Large and persistent life expectancy disparities between India's social groupsⁱ

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Abstract:

India is one of the most rigidly stratified societies in the world, yet little is known about life expectancy disparities in the country. We provide direct estimates of social differences in life expectancy in India using survey data spanning two decades. We show that individuals from the Scheduled Castes and Scheduled Tribes have drastically and persistently lower life expectancies than high caste individuals (between 4.2-4.4 years for women and 6.1-7.0 years for men in 2013-2016). While Muslims had a modest life expectancy disadvantage compared to high castes in 1997-2000, this disadvantage has grown substantially over the past 20 years. Mortality disparities between marginalized and privileged social groups are present across the entire life-course and are increasingly driven by older age mortality. Our findings reveal a pressing need for far greater attention to the health of marginalized populations in India.

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Introduction

India is one of the most rigidly hierarchical societies in the world. Multiple systems of stratification, such as those rooted in caste, religious identity, or indigenous status determine social privilege and disadvantage. At the bottom of the caste hierarchy are the Scheduled Castes, also known as *Dalits* or “ex-untouchables” (Ambedkar 1989b). At the next rung are “Other Backwards Classes,” a group of castes which were not considered “untouchable,” but which are still socially marginalised (Mandal, 1980). At the top are a group of advantaged castes, variously known as the “high”, “upper”, “forward”, or “general” castes (Ambedkar 1936). Scheduled Tribes, who are indigenous peoples also known as *Adivasis* (Xaxa 2008) face similar or worse forms of social disadvantage as Scheduled Castes (Xaxa Committee 2014). Finally, Muslims, who are India’s largest religious minority, face persistent and intensifying political and social marginalization (Government of India 2006; Jaffrelot 2021). Collectively, *Dalits*, *Adivasis*, and Muslims constitute two-fifths of India’s 1.37 billion people (Government of India 2013). They are some of the largest marginalized populations in the world.

Caste, religion, and indigenous identities shape all aspects of life and constrain marginalized individuals’ economic (Thorat et al. 2017), educational (Borooah et al. 2015), occupational (Vaid 2014; Aggarwal, Drèze, and Gupta 2015), and social opportunities (Allendorf and Pandian 2016; Zahran et al. 2015) – contributing to a persistent gap in human development (Azam and Bhatt 2015). These inequalities have fueled widespread public and academic debate in recent years on the magnitude, causes, and solutions to disparities in human development and well-being in India (S. Desai and Dubey 2012).

Longevity is one of the most fundamental dimensions of human development (Alkire 2002). Yet both public discussions and research on social inequalities in India have been slow to examine how caste and religion shape how long individuals live. One potential reason for this is that there are no officially produced estimates of mortality differences across social groups. Vital registration in India is not complete (Rao et al. 2021) and India relies on the Sample Registration System (SRS), a continuous mortality surveillance survey, for mortality estimates (Registrar General of India 2011). Unfortunately, the SRS does not prepare life tables by social group. Contributing to a small but growing body of research on mortality disparities in India (Barik, Desai, and Vanneman 2018; Mohanty and Ram 2010; Saikia, Bora, and Luy 2019; Vyas, Gupta, Aashish, and Hathi, Payal 2021) and low- and middle-income countries broadly (Chiavegatto Filho, Beltrán-Sánchez, and Kawachi 2014; Sudharsanan 2019), we provide direct estimates of the evolution of social differences in mortality across the life course in India. We do this through a novel use of routine household-survey data spanning a period of two decades.

Using data from two rounds of the National Family and Health Surveys – India’s nationally representative Demographic and Health Survey – we answer the following questions: (a) how large are social group differences in life expectancy at birth in India and how have they changed over the past 20 years?; (b) do mortality disparities persist beyond the childhood ages and in particular

which ages contribute the most to the overall life expectancy differences?; and (c) in the context of tremendous geographic heterogeneity in India, how do these differences vary regionally?

Social disadvantage and mortality disparities in India

A growing body of research seeks to understand social differences in mortality in India by using survey data. A substantial portion of the literature has focused on infant and child mortality, estimated from the birth history module implemented in several national surveys including the National Family Health Surveys (India's Demographic and Health Survey). This literature has documented persistent mortality disadvantages for Scheduled Caste and Scheduled Tribe children, despite overall improvements in child health and healthcare provision (Bora, Raushan, and Lutz 2019; Dommaraju, Agadjanian, and Yabiku 2008; Maity 2017; Ramaiah 2015). This literature has also documented a "Muslim mortality paradox:" despite relative economic disadvantages, Muslim children have lower mortality risks compared to Hindu children (Bhalotra, Valente, and Van Soest 2010; Guillot and Allendorf 2010). Geruso and Spears (2018) show that this is likely driven by higher use of toilets by Muslims, exposing Muslim children to a less worse disease environment.

A smaller literature has focused on estimating disparities in mortality beyond the childhood ages (Barik, Desai, and Vanneman 2018; Kumari and Mohanty 2020; Mohanty and Ram 2010; Saikia, Bora, and Luy 2019; Subramanian et al. 2006). Our paper builds on these existing studies of caste and tribe differences in life expectancy in India. Our first contribution to the literature is that our estimates of life expectancy and mortality in the adult ages are based on real age-specific data rather than modelled or indirect estimates. Our second main contribution is that our paper provides a comprehensive overview of how caste, tribe, and religious differences in mortality vary across age, geography, and time. Existing papers describe some of these differences but are often missing key dimensions of heterogeneity. Third, the existing literature has not examined the contribution of mortality disparities in different ages to overall disparities in life expectancy at birth. Fourth, our approach makes an important estimation advance. We demonstrate how survey data on recent household deaths and birth histories can be used to reliably estimate age-specific mortality rates, both overall and across social groups. Finally, complimentary to Vyas et al (2021), we estimate accurate standard errors using a cluster-bootstrap approach. This approach accounts the complex survey design of the NFHS survey and the clustering of observations within primary sampling units (villages or urban blocks) in the NFHS. Thus, by presenting differences across several dimensions using a consistent set of data and methods, our paper provides the most comprehensive picture of social group differences in mortality in India to date.

Unfortunately, our numerical results are difficult to directly compare to existing studies due to these data and methodological differences and because some studies estimate mortality differences using measures other than life expectancy (which is the standard in the mortality literature). Despite the differences in data and methods, our findings align with the extant literature that generally finds evidence of large and important social differences in mortality.

Materials and Methods

Data

Our data are from the second (1998-99) and fourth rounds (2015-16) of the Indian National Family Health Survey (NFHS), India's Demographic and Health Survey. The NFHS is a nationally representative survey of Indian households that collects extensive information on the health, fertility, and socioeconomic characteristics of household members. We were not able to use the first round of the NFHS since it did not distinguish between all the caste and tribe groups and the third round because it did not contain a question on recent deaths of household members.

