Social disadvantage, economic inequality, and life expectancy in nine Indian states

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An extensive literature documents the contributions of discrimination and social exclusion to health disparities. This study investigates life expectancy differentials along lines of caste, religion, and indigenous identity in India, home to some of the largest populations of marginalized social groups in the world. Using a large, high-quality survey that measured mortality, social group, and economic status, we estimate and decompose life expectancy differences between higher-caste Hindus, comprising other backward classes and high-caste Hindus, and three of India’s most disadvantaged social groups: Adivasis, Dalits, and Muslims. Relative to higher-caste Hindus, Adivasi life expectancy is more than 4 y lower, Dalit life expectancy is more than 3 y lower, and Muslim life expectancy is about 1 y lower. Economic status explains less than half of these gaps. The differences between the life expectancy of higher-caste Hindus and the life expectancies of Adivasis and Dalits are comparable to the Black–White gap in the United States in absolute magnitude. The differences are larger in relative terms because overall life expectancy in India is lower. Our findings extend the literature on fundamental causes of global health disparities. Methodologically, we contribute to the literature on mortality estimation and demographic decomposition using survey data from low- and middle-income contexts.

Social disadvantage and health are closely linked. In the United States, for example, disparities in health and mortality between Black and White Americans have persisted over decades despite changes in technology, exposures, and diseases (1, 2). However, the health impacts of social exclusion remain severely understudied in low- and middle-income countries (LMICs) (3). Understanding health disparities in LMICs is important in part because social marginalization is no less present in poorer societies than in rich ones like the United States. Moreover, compared to high-income countries (HICs), patterns of disparities may be distinct in LMICs because population health is poorer, social safety nets are less robust, health care is less accessible, and mortality risk factors differ (4).

This article describes and decomposes life expectancy disparities between socially marginalized and privileged groups in one of the most populated and stratified countries in the world, India. Marginalized social groups in India—Dalits, Adivasis, and Muslims—experience social exclusion based on caste, indigenous identity, and religion, respectively (5–7). Although each social group faces distinct forms of marginalization, together they compose a population of over 450 million, greater than that of the United States. Each group individually is also among the largest marginalized social groups in the world. We compare mortality for these three groups to the combined mortality of other backward classes (OBC) and high-caste Hindus, who are relatively privileged in Indian society. We refer to this group as OBC/high-caste Hindus in the manuscript.

As in other contexts, social and economic disadvantages occur simultaneously in India. Dalits, Adivasis, and Muslims are poorer than privileged groups (8, 9). Because health and economic status are also related (10), we quantify the extent to which differences in socioeconomic status (SES) can account for mortality differences between groups. To do this, we follow the literature on mortality disparities between Black and White Americans (1, 11), which uses standardization and decomposition techniques. These analyses are made possible in HICs by complete vital registration and multiple large surveys that reliably measure mortality, race, and SES (12). In many LMICs, however, decomposing life expectancy differences between groups is constrained by the sparseness of data on all-cause mortality linked with social conditions (13, 14). For this reason, direct estimation of life tables disaggregated by social group and SES is not possible.

We overcome this limitation by using a unique and large-scale survey in nine Indian states from 2010 to 2011 that collected retrospective mortality information, social group, and SES from 4 million households. The sample is sufficient for directly estimating age-specific mortality rates. We find that the overall age-specific mortality rates estimated from this data correspond closely to official life tables. In particular, we compare our sex-specific, aggregated life tables to the life tables generated by the Government of India’s Sample Registration System (SRS), a nationally representative system of mortality monitoring that does not disaggregate data by social group. After establishing

Significance

India is one of the most hierarchical societies in the world. Because vital statistics are incomplete, mortality disparities are not quantified. Using survey data on more than 20 million individuals from nine Indian states representing about half of India’s population, we estimate and decompose life expectancy differences between higher-caste Hindus, comprising other backward classes and high castes, and three marginalized social groups: Adivasis (Indigenous peoples), Dalits (oppressed castes), and Muslims. The three marginalized groups experience large disadvantages in life expectancy at birth relative to higher-caste Hindus. Economic status explains less than half of these gaps. These large disparities underscore parallels between diverse systems of discrimination akin to racism. They highlight the global significance of addressing social inequality in India.

