https://www.pnas.org/doi/epdf/10.1073/pnas.2109226119

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

Sangita Vyas[a,b,1,2], Payal Hathi[b,c,d,1,2], and Aashish Gupta[b,e,1,2]

[a]Department of Economics, University of Texas at Austin, Austin, TX 78712; [b]Research Institute for Compassionate Economics, Amston, CT 06231; [c]Department of Demography, University of California, Berkeley, CA 94720; [d]Department of Sociology, University of California, Berkeley, CA 94720; and [e]Harvard Center for Population and Development Studies, Harvard University, Cambridge, MA 02138

Edited by Anne Case, Princeton University, Princeton, NJ; received May 18, 2021; accepted January 21, 2022

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 inequality | life expectancy | caste | religion | indigenous identity

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.

Author contributions: S.V., P.H., and A.G. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

[1]S.V., P.H., and A.G. contributed equally to this work.

[2]To whom correspondence may be addressed. Email: sangita.vyas@utexas.edu, phathi@berkeley.edu, or aashishg@sas.upenn.edu.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2109226119/-/DCSupplemental.

Published March 1, 2022.

the credibility of overall mortality estimates, we construct period sex-, group-, and SES-specific life tables using standard demographic approaches. To examine the extent to which differences in SES between groups account for differences in life expectancy, we use a nonparametric standardization technique (11). We use a cluster-bootstrap strategy to calculate SEs for the life table and decomposition quantities we estimate (15).

We document lower life expectancy at birth among Adivasis and Dalits compared to OBC/high-caste Hindus within each state. Relative to OBC/high-caste Hindus, Adivasi life expectancy at birth is about 4 y lower for females and 5 y lower for males. Life expectancy gaps between OBC/high-caste Hindus and Dalits is more than 3 y. We also provide estimates of Muslim life expectancy in India. In this region, Muslim life expectancy at birth is about 1 y lower than it is for OBC/high-caste Hindus. We find that lower life expectancy for all three groups relative to OBC/high-caste Hindus is not fully explained by differences in SES. Substantial disparities remain after accounting for differences in rural residence, wealth, and environmental factors.

Our findings have implications for health disparities worldwide, as well as for the global burden of mortality. The estimates of life expectancy at birth for Adivasis and Dalits are comparatively low globally. They are, for example, lower than contemporaneous population-level life expectancy at birth in many poorer contexts in sub-Saharan Africa. In terms of years, the disadvantages that we estimate for Adivasis and Dalits relative to OBC/high-caste Hindus are comparable to the Black–White gap in the United States. In percentage terms, the disparities we observe are more substantial because life expectancy in India is less than four-fifths the level of life expectancy in the United States. Compared to existing estimates on the extent to which SES accounts for the Black–White life expectancy gap (11), the SES factors we use here account for a smaller fraction of the gaps between marginalized and privileged groups.

Our paper makes several contributions to the literature on social disadvantage and health in LMICs. First, we advance the scientific study of empirically estimating mortality in LMICs, which has been stymied by the lack of reliable and direct population-representative estimates (16). We document an example in which a retrospective question on deaths in the household in the recent period produces estimates that follow typical patterns of mortality across the life course. These estimates also match expected levels of age-specific death rates in this context. Second, by examining the extent to which economic status can account for life expectancy disparities, our paper contributes to the existing literature using standardization and decomposition methods. Finally, we further the methodological literature on statistical inference of life table estimates constructed using survey data.

From a policy perspective, the Indian constitution provides protections for certain marginalized groups. However, discussions on health and well-being within and outside India often ignore inequalities based on indigenous identity, caste, and religion. This study highlights the importance of measuring and addressing social disparities within India and other LMIC contexts.

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 (18) and are more rural than other Indian states. The total population in these states is twice that of the United States. We use data from the household roster, which recorded information on usual members living in surveyed households on 1 January 2010. We also use data from the mortality roster, which recorded 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 largest social groups: Adivasis (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 Adivasis 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 Adivasis, 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*.