Both the NFHS 2 and 4 employed a multi-stage stratified sampling design. For the NFHS 2, strata were defined by districts and additional potential geographic and demographic characteristics (International Institute for Population Sciences and ORC Macro 2000, 2). Within rural areas of each stratum, villages were randomly selected from the 1991 Census list of villages. Survey staff then attempted a complete household mapping in each selected village and subsequently randomly sampled households from this mapping. In urban areas within each stratum, a random sample of wards was selected based on listings from 1991 Census list of wards, followed by a random sampling of census enumeration areas within wards. Survey staff then conducted a household listing within selected census enumeration areas and randomly selected households from this listing. The sampling procedure was similar in the NFHS 4, with the main difference that the 2011 Census was used to list villages in rural areas and census enumeration blocks in urban areas. The NFHS 4 also directly sampled census enumeration blocks in urban areas and did not use information on wards.

These surveys involved multiple interviews for each household, including a household questionnaire and a separate woman's questionnaire administered to an ever-married woman in the household between the age of 15-49. The household questionnaire asked the respondent to provide an entire listing of household members with basic demographic information on each member, including their age, sex, and relationship to the household head. Within the household interview, the respondent was also asked about household members that had recently died. The woman's questionnaire asked several health and fertility-related questions, including a full birth history, where women in reproductive ages report details about the children they have had and the survival of the children

Measuring social groups

We classified all individuals into one of five mutually exclusive social groups based on the respondent-reported caste and religion of their household head: Scheduled Castes (SCs), Scheduled Tribes (STs), Muslims, Other Backward Classes (OBCs), and high castes (HCs). The classification is based on two questions asked in the NFHS surveys – one on caste or tribe group and another on religion. We classified individuals as SC and ST regardless of their religion. Although Indian official classifications allow only Sikhs, Hindus, and Buddhists to claim benefits reserved for Scheduled Castes (Fazal 2017), many Scheduled Caste individuals are in fact

members of other religions (Kumar et al. 2020; Louis 2007). The Muslim social group consists of those who reported Islam as their religion but who were not SC or ST. Given the small number of respondents who reported to be Muslim and SC or ST (0.62% of the sample in NFHS-4), this makes little difference to our estimates. High castes and Other Backward Classes are classified as such only if they are Hindu. Appendix Table A1 shows that these five groups account for 97% of deaths and person-years. The remaining sample, about 3% respondents, for whom we are unable to estimate life expectancy, consist of members of minority religions (Sikhs, Jains, Buddhists, Christians, Parsis, etc.) who did not identify as Scheduled Caste or Scheduled Tribe. The approach we follow here is consistent with that of the India Human Development Survey (S. B. Desai et al. 2010).

Measuring mortality

The NFHS 2 and 4 contain information on mortality in the birth history module of the woman's questionnaire and in the recent household deaths module of the household questionnaire. We take advantage of both sources of information. We use the birth history module to estimate under-5 mortality and information on recent household deaths for mortality at all other ages. For both child and adult mortality, we only examine mortality within the two years prior to the date of the household interview to minimize potential recall biases. Since the NFHS 2 and 4 were conducted over an approximately two-year period, our mortality estimates therefore correspond to approximately two four-year periods (1997-2000 and 2013-2016).

The approach of estimating under-5 mortality from the pregnancy module of the DHS surveys is widely applied by both governments and the United Nations and is thought to produce reliable estimates of under-5 mortality in the absence of comprehensive vital registration systems (Moultrie et al. 2013). Within the pregnancy history module, women were asked how many pregnancies they had in their lifetime and whether these pregnancies resulted in a live birth. For each live birth, women were additionally asked information on the date of birth and sex of the child and if the child was still alive at the time of the interview. For children that were reported to have died, women were asked to provide their age at death. Using this information, we created individual life-lines for each live birth, starting at their date of birth and ending at the date of interview for those children who were still alive and the date of death for those children who died. This allows us to identify exactly how many deaths and person-years lived there were for children under the age of 5 in the two years prior to the interview.

We estimate mortality for individuals ages 5 and above from information on household-reported recent deaths. Specifically, the survey respondent was asked if any regular member of the household had died since January 1996 for NFHS 2 and January 2012 for NFHS 4. For each deceased individual, respondents were asked to provide the sex, date of death, and age at death of the deceased. Using this information, we created life-lines for each deceased individual starting from their age two-years prior to the interview to their age at death. Next, we created life-lines for surviving individuals using information on the age and sex of household members enumerated in the household roster. For each household member, we first calculated their age two-years prior to

the interview and then created life-lines that ended at their age at the time of interview. Similar to under-5 mortality, we were then able to use these life-lines to estimate exactly how many deaths and person-years lived there were for each five-year age group between 5 and 85.

Statistical Methods

We first directly estimate age-specific mortality rates for age groups 0-1, 1-4, five-year age groups between 5 and 85, and the open ended age interval 85+ by dividing the number of deaths in each age group by the person-years lived in that age group. We do this separately by social group. We then convert these mortality rates into life tables using standard period life table techniques (S. Preston, Heuveline, and Guillot 2000). Based on the estimated life tables, we examine three life expectancy measures: life expectancy at birth (e_0), age 15 (e_{15}), and age 60 (e_{60}). We estimate life expectancy at three different ages to determine whether social differences in mortality are isolated to specific ages or are present across the life course: e_0 is strongly influenced by mortality in the younger ages, e_{15} captures both midlife and old-age mortality, and e_{60} captures just old-age mortality. The complete set of life tables is provided in the supplementary materials.

The three life expectancy estimates reveal whether mortality differences are present at multiple points of the life course. A second, related, way of assessing the importance of mortality differences across the life course is by decomposing the difference in e_0 across social groups into the contribution of mortality differences at multiple ages. To do this, we apply Arriaga's decomposition (Arriaga 1984) and estimate the contribution of social groups differences in mortality between ages 0-5, 5-15, 15-30, 30-45, 45-60, and 60+ to the overall difference in e_0 between social groups. Intuitively, Arriaga's decomposition determines the importance of each age group to the overall difference in e_0 by seeing how much social group differences in e_0 change when there are no longer mortality differences in that age group across social groups.

Lastly, we investigate whether the size of life expectancy differences across social groups varies geographically by estimating these differences separately by broad regions of India. For this analysis, we only focus on the most recent data from the NFHS 4 since this was the only survey that was designed with a large enough sample size to facilitate regional comparison within India.