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the characteristics of surveyed households’ usual members that died between 1 January 2007 and 31 December 2009. AHS instructions to enumerators are described in SI Appendix, Table S1. SI Appendix, Table S2 describes the sample.

The AHS recorded the caste group and religion of each household. We focus on estimating life expectancies for India’s social groups: Adiavasis (10% of our sample), Dalits (19%), Muslims (14%), and OBC/high-caste Hindus (56%). The data do not allow us to separately identify OBCs and high-caste Hindus. OBCs are relatively privileged compared to Dalits and Adiavasis but marginalized compared to high-caste Hindus. Therefore, we expect the combined life expectancy of OBCs and high-caste Hindus to be lower than it would be for high-caste Hindus on their own. Since the OBC population is greater than that of high-caste Hindus (8), the combined life expectancy figure is likely to be closer to that of OBCs than that of high-caste Hindus. We refer to the combined OBC and high-caste Hindu group as OBC/high-caste Hindus in this article.

Methods
Estimating Mortality Rates and Life Expectancy. Using data from the AHS household and mortality rosters, we construct a dataset that records the number of person-years each individual contributes to each single-year age during the period January 2007 through December 2009, and whether the individual died at that age. We estimate social group-, age-, and sex-specific mortality rates (shown in SI Appendix, Fig. S2). Using standard procedures, we construct eight life tables to calculate life expectancy at birth separately for males and females of each social group. The number of person-years lived by those who died in each age interval, or \( r_{a|x} \), is calculated based on values from the Government of India’s SRS 2007 to 2011 official life tables for states (19). SI Appendix, Fig. S3 shows that life expectancies and disparities calculated based on \( r_{a|x} \) values estimated directly from the AHS are similar to those calculated using \( r_{a|x} \) values estimated indirectly. In additional analyses, we use social group-, state-, and sex-specific life expectancies, as well as social group-, wealth-decile-, and sex-specific ones using the same methods. All estimates use the sample weights provided in the survey to make the data representative of the nine AHS states. SI Appendix, Estimating Mortality Rates and Life Expectancy further describes our methods for estimating life expectancy.

In order to rule out concerns regarding data quality from retrospective survey questions, we conduct additional simulations about mortality rates and life expectancy in nine Indian states.

Data
This study uses the Government of India’s Annual Health Survey (AHS) 2010 to 2011 (17), a household survey that visited over 4 million households across ~20,000 primary sampling units (PSUs) and collected data on over 20 million individuals in nine relatively poor states in India: Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh, and Uttarakhand. These states represent 48.5% of India’s population (AHS) 2010 to 2011 (17), a household survey that visited over 4 million households across ~20,000 primary sampling units (PSUs) and collected data on over 20 million individuals in nine relatively poor states in India: Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh, and Uttarakhand. These states represent 48.5% of India’s population. The data do not allow us to separately identify OBCs and high-caste Hindus. OBCs are relatively privileged compared to Dalits and Adiavasis but marginalized compared to high-caste Hindus. Therefore, we expect the combined life expectancy of OBCs and high-caste Hindus to be lower than it would be for high-caste Hindus on their own. Since the OBC population is greater than that of high-caste Hindus (8), the combined life expectancy figure is likely to be closer to that of OBCs than that of high-caste Hindus. We refer to the combined OBC and high-caste Hindu group as OBC/high-caste Hindus in this article.

SI Appendix, Table S3 shows the composition of the sample by responses to the AHS questions on caste group and religion. Further details on the social group categories we use in the analysis are in SI Appendix, Data Preparation.

Because the AHS asked members to list usual residents in the household and mortality rosters, these estimates are for usual residents of these states. In this respect, our estimates are similar to other demographic estimates. The AHS does not provide individual-level data on migrant status. According to the 2011 Census, out-of-state migration in the AHS states was small (18). The AHS also recorded data on household SES, including rural residence, wealth, and environmental exposures including household solid fuel use and fraction of people defecating in the open in the PSU. To summarize a household’s wealth, we construct a wealth index using a principal component analysis (PCA) of asset ownership and house infrastructure. The index is described in greater detail in SI Appendix, Socioeconomic Status Variables. The relative disadvantage of Adiavasis, Dalits, and Muslims, compared to OBC/high-caste Hindus, is evident in SI Appendix, Fig. S1 and Table S4, which display summary statistics by social group. Data are described further in the SI Appendix, Data Preparation.