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 ${}_na_x$, 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 ${}_na_x$ values estimated directly from the AHS are similar to those calculated using SRS ${}_na_x$ values. In additional analyses, we estimate 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 about mortality within the household (20), we compare age-specific mortality rates estimated from the AHS to those from the SRS (21–23) and the National Family Health Survey (NFHS) (24), India's Demographic and Health Survey (*SI Appendix*, *Comparison of AHS Mortality Rates with SRS and NFHS* and Table S1 describe the SRS and NFHS in greater detail). Fig. 1 displays this analysis. Age-specific rates estimated from the AHS match closely with rates from the SRS and NFHS. They are also smoother than those from the SRS and NFHS. Effects of age-misreporting, which is known to be high in India (26), are apparent at age 75 in the AHS. This is also present to some extent in the SRS and NFHS surveys at older ages. Age-misreporting,

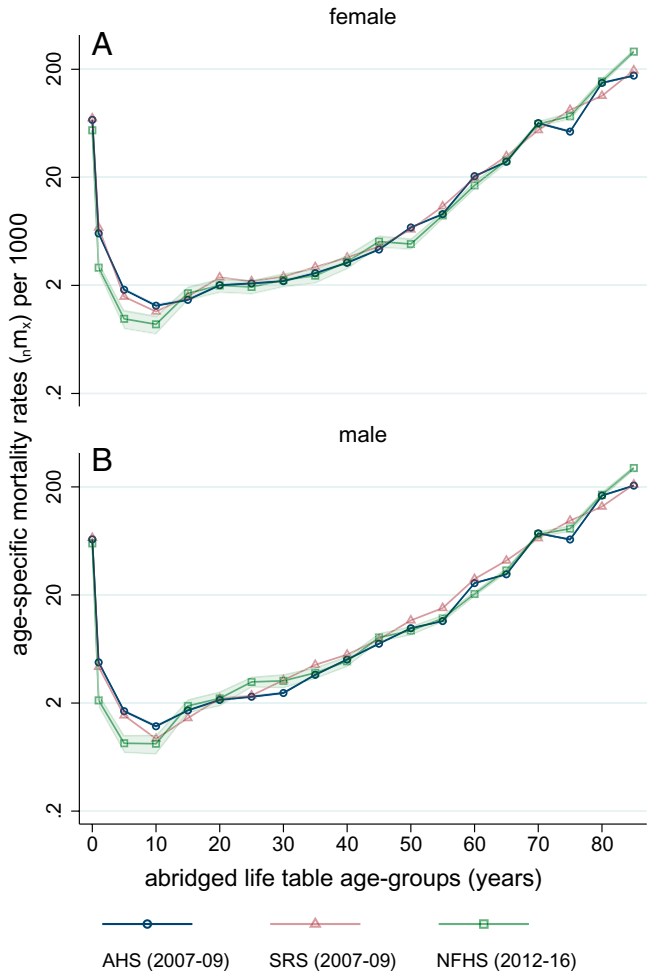

Fig. 1. Similar age-specific mortality rates from the AHS, SRS, and NFHS. Age-specific mortality rates are shown for (*A*) females and (*B*) males separately, from three different surveys. All AHS states are included, except for Uttarakhand, for which SRS data are missing. For the AHS, mortality rates are estimated based on the procedure described in *Methods*. NFHS mortality rates are estimated according to the procedure described in ref. 25. NFHS rates are lower because they are for a later period. For the SRS, we average published age-specific mortality rates for 2007, 2008, and 2009 and weight states by their 2011 Census populations to produce an average across the eight states. Estimates from the AHS and NFHS use sample weights. The 95% confidence intervals calculated using a cluster-bootstrap procedure are shown as shaded areas around the AHS (not visible because they are small) and NFHS lines. SRS age-specific mortality rates do not have confidence intervals because underlying SRS microdata are not publicly available, and the SRS does not estimate clustered SEs in its reports. Sources: AHS 2010 to 2011 (17), SRS 2007 to 2009 (21–23), and NFHS 2015 to 2016 (24).

which is more common among more disadvantaged groups, may lead to biases in estimates of mortality (27). *SI Appendix*, Fig. S4 shows that for ages 40 to 85+, unadjusted mortality rates are similar to Gompertz rates, which adjust for age-misreporting. We show life expectancy differences at age 15 (e_{15}) in *SI Appendix*, Fig. S5, to clarify that our results are not entirely driven by differences in mortality at the youngest ages.