All our estimates are weighted to be nationally representative. We estimated standard errors and 95% confidence intervals using a cluster-bootstrap approach (Cai et al. 2010; Solé-Auró, Beltrán-Sánchez, and Crimmins 2015; Fishman 2015; Vyas, Gupta, Aashish, and Hathi, Payal 2021) that accounts for the fact that the NFHS surveys are multi-stage surveys in which households are selected within randomly selected clusters.

Reliability of mortality estimates

The use of birth history modules to estimate child mortality is widely accepted (Moultrie et al. 2013). However demographers have been concerned about under-reporting of mortality from household-reported prior deaths questions (S. Preston, Heuveline, and Guillot 2000), particularly for children (Hill 1991). We attempted to reduce the potential for these biases by using the birth history for mortality under age 5 and using the household-reported prior deaths for the remaining

ages. To reduce recall bias, we limited the period for which age-specific mortality rates are estimated to just the two years prior to the survey.

Empirically, we assessed whether our estimation approach produces accurate estimates of mortality by comparing our results for men and women to the Indian SRS. We conducted this comparison separately by sex but not also by social group since the SRS does not publish mortality information by caste and tribe. We judged the accuracy of the NFHS 2 and 4 by first comparing our estimates of age-specific mortality rates and life expectancy at birth to those in the closest published SRS life table.

FIGURE 1 Comparison of estimated age-specific mortality rates from National Family Health Surveys and reported age specific mortality rates from Sample Registration Surveys

We found close agreement in the age-specific mortality rates estimated from our approach to the SRS (Figure 1). Interestingly, while close, the life expectancies at birth estimated from the NFHS were about 1.3 years less than life expectancies in the SRSⁱⁱ. This means that the NFHS estimates of age-specific mortality are higher – rather than lower, which is the typical concern when using household-reported deaths – than the SRS. This could be because the SRS underestimates true mortality, or because of differences in reference periods.

The empirical mortality rates we estimate align closely with those derived from modelling approaches, such as the Log-Quad model. This can be seen in Appendix Figure A5 and Table A7. In Appendix Table A8, we confirm that our estimates for overall infant and child mortality are consistent with other estimates, such as those provided by the United Nations Inter-agency for Child Mortality Estimation (UN-IGME 2021) and India’s sample registration system.

Results

Size and trends of life expectancy disparities across Indian social groups

Figure 2 reports estimates of life expectancy at birth, age 15, and age 60 for men and women from Scheduled Caste, Schedule Tribe, Other Backward Class, high caste, and Muslim backgrounds, for the years 1997-2000 and 2013-2016.ⁱⁱⁱ The figure reveals four major findings. First, there were very large absolute caste and tribe differences in life expectancy at birth for both men and women in 1997-2000. For women, high-caste life expectancy was 64.4 compared to just 57.0 among the Scheduled Tribes (a difference of 7.2 years). Similarly, for men, high-caste life expectancy was 62.9 compared to 54.6 among the Scheduled Tribes (a difference of 8.2 years). Differences between high castes and the Scheduled Castes were also very large, with a difference of 6.2 years for women and 4.5 years for men. For both men and women, OBC individuals had life expectancies at birth between the Scheduled Castes/Schedule Tribes and high castes (OBC life expectancy at birth for women was 61.0 and 60.5 for men).

Second, the large caste and tribe differences in life expectancy at birth were not just driven by differences in child mortality. We find evidence of large differences across social groups in life expectancy at age 15 and even 60. For example, the difference in life expectancy between high caste and Scheduled Caste individuals in 1997-2000 was 5.0 years for women and 3.2 years for men at age 15; and 3 years for women and 2.2 years for men at age 60. Similarly, the difference in life expectancy between high caste and Scheduled Tribe individuals in 1997 was 5.1 years for women and 5.5 years for men at age 15; and 2.6 years for women and 2.8 years for men at age 60. As with life expectancy at birth, OBC life expectancy at ages 15 and 60 fell between the high caste and Scheduled Tribe and Scheduled Caste life expectancies. The supplementary materials present age-specific mortality rates and survival curves by social group. Taken together, the results in Figure 2 and in the Supplemental Materials confirm that large differences in mortality persist across the life course and underscore the need to examine differences beyond the childhood ages.

Third, we find that differences in life expectancy did not close between 1997-2000 and 2013-2016. Although absolute levels of life expectancy at birth, age 15, and age 60 improved for all groups, the differences between castes persisted. For example, in 2013-2016, compared to the high castes, life expectancy at birth was still 4.4 years lower for women and 6.1 years lower for men from the Scheduled Castes, and 4.2 years lower for women and 7.0 years lower for men from the Scheduled Tribes. Most worryingly, absolute differences between Scheduled Caste men and High Caste men increased in this period. These patterns contrast with those in the United States, where Black-White differences have narrowed, and are smaller in both absolute and relative terms. Differences in life expectancy between Black and White Americans were 7.0 years 2000 and 3.4 years in 2015 (National Center for Health Statistics 2017), while overall life expectancy was higher than India.

Fourth, we observed a distinct but still important pattern of disparities between Muslims and high-caste Hindus. In 1997-2000, life expectancy at birth disadvantages compared to high castes were

smallest for Muslims, with a difference of 2.1 years among women and 0.3 years for men. However, this relatively small difference was mostly driven by a Muslim advantage in the younger ages. When looking at life expectancy at age 15 and 60, the disparities between Muslims and high-caste Hindus increased substantially to a difference of 2.6 years for women and 0.4 years for men and at age 15; and 2.3 years for women and 1.2 years for men and at age 60. By 2013-16, however, the Muslim disadvantage in life expectancy at birth had increased considerably: Muslim female life expectancy was 69.4 years, 2.8 years less than high caste female life expectancy, and Muslim male life expectancy was 66.8 years, 2.6 years less than high caste male life expectancy. The already important Muslim disadvantage at age 15 and 60 also increased further to a gap relative to high-caste Hindus at age 15 of 2.0 years for women and 2.2 years for men, and at age 60 of 1.8 years for women and 2.9 years for men.

Contribution of mortality differences across age to disparities in life expectancy at birth

Building on the findings that disparities in life expectancy are present at age 15 and 60 as well, we estimate the exact contribution of mortality differences at different age groups to the overall difference in life expectancy at birth using Arriaga's decomposition (Arriaga 1984). Figure 3 shows the contributions of six broad age groups to overall disparities.

Our decomposition results numerically confirm the insights from our previous figures: life expectancy at birth disparities between SC/ST groups and high castes are not just the result of differences in infant or child mortality but also from large mortality disparities in the older adult ages. For example, in 1997-2000, 1.82 years of life expectancy deficits between Scheduled Caste and high caste women came from ages 0-5 and 1.96 years from ages 60+. We observe a similar pattern between Scheduled Tribe and high castes, where 2.35 years of deficit for both men and women came from ages 0-5 while 1.69 years for women and 1.58 years for men were from ages 60+.