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Demographic Reweighting. To understand the extent to which differences in SES can account for social group differentials in life expectancy, we use a demographic reweighting strategy (11). Nonparametric reweighting techniques allow for studying nonlinear functions like life expectancy and, by matching on the full distribution of observed characteristics, are more flexible than regression techniques.

In practice, the demographic reweighting technique estimates counterfactual life expectancies for marginalized social groups, reweighting these groups so that they match the distribution of SES among OBC/high-caste Hindus. Because these marginalized social groups we study have lower SES than OBC/high-caste Hindus, the reweighting strategy produces counterfactual life expectancies by up-weighting wealthier individuals and down-weighting less wealthy individuals in each marginalized group. This is implemented by estimating a reweighting function as follows:

\[ w_{MG}(c_i) = \frac{f(c_i|HC)}{f(c_i|MG)} \]

where MG represents the marginalized group considered and HC represents OBC/high-caste Hindus. \( c_i \) represents a vector of observable characteristics for individual \( i \) that are correlated with life expectancy, including sex, age group, social group, and SES. \( f \) represents the probability density function. Each individual in the sample is multiplied by their corresponding reweighting function to produce counterfactual age-specific mortality rates and counterfactual life expectancies for each marginalized group. Reweighting methods are described further in SI Appendix, Demographic Reweighting.

Inference: Cluster-Bootstrap Method. SES are estimated using the cluster-bootstrap method described in ref. 15. We use this procedure because the AHS randomly sampled PSUs (villages or census enumeration blocks) rather than individuals, and both outcomes and explanatory variables are likely correlated within PSUs. This approach has been previously used to construct SES around life table quantities estimated from cluster sample surveys (25, 30).

Within districts, the AHS randomly sampled villages and urban areas stratified by population size. The number of PSUs randomly sampled from each stratum was determined based on the district's population distribution across strata. All households in sampled PSUs were interviewed.

For the bootstrap, we resample with replacement \( J_{strat} \) PSUs within each district stratum, with \( J_{strat} \) equal to the total number of PSUs in that district's stratum in the original AHS sample. Because our resampling procedure maintains the distribution of PSUs across strata within districts, we use the original AHS sample weights, which vary at the district stratum level, to analyze each resample. Using the dataset generated by each resample, we estimate age-specific mortality rates and life tables. For the decomposition, we estimate a new reweighting function and counterfactual life tables using each resample. We repeat this process 500 times, and the SDs of the 500 resulting estimates for each statistic are used for calculating 95% confidence intervals.

Results
Marginalized Social Groups Have Lower Life Expectancies. Fig. 2 shows female and male life expectancies at birth for the four social groups we study. Confidence intervals are calculated using a cluster-bootstrap approach. Compared to OBC/high-caste Hindus, we observe lower life expectancies at birth among marginalized social groups. Adivasis have the lowest life expectancy among the four groups. Differences between Adivasis and OBC/high-caste Hindus are almost 4 y for women and almost 5 y for men. The gap between Dalits and OBC/high-caste Hindus is of similar magnitude: more than 3 y for both women and men. Muslim life expectancy is about 1 year less than that of OBC/high-caste Hindus. Both overall levels of mortality among marginalized social groups and the absolute
mortality differentials between groups are comparatively large. Life expectancies for Dalits and Adivasis are similar to those of the poorest countries in the world. The overall gaps are similar in absolute terms to the contemporaneous Black–White gap in the United States (31) and the Arab–Jewish gap in Israel (32).

Muslims have overall lower life expectancy at birth compared to OBC/high-caste Hindus. The gap between Muslims and OBC/high-caste Hindus is smaller relative to other marginalized groups. This is consistent with the prior literature (7, 33).

As reasons for lower mortality among Muslims, research has identified lower exposure to open defecation among Muslim children (29), lower rates of cervical cancers among Muslim women (34), lower consumption of alcohol (35), and lower incidence of suicide (36).