The disparities in life expectancy between marginalized groups and OBC/high-caste Hindus that we document are likely conservative for at least two reasons. First, because we cannot distinguish between high-caste Hindus and OBCs, we expect estimates of life expectancy for the combined OBC/high-caste Hindu group to represent a lower bound for high-caste Hindu life expectancy. Second, we are not able to capture mortality that occurs in households in which all members have died, which is more likely in Adivasi and Dalit households. We expect this particular bias to be relatively small. If mortality in single-person households is similar to mortality in two-person households, the closest counterfactual in our data, the number of deaths the AHS would have missed is less than 1% of total observed deaths.

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 the 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:

$$\psi^{MG}(c_i) = \frac{f(c_i|HC)}{f(c_i|MG)}, \quad [1]$$

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*.

The SES characteristics included in the reweighting exercise are determined based on regression analysis of the characteristics associated with mortality (*SI Appendix*, Tables S5 and S6). They include rural residence, wealth (the intersection of wealth index quintile and land ownership), and environmental exposures (household solid fuel use for individuals age 5 and older and household solid fuel use intersected with four categories of the fraction of people defecating in the open in the PSU for children younger than age 5). These factors have been identified in the prior literature as important determinants of mortality (2, 28, 29). The regression equations are described further in *SI Appendix*, *Description of Linear Regression*.

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 $J_{strat,dist}$ PSUs within each district stratum, with $J_{strat,dist}$ 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. Differentials 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

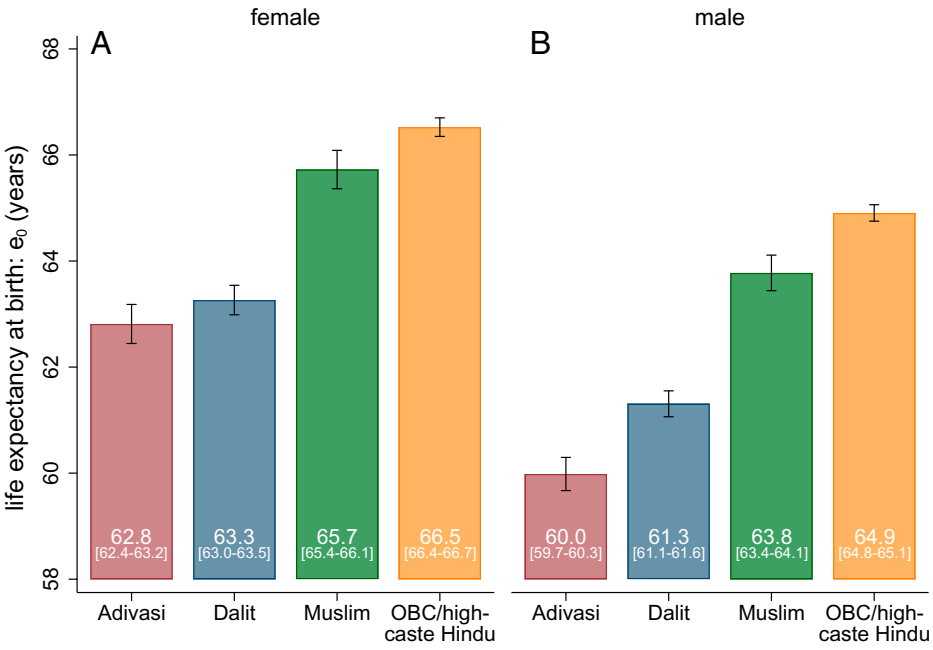

Fig. 2. Lower life expectancy at birth among marginalized groups compared to OBC/high-caste Hindus. Life expectancy estimates for each sex and social group are calculated using standard life table procedures. (*A*) Female life expectancies and (*B*) male life expectancies. Estimates use sample weights. The vertical lines around each estimate represent 95% confidence intervals calculated using a cluster-bootstrap procedure. Source: AHS 2010 to 2011 (22, 23).

mortality differentials between groups are comparatively large. Life expectanies 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

