	31.8	29.8	28.4	31.3	31.1	29.9	32.4
50-54	24.5	23.0	26.2	25.4	23.6	27.4	25.5	24.3	26.8	26.8	25.7	27.9
55-59	20.6	19.2	22.2	21.7	20.0	23.5	21.5	20.3	22.7	22.8	22.0	23.6
60-64	17.0	15.8	18.3	18.1	16.8	19.6	17.8	16.8	18.8	18.8	18.2	19.4
65-69	13.7	12.7	14.9	14.8	13.8	15.9	14.3	13.5	15.2	15.3	14.8	15.8
70-74	10.9	10.1	11.7	11.9	10.9	12.8	11.3	10.7	12.1	12.1	11.7	12.4
75-79	8.2	7.5	8.9	9.1	8.4	9.9	8.7	8.2	9.3	9.5	9.2	9.7
80-84	6.0	5.5	6.5	7.2	6.7	7.7	6.6	6.1	7.0	6.8	6.8	6.9
85+	4.0	3.5	4.6	5.1	4.9	5.4	4.7	4.2	5.2	5.6	6.2	5.3

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Table: 3. Life expectancy by Religions and Sex in India, 2015-16

Age interval	Hindu			Muslim			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	68.1	66.5	69.9	68.3	67.3	69.3	71.3	69.1	73.8	70.6	68.7	72.8
1-4	70.1	68.4	72.1	70.4	69.2	71.7	72.5	70.3	75.0	71.6	69.8	73.6
5-9	66.7	64.9	68.8	66.9	65.5	68.5	69.2	67.0	71.6	67.9	66.1	69.9
10-14	62.0	60.2	64.1	62.1	60.7	63.7	64.6	62.4	66.9	63.1	61.3	65.1
15-19	57.2	55.4	59.3	57.3	55.8	58.9	59.8	57.7	62.0	58.2	56.4	60.2
20-24	52.6	50.7	54.7	52.5	51.1	54.1	55.1	53.0	57.3	53.4	51.6	55.3
25-29	47.9	46.1	50.0	47.9	46.5	49.4	50.3	48.1	52.6	48.7	47.0	50.5
30-34	43.3	41.5	45.4	43.2	41.8	44.7	45.6	43.6	47.8	44.1	42.4	45.9
35-39	38.8	37.0	40.7	38.5	37.1	40.0	41.1	39.0	43.3	39.5	37.9	41.1
40-44	34.3	32.7	36.1	33.9	32.6	35.3	36.6	34.7	38.5	35.2	33.6	36.9
45-49	29.9	28.4	31.5	29.4	28.1	30.8	32.3	30.7	34.0	31.0	29.6	32.4
50-54	25.6	24.3	27.1	25.0	23.9	26.3	28.1	26.8	29.6	26.7	25.5	28.0
55-59	21.7	20.5	22.9	21.1	19.9	22.3	24.0	23.0	25.0	22.7	21.6	23.8
60-64	17.9	17.0	18.9	17.4	16.4	18.4	20.0	19.0	21.1	19.0	18.2	19.7
65-69	14.5	13.7	15.4	14.2	13.4	15.0	16.7	16.0	17.3	15.4	14.6	16.3
70-74	11.4	10.8	12.2	11.5	10.9	12.0	13.0	12.5	13.4	12.2	11.6	12.8
75-79	8.8	8.3	9.4	8.8	8.8	8.9	10.4	10.2	10.5	9.1	8.4	9.9
80-84	6.6	6.2	7.0	6.6	6.5	6.7	7.4	7.5	7.2	6.8	6.2	7.4
85+	4.8	4.5	5.1	4.7	4.5	5.0	6.4	6.1	6.7	5.1	5.2	5.1

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Table: 4. Life expectancy across Regions and Sex in India, 2015-16

Age interval	Northeast			East			North			Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	66.8	64.9	69.1	66.7	66.2	67.1	70.7	68.7	73.0	66.6	65.4	67.9	70.9	68.8	73.2	69.2	66.6	72.2
1-4	68.9	67.0	71.1	69.2	68.4	70.0	72.0	70.0	74.3	69.1	67.7	70.6	71.6	69.6	74.0	70.9	68.4	73.7
5-9	65.7	63.7	68.1	65.7	64.8	66.7	68.4	66.3	70.8	65.7	64.1	67.4	68.1	65.9	70.7	67.8	65.3	70.7
10-14	60.9	58.9	63.3	61.0	60.0	61.9	63.5	61.5	65.9	60.9	59.3	62.6	63.3	61.1	65.9	63.3	60.8	66.2
15-19	56.2	54.1	58.5	56.2	55.2	57.2	58.7	56.7	61.1	56.1	54.6	57.9	58.5	56.2	61.0	58.5	56.0	61.3
20-24	51.5	49.5	53.9	51.5	50.5	52.5	53.9	51.9	56.3	51.5	49.9	53.2	53.7	51.4	56.4	53.7	51.3	56.5
25-29	46.9	44.9	49.2	46.9	45.9	47.9	49.2	47.2	51.6	46.9	45.4	48.7	49.1	46.7	51.8	49.1	46.7	51.8
30-34	42.3	40.3	44.6	42.2	41.3	43.2	44.5	42.6	46.9	42.4	40.9	44.1	44.4	42.1	47.0	44.5	42.1	47.1
35-39	37.7	35.9	39.9	37.7	36.8	38.6	39.9	38.0	42.1	37.8	36.4	39.4	39.7	37.5	42.3	39.9	37.7	42.4
40-44	33.3	31.5	35.4	33.2	32.5	34.0	35.4	33.6	37.5	33.3	31.9	34.9	35.2	33.0	37.6	35.5	33.5	37.7
45-49	29.0	27.3	30.9	28.8	28.2	29.5	30.9	29.2	32.9	28.9	27.6	30.4	30.8	28.8	33.0	31.1	29.2	33.1
50-54	24.9	23.6	26.5	24.5	24.0	25.1	26.7	25.1	28.5	24.7	23.5	25.9	26.6	24.8	28.5	26.8	25.2	28.6
55-59	21.1	19.9	22.5	20.6	20.1	21.1	22.7	21.2	24.3	20.8	19.6	22.1	22.4	21.0	24.0	22.8	21.3	24.4
60-64	17.3	16.3	18.5	17.0	16.6	17.3	18.8	17.7	20.1	17.1	16.1	18.1	18.6	17.5	19.8	19.1	17.8	20.4
65-69	14.4	13.5	15.3	13.5	13.2	13.8	15.2	14.2	16.3	13.9	13.1	14.8	15.2	14.2	16.2	15.6	14.6	16.6
70-74	11.5	11.1	12.0	10.6	10.3	11.0	12.1	11.2	13.1	11.1	10.4	11.9	11.8	11.0	12.7	12.5	11.7	13.2
75-79	9.0	8.6	9.5	8.0	7.7	8.4	9.1	8.3	10.0	8.5	7.9	9.1	9.2	8.7	9.7	10.1	9.6	10.5
80-84	6.6	6.3	6.8	6.0	5.9	6.0	6.6	5.9	7.4	6.4	6.0	6.8	6.8	6.3	7.2	7.6	7.3	8.0
85+	4.9	4.4	5.3	4.0	4.0	4.0	5.1	4.4	5.9	4.6	4.4	4.8	5.2	5.2	5.4	6.1	5.7	6.5

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Table: 5. Probability of death at age 15-59 and premature mortality ages 70 among caste, religion and region in India.

Probability of dying between n to x+n Interval						
Caste	SC	ST	OBC	Others		
15q59	0.1440	0.1553	0.1223	0.1076		
0q70	0.3348	0.3332	0.2980	0.2604		
Religion	Hindu	Muslim	Christians	Others		
15q59	0.1275	0.1136	0.1142	0.1265		
0q70	0.3000	0.3042	0.2647	0.2725		
Region	Northeast	East	North	Central	West	South
15q59	0.1467	0.1325	0.1132	0.1374	0.1125	0.1198
0q70	0.3407	0.3176	0.2584	0.3300	0.2647	0.2872

Table: 6. Probability of death at age 15-59 and premature mortality ages 70 among different categories of caste, religion and regions by Sex in India.

Probability of dying between n to x+n Interval	SC		ST		OBC		Others	
Caste	Male	Female	Male	Female	Male	Female	Male	Female
15q59	0.1732	0.1109	0.1876	0.1202	0.1443	0.0987	0.1322	0.0795
0q70	0.3806	0.2840	0.3926	0.2674	0.3316	0.2628	0.2931	0.2255
Religion	Hindu		Muslim		Christians		Others	
15q59	0.1537	0.0982	0.1265	0.1003	0.1504	0.0757	0.1510	0.0999
0q70	0.3394	0.2572	0.3343	0.2736	0.3167	0.2067	0.3081	0.2349

Probability of dying between n to x+n Interval	Northeast		East		North		Central		West		South	
Regions	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15q59	0.1783	0.1116	0.1474	0.1166	0.1371	0.0860	0.1544	0.1186	0.1456	0.0746	0.1549	0.0821
0q70	0.3859	0.2871	0.3348	0.3013	0.3002	0.2123	0.3614	0.2974	0.3162	0.2074	0.3422	0.2258

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Competing interests

Both the authors hereby declare that there are no competing interests.

DECLARATION FOR DOUBLE BLIND

Availability of data and material

The data used for the study is available online and is available at public domain

(https://dhsprogram.com/what-we-do/survey/survey-display-355.cfm), and

http://www.censusindia.gov.in/vital_statistics/Appendix_SRS_Based_Life_Table.html

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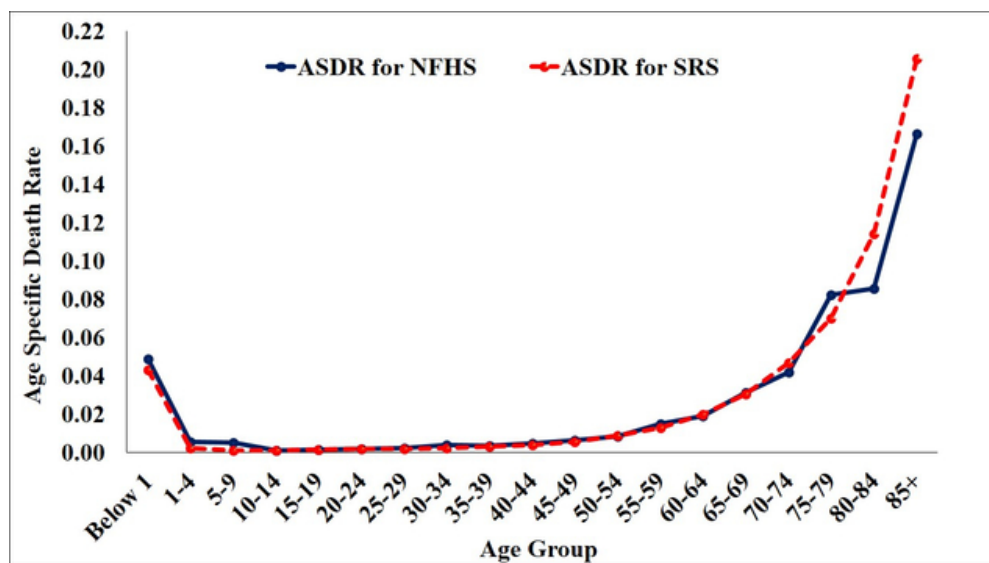   empirical data. *Lancet Glob Heal* 2018;**6**:e1087–99. doi:10.1016/S2214-109X(18)30353-X

Figure 1: Age specific death rate from NFHS-4 and SRS, 2011-2015, in India.

54x30mm (300 x 300 DPI)

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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15 in India.

54x30mm (300 x 300 DPI)

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Figure 3: Adjusted Age Specific death rate across caste groups in India 2015-16.

54x30mm (300 x 300 DPI)

Figure 4: Age Specific death rate by Religions in India.

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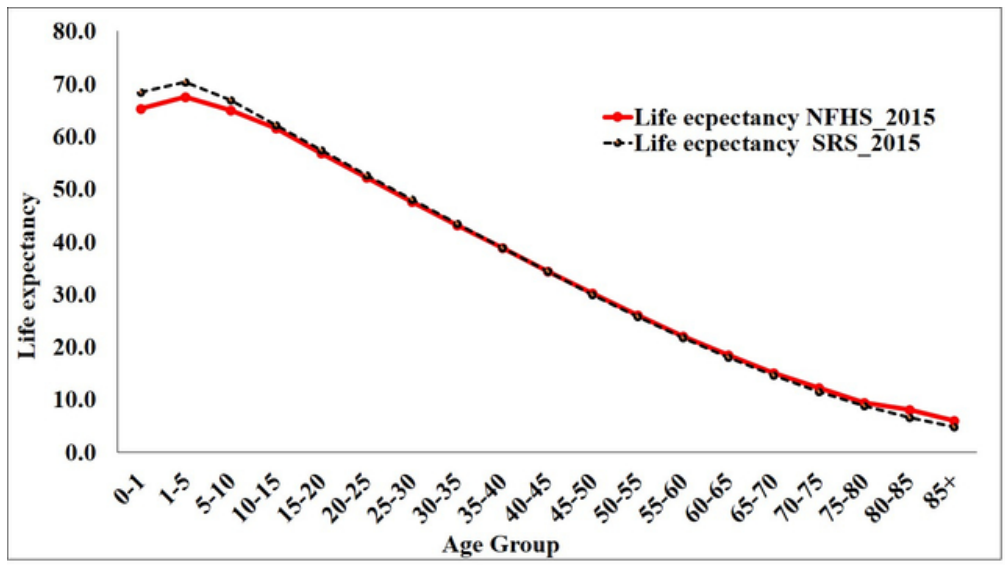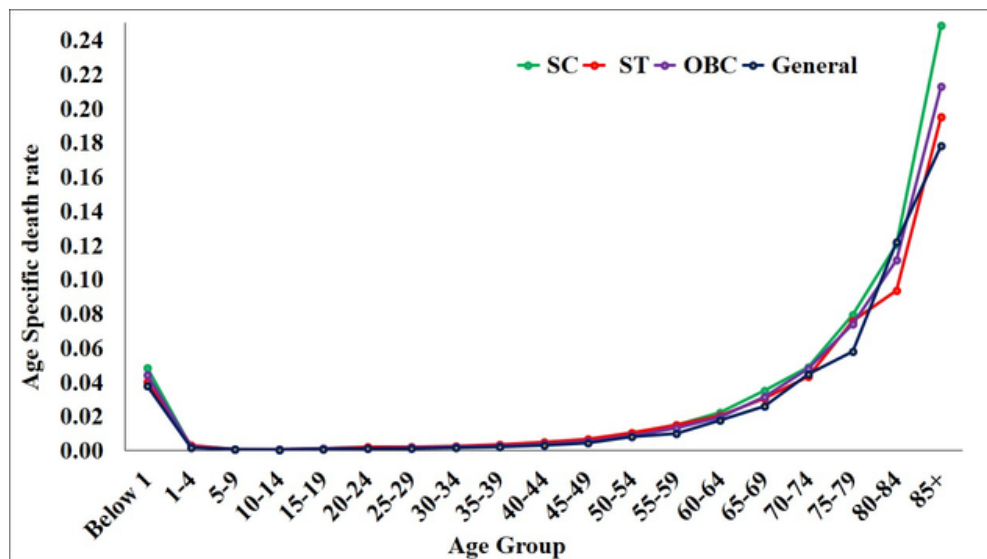43
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Figure 5: Age Specific death rate across Regions of India 2015-16.

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Caste, religion and regional differentials in life expectancy at birth in India

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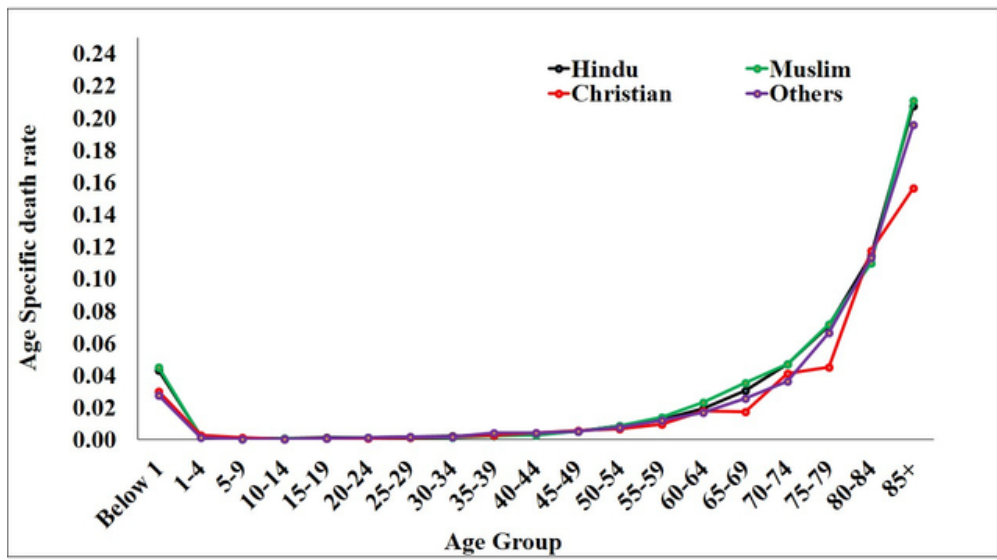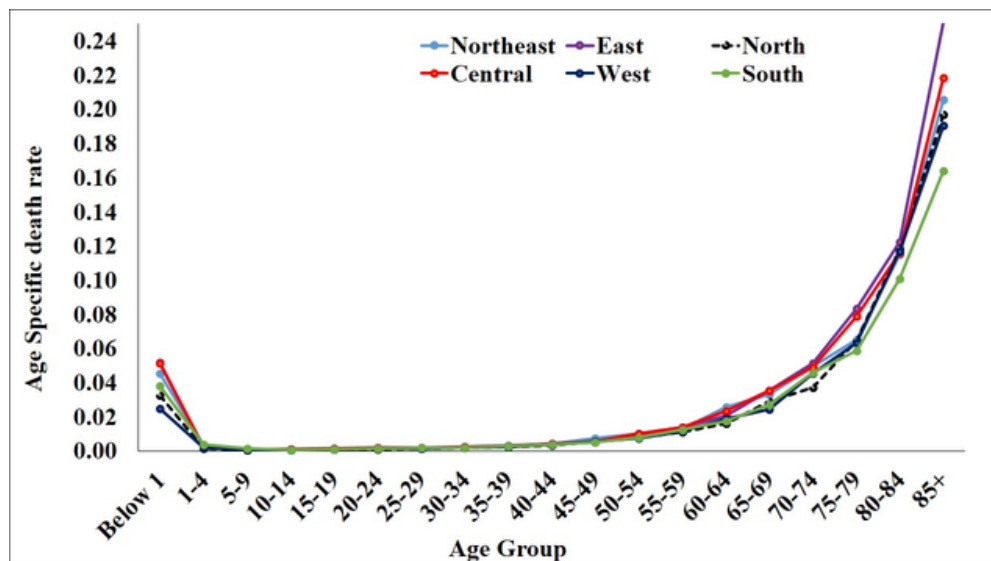41
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Caste, religion and regional differentials in life expectancy at birth in India

Meena Kumari, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088
Email:meenaiips@gmail.com
Prof. Sanjay Kumar Mohanty, Department of Fertility Studies, International Institute for Population Sciences (IIPS) Mumbai-400088, India
Email: sanjayiips@yahoo.co.in

Word Count: 3291

Objective: Though estimates of longevity are available by states, age, sex and place of residence in India, disaggregated estimates by social and economic groups are limited. This study, estimates the life expectancy at birth and premature mortality by caste, religion and regions of India.

Design: This study primarily used data from the National Family Health Survey (NFHS-4), 2015-2016 and the Sample Registration System (SRS), 2011-2015. The NFHS-4 has been the largest ever demographic and health survey covering 601,509 households and 811,808 individuals across all states and union territories in India.

Measures: The abridged life table is constructed to estimate the life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_0q_{70}$) by caste, religion and region.

Results: Life expectancy at birth was estimated at 66.4 years for Scheduled Castes (SC), 67.2 years for Scheduled Tribes (ST), 68.1 years for Other Backward Classes (OBC) and 70.4 years for Others. Life expectancy at birth was higher among females than among males across social groups in India. It was higher among Christians (71.3 years) followed by Muslims (68.3 years) and Hindus (68.1 years). Premature mortality was higher among SC (0.34), followed by ST (0.33), OBC (0.30) and Others (0.26). The regional variation in life expectancy by age and sex is large.

Conclusion: In India, social and religious differentials in life expectancy by sex are large and premature mortality and adult mortality are also high across caste and religious groups.

Strengths and Limitations of the Study

- ➤ This is the first ever study that provides estimates of life expectancy, by caste, religion and region in India.
- ➤ It provides estimates of premature and adult mortality across social groups and regions in India. Sex differentials in life expectancy and premature mortality are large across social groups and regions.
- ➤ Disease burden, disability and cause of premature mortality have not been explored in this study.

➢ State specific estimates of life expectancy, premature mortality have not been estimated due to inadequate sample size.

➢ Estimates of mortality and longevity are not linked to socio-economic status in India.