Research on caste and social identity has emphasized that although there are features of social stratification that are common across India, marginalization manifests differently from region to region (37). Mortality risks also vary across states. Fig. 3 shows

![Graph showing life expectancy by state](image-url)

**Fig. 3.** Life expectancy by state: lower life expectancy at birth among Dalits and Adivasis within states. Life expectancy estimates for each state, sex, and social group are calculated using standard life table procedures. (A) Estimates for females and (B) estimates for males. We generate state- and sex-specific life expectancy estimates for a group if the group’s population is greater than 5% of a state’s population. Estimates use sample weights. The vertical lines around each estimate represent 95% confidence intervals calculated using a cluster-bootstrap procedure. HCH, high-caste Hindu. Source: AHS 2010 to 2011 (19).
life expectancy by social group, sex, and state. We do not estimate mortality rates for social groups that constitute less than 5% of a state’s population. We find that across states, Dalits and Adivasis have lower life expectancy at birth compared to OBC/high-caste Hindus. Except for one state, Muslims have similar or lower life expectancy than OBC/high-caste Hindus.

Among the nine states, Adivasi life expectancy is highest in Assam, a society in which they face less discrimination compared to other AHS sample states (38). The life expectancy of Dalits is lowest in Uttar Pradesh, and that of Adivasis is lowest in Madhya Pradesh. OBC/high-caste life expectancy and absolute disparities are low in Uttar Pradesh. These facts contribute to Uttar Pradesh having the lowest life expectancy among all Indian states (39). Lower life expectancy in Uttar Pradesh across social groups is likely a result of poor environmental health (29) and healthcare provision (40). States with more than 5 y of absolute disparities in life expectancy between OBC/high-caste Hindus and a marginalized social group include Uttarakhand, Jharkhand, Odisha, Chattisgarh, and Madhya Pradesh.

Fig. 4 shows female–male differences in life expectancy at birth by social group. Gaps between female and male life expectancy are greatest for Adivasis and smallest for OBC/high-caste Hindus. Prior research has emphasized relatively less gender inequality among Adivasis compared to other social groups in India (41, 42). The extent to which the patterns documented here are driven by variation in gender inequality across India’s social groups deserves further scientific scrutiny.

Life Expectancy Disparities Remain after Accounting for SES. Given that marginalized social groups are also poorer, to what extent are social group differences in life expectancy driven by economic disadvantage? Fig. 5 shows life expectancy by social group and household wealth decile. These estimates are not adjusted by rural and environmental factors. SI Appendix, Fig. S6 shows that using state-specific PCAs to construct wealth deciles, instead of a combined nine-state PCA, does not meaningfully change these results.

We find that Adivasis and Dalits have lower life expectancies than OBC/high-caste Hindus across wealth categories. Comparing Muslims and OBC/high-caste Hindus, we find similar life expectancies at poorer deciles but lower life expectancies among Muslims at richer deciles. Although further scientific investigation is needed to understand these patterns, a part of the explanation for why OBC/high-caste Hindu and Muslim life expectancies diverge at richer deciles may be due to differences across deciles in the share of OBCs and high-caste Hindus within the OBC/high-caste Hindu group (SI Appendix, Fig. S7).

Fig. 6 explores the extent to which dimensions additional to household wealth can explain differences in life expectancy between social groups. It uses the reweighting approach outlined in Methods. We find that differences in rural residence, wealth, and environmental exposures do not fully account for the life expectancy gaps between marginalized social groups and OBC/high-caste Hindus.

Fig. 6 shows gaps in life expectancy at birth between marginalized groups and OBC/high-caste Hindus, separately for females and males. The vertical lines in Fig. 6 reflect 95% confidence intervals. The leftmost estimates show the raw gaps. The differences are about 1 y for Muslim men and women; more than 3 y for Dalit men, Adivasi women, and Dalit women; and about 5 y for Adivasi men. The second set of estimates show gaps that remain after reweighting the marginalized groups to reflect the distribution across rural and urban residence among OBC/high-caste Hindus. Accounting for rural residence reduces the gap.