FIGURE 2 Disparities in life expectancy at birth, 15 years, and 60 years

Note: 95% CIs calculated using a cluster-bootstrap approach.
The number of bootstrap samples drawn was 100.

The relative contributions of mortality differences in the adult ages further increased between 1997-2000 and 2013-2016. For example, by 2013-2016, 1.73 years of life expectancy deficits for SC women and 2.45 years for SC men came from ages 60+, compared to just 1.45 years for women and 1.19 years for men from ages 0-5. This broad pattern is similar for differences between Scheduled Tribes and high castes. These trends reveal a declining importance of disparities at the younger ages and growing importance of disparities at older, adult, ages.

We observed a distinctly different set of age contributions for disparities between Muslims and high caste Hindus. In 1997-2000, infant mortality was higher for high caste Hindus than Muslims, leading to a negative contribution (life expectancy advantage) to overall life expectancy at birth disparities between Muslims and higher caste Hindus. This finding is consistent with a large literature documenting the "Muslim mortality paradox," where despite facing social disadvantage Muslims have lower rates of infant mortality (Bhalotra, Valente, and Van Soest 2010; Geruso and Spears 2018; Guillot and Allendorf 2010).

We also find smaller or negative contributions of mortality in ages 5-60. Although a full investigation of the underlying processes that contribute to these patterns is constrained by data availability, potential explanations include lower accidental mortality and liver disease among Muslim men because of lower alcohol consumption, lower prevalence of cervical cancers among women because of male circumcision; later-life effects of better early life disease environment; and lower suicide mortality. The patterns documented here are consistent with those observed by Vyas et al., (2021) in nine poor Indian states. Even in 1997-2000, however, this "paradoxical" mortality advantage does not extend to the older ages: 1.58 years of life expectancy at birth deficits for Muslim women and 0.87 years for Muslim men come from their higher levels of mortality above age 60.

By 2013-2016, we no longer find evidence of an infant mortality advantage for Muslims relative to high caste Hindus. 0.58 years for women and 0.39 years for men and of life expectancy at birth deficits relative to high caste Hindus were due to higher child mortality among Muslims. This is a significant departure from the "mortality paradox" and reveals that like other marginalized populations, Muslims now also face an infant mortality disadvantage relative to high caste Hindus. At the same time, consistent with the trends for Scheduled Caste and Scheduled Tribe populations, we see evidence of a growing importance of older age mortality for men, and a consistently high contribution of older age mortality for women.

FIGURE 3 Absolute contributions of mortality differences in different age groups to overall disparities in life expectancy at birth

Note: 95% CIs calculated using a cluster-bootstrap approach. The number of bootstrap samples drawn was 100. Some CIs may extend beyond y-axis limits.

Disparities by region and urban-rural residence

India is strikingly diverse and heterogeneous geographically (Dyson and Moore 1983). Patterns of social inequality, mobilization, and efforts made to improve the condition of the marginalized social groups also vary substantially across states and regions of India (Xaxa 2008; Ambedkar 1989a). We next investigate regional patterns of disparities in life expectancies at birth in 2013-16. We are unable to investigate regional disparities in the earlier 1997-2000 period because of the much smaller sample sizes, and consequently large confidence intervals at regional levels in NFHS-2. In the left panel of Figure 4, we show differences in life expectancy between Scheduled Castes and high castes for six regions in India: North India, the Hindi Belt (the largest region), West, South, East, and North-East.^{iv} The middle panel shows differences between Muslims and high castes for the same regions. For differences between Scheduled Tribes and high castes, we show three regions (right panel): North-East, where most of the population identifies as Scheduled Tribe, Central Indian states with a large Scheduled Tribe population, and the rest of India. These regions correspond with broad differences in indigenous identity within India (Guha 2006). On the maps, darker shades of purple represent larger absolute differences in life expectancy at birth.

We find that geographic differences in the size of SC-HC disparities in life expectancy vary for men and women. For women, there is substantial geographical heterogeneity, with the largest disparity in the Hindi belt (6.1 years). These differences seem to be driven primarily by the absolute level of life expectancy for SC women: SC women have the lowest life expectancy in the Hindi belt. For men, there is lesser geographic variation in the size of SC-HC disparities in life expectancy at birth, although the disparity is higher in the South (7.6 years) compared to the rest of the country. In terms of absolute levels, patterns of life expectancy for SC men was similar to SC women, with the highest life expectancy in the western states and lowest in the Hindi Belt.

Figure 4 Regional patterns of life expectancy disparities, 2013-2016

Note: 95% CIs calculated using a cluster-bootstrap approach. The number of bootstrap samples drawn was 100.

Muslims also face mortality disadvantages in all regions of India except the North-East. As with Scheduled Castes, their life expectancy is also lowest in the Hindi-Belt region. Absolute differences between Muslims and high caste women are highest in North India, and for men they are highest in the western region.

In the North-East, although the 95% CIs overlap, Scheduled Tribes had the highest life expectancies. In these states, Scheduled Tribes have higher social status than other social groups, which these life expectancy patterns likely reflect (Kikon 2017). On the other hand, in states of central India, where Scheduled Tribes face greater marginalization (Xaxa 2008), as well as in rest of India, Scheduled Tribes had lower life expectancies than high castes. Disparities were highest in the central states, with life expectancies of Scheduled Tribes lower by as many as 7.7 years.

Broadly, these patterns show that although Central India and the Hindi belt are regions where marginalized groups have the lowest life expectancies, disparities can be high even in regions with comparatively higher levels of overall human development.

In Figure 5, we consider disparities by rural and urban residence. Three patterns are worth noting. First, urban life expectancy is higher for almost all social groups compared to their rural counterparts. However, differences in life expectancy between rural and urban areas are lowest for Muslims, a pattern consistent with high sanitation use among rural Muslims (Geruso and Spears 2018). Second, disparities have reduced between the two rounds, particularly for rural women. Third, for most marginalized groups, life expectancy is lower than that of Higher-Caste Hindus in both rural and urban areas. However, the magnitude of disparities is not uniformly higher in rural or urban areas. Estimates for Scheduled Tribes in urban areas have large confidence intervals. Given that more than 90% of Scheduled Tribes are residents of rural areas, sample sizes for Scheduled Tribes in urban areas are smaller, particularly for urban Scheduled Tribes in 1997-2000. Finally, comparing marginalized social groups in rural areas and High caste Hindus in urban areas reveals the extent of disparities within India. In 2013-2016, urban High Caste women have life expectancies that are six years higher than life expectancies of rural Scheduled Caste women. Among men, this difference is more than eight years, an exceptionally large disparity in terms of life expectancy.