Introduction

Life expectancy at birth is one of the most frequently used summary measures of health. It is used to quantify the health dimension of the human development index [1]. Globally, life expectancy at birth is converging among and within countries [2–4]. Life expectancy at birth, infant mortality rate, under-five mortality rate and utilisation of basic health services are converging too [5–7]. Though the sex differential in life expectancy at birth has been narrowing down, findings from a large number of studies in developing countries suggest that females are disadvantaged in health and health care utilization [8–13].

Though life expectancy at birth has been rising in almost all societies, mortality differences exist within, as well as between, population sub-groups within national and regional boundaries [14-23]. Regional disparity in mortality is associated with socio-economic well-being and access to health care [24-26]. Conventionally, those with an urban residence and the economically and socially better off tend to have lower mortality and higher longevity [27–30].

India with a population of 1.35 billion in 2018 is experiencing significant improvement in health indicators. Life expectancy at birth has increased from 58.7 years in 1990 to 68.30 years in 2015 (RGI). The state variations in life expectancy have been narrowing down over the years. Although India has witnessed spectacular improvement in mortality, the changes in mortality conditions across the states have been different [26]. There was a strong North-South gradient across the states, with great variations in the level and the pace of mortality reduction over time [31–33]. For instance, life expectancy was higher in Kerala than in Uttar Pradesh in India [34–37]; adult mortality and premature deaths were also high [33]. The national and state average in life expectancy conceal large variation among states and social groups in India.

Caste and religion are important determinants of health, education, employment, social and economic outcomes in India. Caste and religion are often used as key social variables and given priority in national and state policies. The caste structure is also said to be associated with the economic well-being of the household. For the benefit of welfare schemes in India, the population of India is classified into four caste groups, namely Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. The ST population, accounting for 8.6% of the total population is the most deprived followed by SCs. A large number of studies have examined the caste differentials in health and health-care in India and its states, and found that the SC and ST population have poor health [38–40]. However, studies suggest that the increasing socio-economic inequality over the years has led to poor health outcomes among population sub-groups in the country [41–47].

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The Sample Registration System (SRS) provides regular estimates of life expectancy at birth and age-specific death rate for major states, by sex and place of residence. However, such estimates are not available for social groups such as caste and religion and by economic groups. To our knowledge, there were two studies that provided the estimates of life expectancy by social group/economic group. Mohanty and Ram (2010) estimated life expectancy at birth among the social groups using NFHS-2 and NFHS-3 data and found that life expectancy at birth is similar among the poor across caste groups [48]. Recently Asaria (2019) has provided estimates of life expectancy at birth across wealth quintiles using NFHS-4 data and found that life expectancy at birth among the poorest wealth quintile was 65.1 years compared to 72.7 years in the richest wealth quintile. Patel (2018) explains that SC women may be inequitably served by maternal health services and in some cases, even face specific discrimination. Low health status is observed among poor, female, rural and specific minority groups of Scheduled Tribes and Scheduled Castes [49–52]. In comparison to the General castes, lower caste (OBC, SC/ST) women were more likely to experience discrimination in rural western India [53]. Lower caste women reported a higher prevalence of poorer health than women of higher castes [38,54]. At age 60, life expectancy, active life expectancy and inactive life expectancy estimates were significantly higher, by 2.3, 1.9 and 0.4 years, for older persons in the General castes group versus those in the SC/ST/OBC groups respectively [46,55]. Many studies support the finding that life expectancy was lower in the Central region than in other regions [40,56].

The national average conceal large variations across population sub-groups and by socio-economic characteristics. This is the first ever study that estimates the life expectancy and mortality pattern by caste, religion, region and sex in India.

Data Sources

Data from the National Family Health Survey (NFHS-4), 2015-16 and the Sample Registration System (SRS), 2011-2015 have been used. The National Family Health Surveys (NFHSs) are large-scale, multi-round surveys, conducted in a representative sample of households throughout India. The first round of NFHS was conducted in 1992-93 and the fourth round in 2015-16. The NFHS-4 covered 601,509 households and 811,808 individuals. The NFHS provides reliable estimates of fertility, child mortality, family planning, child nutritional status and childhood morbidity for the country. With regard to mortality, NFHS 1, 2 and 3 were intended to provide reliable estimates of infant and child mortality. However, in NFHS-4, an attempt was made to capture overall mortality and data were collected at the national and district levels. It has the distinction of the largest ever population based health survey in the country.

Questions were asked on the death of any members of the household in a three-year reference period. A total of 74,945 deaths was recorded during the survey. Along with death records, data on sex, place of residence, caste, religion and household's assets and amenities were collected. Caste data were collected for Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. Generally, the STs are considered to be socially and economically poorer, followed by SCs and OBCs. Many central and state government welfare schemes have been specifically designed for the welfare of the population. Similarly, data on

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religion were collected in seven groups. These are Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Other religion and Religion not stated. We have combined Sikh, Buddhist, Jain, Other religion and Religion not stated groups owing to sample size constraints. The ASDR from SRS is used to compare the mortality rate across age groups.

Methods:

The SRS data do not provide information on death by socio-economic status (SES). The advantages of using NFHS data is the use of its death statistics by socio-economic characteristics. In the NFHS-4, 0.6 per cent (479) of 74,945 deaths were found missing for one or more socio-economic status (SES). The missing information on SES for age at death were adjusted.

The following steps were used in adjusting missing cases, computing the Age-specific Death Rate (ASDR), life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_0q_{70}$) by caste, religion and region.

1. Adjustment of Missing Death cases: The cases with missing information on SES for age at death were inflated by 100/100-x for each age group [47].

2. A total of 479 cases was found missing for some basic variables like age, sex and other SES characteristics. We have distributed 479 cases equally in each age group.

3. Computing Age-specific Death Rate (ASDR): The number of age-specific deaths were divided by 3 to estimate the annual death rate.

4. Estimation of life expectancy using abridged life table: Life expectancy at birth was computed using age-specific death and midyear population from the NFHS-4 life table approach.

5. To minimize the relative difference between the death rates from NFHS and SRS and make them comparable, the adjustment factor was computed. The adjustment factor is defined as the ratio of mortality rates obtained from SRS to mortality rates estimated from NFHS-4 and was computed for each age group, place of residence and sex. The adjustment factor was multiplied by the age-specific death rate computed using NFHS-4 data to make it equivalent to SRS rates [47].

6. The abridged life table is constructed to estimate life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_0q_{70}$) by caste, religion and region. Premature mortality is defined as any death under 70 years of age. The mathematical form of Premature $(_0q_{70}) = \dfrac{l_0 - l_{70}}{l_0}$; and Mortality in working age $(_{15}q_{59}) = \dfrac{l_{15} - l_{59}}{l_{15}}$ [57].

Mathematically

$$A_{0\text{-}1\,(Male,\,Female,\,Total)} = \frac{M^{SRS}_{0-1\,(Male,\,Female,\,Total)}}{M^{NFHS}_{0-1\,(Male,\,Female,\,Total)}} \quad \text{--------------------- (1)}$$

$$A_{1\text{-}4\,(Male,\,Female,\,Total)} = \frac{M^{SRS}_{1-4\,(Male,\,Female,\,Total)}}{M^{NFHS}_{1-4\,(Male,\,Female,\,Total)}} \quad \text{--------------------- (2)}$$

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$$A_{85+ (Male, Female, Total)} = \frac{M^{SRS}_{85+ (Male, Female, Total)}}{M^{NFHS}_{85+ (Male, Female, Total)}} \text{---------------------- (3)}$$

The above computed adjustment factors for each group 0-5, 5-10 … 80-85 are then used to estimate the mortality rate for each age group as follows:

$$M^{SRS}_{0-1(Male, Female, Total)} = A_{0-1(Male, Female, Total)} * M^{NFHS}_{0-1(Male, Female, Total)} \text{---------- (4)}$$

$$M^{SRS}_{1-4 (Male, Female, Total)} = A_{1-4 (Male, Female, Total)} * M^{NFHS}_{1-5 (Male, Female, Total)} \text{---------- (5)}$$

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$$M^{SRS}_{85+ (Male, Female, Total)} = A_{85+ (Male, Female, Total)} * M^{NFHS}_{85+ (Male, Female, Total)} \text{----------- (6)}$$

In this calculation, *'M'* signifies the mortality rate for the given subgroup from the National Family Health Survey (NFHS) and Sample Registration System (SRS) data set and *'A'* signifies the subgroup specific adjustment factor for each age group. We assumed this adjustment factor to be constant across caste, religion and regional differentials within this subgroup.

Finally, the age-specific death rate was used to compute life expectancy at birth by sex, caste, religion and region using the Chiang method. In the Chiang method the $_na_x$ is estimated by the average number of years lived in the x to x + n age interval by those dying in the interval [57–59].

Patient and public involvement
Patients and the public were not involved. The paper uses secondary data available for public use.

Results

Figure 1 plots the age-specific death rate (ASDR) from SRS and NFHS in a five-year age group. The life expectancy at birth was 68.3 years from SRS and 65.3 years from NFHS – a difference of 1.05 years. In general, the ASDRs is close from both the sources and the ASDRs overlap in a large number of age groups. While keeping the SRS mortality as standard, we have used the adjustment factor for mortality by five-year age groups. The overall age-specific death rate at birth was estimated at 0.048 from NFHS 4 compared to 0.043 from SRS. **Table 1** presents the numerical value of ASDR from SRS and NFHS by a five-year age group and the adjustment factors. **Figure 2** presents the life expectancy at various ages. Results suggest that life-expectancy varies with different social characteristics; caste, religion and region in India.

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Figure 3 summarizes the estimated ASDR by caste in India. The ASDR was higher among SCs (0.048) followed by OBCs (0.044), STs (0.040) and then Others (0.038) at below age one. Similarly, at later ages, the curve shows a skewed pattern in each category. **Figure 4** presents the age-specific death rate by religion. The ASDR was higher among Muslims (0.045) than among Others (0.027) for age below one. Among population aged 50 years, the ASDR was higher for Hindus than for Muslims. But at later ages, the ASDR was higher among Muslims followed by Hindus, Others and Christians in India.

Figure 5 shows that the ASDR for those below one year, was higher in the Eastern region (0.052) followed by the Western region (0.025). The death rate among children aged 1-9 years was higher in the Southern than in the Northern regions (0.004 vs. 0.001). The death rate was almost similar between age groups 10-34. The death rate for population in the age group 65-69 was higher in the Eastern region than in the Western region (0.035 versus 0.024). The variations were visible at age below one and in the 1-4 age group and showed a gap amongst the population of age-groups 60-85.

The life expectancy at birth varies from four years across different caste groups in India (**Table 2).** The life expectancy at birth was estimated at 66.4 years for Scheduled Castes, 67.2 years for Scheduled Tribes, 68.1 years for OBCs and 70.4 years for Others. Females had a higher life expectancy at birth compared to males and this gap remains consistent across all the social groups. However, this gap decreases at the onset of elderly age (60 years) and ranges from 1.2 to 2.8 years across social groups. The life expectancy at age 60 was 17 years for SCs, 17.8 years for OBCs, 18.1 years for STs and 18.8 years for Others. These findings are consistent with those of other studies [8,9]. Women had a higher life expectancy than men across different caste categories in India.

Table 3 summarizes religious differentials in life expectancy. It suggests that the life expectancy at birth was higher among Christians (71.3 years) compared to Muslims (68.3 years) and Hindus (68.1 years)**.** The gap in life expectancy between male and female was highest among Christians (5 years), followed by Others (4 years), Hindus (3 years) and Muslims (2 years). Female life expectancy at birth was highest among Christians (73.8 years) followed by Others (72.8 years) and Hindus (69.9 years) but it was lowest among Muslims (69.3). The sex differential in life expectancy at age 20 was higher among Christians followed by Hindus, Others and Muslims.

Table 4 presents the life expectancy at birth by region in India, which ranges from 67–71 years. With a difference of more than 4 years, the life expectancy was as low as 66.6 years in the Central region compared to 70.9 years in the Western region. However, the life expectancy at age one was 72.0 years in the Northern region and 68.9 years in the Northeast – a difference of 3.1 years. Similarly, among males, the life expectancy at birth ranged from 64.9 years in the Northeast to 68.8 years in the Western region –a difference of 3.9 years. At age one, the gap in life expectancy by sex was as high as 6 years in the South followed by the West (4.4 years), North (4.3 years) and Northeast (4.2 years). Below age one, the gap in life expectancy by sex was lower in the Eastern region. Similarly, life expectancy at birth for females was higher in

the Western region (73.2 years) and lower in the Eastern region (67.1 years), a difference of 6.1 years.

The probability of death for adults (15-59 years) and premature mortality (before at age 70) were estimated by sex, caste, region and religion. Results were presented in Table 5 and 6. **Table 5** shows that the level of adult mortality is higher among males than among females in India. Individuals belonging to SCs have a higher probability of adult death (0.144) than Others caste groups (0.108). Similarly, by religion, the probability of death among Hindus was 0.128 compared to 0.127 among Others, followed by 0.114 among Christians and 0.114 among Muslims. By region, the probability of adult death in the North-eastern region was higher (0.147) than that in the Western regions (0.113). Similarly, premature mortality by caste group revealed that individuals belonging to SCs had a higher probability of premature mortality than General castes (0.335 versus 0.260). Premature mortality was also analyzed by religions and regions in India and was found to vary. For instance, Muslims (0.304) had a higher premature mortality than Christians (0.265). By region, the probability of premature mortality in the Northeast was 0.341 followed by Central 0.330, East 0.318, Southern 0.287, Western 0.265 and Northern regions 0.258. **Table 6** reveals that the adult mortality and premature mortality was higher among males than among females in each social strata; caste, religion, region in India. Premature mortality among males and females was high among STs (0.125) followed by SCs (0.097), OBCs (0.069) and Others (0.068). Similarly, for religion, premature mortality gap was higher among Christians than among Muslims. Regional variations shows that the gap was wider in the South than in other regions.

Prior studies suggests that caste and religion differentials show inequality in mortality across populations, subgroups and geographic areas [44,59,60]. This study addresses social disparities in health and provides evidence for the gap in life expectancy and premature mortality across different social groups in India.

Discussion

Life expectancy at birth is widely used as a summary measure of health. Disaggregated estimates of life expectancy are limited in many developing countries including India. This is the first ever study that estimates life expectancy at birth and premature mortality by social groups such as caste, religion and region in India. The followings are salient findings of this study.

First, life expectancy at birth varies largely across caste, religion and region in India. Life expectancy at birth among SCs was lowest, followed by STs, OBCs and Others. **Second,** the caste and religion differentials in life expectancy were not only observed at birth but also across the ages. Life expectancy at birth was highest among Christians followed by Others, Muslims and Hindus. The gap in life expectancy at birth between Christians and Hindus was 3 years. It was low in the Central region compared to the Western region at age below one year. **Third,** we found consistent sex differentials in life expectancy across caste and religious groups. Life expectancy at birth for women was higher for men across social groups in both rural and urban areas. **Fourth**, adult mortality ($_{15}q_{59}$) was highest among SCs and the gap between SCs and Others was 0.4. However, in the case of religion, the probability of adult death ($_{15}q_{59}$) was

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higher among Hindus than among Muslims. The probability of death was higher among Northeast than in the Western region in India. **Fifth,** premature mortality ($_0q_{70}$) was highest among SCs. In the case of religion, premature deaths ($_0q_{70}$) among Muslims was higher than among Christians. By region, premature mortality ($_0q_{70}$) in the Northeast was higher than in the North.

We put forward the following explanations. Life expectancy has been explained by a combination of biological and behavioural factors [47]. The caste system, with its societal stratification and social restrictions, continues to have a major impact in India [61]. Caste and religion are inextricably linked to and is a proxy for socio-economic status in India. The poor socio-economic status (SES) is significantly associated with poor health outcomes and lower access to health-care facilities. Caste-based exclusion is related to lack of access to services. Lower accessibility and poorer health statistics are observed among the lower castes in India. Similarly, gender variations in health are persistent cutting across caste and religion. Though women are living longer than men, they have higher morbidity and disability at later ages [62]. The average year of disability free life expectancy among females was lower than among male. Adult mortality risks could be a result of chronic diseases or malnutrition in childhood. Most of the non-communicable diseases are non-curable but can be controlled with regular treatment. On the other hand, while the risk of being affected by these life-style conditions is relatively lower among the poor, once affected, they cannot afford the continued high treatment costs and so they experience premature death. The findings indicate significant differences in the population's health across different castes, religions and regions. Hindu children have higher mortality than Muslim children [63].

The reduction of premature mortality, a major public health focus, is one of the UN Sustainable Development Goals [64]. The Mortality rate has decreased for most age groups from 2000 to 2016, especially for adolescents and young adults in many developed and developing regions, but remains high among middle aged adults (ages 36-55) and older adults (55 years). However, premature mortality and adult mortality are still higher among all ethnic groups globally [65–67].

Conclusion

The findings suggest that the mortality differentials are significant across caste, religion and region in India. Though, female life expectancy at birth is higher for females, they might be suffering from higher morbidity. Premature mortality is high across caste and religious groups. Prioritizing reduction of premature mortality, including infant and under-five mortality is recommended.

Figure 1: Age-specific Death Rate from NFHS-4 and SRS, 2011-2015 in India

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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15 in India

Figure 3: Adjusted Age-specific death rate across caste groups in India 2015-16

Figure 4: Age-specific death rate by religion in India 2015-16

Figure 5: Age-specific death rate across regions in India 2015-16

Table 1: ASDR by five-year age group and estimated life expectancy from NFHS 4 and SRS in India, 2015-16

Age Group	ASDR_NFHS	ASDR_SRS	Adjustment Factors	Life Expectancy NFHS_2015	Life Expectancy SRS_2015	Adjustment Factors
0-1	0.0485	0.0429	0.8846	65.3	68.3	1.05
1-5	0.0055	0.0022	0.4021	67.5	70.3	1.04
5-10	0.0049	0.0008	0.1677	65.0	66.9	1.03
10-15	0.0008	0.0007	0.8716	61.5	62.2	1.01
15-20	0.0014	0.0011	0.7546	56.8	57.4	1.01
20-25	0.0018	0.0015	0.8058	52.2	52.7	1.01
25-30	0.0021	0.0017	0.7782	47.6	48.1	1.01
30-35	0.0036	0.0020	0.5686	43.1	43.5	1.01
35-40	0.0032	0.0027	0.8663	38.8	38.9	1.00
40-45	0.0045	0.0038	0.8263	34.4	34.4	1.00
45-50	0.0060	0.0054	0.8924	30.1	30.0	0.99
50-55	0.0083	0.0086	1.0365	26.0	25.7	0.99
55-60	0.0147	0.0127	0.8627	22.0	21.7	0.99
60-65	0.0188	0.0196	1.0422	18.5	18.0	0.97
65-70	0.0311	0.0303	0.9720	15.1	14.6	0.97
70-75	0.0418	0.0465	1.1126	12.2	11.5	0.95
75-80	0.0821	0.0700	0.8529	9.4	8.9	0.94
80-85	0.0856	0.1142	1.3347	8.0	6.6	0.82
85+	0.1664	0.2058	1.2370	6.0	4.9	0.81

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Table: 2. **Life expectancy by caste and sex in India, 2015-16**

Age Interval	SC			ST			OBC			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	66.4	64.4	68.6	67.2	64.7	70.1	68.1	66.7	69.7	70.4	69.2	71.7
1	68.7	66.7	70.9	68.9	66.6	71.6	70.2	68.6	71.9	72.1	70.7	73.6
5	65.3	63.1	67.7	65.7	63.3	68.5	66.8	65.1	68.7	68.6	67.1	70.2
10	60.5	58.4	63.0	60.9	58.5	63.7	62.1	60.3	64.0	63.8	62.4	65.5
15	55.8	53.6	58.2	56.2	53.8	59.0	57.3	55.5	59.2	59.0	57.5	60.6
20	51.1	49.0	53.5	51.6	49.1	54.4	52.6	50.8	54.5	54.3	52.7	55.9
25	46.5	44.4	48.9	47.1	44.6	49.9	47.9	46.2	49.8	49.6	48.1	51.3
30	41.9	39.9	44.3	42.6	40.1	45.3	43.3	41.6	45.2	44.9	43.4	46.5
35	37.4	35.4	39.7	38.1	35.8	40.7	38.7	37.1	40.5	40.2	38.8	41.8
40	32.9	31.1	35.1	33.7	31.6	36.2	34.2	32.7	35.9	35.6	34.4	37.0
45	28.7	27.0	30.6	29.5	27.4	31.8	29.8	28.4	31.3	31.1	29.9	32.4
50	24.5	23.0	26.2	25.4	23.6	27.4	25.5	24.3	26.8	26.8	25.7	27.9
55	20.6	19.2	22.2	21.7	20.0	23.5	21.5	20.3	22.7	22.8	22.0	23.6
60	17.0	15.8	18.3	18.1	16.8	19.6	17.8	16.8	18.8	18.8	18.2	19.4
65	13.7	12.7	14.9	14.8	13.8	15.9	14.3	13.5	15.2	15.3	14.8	15.8
70	10.9	10.1	11.7	11.9	10.9	12.8	11.3	10.7	12.1	12.1	11.7	12.4
75	8.2	7.5	8.9	9.1	8.4	9.9	8.7	8.2	9.3	9.5	9.2	9.7
80	6.0	5.5	6.5	7.2	6.7	7.7	6.6	6.1	7.0	6.8	6.8	6.9
85+	4.0	3.5	4.6	5.1	4.9	5.4	4.7	4.2	5.2	5.6	6.2	5.3