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groups (HC = Adivasi e0, for instance). "Unexplained by rural" shows the gap that remains after accounting for differences in rural residence. "+ economic status" shows the gap that remains after additionally accounting for differences in wealth index quintile intersected with land ownership. "+ environmental factors" shows the gap that remains after additionally accounting for differences in environmental exposures. For children under age 5, this includes household solid fuel use intersected with four categories of PSU open defecation. For individuals age 5 and older, environmental factors only include household solid fuel use. The vertical lines around each estimate represent 95% confidence intervals calculated using a cluster-bootstrap procedure. Source: AHS 2010 to 2011 (19).

for Adivasis and Dalits but not substantially. For Muslims, it increases the gap slightly because Muslims are more likely to live in urban areas than OBC/high-caste Hindus. The third set of estimates adds wealth quintile and land ownership to the reweighting characteristics. Except for Muslim women, this reduces gaps. The rightmost set of estimates adds environmental exposures. For children under age 5, these include household solid fuel use and the fraction of individuals defecating in the open in the PSU. For individuals age 5 and older, we only include household solid fuel use. Environmental exposures do not explain gaps substantially, and for Muslims, they actually increase gaps, given lower exposure to open defecation among Muslims relative to OBC/high-caste Hindus on the other. In addition, environmental stratification and exploitation in India may be contributing to global population health deficits and slower improvements in health worldwide.

From a policy perspective, these findings suggest that population health interventions that explicitly challenge social disadvantage, economic inequality, and life expectancy at birth for Adivasis, Dalits, and Muslims compared to OBC/high-caste Hindus. These disparities cannot be explained by differences in rural residence, wealth, or environmental exposures.

In addition to having comparatively lower life expectancies, marginalized social groups in India are also larger in terms of population than most countries in the world. Our study therefore underscores the global significance of challenging social inequality in health in India. Indeed, extreme social stratification and exploitation in India may be contributing to global population health deficits and slower improvements in health worldwide.

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Discussion

This study examines relationships between social disadvantage, economic status, and life expectancy in India. Using survey data, we document large and important disadvantages in life expectancy at birth for Adivasis, Dalits, and Muslims compared to OBC/high-caste Hindus. These disparities cannot be explained by differences in rural residence, wealth, or environmental exposures.

In addition to having comparatively lower life expectancies, marginalized social groups in India are also larger in terms of population than most countries in the world. Our study therefore underscores the global significance of challenging social inequality in health in India. Indeed, extreme social stratification and exploitation in India may be contributing to global population health deficits and slower improvements in health worldwide.

From a comparative perspective, life expectancy gaps in India are similar in magnitude to ethnic and identity-based disparities such as by race in the United States, Brazil, and South Africa; indigenous identity in New Zealand and Australia; and religion in Israel (25, 31, 32, 43, 44). Even within India, the disparities in life expectancy between Adivasis and Dalits on one hand and OBC/high-caste Hindus on the other are large. Life expectancy for OBC/high-caste Hindus in the nine AHS states is higher than the contemporaneous all-India life expectancy observed around 2010 (39). Life expectancies for Adivasis and Dalits, however, are lower than those observed for all of India in 1996 to 2000, more than 10 y before the AHS survey (39). The gaps documented in this paper are also larger than the within-sample gap in life expectancy at birth between individuals at the 25th and 75th percentiles of the wealth distribution. Using survey data from the NFHS and a similar estimation approach, Gupta and Sudharsanan (25) provide evidence that even when overall life expectancy is higher in other regions of India, such as in South India, disparities are still large.

Our findings highlight several first-order concerns for future research. Given ongoing epidemiological transitions in India and other LMICs, continuous monitoring of mortality within countries and globally is important. This study documents the value of several approaches for studying mortality and its determinants in LMICs. These include large-scale data collection exercises that contain retrospective questions on household deaths, empirical estimation of age-specific mortality rates, nonparametric reweighting techniques, and cluster-bootstrap variance estimation approaches suitable for multistage sample survey data. These approaches are particularly valuable in the context of the large mortality and economic impacts of the COVID-19 pandemic, which has likely affected marginalized social groups more severely. In addition, research on age contributions, causes of death, segregation, behaviors, and risk factors, such as occupational exposures, may help further understand disparities in mortality and life expectancy. Following the qualitative and autobiographical literature (45–47), studies that are able to document causal pathways from violence, exploitation, and discrimination to mortality are also valuable.

From a policy perspective, these findings suggest that population health interventions that explicitly challenge social disadvantage are essential because addressing economic inequality may not be sufficient (48). Unfortunately, health policy in India and globally largely ignores exploitation, violence, and discrimination rooted in social inequality. This study justifies further action on social disparities in health within India and advances the global conversation addressing inequalities based on race, ethnicity, indigenous identity, caste, and religion.
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