Figure 5 Social group disparities by urban and rural residence

Urban estimates are shown by lightly colored bars and black text. Rural estimates are solid bars and white text.
 Note: 95% CIs calculated using a cluster-bootstrap approach. The number of bootstrap samples drawn was 100. Some CIs may extend beyond y-axis limits.

Discussion

More than sixty years ago, Dr. B.R. Ambedkar wrote that “the health of the Untouchable is the care of nobody. Indeed, the death of an Untouchable is regarded as a good riddance.” (Ambedkar 1989b). Our findings reveal that these worries about the mortality and health of marginalized social groups in India are still pressing concerns in contemporary India. We find that Scheduled Castes and Scheduled Tribes have substantially lower life expectancies than high castes and that these large disparities have persisted over a nearly 20-year period between 1997 and 2016. Importantly, we also find that mortality disparities in India are not just a childhood phenomenon and are increasingly becoming an issue of disparities among older individuals.

Disparities between Muslims and higher caste Hindus were comparatively small in 1997, largely due to a Muslim mortality advantage in the younger ages. Our results however reveal a worrying trend: between 1997 and 2016, there was a significant reduction in the Muslim mortality advantage in the younger age. This reduction ultimately led Muslims to lose their parity with high-caste Hindus in terms of life expectancy at birth, with evidence in 2016 of large mortality disparities.

Social differences in longevity in India are exceptionally large in the context of global health disparities. In comparison to race in the United States (Arias and Xu 2019), we find that caste-differences in life expectancy in India are larger in an absolute sense and even more pronounced when considered as a percent difference, since the overall levels of life expectancy in India are lower. Mortality disparities in India are comparable to disparities in other severely stratified contexts, such as between Arabs and Jews in Israel (Saabneh 2015); between indigenous and white residents in New Zealand, Australia, or Canada (Anderson et al. 2016; Phillips et al. 2017; Tjepkema, Bushnik, and Bougie 2019); and by race in Brazil (Chiavegatto Filho, Beltrán-Sánchez, and Kawachi 2014). The salience of the mortality disparities we document is heightened when considering that the combined population size of any two of these three marginalized social groups is as large as the population of the United States. Our results contrast with the emerging literature on adult mortality in low and middle income countries, which has found modest disparities by education (Sudharsanan et al. 2020). This contrast suggests that social group and caste might be a more important axis of stratification in contexts like India.

Our study has three important limitations. First, data limitations prevent us from examining mortality rates for India’s other religious minorities. Second, because our estimates rely on household-reported prior mortality, there is the possibility that households do not report all prior deaths due to recall errors. While we are not aware of studies that empirically provide evidence of such biases in the Indian context, recall biases would likely be greater among more disadvantaged groups. Under that scenario, however, our results would be conservative and our main conclusions about the size and importance of caste and tribe differences in mortality would remain unchanged. The magnitude of this bias may also vary over time and affect our estimates of the time trends in mortality by caste or tribe. Unfortunately, it is ambiguous how such a bias would affect the estimates. Third, mortality estimates may be influenced by age-misreporting, especially for older

adults. Similar to the prior limitation, bias from age-misreporting makes our results conservative since studies have shown that it biases mortality estimates downwards (S. H. Preston, Elo, and Stewart 1999) and is likely more common among more disadvantaged individuals. Modeled estimates show that these biases are modest compared to the extent of the disparities between advantaged and disadvantaged groups.

Despite these limitations, our study benefits from large nationally representative data and demonstrates how such data sources can be used to monitor the inequalities in life expectancy in contexts without comprehensive vital registration systems linked to social indicators. This approach is helpful for understanding other axes of stratification, such as education or class. An important future area of research will be to identify which causes of death and mortality risk-factors contribute to the large and persistent life expectancy differences we observe. Detailed cause of death data in India are currently highly incomplete. Developing the capacity for collecting such information will be key for helping to identify why these social differences in mortality exist and what policy solutions might be able to reduce them.

Ultimately, our findings have two important implications for research to reduce inequalities in human development in India and globally. First, they suggest that far more attention must be paid to marginalized populations in India who continue to face mortality disadvantages despite rapid economic growth. Second, our results underscore that development efforts need to move beyond the historic focus on child health to better understand the sources and ways to reduce disparities among adults globally.

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Notes

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ⁱⁱ Although the SRS is also a survey, 95% CIs are not available for the SRS estimates as the SRS does not release these estimates.

ⁱⁱⁱ Overall deaths and person-years exposed are provided in Table A1. Life expectancy at birth estimates and 95% CIs are also provided in Table A2 in the supplementary material. Abridged life tables for these four social groups are available in Tables A3-A6.

^{iv} The Hindi Belt is the region below North-India in the maps on the left panel which compares SCs and HCs. It is also the largest region in the maps in the left panel. The regions are also labeled on the maps.

Appendix: Supplemental Materials

Large & persistent life expectancy disparities among India's social groups

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Supplementary Text

Figures A1 to A3

Tables A1 to A6

Supplementary Text

Deaths and person-years

Table A1 reports the number of deaths and person-years we observe, by sex, period, social group, and overall. For the period 1997-2000, we observe 4,355 deaths among women, and 4,930 deaths among men from NFHS-2. Because of its larger sample size, we observe comparatively more deaths in the NFHS-4. From NFHS-4, we observe 18,896 deaths among women, and 24,079 deaths among men, corresponding to the period 2013-2016.

Mortality differences across the life course

In Table A2, we report life expectancies at birth, age 15, and age 60. With the exception of overall estimates, the estimates by social group are also presented in figure 2 in the main text. Tables A3-A6 present abridged life tables by period, sex, and social group. We present three life tables quantities: age-specific mortality rates between ages x and $x + n$, or ${}_nm_x$; survivors to age x starting from a hypothetical cohort of 1,000, or l_x ; and life expectancy at age x , or e_x . Based on these life tables, Figure A1 shows survival curves by age, caste, sex, and period, and Figure A2 shows respective age specific mortality rates. These two sets of figures show High Caste survival advantage across the life course.

Robustness

Figure A3 and Table A7 show comparisons between empirical and modeled mortality or life expectancy estimates. We find close correspondence between predicted Log-Quad mortality rates using empirical input parameters (5q0 and 45q15) from the NFHS surveys. It is worth noting here that the log-quad model relies on extrapolation from these input parameters using age-specific mortality rates based on available life tables, mostly from

high-income countries. It could well be the case that Indian mortality patterns, as observed in the SRS and the NFHS, could be different from extrapolated patterns based on documented life tables from other contexts. Mortality among women in the younger ages is particularly different in the log-quad model and the NFHS. In this regard, the NFHS is similar to the SRS (see also Figure 1 in the main paper). These patterns of higher mortality among women in younger ages may be related to the vulnerable position of young women in Indian society, and deserve further scrutiny. Mortality estimates at older ages, where biases in empirical estimates would be predicted to be higher, are similar across estimates from the NFHS, SRS, and the Log-Quad model.