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Table: 3. Life Expectancy by religion and sex in India, 2015-16

Age Interval	Hindu			Muslim			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	68.1	66.5	69.9	68.3	67.3	69.3	71.3	69.1	73.8	70.6	68.7	72.8
1	70.1	68.4	72.1	70.4	69.2	71.7	72.5	70.3	75.0	71.6	69.8	73.6
5	66.7	64.9	68.8	66.9	65.5	68.5	69.2	67.0	71.6	67.9	66.1	69.9
10	62.0	60.2	64.1	62.1	60.7	63.7	64.6	62.4	66.9	63.1	61.3	65.1
15	57.2	55.4	59.3	57.3	55.8	58.9	59.8	57.7	62.0	58.2	56.4	60.2
20	52.6	50.7	54.7	52.5	51.1	54.1	55.1	53.0	57.3	53.4	51.6	55.3
25	47.9	46.1	50.0	47.9	46.5	49.4	50.3	48.1	52.6	48.7	47.0	50.5
30	43.3	41.5	45.4	43.2	41.8	44.7	45.6	43.6	47.8	44.1	42.4	45.9
35	38.8	37.0	40.7	38.5	37.1	40.0	41.1	39.0	43.3	39.5	37.9	41.1
40	34.3	32.7	36.1	33.9	32.6	35.3	36.6	34.7	38.5	35.2	33.6	36.9
45	29.9	28.4	31.5	29.4	28.1	30.8	32.3	30.7	34.0	31.0	29.6	32.4
50	25.6	24.3	27.1	25.0	23.9	26.3	28.1	26.8	29.6	26.7	25.5	28.0
55	21.7	20.5	22.9	21.1	19.9	22.3	24.0	23.0	25.0	22.7	21.6	23.8
60	17.9	17.0	18.9	17.4	16.4	18.4	20.0	19.0	21.1	19.0	18.2	19.7
65	14.5	13.7	15.4	14.2	13.4	15.0	16.7	16.0	17.3	15.4	14.6	16.3
70	11.4	10.8	12.2	11.5	10.9	12.0	13.0	12.5	13.4	12.2	11.6	12.8
75	8.8	8.3	9.4	8.8	8.8	8.9	10.4	10.2	10.5	9.1	8.4	9.9
80	6.6	6.2	7.0	6.6	6.5	6.7	7.4	7.5	7.2	6.8	6.2	7.4
85+	4.8	4.5	5.1	4.7	4.5	5.0	6.4	6.1	6.7	5.1	5.2	5.1

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Table: 4. Life expectancy across regions and sex in India, 2015-16

Age Interval	Northeast			East			North			Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	66.8	64.9	69.1	66.7	66.2	67.1	70.7	68.7	73.0	66.6	65.4	67.9	70.9	68.8	73.2	69.2	66.6	72.2
1	68.9	67.0	71.1	69.2	68.4	70.0	72.0	70.0	74.3	69.1	67.7	70.6	71.6	69.6	74.0	70.9	68.4	73.7
5	65.7	63.7	68.1	65.7	64.8	66.7	68.4	66.3	70.8	65.7	64.1	67.4	68.1	65.9	70.7	67.8	65.3	70.7
10	60.9	58.9	63.3	61.0	60.0	61.9	63.5	61.5	65.9	60.9	59.3	62.6	63.3	61.1	65.9	63.3	60.8	66.2
15	56.2	54.1	58.5	56.2	55.2	57.2	58.7	56.7	61.1	56.1	54.6	57.9	58.5	56.2	61.0	58.5	56.0	61.3
20	51.5	49.5	53.9	51.5	50.5	52.5	53.9	51.9	56.3	51.5	49.9	53.2	53.7	51.4	56.4	53.7	51.3	56.5
25	46.9	44.9	49.2	46.9	45.9	47.9	49.2	47.2	51.6	46.9	45.4	48.7	49.1	46.7	51.8	49.1	46.7	51.8
30	42.3	40.3	44.6	42.2	41.3	43.2	44.5	42.6	46.9	42.4	40.9	44.1	44.4	42.1	47.0	44.5	42.1	47.1
35	37.7	35.9	39.9	37.7	36.8	38.6	39.9	38.0	42.1	37.8	36.4	39.4	39.7	37.5	42.3	39.9	37.7	42.4
40	33.3	31.5	35.4	33.2	32.5	34.0	35.4	33.6	37.5	33.3	31.9	34.9	35.2	33.0	37.6	35.5	33.5	37.7
45	29.0	27.3	30.9	28.8	28.2	29.5	30.9	29.2	32.9	28.9	27.6	30.4	30.8	28.8	33.0	31.1	29.2	33.1
50	24.9	23.6	26.5	24.5	24.0	25.1	26.7	25.1	28.5	24.7	23.5	25.9	26.6	24.8	28.5	26.8	25.2	28.6
55	21.1	19.9	22.5	20.6	20.1	21.1	22.7	21.2	24.3	20.8	19.6	22.1	22.4	21.0	24.0	22.8	21.3	24.4
60	17.3	16.3	18.5	17.0	16.6	17.3	18.8	17.7	20.1	17.1	16.1	18.1	18.6	17.5	19.8	19.1	17.8	20.4
65	14.4	13.5	15.3	13.5	13.2	13.8	15.2	14.2	16.3	13.9	13.1	14.8	15.2	14.2	16.2	15.6	14.6	16.6
70	11.5	11.1	12.0	10.6	10.3	11.0	12.1	11.2	13.1	11.1	10.4	11.9	11.8	11.0	12.7	12.5	11.7	13.2
75	9.0	8.6	9.5	8.0	7.7	8.4	9.1	8.3	10.0	8.5	7.9	9.1	9.2	8.7	9.7	10.1	9.6	10.5
80	6.6	6.3	6.8	6.0	5.9	6.0	6.6	5.9	7.4	6.4	6.0	6.8	6.8	6.3	7.2	7.6	7.3	8.0
85+	4.9	4.4	5.3	4.0	4.0	4.0	5.1	4.4	5.9	4.6	4.4	4.8	5.2	5.2	5.4	6.1	5.7	6.5

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Table: 5. Probability of death at age 15-59 and premature mortality at age 70 by caste, religion and region in India

Probability of dying between n to x+n Interval						
Caste	SC	ST	OBC	Others		
15q59	0.1440	0.1553	0.1223	0.1076		
0q70	0.3348	0.3332	0.2980	0.2604		
Religion	Hindus	Muslims	Christians	Others		
15q59	0.1275	0.1136	0.1142	0.1265		
0q70	0.3000	0.3042	0.2647	0.2725		
Region	Northeast	East	North	Central	West	South
15q59	0.1467	0.1325	0.1132	0.1374	0.1125	0.1198
0q70	0.3407	0.3176	0.2584	0.3300	0.2647	0.2872

Table: 6. Probability of death at age 15-59 and premature mortality at age 70 among different categories of caste, religion and region by sex in India

Probability of dying between n to x+n Interval	SC		ST		OBC		Others	
Caste	Male	Female	Male	Female	Male	Female	Male	Female
15q59	0.1732	0.1109	0.1876	0.1202	0.1443	0.0987	0.1322	0.0795
0q70	0.3806	0.2840	0.3926	0.2674	0.3316	0.2628	0.2931	0.2255
Religion	Hindus		Muslims		Christians		Others	
15q59	0.1537	0.0982	0.1265	0.1003	0.1504	0.0757	0.1510	0.0999
0q70	0.3394	0.2572	0.3343	0.2736	0.3167	0.2067	0.3081	0.2349

Probability of dying between n to x+n Interval	Northeast		East		North		Central		West		South	
Regions	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15q59	0.1783	0.1116	0.1474	0.1166	0.1371	0.0860	0.1544	0.1186	0.1456	0.0746	0.1549	0.0821
0q70	0.3859	0.2871	0.3348	0.3013	0.3002	0.2123	0.3614	0.2974	0.3162	0.2074	0.3422	0.2258

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DECLARATION FOR DOUBLE BLIND

Availability of Data and Material

The data used for the study are in the public domain and available online

(https://dhsprogram.com/what-we-do/survey/survey-display-355.cfm), and

http://www.censusindia.gov.in/vital_statistics/Appendix_SRS_Based_Life_Table.html

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Figure 1: Age specific death rate from NFHS-4 and SRS, 2011-2015, in India

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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15, in India

54x30mm (600 x 600 DPI)

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Figure 3: Adjusted Age Specific death rate across caste groups in India, 2015-16

54x30mm (600 x 600 DPI)

Figure 4: Age-specific death rate by religion in India, 2015-16

54x30mm (600 x 600 DPI)

Figure 5: Age Specific death rate across Regions of India, 2015-16

54x30mm (600 x 600 DPI)

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Caste, religion and regional differentials in life expectancy at birth in India

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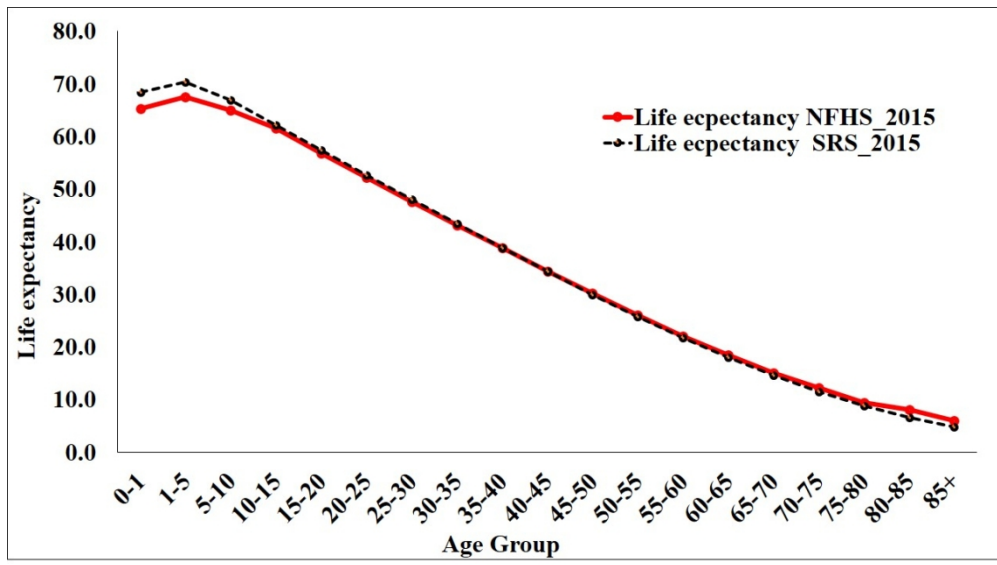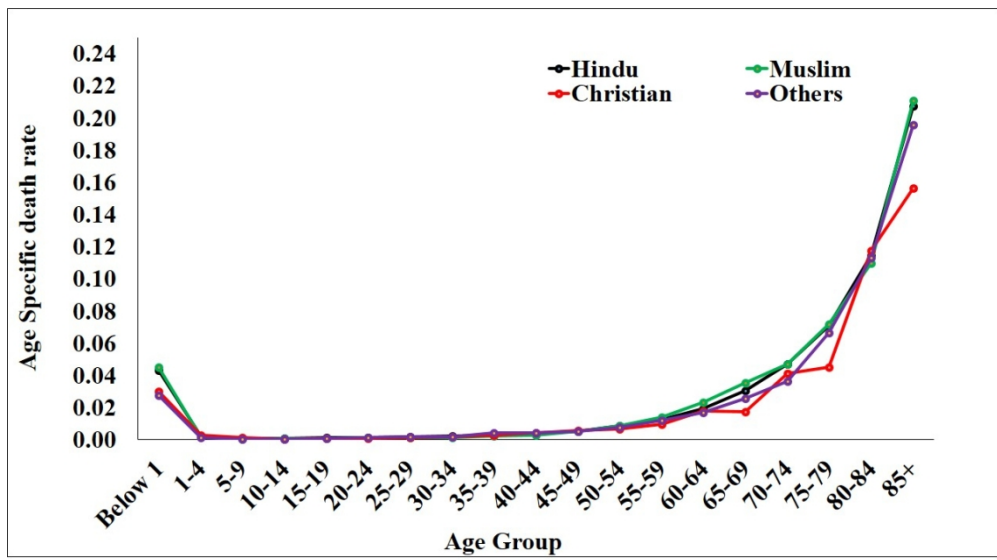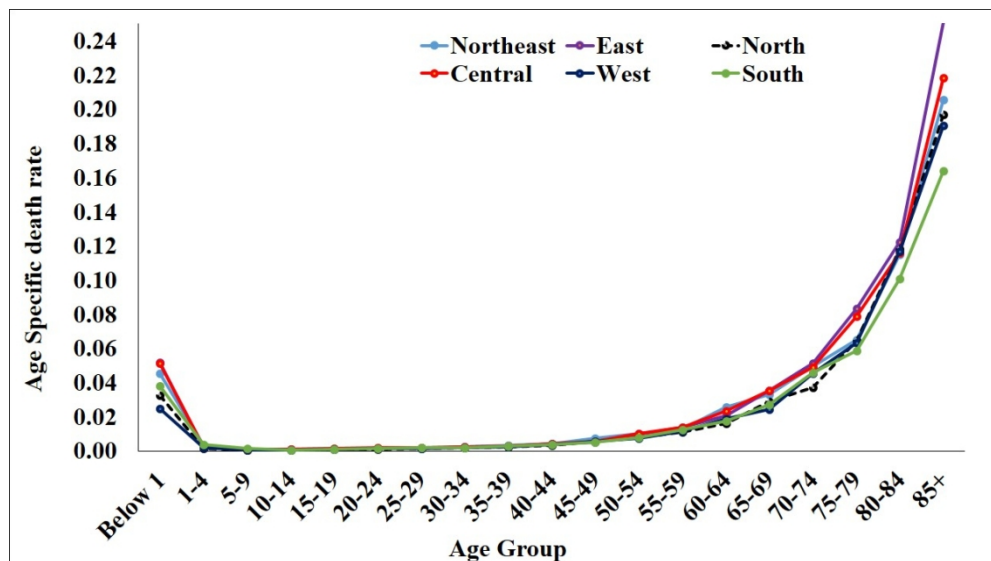41
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Caste, religion and regional differentials in life expectancy at birth in India

Meena Kumari, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088
Email:meenaiips@gmail.com
Prof. Sanjay Kumar Mohanty, Department of Fertility Studies, International Institute for Population Sciences (IIPS) Mumbai-400088, India
Email: sanjayiips@yahoo.co.in

Word Count: 3115

Objective: Though estimates of longevity are available by states, age, sex and place of residence in India, disaggregated estimates by social and economic groups are limited. This study, estimates the life expectancy at birth and premature mortality by caste, religion and regions of India.

Design: This study primarily used data from the National Family Health Survey (NFHS-4), 2015-2016 and the Sample Registration System (SRS), 2011-2015. The NFHS-4 has been the largest ever demographic and health survey covering 601,509 households and 811,808 individuals across all states and union territories in India.

Measures: The abridged life table is constructed to estimate the life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_{0}q_{70}$) by caste, religion and region.

Results: Life expectancy at birth was estimated at 63.1 years [95% CI: 62.60-63.64] for Scheduled Castes (SC), 64.0 years [95% CI: 63.25-64.88] for Scheduled Tribes (ST), 65.1 years [95% CI: 64.69-65.42] for Other Backward Classes (OBC) and 68.0 years [95%: 67.44-68.45] for Others. Life expectancy at birth was higher among females than among males across social groups in India. It was higher among Christians 68.1 years [95% CI: 69.81-74.30] followed by Muslims 66.0 years [95% CI: 66.71-68.45] and Hindus 65.0 years [95% CI: 67.34-68.09]. Premature mortality was higher among SC (0.382), followed by ST (0.381), OBC (0.344) and Others (0.301). The regional variation in life expectancy by age and sex is large.

Conclusion: In India, social and religious differentials in life expectancy by sex are large. Premature mortality and adult mortality are also high across caste and religious groups.

Strengths and Limitations of the Study

- ➤ This is the first ever study that provides estimates of life expectancy, by caste, religion and region in India.
- ➤ It provides estimates of premature and adult mortality across social groups and regions in India. Sex differentials in life expectancy and premature mortality are large across social groups and regions.
- ➤ Disease burden, disability and cause of premature mortality have not been explored in this study.

> ➢ State specific estimates of life expectancy, premature mortality have not been estimated due to inadequate sample size.
> ➢ Estimates of mortality and longevity are not linked to socio-economic status in India.

Introduction

Life expectancy at birth is one of the most frequently used summary measures of health. It is used to quantify the health dimension of the human development index [1]. Globally, life expectancy at birth is converging among and within countries [2–4]. Life expectancy at birth, infant mortality rate, under-five mortality rate and utilisation of basic health services are converging too [5–7]. Though the sex differential in life expectancy at birth has been narrowing down, findings from a large number of studies in developing countries suggest that females are disadvantaged in health and health care utilization [8–13].

Though life expectancy at birth has been rising in almost all societies, mortality differences exist within, as well as between, population sub-groups within national and regional boundaries [14-23]. Regional disparity in mortality is associated with socio-economic well-being and access to health care [24-26]. Conventionally, those with an urban residence and the economically and socially better off tend to have lower mortality and higher longevity [27–30].India with a population of 1.35 billion in 2018 is experiencing significant improvement in health indicators. Life expectancy at birth has increased from 58.7 years in 1990 to 68.30 years in 2015 (RGI). The state variations in life expectancy have been narrowing down over the years. Although India has witnessed spectacular improvement in mortality, the changes in mortality conditions across the states have been different [26]. There was a strong North-South gradient across the states, with great variations in the level and the pace of mortality reduction over time [31–33]. For instance, life expectancy was higher in Kerala than in Uttar Pradesh in India [34–37]; adult mortality and premature deaths were also high [33]. The national and state average in life expectancy conceal large variation among states and social groups in India.

Health, education, employment in India varies by social and economic groups in India. Caste and religion are often used as key social variables and given priority in national and state policies. The caste structure is also said to be associated with the economic well-being of the household. For the benefit of welfare schemes in India, the population of India is classified into four caste groups, namely Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. The ST population, accounting for 8.6% of the total population is the most deprived followed by SCs. A large number of studies have examined the caste differentials in health and health-care in India and its states, and found that the SC and ST population have poor health [38–40]. However, studies suggest that the increasing socio-economic inequality over the years has led to poor health outcomes among population sub-groups in the country [41–47].

The Sample Registration System (SRS) provides regular estimates of life expectancy at birth and age-specific death rate for major states, by sex and place of residence. However, such estimates are not available for social groups such as caste and religion and by economic groups.

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To our knowledge, there are few studies that provided the estimates of life expectancy by social group/economic group. Mohanty and Ram (2010) estimated life expectancy at birth among the social groups using NFHS-2 and NFHS-3 data and found that life expectancy at birth is similar among the poor across caste groups [48]. Recently Asaria et al. (2019) has provided estimates of life expectancy at birth across wealth quintiles using NFHS-4 data and found that life expectancy at birth among the poorest wealth quintile was 65.1 years compared to 72.7 years in the richest wealth quintile. Patel (2018) explains that SC women may be inequitably served by maternal health services and in some cases, even face specific discrimination. Low health status is observed among poor, female, rural and specific minority groups of Scheduled Tribes and Scheduled Castes [49–52]. In comparison to the General castes, lower caste (OBC, SC/ST) women were more likely to experience discrimination in rural western India [53]. Lower caste women reported a higher prevalence of poorer health than women of higher castes [38,54]. At age 60, life expectancy, active life expectancy and inactive life expectancy estimates were significantly higher, by 2.3, 1.9 and 0.4 years, for older persons in the General castes group versus those in the SC/ST/OBC groups respectively [46,55]. Many studies support the finding that life expectancy was lower in the Central region than in other regions [40,56].

The national average in longevity conceal large variations across population sub-groups and by socio-economic characteristics. This is the first ever study that estimates the life expectancy and mortality pattern by caste, religion, region and sex in India.

Data Sources

Data from the National Family Health Survey (NFHS-4), 2015-16 and the Sample Registration System (SRS), 2011-2015 have been used. The National Family Health Surveys (NFHSs) are large-scale, multi-round surveys, conducted in a representative sample of households throughout India. The first round of NFHS was conducted in 1992-93 and the fourth round in 2015-16. The NFHS-4 covered 601,509 households and 811,808 individuals. The NFHS provides reliable estimates of fertility, child mortality, family planning, child nutritional status and childhood morbidity for the country. With regard to mortality, NFHS 1, 2 and 3 were intended to provide reliable estimates of infant and child mortality. However, in NFHS-4, an attempt was made to capture overall mortality and data were collected at the national and district levels. It has the distinction of the largest ever population based health survey in the country.

Questions were asked on the death of any members of the household in a three-year reference period. A total of 74,945 deaths was recorded during the survey. Along with death records, data on sex, place of residence, caste, religion and household's assets and amenities were collected. Caste data were collected for Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. Generally, the STs are considered to be socially and economically poorer, followed by SCs and OBCs. Many central and state government welfare schemes have been specifically designed for the welfare of the population. Similarly, data on religion were collected in seven groups. These are Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Other religion and Religion not stated. We have combined Sikh, Buddhist, Jain, Other

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religion and Religion not stated groups owing to sample size constraints. The ASDR from SRS is used to compare the mortality rate across age groups.

Methods:

The SRS data do not provide information on death by socio-economic status (SES). The advantages of using NFHS data is the use of its death statistics by socio-economic characteristics. In the NFHS-4, 0.6 per cent (479) of 74,945 deaths were found missing for one or more socio-economic status (SES). The missing information on SES for age at death were adjusted.

The following steps were used in adjusting missing cases, computing the Age-specific Death Rate (ASDR), life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_{0}q_{70}$) by caste, religion and region.

1. Adjustment of Missing Death cases: The cases with missing information on SES for age at death were inflated by 100/100-x for each age group [47].

2. A total of 479 cases was found missing for some basic variables like age, sex and other SES characteristics. We have distributed 479 cases equally in each age group.

3. Estimation of Age Specific Annual Death Rate (ASDR): The annual ASDR was estimated as the data were collected in three year reference period.
   Estimation of life expectancy using abridged life table: Life expectancy at birth was computed using age-specific death and midyear population from the NFHS-4 life table approach. The 95% confidence interval of estimates are provided.

4. The abridged life table is constructed to estimate life expectancy at birth, adult mortality ($_{15}q_{59}$) and premature mortality ($_{0}q_{70}$) by caste, religion and region. Premature mortality is defined as any death under 70 years of age. The mathematical form of Premature $(_{0}q_{70}) = \dfrac{l_0 - l_{70}}{l_0}$; and Mortality in working age $(_{15}q_{59}) = \dfrac{l_{15} - l_{59}}{l_{15}}$ [57].

Finally, the age-specific death rate was used to compute life expectancy at birth by sex, caste, religion and region using the Chiang method. In the Chiang method the $_{n}a_{x}$ is estimated by the average number of years lived in the x to x + n age interval by those dying in the interval [57–59].

Patient and public involvement

Patients and the public were not involved. The paper uses secondary data available for public use.

Results

Figure 1 plots the age-specific death rate (ASDR) from SRS and NFHS in a five-year age group. The life expectancy at birth was 68.3 years from SRS and 65.3 years from NFHS 4. In general, the ASDRs is close from both the sources and the ASDRs overlap in a large number of age groups. **Table 1** presents the numerical value of ASDR from SRS and NFHS by a five-

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year age group. **Figure 2** presents the life expectancy at various ages. Results suggest that life-expectancy varies with different social characteristics; caste, religion and region in India.

Figure 3 summarizes the estimated ASDR by caste in India. The ASDR was higher among SCs (0.055) followed by OBCs (0.050), STs (0.045) and then Others (0.043) at below age one. Similarly, at later ages, the curve shows a skewed pattern in each category. **Figure 4** presents the age-specific death rate by religion. The ASDR was higher among Muslims (0.051) than among Others (0.031) for age below one. Among population aged 50 years, the ASDR was higher for Hindus than for Christian. But at later ages, the ASDR was higher among Muslims followed by Hindus, Others and Christians in India.

Figure 5 shows that the ASDR for those below one year, was higher in the Eastern region (0.059) followed by the Central region (0.025). The death rate among children aged 1-9 years was higher in the Southern than in the Northern regions (0.009 vs. 0.003). The death rate was almost similar between age groups 10-34. The death rate for population in the age group 65-69 was higher in the Eastern region than in the Western region (0.036 versus 0.025). The variations were visible at age below one and in the 1-4 age group and showed a gap amongst the population of age-groups 60-85.

The life expectancy at birth varies from four years across different caste groups in India (**Table 2).** The life expectancy at birth was estimated at 63.1 years [95% CI: 62.60-63.64] for Scheduled Castes, 64.0 years [95% CI: 63.25-64.88] for Scheduled Tribes, 65.1 years [95% CI: 64.69-65.42] for OBCs and 68.0 years [95% CI: 67.44-68.45] for Others (See Appendix Table 1). Females had a higher life expectancy at birth compared to males and this gap remains consistent across all the social groups. However, this gap decreases at the onset of elderly age (60 years) and ranges from 0.8 to 2.5 years across social groups. The life expectancy at age 60 was 17 years for SCs, 18.2 years for OBCs, 18.6 years for STs and 19.5 years for Others. These findings are consistent with those of other studies [8,9]. Women had a higher life expectancy than men across different caste categories in India.

Table 3 summarizes religious differentials in life expectancy. It suggests that the life expectancy at birth was higher among Others 68.6 years [95% CI: 67.38-69.80] compared to Christian 68.1 years [95% CI: 66.44-69.60] and Muslims 65.9 years [95% CI: 65.29-66.54] than India 65.0 years [95% CI: 64.74-65.22] (See Appendix Table 2)**.** The gap in life expectancy between male and female was highest among Christians (8 years), followed by Others (6 years), Hindus (5 years) and Muslims (3 years). Female life expectancy at birth was highest among Christians (72.1 years) followed by Others (71.5 years) and Hindus (67.7 years) but it was lowest among Muslims (67.6). The sex differential in life expectancy at age 20 was higher among Christians followed by Hindus, Others and Muslims.

Table 4 presents the life expectancy at birth by region in India, which ranges from 64–69 years. With a difference of more than 5 years, the life expectancy was as low as 63.6 years [95% CI: 63.12-64.05] in the East region compared to 68.7 years [95% CI: 68.06-69.34] (See Appendix Table 3) in the North region. However, the life expectancy at age one was 68.7 years in the Northern region and 63.8 years in the Northeast – a difference of 4.9 years. Similarly, among males, the life expectancy at birth ranged from 66.2 years [95% CI: 65.42-67.09] in the West

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to 60.9 years [95% CI: 59.16-62.58] (See Appendix Table 3) in the Northeast region –a difference of 5.3 years. At age one, the gap in life expectancy by sex was as high as 8 years in the South followed by the Northeast (5.5 years), North (5.4 years) and West (4.8 years). Below age one, the gap in life expectancy by sex was lower in the Eastern region. Similarly, life expectancy at birth for females was higher in the North region 71.8 years [95% CI: 70.96-72.73] and lower in the Eastern region 64.8 years [95% CI: 64.15-65.45] (See Appendix Table 3), a difference of 7.0 years.

The probability of death for adults (15-59 years) and premature mortality (before at age 70) were estimated by sex, caste, region and religion. Results were presented in Table 5 and 6. **Table 5** shows that the level of adult mortality is higher among males than among females in India. Individuals belonging to STs have a higher probability of adult death (0.178) than SCs caste groups (0.165). Similarly, by religion, the probability of death among Hindus was 0.147 compared to 0.145 among Others, followed by 0.133 among Christians and 0.129 among Muslims. By region, the probability of adult death in the North-eastern region was higher (0.167) than that in the Central regions (0.158). Similarly, premature mortality by caste group revealed that individuals belonging to SCs had a higher probability of premature mortality than General castes (0.382 versus 0.301). Premature mortality was also analyzed by religions and regions in India and was found to vary. For instance, Hindu (0.347) had a higher premature mortality than Muslim (0.341) and Christians (0.316). By region, the probability of premature mortality in the Northeast was 0.385 followed by Central 0.372, East 0.364, Southern 0.349, Western 0.303 and Northern regions 0.294. **Table 6** reveals that the adult mortality and premature mortality was higher among males than among females in each social strata; caste, religion, region in India. Premature mortality among males and females was high among STs (0.159) followed by SCs (0.127), OBCs (0.099) and Others (0.097). Similarly, for religion, premature mortality gap was higher among Christians than among Hindu. Regional variations shows that the gap was wider in the South than in other regions.

Prior studies suggests that caste and religion differentials show inequality in mortality across populations, subgroups and geographic areas [44,59,60]. This study addresses social disparities in health and provides evidence for the gap in life expectancy and premature mortality across different social groups in India.

Discussion

Life expectancy at birth is widely used as a summary measure of health. Disaggregated estimates of life expectancy are limited in many developing countries including India. This is the first ever study that estimates life expectancy at birth and premature mortality by social groups such as caste, religion and region in India. The followings are salient findings of this study.

First, life expectancy at birth varies largely across caste, religion and region in India. Life expectancy at birth among SCs was lowest, followed by STs, OBCs and Others. **Second,** the caste and religion differentials in life expectancy were not only observed at birth but also across the ages. Life expectancy at birth was highest among Christians followed by Others, Muslims and Hindus. The gap in life expectancy at birth between Christians and Hindus was 3 years. It

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was low in the Central region compared to the Western region at age below one year. **Third,** we found consistent sex differentials in life expectancy across caste and religious groups. Life expectancy at birth for women was higher for men across social groups in both rural and urban areas. **Fourth**, adult mortality ($_{15}q_{59}$) was highest among SCs and the gap between SCs and Others was 0.4. However, in the case of religion, the probability of adult death ($_{15}q_{59}$) was higher among Hindus than among Muslims. The probability of death was higher among Northeast than in the Western region in India. **Fifth,** premature mortality ($_0q_{70}$) was highest among SCs. In the case of religion, premature deaths ($_0q_{70}$) among Muslims was higher than among Christians. By region, premature mortality ($_0q_{70}$) in the Northeast was higher than in the North.

We put forward the following explanations. Life expectancy has been explained by a combination of biological and behavioural factors [47]. The caste system, with its societal stratification and social restrictions, continues to have a major impact in India [61]. Caste and religion are inextricably linked to and is a proxy for socio-economic status in India. The poor socio-economic status (SES) is significantly associated with poor health outcomes and lower access to health-care facilities. Caste-based exclusion is related to lack of access to services. Lower accessibility and poorer health statistics are observed among the lower castes in India. Similarly, gender variations in health are persistent cutting across caste and religion. Though women are living longer than men, they have higher morbidity and disability at later ages [62]. The average year of disability free life expectancy among females was lower than among male. Adult mortality risks could be a result of chronic diseases or malnutrition in childhood. Most of the non-communicable diseases are non-curable but can be controlled with regular treatment. On the other hand, while the risk of being affected by these life-style conditions is relatively lower among the poor, once affected, they cannot afford the continued high treatment costs and so they experience premature death. The findings indicate significant differences in the population's health across different castes, religions and regions. Hindu children have higher mortality than Muslim children [63].

The reduction of premature mortality, a major public health focus, is one of the UN Sustainable Development Goals [64]. The Mortality rate has decreased for most age groups from 2000 to 2016, especially for adolescents and young adults in many developed and developing regions, but remains high among middle aged adults (ages 36-55) and older adults (55 years). However, premature mortality and adult mortality are still higher among all ethnic groups globally [65–67].

Conclusion

The findings suggest that the mortality differentials are significant across caste, religion and region in India. Though, female life expectancy at birth is higher for females, they might be suffering from higher morbidity. Premature mortality is high across caste and religious groups. Prioritizing reduction of premature mortality, including infant and under-five mortality is recommended.

Figure 1: Age-specific Death Rate from NFHS-4 and SRS, 2011-2015, in India

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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15, in India

Figure 3: Age-specific death rate across caste groups in India, 2015-16

Figure 4: Age-specific death rate by religion in India, 2015-16

Figure 5: Age-specific death rate across regions in India, 2015-16

Table 1: ASDR by five-year age group and estimated life expectancy from NFHS 4 and SRS in India, 2015-16

Age Group	ASDR_NFHS	ASDR_SRS	Life Expectancy NFHS_2015 with CIs	Life Expectancy SRS_2015
0-1	0.0485	0.0429	65.3 (65.08-65.54)	68.3
1-5	0.0055	0.0022	67.5 (67.34-67.75)	70.3
5-10	0.0049	0.0008	65.0 (64.79-65.20)	66.9
10-15	0.0008	0.0007	61.5 (61.35-61.74)	62.2
15-20	0.0014	0.0011	56.8 (56.59-56.94)	57.4
20-25	0.0018	0.0015	52.2 (51.98-52.34)	52.7
25-30	0.0021	0.0017	47.6 (47.44-47.79)	48.1
30-35	0.0036	0.0020	43.1 (42.93-43.28)	43.5
35-40	0.0032	0.0027	38.8 (38.68-39.01)	38.9
40-45	0.0045	0.0038	34.4 (34.24-34.57)	34.4
45-50	0.0060	0.0054	30.1 (29.98-30.31)	30.0
50-55	0.0083	0.0086	26.0 (25.83-26.15)	25.7
55-60	0.0147	0.0127	22.0 (21.84-22.15)	21.7
60-65	0.0188	0.0196	18.5 (18.32-18.63)	18.0
65-70	0.0311	0.0303	15.1 (14.91-15.20)	14.6
70-75	0.0418	0.0465	12.2 (12.04-12.32)	11.5
75-80	0.0821	0.0700	9.4 (9.29-9.58)	8.9
80-85	0.0856	0.1142	8.0 (7.89-8.13)	6.6
85+	0.1664	0.2058	6.0 (6.01-6.01)	4.9

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Table: 2. Life expectancy by caste and sex in India, 2015-16

Age Interval	SC			ST			OBC			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.13	60.32	66.31	64.02	60.53	67.89	65.06	62.88	67.47	67.94	66.09	69.95
1	65.65	63.13	68.48	65.96	62.90	69.34	67.35	65.25	69.64	69.89	68.11	71.81
5	63.12	60.59	65.95	63.84	60.98	67.01	64.82	62.81	67.00	67.07	65.26	69.01
10	59.70	57.18	62.52	60.04	57.18	63.19	61.43	59.41	63.62	63.59	61.89	65.41
15	54.96	52.43	57.78	55.35	52.52	58.47	56.65	54.62	58.87	58.77	57.06	60.58
20	50.39	47.90	53.17	50.83	47.98	53.98	52.03	49.98	54.26	54.10	52.37	55.96
25	45.87	43.42	48.61	46.44	43.58	49.60	47.48	45.46	49.69	49.53	47.77	51.41
30	41.45	39.08	44.11	42.06	39.29	45.14	42.96	41.02	45.07	44.92	43.25	46.71
35	37.25	35.02	39.75	37.96	35.38	40.80	38.70	36.90	40.68	40.48	38.98	42.10
40	32.87	30.83	35.17	33.72	31.36	36.30	34.27	32.64	36.07	35.96	34.62	37.40
45	28.76	26.98	30.77	29.65	27.42	32.08	29.97	28.53	31.55	31.55	30.36	32.82
50	24.66	23.04	26.47	25.69	23.75	27.77	25.78	24.56	27.13	27.31	26.30	28.39
55	20.76	19.45	22.26	21.88	20.30	23.63	21.74	20.72	22.91	23.30	22.73	23.97
60	17.39	16.27	18.69	18.62	17.44	19.93	18.24	17.44	19.15	19.51	19.16	19.96
65	14.09	13.20	15.10	15.29	14.44	16.21	14.79	14.14	15.53	16.01	15.82	16.29
70	11.37	10.72	12.12	12.47	11.69	13.28	11.95	11.44	12.52	12.93	12.87	13.08
75	8.55	8.00	9.15	9.63	9.04	10.19	9.22	8.85	9.61	10.27	10.34	10.28
80	7.22	6.66	7.78	8.70	8.28	9.09	7.95	7.51	8.39	8.44	8.66	8.34
85+	4.97	4.47	5.43	6.35	6.32	6.38	5.82	5.46	6.15	6.95	7.97	6.28

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Table: 3. Life Expectancy by religion and sex in India, 2015-16

Age Interval	Hindu			Muslim			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	64.98	62.51	67.71	65.89	64.39	67.55	68.07	64.33	72.06	68.59	65.89	71.53
1	67.22	64.94	69.71	68.32	66.84	69.92	69.41	65.80	73.24	69.74	67.39	72.28
5	64.74	62.54	67.14	65.54	63.92	67.29	67.19	64.11	70.40	66.60	64.46	68.91
10	61.39	59.19	63.78	61.61	60.03	63.33	64.40	61.88	66.96	62.53	60.30	64.94
15	56.63	54.42	59.03	56.82	55.20	58.58	59.60	57.18	62.05	57.64	55.41	60.05
20	52.03	49.81	54.45	52.15	50.59	53.84	54.97	52.50	57.48	52.91	50.75	55.22
25	47.51	45.30	49.91	47.60	46.03	49.30	50.26	47.74	52.83	48.27	46.23	50.44
30	43.01	40.90	45.32	42.96	41.45	44.62	45.66	43.28	48.09	43.77	41.74	45.94
35	38.77	36.83	40.89	38.51	37.07	40.09	41.45	39.10	43.83	39.44	37.72	41.25
40	34.35	32.59	36.28	34.01	32.66	35.50	37.02	34.94	39.14	35.33	33.58	37.16
45	30.10	28.55	31.79	29.55	28.26	30.98	32.91	31.19	34.64	31.22	29.79	32.71
50	25.95	24.60	27.42	25.32	24.18	26.58	28.90	27.47	30.35	27.11	25.81	28.44
55	21.97	20.93	23.14	21.31	20.33	22.42	24.75	23.85	25.72	23.04	22.05	24.10
60	18.45	17.64	19.36	17.87	17.08	18.77	21.02	20.11	21.98	19.54	18.93	20.20
65	14.99	14.37	15.70	14.66	14.16	15.22	17.68	17.20	18.18	15.99	15.35	16.69
70	12.10	11.60	12.66	12.09	11.79	12.43	14.08	13.81	14.39	12.89	12.48	13.33
75	9.37	8.97	9.80	9.36	9.49	9.23	11.44	11.40	11.49	9.74	9.19	10.33
80	7.97	7.61	8.34	8.01	7.97	8.07	9.16	9.41	8.92	8.24	7.77	8.71
85+	5.97	5.85	6.09	5.86	5.86	5.89	7.91	7.89	7.96	6.32	6.68	6.06

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Table: 4. Life expectancy across regions and sex in India, 2015-16

Age Interval	Northeast			East			North			Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.77	60.88	67.09	63.57	62.39	64.79	68.68	65.97	71.82	63.76	61.80	65.94	68.64	66.19	71.35	64.87	60.97	69.22
1	66.11	63.56	69.04	66.37	65.22	67.56	70.24	67.75	73.11	66.55	64.76	68.52	69.58	67.28	72.11	66.69	63.14	70.59
5	64.07	61.63	66.86	63.59	62.44	64.77	67.15	64.75	69.89	63.95	62.02	66.08	66.78	64.48	69.30	65.04	61.87	68.46
10	60.26	57.79	63.11	60.19	59.01	61.40	63.12	60.74	65.83	60.11	58.25	62.17	62.93	60.39	65.72	62.90	59.94	66.08
15	55.53	53.07	58.34	55.46	54.24	56.70	58.30	55.91	61.03	55.38	53.51	57.45	58.07	55.52	60.88	58.09	55.16	61.22
20	51.01	48.55	53.82	50.87	49.65	52.11	53.63	51.24	56.35	50.85	48.99	52.89	53.41	50.80	56.29	53.41	50.50	56.50
25	46.42	44.04	49.17	46.34	45.13	47.57	49.00	46.62	51.70	46.41	44.56	48.45	48.84	46.19	51.77	48.82	45.99	51.84
30	41.95	39.65	44.61	41.77	40.61	42.96	44.37	42.07	46.99	42.00	40.24	43.95	44.25	41.66	47.12	44.35	41.66	47.23
35	37.70	35.59	40.14	37.59	36.54	38.68	39.99	37.85	42.43	37.77	36.17	39.57	39.87	37.42	42.54	40.10	37.66	42.71
40	33.38	31.37	35.71	33.16	32.32	34.04	35.54	33.53	37.82	33.32	31.81	35.02	35.38	33.07	37.90	35.76	33.56	38.12
45	29.19	27.38	31.29	28.92	28.27	29.62	31.18	29.33	33.28	29.08	27.71	30.63	31.11	29.07	33.32	31.49	29.53	33.57
50	25.29	23.80	27.03	24.72	24.18	25.30	27.07	25.39	28.97	24.90	23.67	26.28	26.98	25.18	28.87	27.34	25.64	29.15
55	21.44	20.30	22.84	20.78	20.42	21.18	23.03	21.66	24.63	21.01	19.98	22.19	22.85	21.53	24.29	23.29	21.96	24.76
60	17.91	16.96	19.06	17.32	17.10	17.60	19.37	18.36	20.59	17.52	16.68	18.49	19.27	18.30	20.29	19.83	18.72	21.04
65	14.93	14.21	15.77	13.86	13.72	14.02	15.74	14.85	16.80	14.31	13.69	15.04	15.84	15.09	16.62	16.34	15.54	17.21
70	12.22	11.92	12.57	11.13	11.00	11.30	12.85	12.08	13.76	11.66	11.11	12.28	12.61	12.02	13.21	13.39	12.88	13.93
75	9.64	9.31	10.01	8.38	8.24	8.55	9.72	9.03	10.51	8.91	8.46	9.41	9.90	9.62	10.17	10.88	10.62	11.13
80	7.99	7.77	8.23	7.16	7.20	7.15	8.11	7.32	8.96	7.76	7.44	8.08	8.27	7.89	8.62	9.36	9.03	9.66
85+	6.01	5.74	6.29	4.94	5.18	4.74	6.28	5.63	6.95	5.67	5.67	5.68	6.49	6.70	6.38	7.55	7.35	7.72

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Table: 5. Probability of death at age 15-59 and premature mortality at age 70 by caste, religion and region in India

Probability of dying between n to x+n Interval						
Caste	**SC**	**ST**	**OBC**	**Others**		
15q59	0.1651	0.1783	0.1407	0.1223		
0q70	0.3823	0.3811	0.3443	0.3006		
Religion	**Hindus**	**Muslims**	**Christians**	**Others**		
15q59	0.1466	0.1286	0.1326	0.1453		
0q70	0.3473	0.3412	0.3164	0.3089		
Region	**Northeast**	**East**	**North**	**Central**	**West**	**South**
15q59	0.1671	0.1520	0.1291	0.1575	0.1292	0.1380
0q70	0.3851	0.3636	0.2935	0.3724	0.3029	0.3493

Table: 6. Probability of death at age 15-59 and premature mortality at age 70 among different categories of caste, religion and region by sex in India

Probability of dying between n to x+n Interval	**SC**		**ST**		**OBC**		**Others**	
Caste	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
15q59	0.2097	0.1201	0.2263	0.1307	0.1754	0.1064	0.1593	0.0861
0q70	0.4430	0.3157	0.4567	0.2979	0.3923	0.2929	0.3478	0.2512
Religion	**Hindus**		**Muslims**		**Christians**		**Others**	
15q59	0.1866	0.1067	0.1523	0.1059	0.1815	0.0869	0.1842	0.1065
0q70	0.4018	0.2886	0.3828	0.2967	0.3888	0.2394	0.3606	0.2542

Probability of dying between n to x+n Interval	**Northeast**		**East**		**North**		**Central**		**West**		**South**	
Regions	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
15q59	0.2142	0.1197	0.1795	0.1253	0.1655	0.0925	0.1879	0.1271	0.1753	0.0830	0.1884	0.0891
0q70	0.4464	0.3144	0.3945	0.3318	0.3500	0.2321	0.4179	0.3233	0.3655	0.2353	0.4234	0.2683

DECLARATION FOR DOUBLE BLIND

Availability of Data and Material

Data are available in a public, open access repository

(https://dhsprogram.com/what-we-do/survey/survey-display-355.cfm), and

http://www.censusindia.gov.in/vital_statistics/Appendix_SRS_Based_Life_Table.html

Contributors: Meena Kumari[#] and Sanjay Kumar Mohanty conceptualized the paper,

prepared the analytical plan and wrote the paper.