Overall life expectancy estimates using the Log-Quad model are also similar to the NFHS estimates, though in general overall life expectancy estimates in the Log-Quad model are higher. This suggests that the Log-Quad model potentially under-estimates mortality. We find some evidence of higher differences between modeled and empirical estimates in the earlier NFHS round, among marginalized social groups, and among women. The higher differences among women may be due to the inability of the Log-Quad approach to model female mortality in the younger ages. In general, however, similarly large disparities can be seen in both sets of estimates.

Table A8 compares estimates of child mortality from the NFHS (derived from our life table approach), the Sample Registration System, and the UN-IGME. Although overall levels of infant and child mortality in the three sources are similar, the UN-IGME is closer to the SRS. This is because the UN-IGME models its mortality rates by smoothing SRS inputs. The UN-IGME also predicts greater decline in child mortality rates than the SRS or the NFHS.

Figure A1: Survival curves by social group

Note: 95% CIs calculated using a cluster-bootstrap approach.
The number of bootstrap samples drawn was 100.

Figure A2: Age-specific death rates by social group

Figure A3: Robustness: Comparison of predicted mortality rates from the log-quad model (Wilmoth et al 2012) and empirical age-specific mortality rates observed in the NFHS surveys

Table A1: Observed deaths and person-years

	women		men	
	deaths	person-years	deaths	person-years
<u>1997-2000</u>				
Scheduled Caste	885	85,200	987	90,536
Scheduled Tribe	433	41,984	536	43,277
Muslim	503	61,941	512	64,309
Other Backward Class	1,308	133,515	1,462	141,118
High Caste	1,119	131,016	1,303	139,038
Others	107	15,447	128	16,155
Overall	4,355	469,103	4,930	494,435
<u>2013-2016</u>				
Scheduled Caste	4,008	549,666	5,409	562,778
Scheduled Tribe	1,683	251,950	2,319	251,686
Muslim	2,205	363,912	2,663	362,472
Other Backward Class	6,887	938,817	8,719	961,527
High Caste	3,675	499,544	4,361	518,144
Others	438	71,466	608	73,493
Overall	18,896	2,675,354	24,079	2,730,100

All estimates weighted by national households weights.

Table A2: Life expectancy estimates by social group

life expectancy at:	birth		age 15		age 60	
			Female, 1997-2000			
Scheduled Caste	58.0	[56.8-59.2]	50.4	[49.7-51.1]	13.5	[13.1-13.9]
Scheduled Tribe	57.0	[54.7-59.3]	50.4	[48.6-52.2]	13.9	[12.9-14.9]
Other Backward Class	60.9	[59.8-62.0]	53.2	[52.7-53.7]	14.9	[14.6-15.2]
High Caste	64.2	[63.2-65.2]	55.3	[54.7-55.9]	16.2	[15.9-16.5]
Overall	61.3	[61.0-61.6]	53.2	[53.1-53.3]	15.0	[14.9-15.1]
			Male, 1997-2000			
Scheduled Caste	58.3	[57.4-59.2]	50.2	[49.7-50.7]	13.3	[12.9-13.7]
Scheduled Tribe	54.6	[52.5-56.7]	47.8	[46.1-49.5]	12.8	[11.8-13.8]
Other Backward Class	60.5	[59.8-61.2]	51.1	[50.6-51.6]	14.5	[14.2-14.8]
High Caste	62.8	[62.2-63.4]	53.2	[52.7-53.7]	15.3	[15.0-15.6]
Overall	60.5	[60.3-60.7]	51.5	[51.3-51.7]	14.5	[14.4-14.6]
			Female, 2013-2016			
Scheduled Caste	67.8	[67.6-68.0]	57.1	[57.0-57.2]	16.8	[16.7-16.9]
Scheduled Tribe	68.0	[67.7-68.3]	57.1	[56.8-57.4]	17.4	[17.2-17.6]
Other Backward Class	69.4	[69.3-69.5]	58.4	[58.3-58.5]	17.7	[17.7-17.7]
High Caste	72.2	[71.9-72.5]	60.2	[60.0-60.4]	19.0	[18.9-19.1]
Overall	69.6	[69.6-69.6]	58.5	[58.5-58.5]	17.9	[17.9-17.9]
			Male, 2013-2016			
Scheduled Caste	63.3	[63.1-63.5]	52.6	[52.4-52.8]	15.1	[15.0-15.2]
Scheduled Tribe	62.4	[62.1-62.7]	52.2	[52.0-52.4]	15.2	[15.1-15.3]
Other Backward Class	66.1	[66.0-66.2]	55.1	[55.0-55.2]	16.3	[16.3-16.3]
High Caste	69.4	[69.1-69.7]	57.5	[57.3-57.7]	18.5	[18.4-18.6]
Overall	66.0	[65.9-66.1]	54.9	[54.9-54.9]	16.5	[16.5-16.5]

All estimates weighted by national households weights. 95% CIs estimated using a cluster-bootstrap approach in square brackets. The number of bootstrap samples drawn was 100.

Table A3: Life tables by social group, Female, 1997-2000

age	Scheduled Caste			Scheduled Tribe			Muslim			Other Backward Class			High Caste		
	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x
0-1	0.0743	1000	58.0	0.0747	1000	57.0	0.0515	1000	62.2	0.0766	1000	60.7	0.0578	1000	64.3
1-4	0.0090	930	61.4	0.0111	929	60.4	0.0058	950	64.5	0.0061	928	64.4	0.0056	945	67.1
5-9	0.0021	897	59.6	0.0028	889	59.0	0.0017	929	61.9	0.0025	905	62.0	0.0018	924	64.6
10-14	0.0011	887	55.2	0.0024	877	54.8	0.0016	921	57.4	0.0015	894	57.7	0.0011	915	60.2
15-19	0.0025	883	50.5	0.0030	866	50.4	0.0019	914	52.9	0.0032	887	53.1	0.0022	910	55.5
20-24	0.0049	872	46.1	0.0059	854	46.2	0.0023	905	48.4	0.0040	873	49.0	0.0033	900	51.1
25-29	0.0042	851	42.1	0.0039	829	42.5	0.0041	894	43.9	0.0030	856	44.9	0.0022	886	46.8
30-34	0.0037	833	38.0	0.0040	813	38.3	0.0023	876	39.7	0.0028	843	40.5	0.0022	876	42.3
35-39	0.0041	818	33.6	0.0090	796	34.0	0.0029	867	35.2	0.0039	832	36.1	0.0032	866	37.8
40-44	0.0048	801	29.3	0.0057	761	30.4	0.0059	854	30.6	0.0031	816	31.7	0.0031	852	33.4
45-49	0.0110	782	24.9	0.0090	740	26.2	0.0066	829	26.5	0.0092	803	27.2	0.0059	839	28.8
50-54	0.0176	740	21.2	0.0084	707	22.3	0.0123	802	22.3	0.0062	767	23.3	0.0060	815	24.6
55-59	0.0077	678	17.9	0.0090	678	18.2	0.0096	754	18.5	0.0139	743	19.0	0.0133	791	20.3
60-64	0.0328	652	13.5	0.0450	648	13.9	0.0338	719	14.3	0.0292	693	15.2	0.0222	740	16.5
65-69	0.0390	553	10.4	0.0318	517	11.8	0.0336	606	11.5	0.0336	599	12.1	0.0265	662	13.1
70-74	0.1268	454	7.1	0.0864	440	8.3	0.0885	512	8.1	0.0731	505	8.9	0.0701	579	9.6
75-79	0.0817	234	6.4	0.0995	283	6.6	0.0912	326	6.3	0.0880	349	6.7	0.0682	406	7.7
80-84	0.2813	155	3.5	0.2271	170	4.2	0.2868	205	3.5	0.2239	223	4.1	0.1775	288	4.8
85+	0.3270	28	3.1	0.2593	48	3.9	0.2719	36	3.7	0.3048	64	3.3	0.2880	112	3.5