[#] Corresponding author: meenaiips@gmail.com

International Institute for Population Sciences, Mumbai

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Figure 1: Age-specific Death Rate from NFHS-4 and SRS, 2011-2015, in India

54x30mm (300 x 300 DPI)

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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15, in India

54x30mm (300 x 300 DPI)

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Figure 3: Age-specific death rate across caste groups in India, 2015-16

108x60mm (300 x 300 DPI)

Figure 4: Age-specific death rate by religion in India, 2015-16

108x60mm (300 x 300 DPI)

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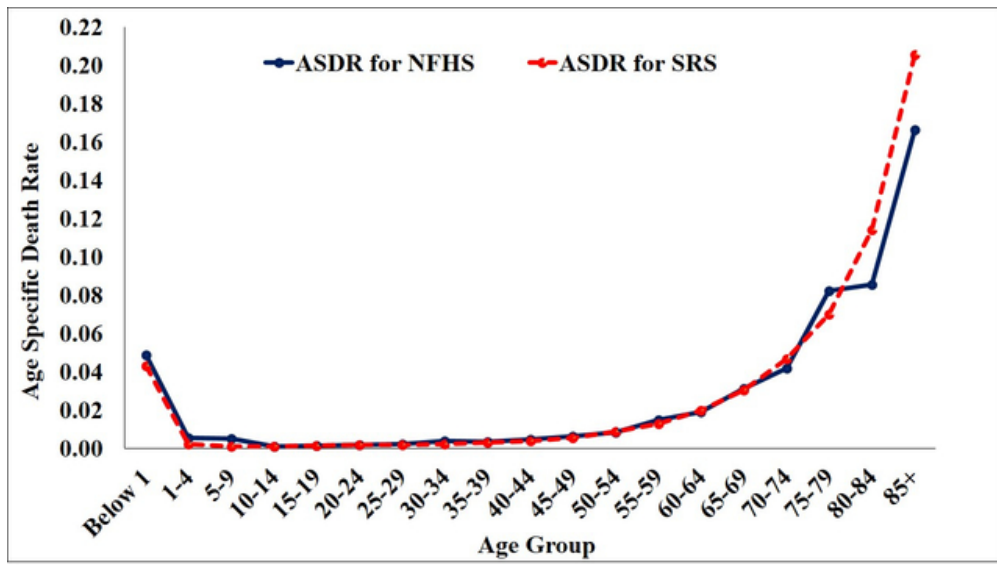50
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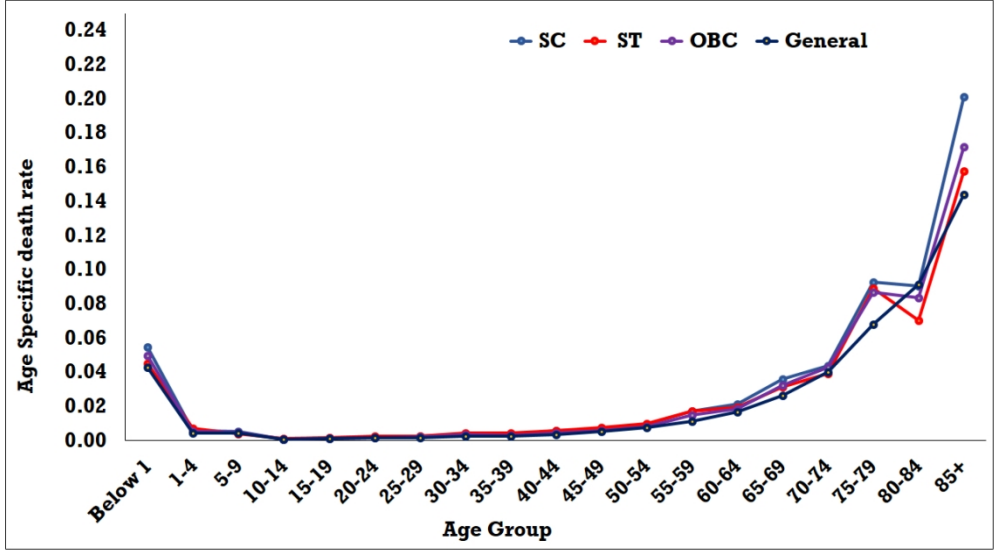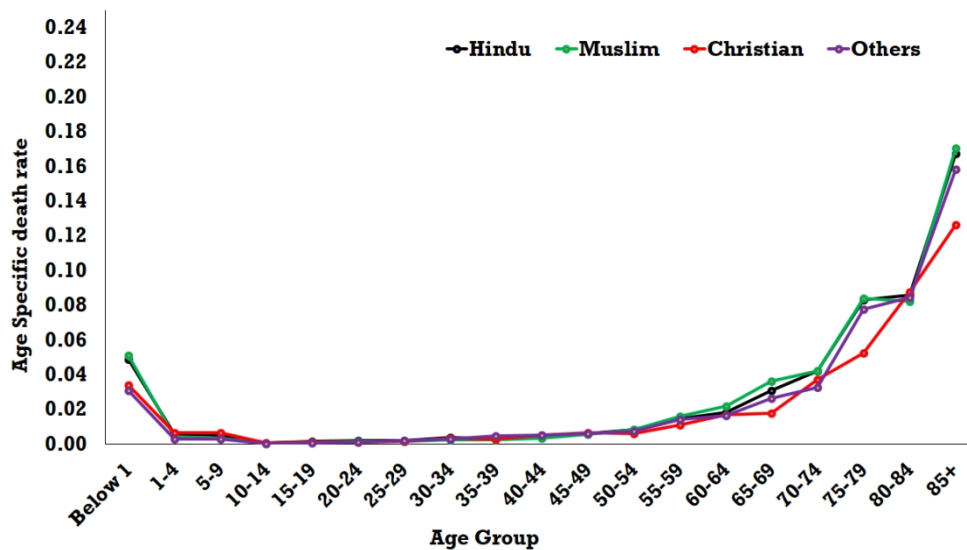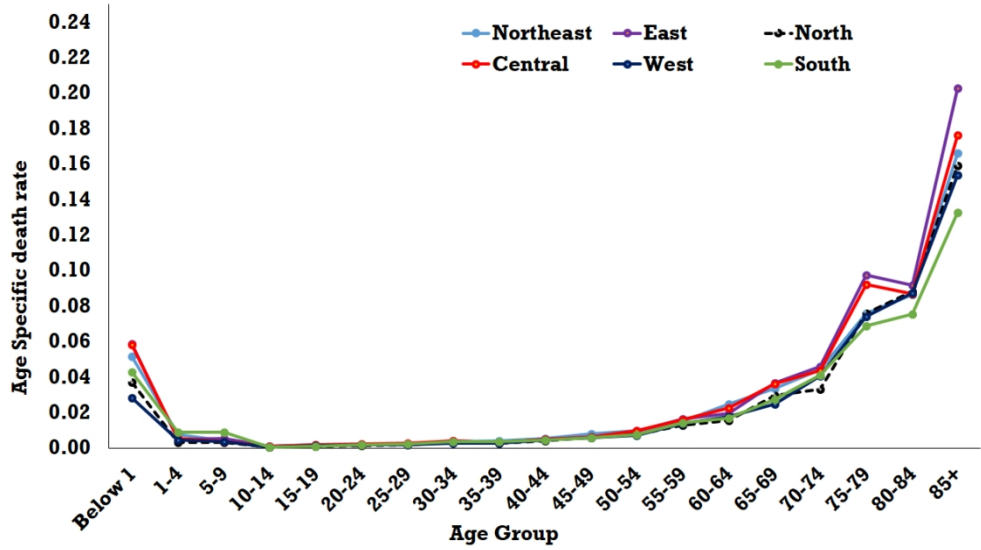Figure 5: Age-specific death rate across regions in India, 2015-16

108x60mm (300 x 300 DPI)

Appendices

Appendix Table 1: 95% Confidence interval (CIs) of life expectancy by caste and sex in India, 2015-16

Age Group	SC Total	SC Male	SC Female	ST Total	ST Male	ST Female	OBC Total	OBC Male	OBC Female	Other Total	Other Male	Other Female
Below 1	62.60-63.64	59.65-61.00	65.57-67.07	63.25-64.88	59.49-61.63	66.85-68.99	64.69-65.42	62.38-63.40	66.98-67.99	67.44-68.45	65.34-66.74	69.25-70.64
1	65.21-66.13	62.48-63.74	67.83-69.22	65.24-66.70	61.97-63.87	68.24-70.48	67.04-67.69	64.82-65.72	69.15-70.10	69.48-70.32	67.48-68.78	71.24-72.45
5	62.66-63.54	60.04-61.22	65.36-66.6	63.17-64.53	60.04-61.95	66.06-68.16	64.52-65.12	62.39-63.23	66.58-67.46	66.67-67.53	64.70-65.93	68.46-69.62
10	59.29-60.12	56.66-57.78	61.93-63.10	59.39-60.70	56.33-58.14	62.23-64.22	61.16-61.71	59.02-59.80	63.22-64.02	63.22-63.96	61.35-62.42	64.92-65.95
15	54.56-55.34	51.90-53.03	57.22-58.41	54.66-56.08	51.60-53.44	57.58-59.49	56.39-56.95	54.22-55.03	58.46-59.27	58.39-59.15	56.51-57.60	60.04-61.10
20	49.98-50.79	47.36-48.45	52.59-53.76	50.20-51.51	47.09-48.91	53.06-54.90	51.75-52.30	49.60-50.36	53.88-54.63	53.74-54.45	51.83-52.90	55.46-56.48
25	45.49-46.27	42.89-43.93	48.00-49.22	45.78-47.14	42.76-44.52	48.75-50.53	47.23-47.77	45.09-45.83	49.32-50.09	49.17-49.86	47.24-48.30	50.95-51.91
30	41.07-41.84	38.57-39.58	43.51-44.66	41.39-42.72	38.45-40.23	44.24-46.05	42.69-43.23	40.66-41.42	44.70-45.44	44.56-45.28	42.75-43.79	46.26-47.17
35	36.89-37.64	34.52-35.51	39.23-40.28	37.32-38.59	34.61-36.20	39.94-41.62	38.44-38.96	36.53-37.25	40.33-41.04	40.13-40.81	38.45-39.51	41.62-42.60
40	32.51-33.23	30.35-31.35	34.62-35.70	33.13-34.35	30.51-32.24	35.41-37.18	34.02-34.54	32.29-32.97	35.72-36.45	35.62-36.30	34.14-35.13	36.93-37.88
45	28.41-29.11	26.53-27.45	30.23-31.28	29.06-30.27	26.61-28.22	31.24-32.93	29.71-30.21	28.14-28.87	31.20-31.91	31.23-31.89	29.89-30.90	32.35-33.29
50	24.32-25.02	22.59-23.52	25.92-27.02	25.09-26.29	22.95-24.60	26.99-28.64	25.56-26.03	24.24-24.90	26.79-27.48	27.00-27.62	25.85-26.77	27.95-28.83
55	20.44-21.08	19.02-19.90	21.76-22.77	21.35-22.44	19.56-21.11	22.78-24.45	21.53-21.99	20.41-21.03	22.58-23.22	22.98-23.62	22.32-23.19	23.53-24.42
60	17.07-17.71	15.84-16.72	18.20-19.20	18.07-19.22	16.69-18.21	19.11-20.78	18.01-18.48	17.12-17.73	18.82-19.47	19.21-19.82	18.73-19.59	19.54-20.37
65	13.77-14.42	12.81-13.62	14.61-15.61	14.78-15.87	13.74-15.32	15.37-16.96	14.58-15.02	13.84-14.43	15.17-15.84	15.72-16.29	15.41-16.25	15.86-16.69
70	11.07-11.70	10.32-11.16	11.65-12.57	11.92-13.06	10.95-12.54	12.42-14.15	11.72-12.17	11.17-11.73	12.17-12.86	12.62-13.23	12.43-13.33	12.69-13.50
75	8.26-8.90	7.59-8.43	8.67-9.61	9.06-10.22	8.29-9.91	9.36-11.03	9.00-9.43	8.55-9.15	9.30-9.92	9.98-10.54	9.90-10.81	9.90-10.68
80	6.96-7.46	6.29-7.02	7.39-8.15	8.23-9.17	7.54-9.02	8.47-9.68	7.77-8.13	7.26-7.75	8.12-8.64	8.19-8.69	8.29-9.06	8.03-8.64
85+	4.97-4.97	4.47-4.47	5.43-5.43	6.35-6.35	6.32-6.32	6.38-6.38	5.82-5.82	5.46-5.46	6.15-6.15	6.95-6.95	7.97-7.97	6.28-6.28

Appendix Table 2: 95% Confidence interval (CIs) of life expectancy by religion and sex in India, 2015-16

Age Group	Hindu			Muslims			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	64.74-65.22	62.15-62.87	67.34-68.09	65.29-66.54	63.57-65.25	66.71-68.45	66.44-69.60	61.93-66.62	69.81-74.30	67.38-69.80	64.32-67.56	69.91-73.24
1	66.99-67.46	64.65-65.25	69.38-70.05	67.73-68.87	66.07-67.62	69.14-70.71	67.96-70.95	63.76-68.03	71.29-75.40	68.64-70.95	65.81-68.96	70.87-73.95
5	64.53-64.97	62.22-62.84	66.83-67.48	65.00-66.10	63.20-64.69	66.52-68.10	65.83-68.64	62.17-66.13	68.45-72.32	65.57-67.66	63.04-66.00	67.43-70.38
10	61.20-61.59	62.22-62.84	63.48-64.09	61.10-62.16	59.35-60.77	62.57-64.08	63.16-65.66	60.19-63.84	65.19-68.75	61.64-63.61	58.83-61.68	63.56-66.34
15	56.42-56.83	54.13-54.70	58.73-59.32	56.29-57.34	54.49-55.91	57.85-59.37	58.35-60.91	55.44-59.05	60.40-63.75	56.73-58.67	54.03-56.72	58.73-61.46
20	51.84-52.23	49.53-50.10	54.17-54.73	51.60-52.65	49.91-51.39	53.13-54.63	53.85-56.25	50.80-54.27	55.81-59.24	51.99-53.88	49.34-52.14	53.94-56.60
25	47.32-47.70	45.03-45.56	49.63-50.18	47.12-48.10	45.34-46.75	48.57-50.05	49.04-51.56	45.97-49.55	51.18-54.66	47.34-49.23	44.85-47.72	49.12-51.86
30	42.81-43.20	40.62-41.17	45.07-45.60	42.42-43.45	40.78-42.16	43.90-45.38	44.56-46.86	41.71-45.07	46.49-49.82	42.81-44.80	40.40-43.24	44.54-47.38
35	38.57-38.96	36.59-37.10	40.61-41.17	38.01-38.99	36.40-37.75	39.33-40.82	40.29-42.74	37.38-40.73	42.33-45.52	38.42-40.37	36.48-39.11	40.04-42.61
40	34.17-34.54	32.34-32.87	36.02-36.56	33.49-34.51	32.01-33.35	34.83-36.23	35.98-38.23	33.27-36.70	37.57-40.76	34.46-36.33	32.34-34.82	35.89-38.42
45	29.92-30.29	28.31-28.80	31.55-32.07	29.07-30.02	27.65-28.90	30.32-31.71	31.76-34.00	29.71-32.73	33.34-36.20	30.30-32.15	28.57-31.02	31.43-33.98
50	25.78-26.14	24.36-24.83	27.18-27.70	24.88-25.82	23.53-24.82	25.91-27.27	27.86-30.05	25.97-29.02	28.70-31.96	26.30-27.99	24.58-27.02	27.25-29.64
55	21.80-22.14	20.72-21.16	22.88-23.37	20.87-21.73	19.70-20.93	21.76-23.12	23.74-25.86	22.42-25.27	24.21-27.32	22.25-23.88	20.92-23.23	22.94-25.38
60	18.29-18.60	17.42-17.85	19.13-19.61	17.44-18.31	16.50-17.68	18.11-19.46	19.96-22.08	18.54-21.62	20.57-23.57	18.74-20.36	17.90-20.05	19.01-21.43
65	14.85-15.16	14.15-14.58	15.46-15.94	14.21-15.11	13.54-14.77	14.60-15.90	16.67-18.72	15.75-18.76	16.77-19.73	15.23-16.81	14.30-16.41	15.65-17.96
70	11.95-12.27	11.38-11.82	12.41-12.90	11.66-12.57	11.17-12.48	11.81-13.10	13.08-15.14	12.44-15.37	12.94-15.93	12.12-13.70	11.45-13.57	12.27-14.46
75	9.21-9.53	8.76-9.20	9.58-10.04	8.92-9.81	8.87-10.10	8.60-9.87	10.46-12.44	9.97-12.93	10.06-13.04	8.99-10.54	8.17-10.30	9.28-11.46
80	7.84-8.11	7.41-7.80	8.15-8.51	7.68-8.36	7.44-8.52	7.52-8.59	8.26-10.10	8.15-10.52	7.66-10.22	7.66-8.89	6.93-8.77	7.97-9.46
85+	5.97-5.97	5.85-5.85	6.09-6.09	5.86-5.86	5.86-5.86	5.89-5.89	7.91-7.91	7.89-7.89	7.96-7.96	6.32-6.32	6.68-6.68	6.06-6.06

Appendix Table 3: 95% Confidence interval (CIs) of life expectancy by regions and sex in India, 2015-16