Table A4: Life tables by social group, Male, 1997-2000

age	Scheduled Caste			Scheduled Tribe			Muslim			Other Backward Class			High Caste		
	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x
0-1	0.0812	1000	58.3	0.0809	1000	54.5	0.0575	1000	62.6	0.0665	1000	60.2	0.0639	1000	62.9
1-4	0.0041	923	62.1	0.0092	924	58.0	0.0036	945	65.2	0.0036	937	63.3	0.0036	939	65.9
5-9	0.0026	909	59.1	0.0045	890	56.1	0.0017	931	62.1	0.0016	923	60.2	0.0005	926	62.9
10-14	0.0012	897	54.8	0.0018	871	52.3	0.0009	924	57.6	0.0009	916	55.6	0.0012	924	58.0
15-19	0.0021	891	50.1	0.0021	863	47.8	0.0009	919	52.9	0.0023	912	50.9	0.0017	918	53.3
20-24	0.0014	882	45.6	0.0050	854	43.3	0.0014	915	48.1	0.0034	902	46.4	0.0026	910	48.8
25-29	0.0037	876	40.9	0.0043	833	39.3	0.0019	909	43.4	0.0032	887	42.2	0.0023	899	44.4
30-34	0.0030	860	36.7	0.0067	815	35.1	0.0023	900	38.8	0.0044	873	37.8	0.0037	888	39.9
35-39	0.0048	847	32.2	0.0044	788	31.2	0.0041	890	34.2	0.0038	854	33.6	0.0050	872	35.6
40-44	0.0085	827	27.9	0.0093	771	26.8	0.0096	872	29.9	0.0084	838	29.2	0.0038	850	31.4
45-49	0.0109	792	24.0	0.0128	736	23.0	0.0089	831	26.2	0.0101	803	25.3	0.0080	834	26.9
50-54	0.0198	751	20.2	0.0223	690	19.3	0.0132	795	22.3	0.0170	764	21.5	0.0129	802	22.9
55-59	0.0166	680	17.0	0.0194	617	16.3	0.0082	744	18.7	0.0156	701	18.2	0.0144	752	19.3
60-64	0.0409	625	13.3	0.0490	560	12.7	0.0312	714	14.3	0.0343	649	14.4	0.0271	699	15.5
65-69	0.0313	509	10.7	0.0482	437	10.6	0.0483	611	11.3	0.0436	546	11.7	0.0358	610	12.4
70-74	0.1173	435	7.1	0.1068	343	7.8	0.0924	479	8.7	0.0779	438	8.9	0.0754	510	9.4
75-79	0.1076	237	5.9	0.0811	198	6.6	0.0642	299	7.5	0.0877	295	7.0	0.0684	348	7.6
80-84	0.2839	137	3.5	0.2906	132	3.7	0.2289	216	4.4	0.2079	189	4.5	0.1911	247	4.6
85+	0.3165	25	3.2	0.2070	23	4.8	0.2305	61	4.3	0.2603	62	3.8	0.2764	89	3.6

Table A5: Life tables by social group, Female, 2013-2016

age	Scheduled Caste			Scheduled Tribe			Muslim			Other Backward Class			High Caste		
	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x	n _m _x	l _x	e _x
0-1	0.0438	1000	67.8	0.0404	1000	68.0	0.0414	1000	69.4	0.0417	1000	69.4	0.0336	1000	72.2
1-4	0.0029	958	69.8	0.0028	961	69.8	0.0022	960	71.3	0.0021	960	71.3	0.0011	967	73.6
5-9	0.0010	947	66.6	0.0009	950	66.5	0.0005	951	67.9	0.0008	952	67.8	0.0004	963	70.0
10-14	0.0007	942	61.9	0.0010	946	61.8	0.0006	949	63.1	0.0008	948	63.1	0.0004	961	65.1
15-19	0.0013	938	57.1	0.0018	941	57.1	0.0010	946	58.2	0.0016	944	58.4	0.0012	959	60.2
20-24	0.0017	932	52.5	0.0027	933	52.6	0.0017	941	53.5	0.0017	937	53.8	0.0016	953	55.6
25-29	0.0021	925	47.9	0.0023	921	48.3	0.0015	933	49.0	0.0019	929	49.2	0.0013	946	51.0
30-34	0.0026	915	43.4	0.0019	910	43.8	0.0010	927	44.3	0.0019	920	44.7	0.0014	940	46.3
35-39	0.0017	903	38.9	0.0025	902	39.2	0.0024	922	39.5	0.0022	911	40.1	0.0022	933	41.6
40-44	0.0026	895	34.2	0.0037	891	34.6	0.0034	911	35.0	0.0022	901	35.5	0.0020	923	37.1
45-49	0.0055	884	29.6	0.0060	874	30.2	0.0027	896	30.5	0.0035	892	30.9	0.0037	914	32.4
50-54	0.0054	860	25.4	0.0041	849	26.1	0.0044	884	25.9	0.0044	876	26.4	0.0032	897	27.9
55-59	0.0095	837	21.0	0.0087	831	21.6	0.0090	864	21.4	0.0081	857	21.9	0.0068	883	23.4
60-64	0.0163	798	16.9	0.0144	796	17.4	0.0177	826	17.3	0.0141	823	17.7	0.0118	854	19.1
65-69	0.0266	735	13.1	0.0256	741	13.5	0.0283	756	13.6	0.0247	767	13.8	0.0215	805	15.1
70-74	0.0676	643	9.6	0.0688	651	10.0	0.0611	656	10.3	0.0583	677	10.2	0.0443	722	11.5
75-79	0.0796	456	7.5	0.0674	459	8.1	0.0705	481	8.1	0.0779	504	7.9	0.0621	578	8.7
80-84	0.1687	304	4.9	0.1562	326	5.3	0.1416	336	5.5	0.1434	339	5.5	0.1195	422	6.0
85+	0.2877	124	3.5	0.2526	143	4.0	0.2649	161	3.8	0.2650	161	3.8	0.2532	228	3.9