Age Group	Northeast			East			North		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Below 1	62.43-65.00	59.15-62.58	65.40-68.81	63.12-64.04	61.68-63.07	64.15-65.45	68.06-69.34	65.17-66.86	70.96-72.73
1	65.02-67.28	61.94-65.26	67.38-70.95	65.95-66.82	64.62-65.79	66.95-68.18	69.68-70.83	66.99-68.52	72.37-73.93
5	62.98-65.25	60.16-63.13	65.26-68.68	63.20-64.00	61.82-62.99	64.20-65.37	66.67-67.66	64.07-65.51	69.12-70.71
10	59.13-61.32	56.34-59.35	61.65-64.83	59.82-60.58	58.44-59.54	60.88-61.98	62.62-63.66	60.05-61.46	65.11-66.52
15	54.50-56.59	51.63-54.68	56.94-59.96	55.09-55.82	53.69-54.78	56.19-57.24	57.79-58.82	55.25-56.61	60.20-61.80
20	50.04-52.05	47.20-50.05	52.30-55.35	50.49-51.26	49.08-50.19	51.60-52.64	53.13-54.09	50.57-51.92	55.65-57.10
25	45.49-47.54	42.74-45.43	47.66-50.68	45.98-46.71	44.60-45.64	47.08-48.07	48.50-49.51	45.93-47.33	50.99-52.44
30	41.00-43.05	38.32-41.08	43.20-46.19	41.44-42.14	40.12-41.13	42.47-43.48	43.88-44.89	41.41-42.78	46.24-47.72
35	36.72-38.73	34.34-37.02	38.70-41.69	37.24-37.92	36.05-37.03	38.17-39.20	39.53-40.50	37.23-38.50	41.71-43.13
40	32.39-34.38	30.10-32.76	34.39-37.26	32.82-33.49	31.85-32.80	33.57-34.56	35.08-36.03	32.92-34.16	37.17-38.58
45	28.30-30.21	26.12-28.79	29.90-32.82	28.59-29.25	27.83-28.73	29.18-30.10	30.75-31.66	28.75-29.93	32.61-34.00
50	24.34-26.22	22.57-25.10	25.66-28.40	24.42-25.03	23.78-24.59	24.85-25.79	26.64-27.55	24.82-26.01	28.28-29.61
55	20.48-22.39	19.13-21.56	21.45-24.39	20.49-21.09	19.99-20.82	20.76-21.62	22.57-23.46	21.10-22.26	24.00-25.31
60	16.93-18.84	15.87-18.25	17.62-20.61	17.05-17.62	16.69-17.51	17.19-18.02	18.98-19.78	17.86-18.93	19.94-21.25
65	14.08-15.87	13.10-15.53	14.38-17.14	13.57-14.12	13.34-14.12	13.59-14.48	15.30-16.15	14.31-15.40	16.15-17.47
70	11.39-13.15	10.72-13.14	11.26-14.00	10.85-11.42	10.61-11.39	10.91-11.73	12.44-13.28	11.59-12.62	13.13-14.39
75	8.81-10.59	8.19-10.48	8.82-11.46	8.10-8.66	7.85-8.61	8.15-8.98	9.33-10.13	8.55-9.60	9.90-11.18
80	7.28-8.73	6.85-8.72	7.11-9.36	6.93-7.38	6.89-7.53	6.83-7.46	7.80-8.43	6.86-7.76	8.45-9.44
85+	6.01-6.01	5.74-5.74	6.29-6.29	4.94-4.94	5.18-5.18	4.74-4.74	6.28-6.28	5.63-5.63	6.95-6.95

Appendix Table 3 (Continued): 95% Confidence interval (CIs) of life expectancy by regions and sex in India, 2015-16

Age Group	Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.29-64.20	61.16-62.50	65.20-66.66	68.07-69.21	65.42-67.09	70.40-72.12	64.30-65.40	60.18-61.74	68.43-70.03
1	66.17-66.96	64.17-65.34	67.94-69.14	69.03-70.13	66.56-68.00	71.36-72.93	66.19-67.19	62.43-63.88	69.90-71.33
5	63.56-64.34	61.49-62.56	65.48-66.66	66.27-67.30	63.80-65.16	68.55-70.09	64.53-65.50	61.23-62.53	67.82-69.15
10	59.73-60.51	57.74-58.81	61.62-62.73	62.44-63.42	59.74-61.10	65.03-66.43	62.49-63.29	59.38-60.52	65.51-66.63
15	55.02-55.75	52.97-54.06	56.88-58.01	57.62-58.51	54.86-56.16	60.20-61.56	57.68-58.46	54.60-55.73	60.65-61.85
20	50.48-51.20	48.46-49.55	52.36-53.43	52.98-53.89	50.16-51.45	55.69-56.94	53.02-53.81	49.97-51.10	56.00-57.05
25	46.06-46.78	44.05-45.08	47.93-48.98	48.39-49.29	45.55-46.87	51.14-52.44	48.42-49.19	45.42-46.56	51.32-52.41
30	41.63-42.38	39.73-40.74	43.45-44.50	43.84-44.66	41.07-42.28	46.51-47.78	44.00-44.73	41.11-42.21	46.66-47.76
35	37.41-38.14	35.71-36.66	39.07-40.10	39.45-40.30	36.82-38.02	41.92-43.17	39.72-40.47	37.14-38.18	42.19-43.23
40	32.97-33.69	31.31-32.28	34.52-35.52	34.99-35.83	32.50-33.72	37.33-38.49	35.41-36.12	33.01-34.09	37.62-38.65
45	28.77-29.44	27.24-28.16	30.17-31.13	30.70-31.55	28.48-29.67	32.73-33.95	31.14-31.84	29.06-30.01	33.08-34.10
50	24.58-25.24	23.19-24.11	25.80-26.78	26.58-27.37	24.57-25.76	28.28-29.46	26.97-27.69	25.18-26.13	28.65-29.67
55	20.68-21.32	19.56-20.41	21.72-22.70	22.45-23.24	21.00-22.10	23.72-24.87	22.96-23.63	21.50-22.45	24.28-25.26
60	17.22-17.83	16.29-17.08	18.05-18.94	18.92-19.63	17.80-18.84	19.75-20.88	19.50-20.17	18.26-19.19	20.56-21.56
65	14.02-14.61	13.29-14.10	14.58-15.51	15.47-16.23	14.60-15.59	16.03-17.20	16.01-16.67	15.07-15.99	16.73-17.73
70	11.36-11.98	10.72-11.52	11.85-12.72	12.26-12.97	11.52-12.56	12.69-13.75	13.05-13.73	12.40-13.33	13.47-14.44
75	8.61-9.20	8.05-8.84	9.00-9.83	9.54-10.29	9.11-10.16	9.64-10.73	10.54-11.23	10.17-11.11	10.64-11.63
80	7.50-7.98	7.08-7.77	7.77-8.44	7.93-8.62	7.37-8.39	8.20-9.05	9.06-9.65	8.57-9.48	9.23-10.07
85+	5.67-5.67	5.67-5.67	5.68-5.68	6.49-6.49	6.70-6.70	6.38-6.38	7.55-7.55	7.35-7.35	7.72-7.72

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Caste, religion and regional differentials in life expectancy at birth in India: cross sectional estimates from recent National Family Health Survey

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Caste, religion and regional differentials in life expectancy at birth in India: cross sectional estimates from recent National Family Health Survey

Meena Kumari, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088
Email:meenaiips@gmail.com
Prof. Sanjay Kumar Mohanty, Department of Fertility Studies, International Institute for Population Sciences (IIPS) Mumbai-400088, India
Email: sanjayiips@yahoo.co.in

[#]Corresponding author: meenaiips@gmail.com

International Institute for Population Sciences, Mumbai

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Objective: Though estimates of longevity are available by states, age, sex and place of residence in India, disaggregated estimates by social and economic groups are limited. This study, estimates the life expectancy at birth and premature mortality by caste, religion and regions of India.

Design: This study primarily used cross sectional data from the National Family Health Survey (NFHS-4), 2015-2016 and the Sample Registration System (SRS), 2011-2015. The NFHS-4 is the largest ever demographic and health survey covering 601,509 households and 811,808 individuals across all states and union territories in India.

Measures: The abridged life table is constructed to estimate the life expectancy at birth, adult mortality ($_{45}q_{15}$) and premature mortality ($_{70}q_0$) by caste, religion and region.

Results: Life expectancy at birth was estimated at 63.1 years [95% CI: 62.60-63.64] for Scheduled Castes (SC), 64.0 years [95% CI: 63.25-64.88] for Scheduled Tribes (ST), 65.1 years [95% CI: 64.69-65.42] for Other Backward Classes (OBC) and 68.0 years [95%: 67.44-68.45] for Others. It was higher among Others 68.6 years [95% CI: 67.38-69.80] followed by Christians 68.1 years [95% CI: 66.44-69.60] than Muslims 66.0 years [95% CI: 65.29-66.54] and Hindus 65.0 years [95% CI: 64.74-65.22]. Life expectancy at birth was higher among females than among males across social groups in India. Premature mortality was higher among SC (0.382), followed by ST (0.381), OBC (0.344) and Others (0.301). The regional variation in life expectancy by age and sex is large.

Conclusion: In India, social and religious differentials in life expectancy by sex are modest and need to be investigated among poor and rich within these groups. Premature mortality and adult mortality are also high across social and religious groups.

Strengths and Limitations of the Study

➢ This is the first ever study that provides estimates of life expectancy, by caste, religion and region in India.

➢ It provides estimates of premature and adult mortality across social groups and regions in India.

➢ Disease burden, disability and cause of premature mortality have not been explored in this study.

➢ State specific estimates of life expectancy, premature mortality have not been estimated due to inadequate sample size.

➢ Estimates of mortality and longevity are not linked to socio-economic status in India.

Introduction

Life expectancy at birth is one of the most frequently used summary measures of health. It is used to quantify the health dimension of the human development index [1]. Globally, life expectancy at birth is converging among and within countries [2–4]. Countries are also converging in infant mortality rate, under-five mortality rate and utilisation of basic health services [5–7]. Despite higher life expectancy at birth of females than male, findings from a large number of studies in developing countries suggest that females are disadvantaged in health and health care utilization [8–13]. Though life expectancy at birth has been rising in almost all societies, mortality differences exist within, as well as between, population sub-groups within national and regional boundaries [14-23]. Regional disparity in mortality is associated with socio-economic well-being and access to health care [24-26]. Conventionally, those with an urban residence and the economically and socially better off tend to have lower mortality and higher longevity [27–30].

India with a population of 1.35 billion in 2018 is experiencing significant improvement in health indicators. Life expectancy at birth has increased from 58.7 years in 1990 to 68.30 years in 2015 (RGI). The state variations in life expectancy have been narrowing down over the years. Although India has witnessed spectacular improvement in mortality, the changes in mortality conditions across the states have been different [26]. There is strong North-South gradient across the states, with great variations in the level and the pace of mortality reduction over time [31–33]. For instance, life expectancy was higher in Kerala than in Uttar Pradesh in India [34–37]; adult mortality and premature deaths were also high [33]. The national and state average in life expectancy conceal large variation among states and social groups in India.

Health, education, employment in India varies by social and economic groups in India. Caste and religion are often used as key social variables and given priority in national and state policies. The caste structure is also said to be associated with the economic well-being of the household. The population of India is classified into four caste groups, namely Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. The ST population, accounting for 8.6% of the total population is the most deprived followed by SCs. A large number of studies have examined the caste differentials in health and health-care in India and its states, and found that the SC and ST population have poor health [38–40].

However, studies suggest that the increasing socio-economic inequality over the years has led to poor health outcomes among population sub-groups in the country [41–47].

The Sample Registration System (SRS) provides regular estimates of life expectancy at birth and age-specific death rate for major states, by sex and place of residence. However, such estimates are not available for social groups such as caste and religion and by economic groups. To our knowledge, there are few studies that provided the estimates of life expectancy by social group/economic group. Mohanty and Ram (2010) estimated life expectancy at birth among the social groups using NFHS-2 and NFHS-3 data and found that life expectancy at birth is similar among the poor across caste groups [48]. Recently Asaria et al. (2019) has provided estimates of life expectancy at birth across wealth quintiles using NFHS-4 data and found that life expectancy at birth among the poorest wealth quintile was 65.1 years compared to 72.7 years in the richest wealth quintile.

Patel (2018) explains that SC women may be inequitably served by maternal health services and in some cases, even face specific discrimination. Low health status is observed among poor, female, rural and specific minority groups of Scheduled Tribes and Scheduled Castes [49–52]. In comparison to the General castes, lower caste (OBC, SC/ST) women were more likely to experience discrimination in rural western India [53]. Lower caste women reported a higher prevalence of poorer health than women of higher castes [38,54]. At age 60, life expectancy, active life expectancy and inactive life expectancy estimates were significantly higher, by 2.3, 1.9 and 0.4 years, for older persons in the General castes group versus those in the SC/ST/OBC groups respectively [46,55]. Many studies support the finding that life expectancy was lower in the Central region than in other regions [40,56].

The national average in longevity conceals large variations across population sub-groups and by socio-economic characteristics. This is the first ever study that estimates the life expectancy and mortality pattern by caste, religion, region and sex in India.

Data Sources

Data from the National Family Health Survey (NFHS-4), 2015-16 and the Sample Registration System (SRS), 2011-2015 have been used. The National Family Health Surveys (NFHS) are cross sectional study based on large-scale, multi-round surveys, conducted in a representative sample of households throughout India. The first round of NFHS was conducted in 1992-93 and the fourth round in 2015-16. The NFHS-4 covered 601,509 households and 811,808 individuals. The NFHS provides reliable estimates of fertility, child mortality, family planning, child nutritional status and childhood morbidity for the country. With regard to mortality, NFHS 1, 2 and 3 were intended to provide reliable estimates of infant and child mortality. However, in NFHS-4, an attempt was made to capture overall mortality and data were collected at the national and district levels. It has the distinction of the largest ever population based health survey in the country.

Questions were asked on the death of any members of the household in a three-year reference period. A total of 74,945 deaths was recorded during the survey. Along with death records,

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data on sex, place of residence, caste, religion and household's assets and amenities were collected. Caste data were collected for Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Others. Generally, the STs are considered to be socially and economically poorer, followed by SCs and OBCs. Many central and state government welfare schemes have been specifically designed for the welfare of the population. Similarly, data on religion were collected in seven groups. These are Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Other religion and Religion not stated. We have combined Sikh, Buddhist, Jain, Other religion and Religion not stated groups owing to sample size constraints. The ASDR from SRS is used to compare the mortality rate across age groups.

Methods:

The SRS data do not provide information on death by socio-economic status (SES). The advantages of using NFHS data is the use of its death statistics by socio-economic characteristics. In the NFHS-4, 0.6 per cent (479) of 74,945 deaths were found missing for one or more socio-economic status (SES). The missing information on SES for age at death were adjusted.

The following steps were used in adjusting missing cases, computing the Age-specific Death Rate (ASDR), life expectancy at birth, adult mortality ($_{45}q_{15}$) and premature mortality ($_{70}q_0$) by caste, religion and region.

1. Adjustment of Missing Death cases: The cases with missing information on SES for age at death were inflated by 100/100-x for each age group [47].
2. A total of 479 cases was found missing for some basic variables like age, sex and other SES characteristics. We have distributed 479 cases equally in each age group.
3. Estimation of Age Specific Annual Death Rate (ASDR): The annual ASDR was estimated as the data were collected in three year reference period.
4. Estimation of life expectancy using abridged life table: Life expectancy at birth was computed using age-specific death and midyear population from the NFHS-4 life table approach. The 95% confidence interval of estimates are provided [57].
5. The abridged life table is constructed to estimate life expectancy at birth, adult mortality ($_{45}q_{15}$) and premature mortality ($_{70}q_0$) by caste, religion and region. Premature mortality is defined as any death under 70 years of age. The mathematical form of Premature mortality $(_{70}q_0) = 1 - \frac{l_{70}}{l_0}$; and Mortality in working age $(_{45}q_{15}) = 1 - \frac{l_{60}}{l_{15}}$ [58].

Finally, the age-specific death rate was used to compute life expectancy at birth by sex, caste, religion and region using the Chiang method. In the Chiang method the $_na_x$ is estimated by the average number of years lived in the x to x + n age interval by those dying in the interval [58–60].

Patient and public involvement

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Patients and the public were not involved. The paper uses secondary data available for public use.

Results

Figure 1 plots the age-specific death rate (ASDR) from SRS and NFHS in a five-year age group. The SRS estimates of life expectancy at birth in India was 68.3 years and that from NFHS-4 is 65.3 years. In general, the ASDRs is close from both the sources and the ASDRs overlap in a large number of age groups. **Table 1** presents the numerical value of ASDR from SRS and NFHS by a five-year age group. **Figure 2** presents the life expectancy at various ages. Results suggest that life-expectancy varies with different social characteristics; caste, religion and region in India.

Figure 3 summarizes the estimated ASDR by caste in India. The ASDR was higher among SCs (0.055) followed by OBCs (0.050), STs (0.045) and then Others (0.043) at below age one. Similarly, at later ages, the curve shows a skewed pattern in each category. **Figure 4** presents the age-specific death rate by religion. The ASDR was higher among Muslims (0.051) than among Others (0.031) for age below one. Among population aged 50 years, the ASDR was higher for Hindus than for Christian. But at later ages, the ASDR was higher among Muslims followed by Hindus, Others and Christians in India.

Figure 5 shows that the ASDR for those below one year, was higher in the Eastern region (0.059) followed by the Central region (0.025). The death rate among children aged 1-9 years was higher in the Southern than in the Northern regions (0.009 vs. 0.003). The death rate was almost similar between age groups 10-34. The death rate for population in the age group 65-69 was higher in the Eastern region than in the Western region (0.036 versus 0.025). The variations were visible at age below one and in the 1-4 age group and showed a gap amongst the population of age-groups 60-85.

The life expectancy at birth varies from four years across different caste groups in India (**Table 2).** The life expectancy at birth was estimated at 63.1 years [95% CI: 62.60-63.64] for Scheduled Castes, 64.0 years [95% CI: 63.25-64.88] for Scheduled Tribes, 65.1 years [95% CI: 64.69-65.42] for OBCs and 68.0 years [95% CI: 67.44-68.45] for Others (See Appendix Table 1). Females had a higher life expectancy at birth compared to males and this gap remains consistent across all the social groups. However, this gap decreases at the onset of elderly age (60 years) and ranges from 0.8 to 2.5 years across social groups. The life expectancy at age 60 was 17 years for SCs, 18.2 years for OBCs, 18.6 years for STs and 19.5 years for Others. These findings are consistent with those of other studies [8,9]. Women had a higher life expectancy than men across different caste categories in India.

Table 3 summarizes religious differentials in life expectancy. It suggests that the life expectancy at birth was higher among Others 68.6 years [95% CI: 67.38-69.80] compared to Christian 68.1 years [95% CI: 66.44-69.60] and Muslims 65.9 years [95% CI: 65.29-66.54] than India 65.0 years [95% CI: 64.74-65.22] (See Appendix Table 2)**.** The gap in life expectancy between male and female was highest among Christians (8 years), followed by Others (6 years), Hindus (5 years) and Muslims (3 years). Female life expectancy at birth was

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highest among Christians (72.1 years) followed by Others (71.5 years) and Hindus (67.7 years) but it was lowest among Muslims (67.6). The sex differential in life expectancy at age 20 was higher among Christians followed by Hindus, Others and Muslims.

Table 4 presents the life expectancy at birth by region in India, which ranges from 64–69 years. With a difference of more than 5 years, the life expectancy was as low as 63.6 years [95% CI: 63.12-64.05] in the East region compared to 68.7 years [95% CI: 68.06-69.34] (See Appendix Table 3) in the North region. However, the life expectancy at age one was 68.7 years in the Northern region and 63.8 years in the Northeast – a difference of 4.9 years. Similarly, among males, the life expectancy at birth ranged from 66.2 years [95% CI: 65.42-67.09] in the West to 60.9 years [95% CI: 59.16-62.58] (See Appendix Table 3) in the Northeast region –a difference of 5.3 years. At age one, the gap in life expectancy by sex was as high as 8 years in the South followed by the Northeast (5.5 years), North (5.4 years) and West (4.8 years). Below age one, the gap in life expectancy by sex was lower in the Eastern region. Similarly, life expectancy at birth for females was higher in the North region 71.8 years [95% CI: 70.96-72.73] and lower in the Eastern region 64.8 years [95% CI: 64.15-65.45] (See Appendix Table 3), a difference of 7.0 years.

The probability of death for adults (15-59 years) and premature mortality (before at age 70) were estimated by sex, caste, region and religion. Results were presented in Table 5 and 6. **Table 5** shows that the level of adult mortality is higher among males than among females in India. Individuals belonging to STs have a higher probability of adult death (0.178) than SCs caste groups (0.165). Similarly, by religion, the probability of death among Hindus was 0.147 compared to 0.145 among Others, followed by 0.133 among Christians and 0.129 among Muslims. By region, the probability of adult death in the North-eastern region was higher (0.167) than that in the Central regions (0.158). Similarly, premature mortality by caste group revealed that individuals belonging to SCs had a higher probability of premature mortality than General castes (0.382 versus 0.301). Premature mortality was also analyzed by religions and regions in India and was found to vary. For instance, Hindu (0.347) had a higher premature mortality than Muslim (0.341) and Christians (0.316). By region, the probability of premature mortality in the Northeast was 0.385 followed by Central 0.372, East 0.364, Southern 0.349, Western 0.303 and Northern regions 0.294. **Table 6** reveals that the adult mortality and premature mortality was higher among males than among females in each social strata; caste, religion, region in India. Premature mortality among males and females was high among STs (0.159) followed by SCs (0.127), OBCs (0.099) and Others (0.097). Similarly, for religion, premature mortality gap was higher among Christians than among Hindu. Regional variations shows that the gap was wider in the South than in other regions.

Prior studies suggests that caste and religion differentials show inequality in mortality across populations, subgroups and geographic areas [44,60,61]. This study addresses social disparities in health and provides evidence for the gap in life expectancy and premature mortality across different social groups in India.

Discussion

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Life expectancy at birth is widely used as a summary measure of health. Disaggregated estimates of life expectancy are limited in many developing countries including India. This is the first ever study that estimates life expectancy at birth and premature mortality by social groups such as caste, religion and region in India. The followings are salient findings of this study.

First, life expectancy at birth varies largely across caste, religion and region in India. Life expectancy at birth among SCs was lowest, followed by STs, OBCs and Others. **Second,** the caste and religion differentials in life expectancy were not only observed at birth but also across the ages. Life expectancy at birth was highest among Christians followed by Others, Muslims and Hindus. The gap in life expectancy at birth between Christians and Hindus was 3 years. It was low in the Central region compared to the Western region at age below one year. **Third,** we found consistent sex differentials in life expectancy across caste and religious groups. Life expectancy at birth for women was higher for men across social groups in both rural and urban areas. **Fourth**, adult mortality ($_{45}q_{15}$) was highest among SCs. However, in the case of religion, the probability of adult death ($_{45}q_{15}$) was higher among Hindus than among Muslims. The probability of death was higher among Northeast than in the Western region in India. **Fifth,** premature mortality ($_{70}q_0$) was highest among SCs. In the case of religion, premature deaths ($_{0}q_{70}$) among Muslims was higher than among Christians. By region, premature mortality ($_{70}q_0$) in the Northeast was higher than in the North.

We put forward the following explanations. Life expectancy has been explained by a combination of biological and behavioural factors [47]. The caste system, with its societal stratification and social restrictions, continues to have a major impact in India [62]. Caste and religion are inextricably linked to and is a proxy for socio-economic status in India. The poor socio-economic status (SES) is significantly associated with poor health outcomes and lower access to health-care facilities. The benefits of caste based employment, education and health schemes are largely availed by better off within the deprived caste group. As a result, the average remained low and poorer are getting poorer. Similarly, gender variations in health are persistent cutting across caste and religion. Though women are living longer than men, they have higher morbidity and disability at later ages [63]. The average year of disability free life expectancy among females was lower than among male. Adult mortality risks could be a result of chronic diseases or malnutrition in childhood. Most of the non-communicable diseases are non-curable but can be controlled with regular treatment. On the other hand, while the risk of being affected by these life-style conditions is relatively lower among the poor, once affected, they cannot afford the continued high treatment costs and so they experience premature death. The findings indicate significant differences in the population's health across different castes, religions and regions. Hindu children have higher mortality than Muslim children [64].

The study has some limitations too. Several studies indicates that socio-economic status and educational attainment significantly associated with adult deaths. The scope of further research is to examine the differential within caste group, say poor and rich within SCs and STs which is not captured in the study. We believe that the inequality within the caste group is high and contribute to mortality differentials and longevity. Second, the life expectancy in the paper is not comparable with the SRS due to non-use of adjustment factor used in

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estimation of CI. The CI and life expectancy was estimated without adjustment factor. Third, the paper provide result of probability of dying and life expectancy without adjusting for cause of death across the caste, religion and region.

The reduction of premature mortality, a major public health focus, is one of the UN Sustainable Development Goals [65]. The mortality rate has decreased for most age groups from 2000 to 2016, especially for adolescents and young adults in many developed and developing regions, but remains high among middle aged adults (ages 36-55) and older adults (55 years). However, premature mortality and adult mortality are still higher among all ethnic groups globally [66–68].

Conclusion

The findings suggest that the mortality differentials are significant across caste, religion and region in India. Though, female life expectancy at birth is higher for females, they might be suffering from higher morbidity. Premature mortality is high across caste and religious groups. Prioritizing reduction of premature mortality, including infant and under-five mortality is recommended.

Figure 1: Age-specific Death Rate from NFHS-4 and SRS, 2011-2015, in India

Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15, in India

Figure 3: Age-specific death rate across caste groups in India, 2015-16

Figure 4: Age-specific death rate by religion in India, 2015-16

Figure 5: Age-specific death rate across regions in India, 2015-16

Table 1: ASDR by five-year age group and estimated life expectancy from NFHS 4 and SRS in India, 2015-16

Age Group	ASDR_NFHS	ASDR_SRS	Life Expectancy NFHS_2015 with CIs	Life Expectancy SRS_2015
0-1	0.0485	0.0429	65.3 (65.08-65.54)	68.3
1-5	0.0055	0.0022	67.5 (67.34-67.75)	70.3
5-10	0.0049	0.0008	65.0 (64.79-65.20)	66.9
10-15	0.0008	0.0007	61.5 (61.35-61.74)	62.2
15-20	0.0014	0.0011	56.8 (56.59-56.94)	57.4
20-25	0.0018	0.0015	52.2 (51.98-52.34)	52.7
25-30	0.0021	0.0017	47.6 (47.44-47.79)	48.1
30-35	0.0036	0.0020	43.1 (42.93-43.28)	43.5
35-40	0.0032	0.0027	38.8 (38.68-39.01)	38.9
40-45	0.0045	0.0038	34.4 (34.24-34.57)	34.4
45-50	0.0060	0.0054	30.1 (29.98-30.31)	30.0

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50-55	0.0083	0.0086	26.0 (25.83-26.15)	25.7
55-60	0.0147	0.0127	22.0 (21.84-22.15)	21.7
60-65	0.0188	0.0196	18.5 (18.32-18.63)	18.0
65-70	0.0311	0.0303	15.1 (14.91-15.20)	14.6
70-75	0.0418	0.0465	12.2 (12.04-12.32)	11.5
75-80	0.0821	0.0700	9.4 (9.29-9.58)	8.9
80-85	0.0856	0.1142	8.0 (7.89-8.13)	6.6
85+	0.1664	0.2058	6.0 (6.01-6.01)	4.9

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Table: 2. Life expectancy by caste and sex in India, 2015-16

Age Interval	SC			ST			OBC			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.13	60.32	66.31	64.02	60.53	67.89	65.06	62.88	67.47	67.94	66.09	69.95
1	65.65	63.13	68.48	65.96	62.90	69.34	67.35	65.25	69.64	69.89	68.11	71.81
5	63.12	60.59	65.95	63.84	60.98	67.01	64.82	62.81	67.00	67.07	65.26	69.01
10	59.70	57.18	62.52	60.04	57.18	63.19	61.43	59.41	63.62	63.59	61.89	65.41
15	54.96	52.43	57.78	55.35	52.52	58.47	56.65	54.62	58.87	58.77	57.06	60.58
20	50.39	47.90	53.17	50.83	47.98	53.98	52.03	49.98	54.26	54.10	52.37	55.96
25	45.87	43.42	48.61	46.44	43.58	49.60	47.48	45.46	49.69	49.53	47.77	51.41
30	41.45	39.08	44.11	42.06	39.29	45.14	42.96	41.02	45.07	44.92	43.25	46.71
35	37.25	35.02	39.75	37.96	35.38	40.80	38.70	36.90	40.68	40.48	38.98	42.10
40	32.87	30.83	35.17	33.72	31.36	36.30	34.27	32.64	36.07	35.96	34.62	37.40
45	28.76	26.98	30.77	29.65	27.42	32.08	29.97	28.53	31.55	31.55	30.36	32.82
50	24.66	23.04	26.47	25.69	23.75	27.77	25.78	24.56	27.13	27.31	26.30	28.39
55	20.76	19.45	22.26	21.88	20.30	23.63	21.74	20.72	22.91	23.30	22.73	23.97
60	17.39	16.27	18.69	18.62	17.44	19.93	18.24	17.44	19.15	19.51	19.16	19.96
65	14.09	13.20	15.10	15.29	14.44	16.21	14.79	14.14	15.53	16.01	15.82	16.29
70	11.37	10.72	12.12	12.47	11.69	13.28	11.95	11.44	12.52	12.93	12.87	13.08
75	8.55	8.00	9.15	9.63	9.04	10.19	9.22	8.85	9.61	10.27	10.34	10.28
80	7.22	6.66	7.78	8.70	8.28	9.09	7.95	7.51	8.39	8.44	8.66	8.34
85+	4.97	4.47	5.43	6.35	6.32	6.38	5.82	5.46	6.15	6.95	7.97	6.28

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Table: 3. Life Expectancy by religion and sex in India, 2015-16

Age Interval	Hindu			Muslim			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	64.98	62.51	67.71	65.89	64.39	67.55	68.07	64.33	72.06	68.59	65.89	71.53
1	67.22	64.94	69.71	68.32	66.84	69.92	69.41	65.80	73.24	69.74	67.39	72.28
5	64.74	62.54	67.14	65.54	63.92	67.29	67.19	64.11	70.40	66.60	64.46	68.91
10	61.39	59.19	63.78	61.61	60.03	63.33	64.40	61.88	66.96	62.53	60.30	64.94
15	56.63	54.42	59.03	56.82	55.20	58.58	59.60	57.18	62.05	57.64	55.41	60.05
20	52.03	49.81	54.45	52.15	50.59	53.84	54.97	52.50	57.48	52.91	50.75	55.22
25	47.51	45.30	49.91	47.60	46.03	49.30	50.26	47.74	52.83	48.27	46.23	50.44
30	43.01	40.90	45.32	42.96	41.45	44.62	45.66	43.28	48.09	43.77	41.74	45.94
35	38.77	36.83	40.89	38.51	37.07	40.09	41.45	39.10	43.83	39.44	37.72	41.25
40	34.35	32.59	36.28	34.01	32.66	35.50	37.02	34.94	39.14	35.33	33.58	37.16
45	30.10	28.55	31.79	29.55	28.26	30.98	32.91	31.19	34.64	31.22	29.79	32.71
50	25.95	24.60	27.42	25.32	24.18	26.58	28.90	27.47	30.35	27.11	25.81	28.44
55	21.97	20.93	23.14	21.31	20.33	22.42	24.75	23.85	25.72	23.04	22.05	24.10
60	18.45	17.64	19.36	17.87	17.08	18.77	21.02	20.11	21.98	19.54	18.93	20.20
65	14.99	14.37	15.70	14.66	14.16	15.22	17.68	17.20	18.18	15.99	15.35	16.69
70	12.10	11.60	12.66	12.09	11.79	12.43	14.08	13.81	14.39	12.89	12.48	13.33
75	9.37	8.97	9.80	9.36	9.49	9.23	11.44	11.40	11.49	9.74	9.19	10.33
80	7.97	7.61	8.34	8.01	7.97	8.07	9.16	9.41	8.92	8.24	7.77	8.71
85+	5.97	5.85	6.09	5.86	5.86	5.89	7.91	7.89	7.96	6.32	6.68	6.06

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Table: 4. Life expectancy across regions and sex in India, 2015-16

Age Interval	Northeast			East			North			Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.77	60.88	67.09	63.57	62.39	64.79	68.68	65.97	71.82	63.76	61.80	65.94	68.64	66.19	71.35	64.87	60.97	69.22
1	66.11	63.56	69.04	66.37	65.22	67.56	70.24	67.75	73.11	66.55	64.76	68.52	69.58	67.28	72.11	66.69	63.14	70.59
5	64.07	61.63	66.86	63.59	62.44	64.77	67.15	64.75	69.89	63.95	62.02	66.08	66.78	64.48	69.30	65.04	61.87	68.46
10	60.26	57.79	63.11	60.19	59.01	61.40	63.12	60.74	65.83	60.11	58.25	62.17	62.93	60.39	65.72	62.90	59.94	66.08
15	55.53	53.07	58.34	55.46	54.24	56.70	58.30	55.91	61.03	55.38	53.51	57.45	58.07	55.52	60.88	58.09	55.16	61.22
20	51.01	48.55	53.82	50.87	49.65	52.11	53.63	51.24	56.35	50.85	48.99	52.89	53.41	50.80	56.29	53.41	50.50	56.50
25	46.42	44.04	49.17	46.34	45.13	47.57	49.00	46.62	51.70	46.41	44.56	48.45	48.84	46.19	51.77	48.82	45.99	51.84
30	41.95	39.65	44.61	41.77	40.61	42.96	44.37	42.07	46.99	42.00	40.24	43.95	44.25	41.66	47.12	44.35	41.66	47.23
35	37.70	35.59	40.14	37.59	36.54	38.68	39.99	37.85	42.43	37.77	36.17	39.57	39.87	37.42	42.54	40.10	37.66	42.71
40	33.38	31.37	35.71	33.16	32.32	34.04	35.54	33.53	37.82	33.32	31.81	35.02	35.38	33.07	37.90	35.76	33.56	38.12
45	29.19	27.38	31.29	28.92	28.27	29.62	31.18	29.33	33.28	29.08	27.71	30.63	31.11	29.07	33.32	31.49	29.53	33.57
50	25.29	23.80	27.03	24.72	24.18	25.30	27.07	25.39	28.97	24.90	23.67	26.28	26.98	25.18	28.87	27.34	25.64	29.15
55	21.44	20.30	22.84	20.78	20.42	21.18	23.03	21.66	24.63	21.01	19.98	22.19	22.85	21.53	24.29	23.29	21.96	24.76
60	17.91	16.96	19.06	17.32	17.10	17.60	19.37	18.36	20.59	17.52	16.68	18.49	19.27	18.30	20.29	19.83	18.72	21.04
65	14.93	14.21	15.77	13.86	13.72	14.02	15.74	14.85	16.80	14.31	13.69	15.04	15.84	15.09	16.62	16.34	15.54	17.21
70	12.22	11.92	12.57	11.13	11.00	11.30	12.85	12.08	13.76	11.66	11.11	12.28	12.61	12.02	13.21	13.39	12.88	13.93
75	9.64	9.31	10.01	8.38	8.24	8.55	9.72	9.03	10.51	8.91	8.46	9.41	9.90	9.62	10.17	10.88	10.62	11.13
80	7.99	7.77	8.23	7.16	7.20	7.15	8.11	7.32	8.96	7.76	7.44	8.08	8.27	7.89	8.62	9.36	9.03	9.66
85+	6.01	5.74	6.29	4.94	5.18	4.74	6.28	5.63	6.95	5.67	5.67	5.68	6.49	6.70	6.38	7.55	7.35	7.72

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Table: 5. Probability of death at age 15-60 and premature mortality at age 70 by caste, religion and region in India

Probability of dying between n to x+n Interval						
Caste	SC	ST	OBC	Others		
$_{45}q_{15}$	0.1651	0.1783	0.1407	0.1223		
$_{70}q_0$	0.3823	0.3811	0.3443	0.3006		
Religion	Hindus	Muslims	Christians	Others		
$_{45}q_{15}$	0.1466	0.1286	0.1326	0.1453		
$_{70}q_0$	0.3473	0.3412	0.3164	0.3089		
Region	Northeast	East	North	Central	West	South
$_{45}q_{15}$	0.1671	0.1520	0.1291	0.1575	0.1292	0.1380
$_{70}q_0$	0.3851	0.3636	0.2935	0.3724	0.3029	0.3493

Table: 6. Probability of death at age 15-60 and premature mortality at age 70 among different categories of caste, religion and region by sex in India

Probability of dying between n to x+n Interval	SC		ST		OBC		Others	
Caste	Male	Female	Male	Female	Male	Female	Male	Female
$_{45}q_{15}$	0.2097	0.1201	0.2263	0.1307	0.1754	0.1064	0.1593	0.0861
$_{70}q_0$	0.4430	0.3157	0.4567	0.2979	0.3923	0.2929	0.3478	0.2512
Religion	Hindus		Muslims		Christians		Others	
$_{45}q_{15}$	0.1866	0.1067	0.1523	0.1059	0.1815	0.0869	0.1842	0.1065
$_{70}q_0$	0.4018	0.2886	0.3828	0.2967	0.3888	0.2394	0.3606	0.2542

Probability of dying between n to x+n Interval	Northeast		East		North		Central		West		South	
Regions	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
$_{45}q_{15}$	0.2142	0.1197	0.1795	0.1253	0.1655	0.0925	0.1879	0.1271	0.1753	0.0830	0.1884	0.0891
$_{70}q_0$	0.4464	0.3144	0.3945	0.3318	0.3500	0.2321	0.4179	0.3233	0.3655	0.2353	0.4234	0.2683

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DECLARATION FOR DOUBLE BLIND

Availability of Data and Material

Data are available in a public, open access repository

(https://dhsprogram.com/what-we-do/survey/survey-display-355.cfm), and

http://www.censusindia.gov.in/vital_statistics/Appendix_SRS_Based_Life_Table.html

Contributors:

Conception and design of the study: Meena Kumari and Sanjay Kumar Mohanty, Analysis

and/or interpretation of data: Meena Kumari and Sanjay Kumar Mohanty; drafting the

manuscript: Meena Kumari and Sanjay Kumar Mohanty; revising the manuscript critically

for important content: Sanjay Kumar Mohanty.

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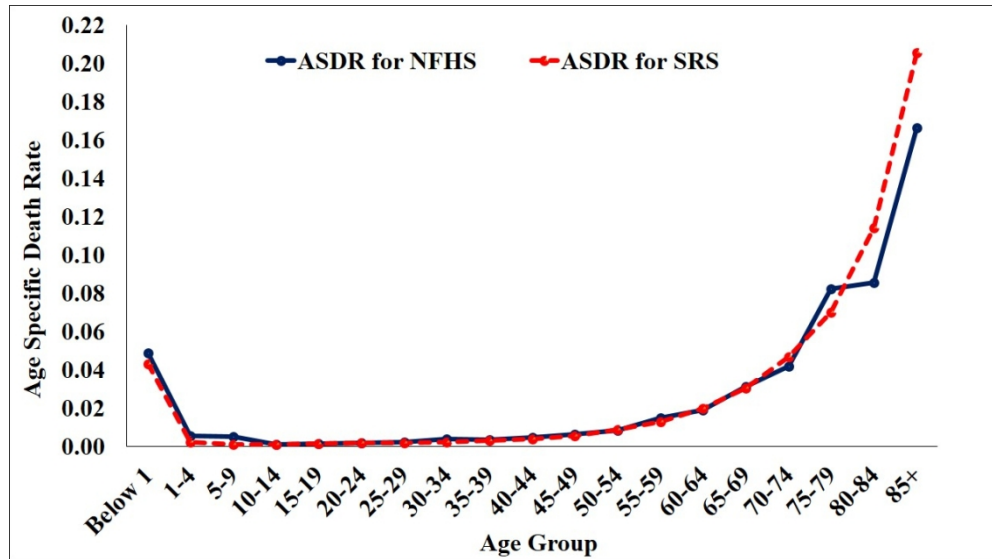52
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Figure 1: Age-specific Death Rate from NFHS-4 and SRS, 2011-2015, in India
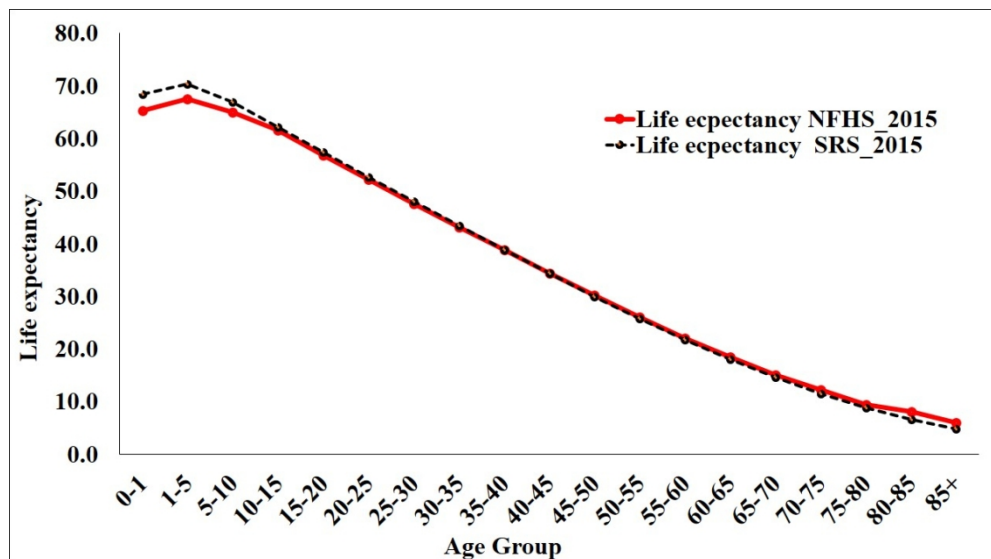
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Figure 2: Estimated life expectancy at birth from NFHS-4, 2015-16 and SRS, 2011-15, in India