Table A6: Life tables by social group, Male, 2013-2016

age	Scheduled Caste			Scheduled Tribe			Muslim			Other Backward Class			High Caste		
	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x	n _{m_x}	l _x	e _x
0-1	0.0539	1000	63.3	0.0549	1000	62.4	0.0398	1000	66.8	0.0469	1000	66.0	0.0360	1000	69.4
1-4	0.0020	948	65.8	0.0032	947	64.9	0.0014	962	68.5	0.0020	955	68.1	0.0009	965	70.9
5-9	0.0006	941	62.3	0.0010	936	61.7	0.0007	956	64.9	0.0008	947	64.6	0.0006	962	67.2
10-14	0.0007	938	57.4	0.0009	931	57.0	0.0006	953	60.1	0.0007	944	59.9	0.0005	959	62.4
15-19	0.0019	935	52.6	0.0019	927	52.2	0.0013	950	55.3	0.0013	940	55.1	0.0011	956	57.5
20-24	0.0022	926	48.1	0.0027	918	47.7	0.0016	944	50.6	0.0019	934	50.4	0.0013	951	52.8
25-29	0.0031	916	43.6	0.0034	906	43.3	0.0021	936	46.0	0.0025	925	45.9	0.0022	945	48.1
30-34	0.0035	902	39.2	0.0034	891	39.0	0.0023	926	41.5	0.0029	914	41.4	0.0025	935	43.6
35-39	0.0049	887	34.9	0.0050	875	34.6	0.0022	915	36.9	0.0035	901	37.0	0.0040	923	39.1
40-44	0.0062	865	30.7	0.0069	854	30.5	0.0043	905	32.3	0.0048	885	32.6	0.0038	905	34.9
45-49	0.0092	839	26.6	0.0096	825	26.4	0.0071	886	28.0	0.0084	864	28.3	0.0060	888	30.5
50-54	0.0113	801	22.7	0.0133	786	22.6	0.0068	855	23.9	0.0081	828	24.4	0.0085	862	26.3
55-59	0.0143	757	18.9	0.0147	735	19.0	0.0127	826	19.6	0.0120	795	20.3	0.0117	826	22.4
60-64	0.0236	704	15.1	0.0257	683	15.2	0.0258	776	15.7	0.0190	749	16.4	0.0146	779	18.6
65-69	0.0375	626	11.6	0.0382	600	12.0	0.0325	681	12.5	0.0303	681	12.8	0.0249	724	14.8
70-74	0.0799	518	8.5	0.0745	495	9.0	0.0732	578	9.3	0.0702	585	9.5	0.0460	639	11.4
75-79	0.0999	345	6.5	0.1011	339	6.9	0.0934	399	7.3	0.0805	409	7.5	0.0640	507	8.7
80-84	0.2068	207	4.2	0.1940	202	4.9	0.1427	247	5.3	0.1676	272	4.9	0.1290	367	6.0
85+	0.3553	67	2.8	0.2300	71	4.3	0.2942	118	3.4	0.2852	113	3.5	0.2255	189	4.4

Table A7: Comparison of empirical and modeled life expectancy estimates

	NFHS (empirical)			Log-Quad (modeled)
	$5q_0$	$45q_{15}$	e_0	e_0
<u>Female, 1997-2000</u>				
Scheduled Caste	0.103	0.261	58.0	59.5
Scheduled Tribe	0.111	0.252	57.0	59.3
Muslims	0.071	0.213	62.2	64.2
Other Backward Classes	0.095	0.218	60.7	62.1
High Caste	0.076	0.187	64.3	65.0
Overall	0.089	0.217	61.3	62.6
<u>Male, 1997-2000</u>				
Scheduled Caste	0.091	0.299	58.3	58.7
Scheduled Tribe	0.110	0.351	54.5	55.4
Muslims	0.069	0.223	62.6	63.5
Other Backward Classes	0.077	0.289	60.2	60.2
High Caste	0.074	0.238	62.9	62.4
Overall	0.080	0.271	60.6	60.7
<u>Female, 2013-2016</u>				
Scheduled Caste	0.053	0.149	67.8	68.8
Scheduled Tribe	0.050	0.154	68.0	68.9
Muslims	0.049	0.127	69.4	70.3
Other Backward Classes	0.048	0.128	69.4	70.2
High Caste	0.037	0.110	72.2	72.3
Overall	0.047	0.129	69.6	70.3
<u>Male, 2013-2016</u>				
Scheduled Caste	0.059	0.247	63.3	63.3
Scheduled Tribe	0.064	0.263	62.4	62.2
Muslims	0.044	0.184	66.8	67.2
Other Backward Classes	0.053	0.204	65.5	65.6
High Caste	0.038	0.186	69.4	67.6
Overall	0.051	0.211	66.0	65.4

Estimates for probability of death between ages 0 and 5 ($5q_0$), probability of death between 15 and 60 ($45q_{15}$), and life expectancy at birth e_0 from the NFHS are empirically estimated. Modeled life expectancy estimates using the Log-Quad model (Wilmoth et al 2012) were calculated on the basis of empirical $5q_0$ and $45q_{15}$ from the NFHS.

Table A8: Comparison of estimates of probability of child mortality from NFHS, SRS, and UN-IGME

	Female			Male		
	NFHS	SRS	UN-IGME	NFHS	SRS	UN-IGME
<u>$1q_0$ (probability of death by age 1)</u>						
1997-2000	0.063	0.071	0.072	0.065	0.070	0.071
2013-2016	0.039	0.041	0.037	0.044	0.039	0.037
<u>$5q_0$ (probability of death by age 5)</u>						
1997-2000	0.089	0.100	0.104	0.080	0.090	0.094
2013-2016	0.047	0.502	0.048	0.051	0.452	0.045

Estimates for probability of death between ages 0 and 5 ($5q_0$), probability of death between 15 and 60 ($45q_{15}$), and life expectancy at birth e_0 from the NFHS are empirically estimated. Modeled life expectancy estimates using the Log-Quad model (Wilmoth et al 2012) were calculated on the basis of empirical $5q_0$ and $45q_{15}$ from the NFHS.