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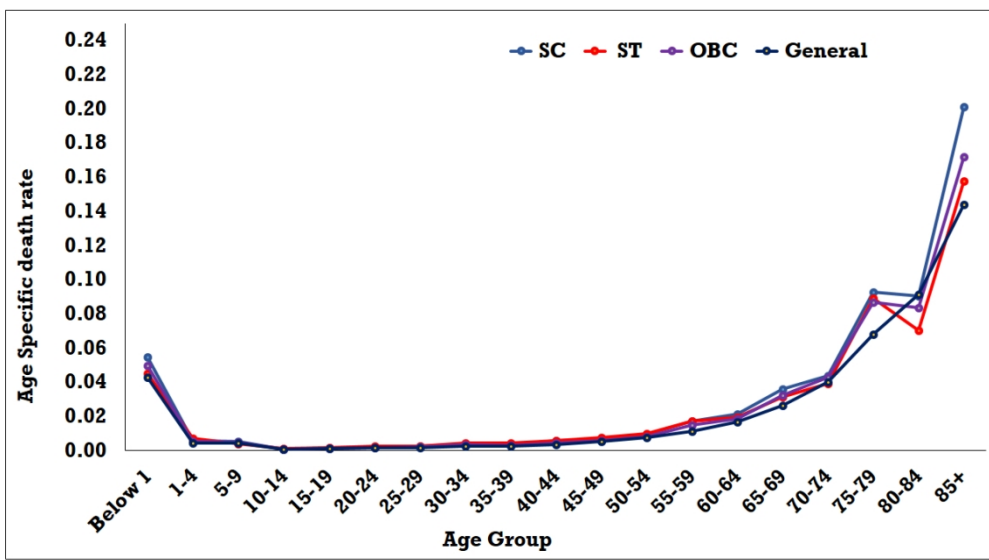51
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Figure 3: Age-specific death rate across caste groups in India, 2015-16
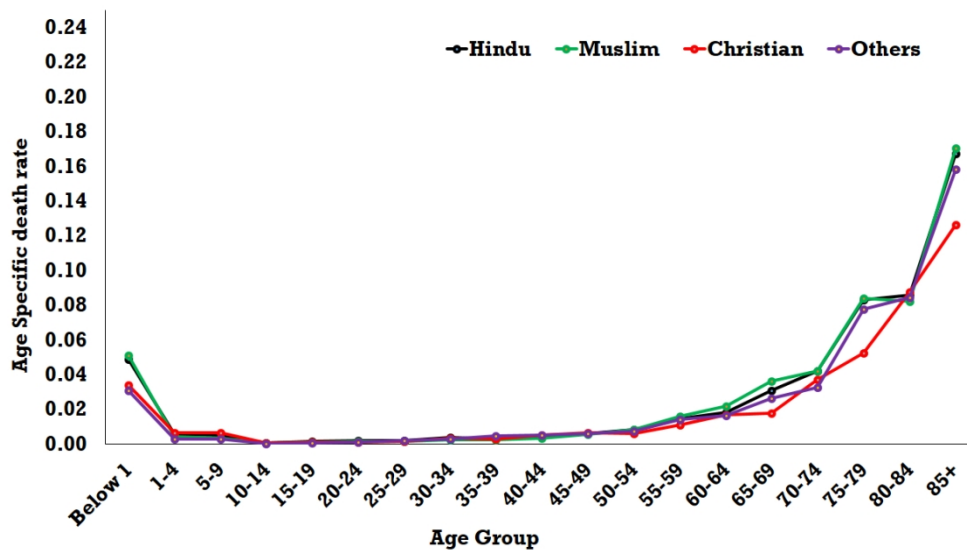
108x60mm (300 x 300 DPI)

Figure 4: Age-specific death rate by religion in India, 2015-16

108x60mm (300 x 300 DPI)

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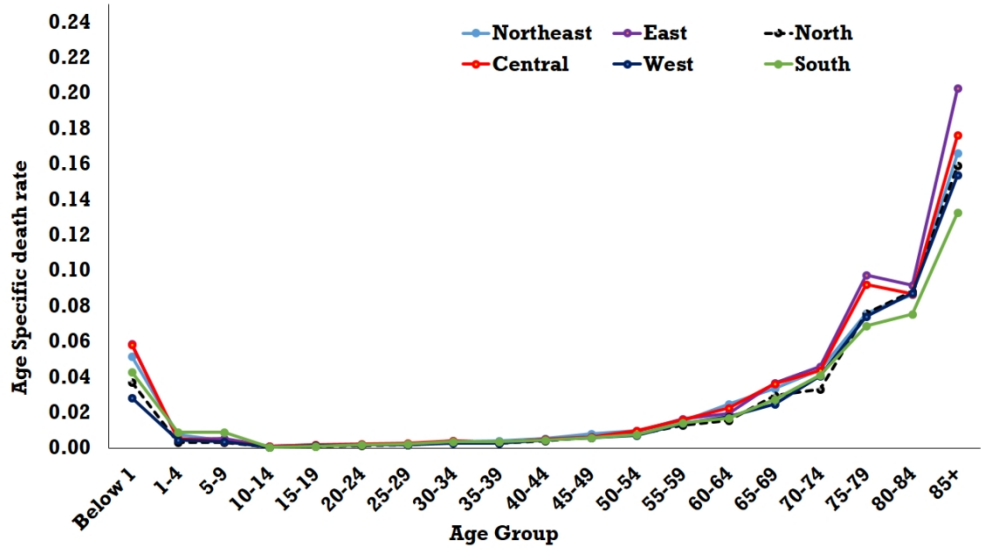50
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Figure 5: Age-specific death rate across regions in India, 2015-16

108x60mm (300 x 300 DPI)

Appendices

Appendix Table 1: 95% Confidence interval (CIs) of life expectancy by caste and sex in India, 2015-16

Age Group	SC			ST			OBC			Other		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	62.60-63.64	59.65-61.00	65.57-67.07	63.25-64.88	59.49-61.63	66.85-68.99	64.69-65.42	62.38-63.40	66.98-67.99	67.44-68.45	65.34-66.74	69.25-70.64
1	65.21-66.13	62.48-63.74	67.83-69.22	65.24-66.70	61.97-63.87	68.24-70.48	67.04-67.69	64.82-65.72	69.15-70.10	69.48-70.32	67.48-68.78	71.24-72.45
5	62.66-63.54	60.04-61.22	65.36-66.6	63.17-64.53	60.04-61.95	66.06-68.16	64.52-65.12	62.39-63.23	66.58-67.46	66.67-67.53	64.70-65.93	68.46-69.62
10	59.29-60.12	56.66-57.78	61.93-63.10	59.39-60.70	56.33-58.14	62.23-64.22	61.16-61.71	59.02-59.80	63.22-64.02	63.22-63.96	61.35-62.42	64.92-65.95
15	54.56-55.34	51.90-53.03	57.22-58.41	54.66-56.08	51.60-53.44	57.58-59.49	56.39-56.95	54.22-55.03	58.46-59.27	58.39-59.15	56.51-57.60	60.04-61.10
20	49.98-50.79	47.36-48.45	52.59-53.76	50.20-51.51	47.09-48.91	53.06-54.90	51.75-52.30	49.60-50.36	53.88-54.63	53.74-54.45	51.83-52.90	55.46-56.48
25	45.49-46.27	42.89-43.93	48.00-49.22	45.78-47.14	42.76-44.52	48.75-50.53	47.23-47.77	45.09-45.83	49.32-50.09	49.17-49.86	47.24-48.30	50.95-51.91
30	41.07-41.84	38.57-39.58	43.51-44.66	41.39-42.72	38.45-40.23	44.24-46.05	42.69-43.23	40.66-41.42	44.70-45.44	44.56-45.28	42.75-43.79	46.26-47.17
35	36.89-37.64	34.52-35.51	39.23-40.28	37.32-38.59	34.61-36.20	39.94-41.62	38.44-38.96	36.53-37.25	40.33-41.04	40.13-40.81	38.45-39.51	41.62-42.60
40	32.51-33.23	30.35-31.35	34.62-35.70	33.13-34.35	30.51-32.24	35.41-37.18	34.02-34.54	32.29-32.97	35.72-36.45	35.62-36.30	34.14-35.13	36.93-37.88
45	28.41-29.11	26.53-27.45	30.23-31.28	29.06-30.27	26.61-28.22	31.24-32.93	29.71-30.21	28.14-28.87	31.20-31.91	31.23-31.89	29.89-30.90	32.35-33.29
50	24.32-25.02	22.59-23.52	25.92-27.02	25.09-26.29	22.95-24.60	26.99-28.64	25.56-26.03	24.24-24.90	26.79-27.48	27.00-27.62	25.85-26.77	27.95-28.83
55	20.44-21.08	19.02-19.90	21.76-22.77	21.35-22.44	19.56-21.11	22.78-24.45	21.53-21.99	20.41-21.03	22.58-23.22	22.98-23.62	22.32-23.19	23.53-24.42
60	17.07-17.71	15.84-16.72	18.20-19.20	18.07-19.22	16.69-18.21	19.11-20.78	18.01-18.48	17.12-17.73	18.82-19.47	19.21-19.82	18.73-19.59	19.54-20.37
65	13.77-14.42	12.81-13.62	14.61-15.61	14.78-15.87	13.74-15.32	15.37-16.96	14.58-15.02	13.84-14.43	15.17-15.84	15.72-16.29	15.41-16.25	15.86-16.69
70	11.07-11.70	10.32-11.16	11.65-12.57	11.92-13.06	10.95-12.54	12.42-14.15	11.72-12.17	11.17-11.73	12.17-12.86	12.62-13.23	12.43-13.33	12.69-13.50
75	8.26-8.90	7.59-8.43	8.67-9.61	9.06-10.22	8.29-9.91	9.36-11.03	9.00-9.43	8.55-9.15	9.30-9.92	9.98-10.54	9.90-10.81	9.90-10.68
80	6.96-7.46	6.29-7.02	7.39-8.15	8.23-9.17	7.54-9.02	8.47-9.68	7.77-8.13	7.26-7.75	8.12-8.64	8.19-8.69	8.29-9.06	8.03-8.64
85+	4.97-4.97	4.47-4.47	5.43-5.43	6.35-6.35	6.32-6.32	6.38-6.38	5.82-5.82	5.46-5.46	6.15-6.15	6.95-6.95	7.97-7.97	6.28-6.28

Appendix Table 2: 95% Confidence interval (CIs) of life expectancy by religion and sex in India, 2015-16

Age Group	Hindu			Muslims			Christian			Others		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	64.74-65.22	62.15-62.87	67.34-68.09	65.29-66.54	63.57-65.25	66.71-68.45	66.44-69.60	61.93-66.62	69.81-74.30	67.38-69.80	64.32-67.56	69.91-73.24
1	66.99-67.46	64.65-65.25	69.38-70.05	67.73-68.87	66.07-67.62	69.14-70.71	67.96-70.95	63.76-68.03	71.29-75.40	68.64-70.95	65.81-68.96	70.87-73.95
5	64.53-64.97	62.22-62.84	66.83-67.48	65.00-66.10	63.20-64.69	66.52-68.10	65.83-68.64	62.17-66.13	68.45-72.32	65.57-67.66	63.04-66.00	67.43-70.38
10	61.20-61.59	62.22-62.84	63.48-64.09	61.10-62.16	59.35-60.77	62.57-64.08	63.16-65.66	60.19-63.84	65.19-68.75	61.64-63.61	58.83-61.68	63.56-66.34
15	56.42-56.83	54.13-54.70	58.73-59.32	56.29-57.34	54.49-55.91	57.85-59.37	58.35-60.91	55.44-59.05	60.40-63.75	56.73-58.67	54.03-56.72	58.73-61.46
20	51.84-52.23	49.53-50.10	54.17-54.73	51.60-52.65	49.91-51.39	53.13-54.63	53.85-56.25	50.80-54.27	55.81-59.24	51.99-53.88	49.34-52.14	53.94-56.60
25	47.32-47.70	45.03-45.56	49.63-50.18	47.12-48.10	45.34-46.75	48.57-50.05	49.04-51.56	45.97-49.55	51.18-54.66	47.34-49.23	44.85-47.72	49.12-51.86
30	42.81-43.20	40.62-41.17	45.07-45.60	42.42-43.45	40.78-42.16	43.90-45.38	44.56-46.86	41.71-45.07	46.49-49.82	42.81-44.80	40.40-43.24	44.54-47.38
35	38.57-38.96	36.59-37.10	40.61-41.17	38.01-38.99	36.40-37.75	39.33-40.82	40.29-42.74	37.38-40.73	42.33-45.52	38.42-40.37	36.48-39.11	40.04-42.61
40	34.17-34.54	32.34-32.87	36.02-36.56	33.49-34.51	32.01-33.35	34.83-36.23	35.98-38.23	33.27-36.70	37.57-40.76	34.46-36.33	32.34-34.82	35.89-38.42
45	29.92-30.29	28.31-28.80	31.55-32.07	29.07-30.02	27.65-28.90	30.32-31.71	31.76-34.00	29.71-32.73	33.34-36.20	30.30-32.15	28.57-31.02	31.43-33.98
50	25.78-26.14	24.36-24.83	27.18-27.70	24.88-25.82	23.53-24.82	25.91-27.27	27.86-30.05	25.97-29.02	28.70-31.96	26.30-27.99	24.58-27.02	27.25-29.64
55	21.80-22.14	20.72-21.16	22.88-23.37	20.87-21.73	19.70-20.93	21.76-23.12	23.74-25.86	22.42-25.27	24.21-27.32	22.25-23.88	20.92-23.23	22.94-25.38
60	18.29-18.60	17.42-17.85	19.13-19.61	17.44-18.31	16.50-17.68	18.11-19.46	19.96-22.08	18.54-21.62	20.57-23.57	18.74-20.36	17.90-20.05	19.01-21.43
65	14.85-15.16	14.15-14.58	15.46-15.94	14.21-15.11	13.54-14.77	14.60-15.90	16.67-18.72	15.75-18.76	16.77-19.73	15.23-16.81	14.30-16.41	15.65-17.96
70	11.95-12.27	11.38-11.82	12.41-12.90	11.66-12.57	11.17-12.48	11.81-13.10	13.08-15.14	12.44-15.37	12.94-15.93	12.12-13.70	11.45-13.57	12.27-14.46
75	9.21-9.53	8.76-9.20	9.58-10.04	8.92-9.81	8.87-10.10	8.60-9.87	10.46-12.44	9.97-12.93	10.06-13.04	8.99-10.54	8.17-10.30	9.28-11.46
80	7.84-8.11	7.41-7.80	8.15-8.51	7.68-8.36	7.44-8.52	7.52-8.59	8.26-10.10	8.15-10.52	7.66-10.22	7.66-8.89	6.93-8.77	7.97-9.46
85+	5.97-5.97	5.85-5.85	6.09-6.09	5.86-5.86	5.86-5.86	5.89-5.89	7.91-7.91	7.89-7.89	7.96-7.96	6.32-6.32	6.68-6.68	6.06-6.06

Appendix Table 3: 95% Confidence interval (CIs) of life expectancy by regions and sex in India, 2015-16

Age Group	Northeast			East			North		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	62.43-65.00	59.15-62.58	65.40-68.81	63.12-64.04	61.68-63.07	64.15-65.45	68.06-69.34	65.17-66.86	70.96-72.73
1	65.02-67.28	61.94-65.26	67.38-70.95	65.95-66.82	64.62-65.79	66.95-68.18	69.68-70.83	66.99-68.52	72.37-73.93
5	62.98-65.25	60.16-63.13	65.26-68.68	63.20-64.00	61.82-62.99	64.20-65.37	66.67-67.66	64.07-65.51	69.12-70.71
10	59.13-61.32	56.34-59.35	61.65-64.83	59.82-60.58	58.44-59.54	60.88-61.98	62.62-63.66	60.05-61.46	65.11-66.52
15	54.50-56.59	51.63-54.68	56.94-59.96	55.09-55.82	53.69-54.78	56.19-57.24	57.79-58.82	55.25-56.61	60.20-61.80
20	50.04-52.05	47.20-50.05	52.30-55.35	50.49-51.26	49.08-50.19	51.60-52.64	53.13-54.09	50.57-51.92	55.65-57.10
25	45.49-47.54	42.74-45.43	47.66-50.68	45.98-46.71	44.60-45.64	47.08-48.07	48.50-49.51	45.93-47.33	50.99-52.44
30	41.00-43.05	38.32-41.08	43.20-46.19	41.44-42.14	40.12-41.13	42.47-43.48	43.88-44.89	41.41-42.78	46.24-47.72
35	36.72-38.73	34.34-37.02	38.70-41.69	37.24-37.92	36.05-37.03	38.17-39.20	39.53-40.50	37.23-38.50	41.71-43.13
40	32.39-34.38	30.10-32.76	34.39-37.26	32.82-33.49	31.85-32.80	33.57-34.56	35.08-36.03	32.92-34.16	37.17-38.58
45	28.30-30.21	26.12-28.79	29.90-32.82	28.59-29.25	27.83-28.73	29.18-30.10	30.75-31.66	28.75-29.93	32.61-34.00
50	24.34-26.22	22.57-25.10	25.66-28.40	24.42-25.03	23.78-24.59	24.85-25.79	26.64-27.55	24.82-26.01	28.28-29.61
55	20.48-22.39	19.13-21.56	21.45-24.39	20.49-21.09	19.99-20.82	20.76-21.62	22.57-23.46	21.10-22.26	24.00-25.31
60	16.93-18.84	15.87-18.25	17.62-20.61	17.05-17.62	16.69-17.51	17.19-18.02	18.98-19.78	17.86-18.93	19.94-21.25
65	14.08-15.87	13.10-15.53	14.38-17.14	13.57-14.12	13.34-14.12	13.59-14.48	15.30-16.15	14.31-15.40	16.15-17.47
70	11.39-13.15	10.72-13.14	11.26-14.00	10.85-11.42	10.61-11.39	10.91-11.73	12.44-13.28	11.59-12.62	13.13-14.39
75	8.81-10.59	8.19-10.48	8.82-11.46	8.10-8.66	7.85-8.61	8.15-8.98	9.33-10.13	8.55-9.60	9.90-11.18
80	7.28-8.73	6.85-8.72	7.11-9.36	6.93-7.38	6.89-7.53	6.83-7.46	7.80-8.43	6.86-7.76	8.45-9.44
85+	6.01-6.01	5.74-5.74	6.29-6.29	4.94-4.94	5.18-5.18	4.74-4.74	6.28-6.28	5.63-5.63	6.95-6.95

Appendix Table 3 (Continued): 95% Confidence interval (CIs) of life expectancy by regions and sex in India, 2015-16

Age Group	Central			West			South		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Below 1	63.29-64.20	61.16-62.50	65.20-66.66	68.07-69.21	65.42-67.09	70.40-72.12	64.30-65.40	60.18-61.74	68.43-70.03
1	66.17-66.96	64.17-65.34	67.94-69.14	69.03-70.13	66.56-68.00	71.36-72.93	66.19-67.19	62.43-63.88	69.90-71.33
5	63.56-64.34	61.49-62.56	65.48-66.66	66.27-67.30	63.80-65.16	68.55-70.09	64.53-65.50	61.23-62.53	67.82-69.15
10	59.73-60.51	57.74-58.81	61.62-62.73	62.44-63.42	59.74-61.10	65.03-66.43	62.49-63.29	59.38-60.52	65.51-66.63
15	55.02-55.75	52.97-54.06	56.88-58.01	57.62-58.51	54.86-56.16	60.20-61.56	57.68-58.46	54.60-55.73	60.65-61.85
20	50.48-51.20	48.46-49.55	52.36-53.43	52.98-53.89	50.16-51.45	55.69-56.94	53.02-53.81	49.97-51.10	56.00-57.05
25	46.06-46.78	44.05-45.08	47.93-48.98	48.39-49.29	45.55-46.87	51.14-52.44	48.42-49.19	45.42-46.56	51.32-52.41
30	41.63-42.38	39.73-40.74	43.45-44.50	43.84-44.66	41.07-42.28	46.51-47.78	44.00-44.73	41.11-42.21	46.66-47.76
35	37.41-38.14	35.71-36.66	39.07-40.10	39.45-40.30	36.82-38.02	41.92-43.17	39.72-40.47	37.14-38.18	42.19-43.23
40	32.97-33.69	31.31-32.28	34.52-35.52	34.99-35.83	32.50-33.72	37.33-38.49	35.41-36.12	33.01-34.09	37.62-38.65
45	28.77-29.44	27.24-28.16	30.17-31.13	30.70-31.55	28.48-29.67	32.73-33.95	31.14-31.84	29.06-30.01	33.08-34.10
50	24.58-25.24	23.19-24.11	25.80-26.78	26.58-27.37	24.57-25.76	28.28-29.46	26.97-27.69	25.18-26.13	28.65-29.67
55	20.68-21.32	19.56-20.41	21.72-22.70	22.45-23.24	21.00-22.10	23.72-24.87	22.96-23.63	21.50-22.45	24.28-25.26
60	17.22-17.83	16.29-17.08	18.05-18.94	18.92-19.63	17.80-18.84	19.75-20.88	19.50-20.17	18.26-19.19	20.56-21.56
65	14.02-14.61	13.29-14.10	14.58-15.51	15.47-16.23	14.60-15.59	16.03-17.20	16.01-16.67	15.07-15.99	16.73-17.73
70	11.36-11.98	10.72-11.52	11.85-12.72	12.26-12.97	11.52-12.56	12.69-13.75	13.05-13.73	12.40-13.33	13.47-14.44
75	8.61-9.20	8.05-8.84	9.00-9.83	9.54-10.29	9.11-10.16	9.64-10.73	10.54-11.23	10.17-11.11	10.64-11.63
80	7.50-7.98	7.08-7.77	7.77-8.44	7.93-8.62	7.37-8.39	8.20-9.05	9.06-9.65	8.57-9.48	9.23-10.07
85+	5.67-5.67	5.67-5.67	5.68-5.68	6.49-6.49	6.70-6.70	6.38-6.38	7.55-7.55	7.35-7.35	7.72-7.72

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3-4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-4
Bias	9	Describe any efforts to address potential sources of bias	*NA*
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	3-4
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4
		(*b*) Describe any methods used to examine subgroups and interactions	4
		(*c*) Explain how missing data were addressed	4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	4
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	4-6
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	4-6
		(b) Indicate number of participants with missing data for each variable of interest	4
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	4-6
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	5-6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	7-8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	7-8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.