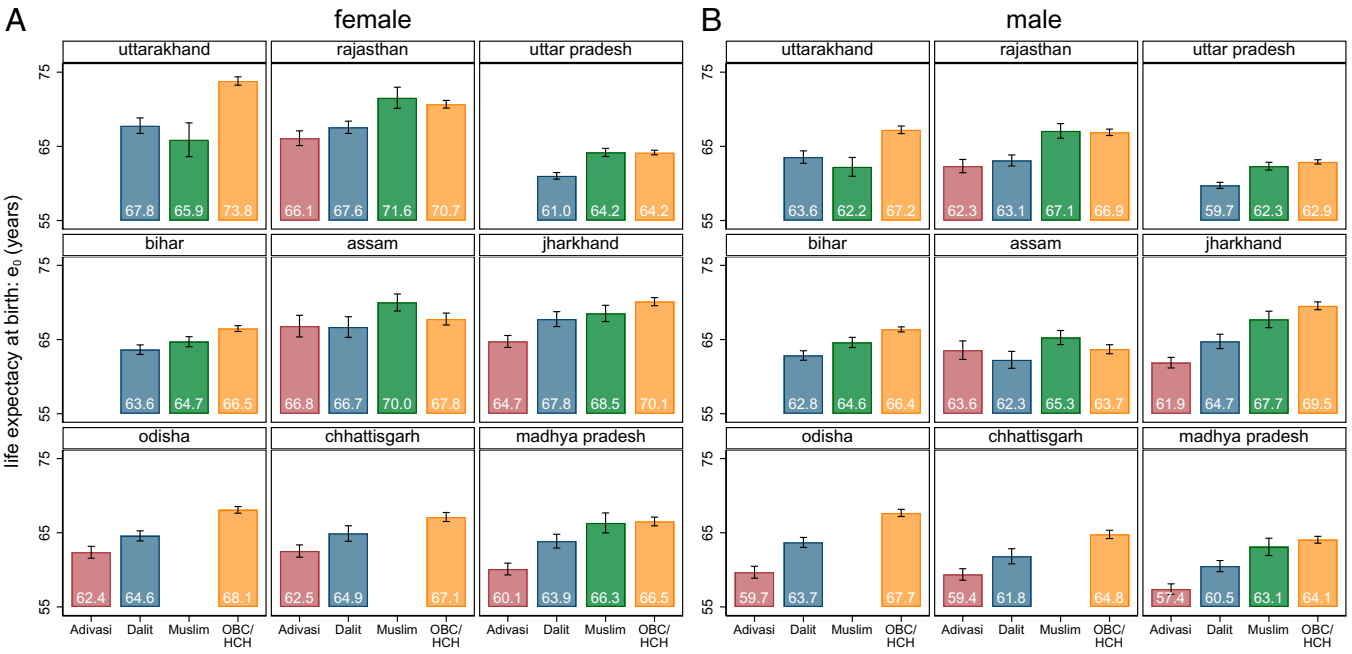

Fig. 3. Life expectancy by state: lower life expectancy at birth among Dalits and Adivasis within states. Life expectancy estimates for each state, sex, and social group are calculated using standard life table procedures. (*A*) Estimates for females and (*B*) estimates for males. We generate state- 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).

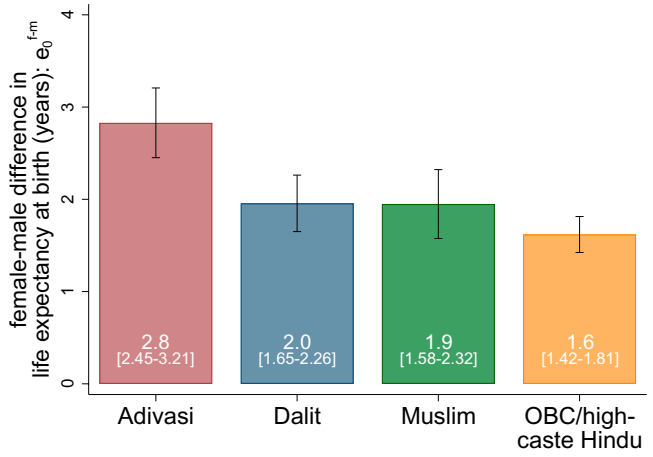

Fig. 4. Female–male difference in life expectancy at birth by social group. Life expectancy estimates for each sex and social group are calculated using standard life table procedures. Estimates use sample weights. The vertical lines around each estimate represent 95% confidence intervals calculated using a cluster-bootstrap procedure. Source: AHS 2010 to 2011 (19).

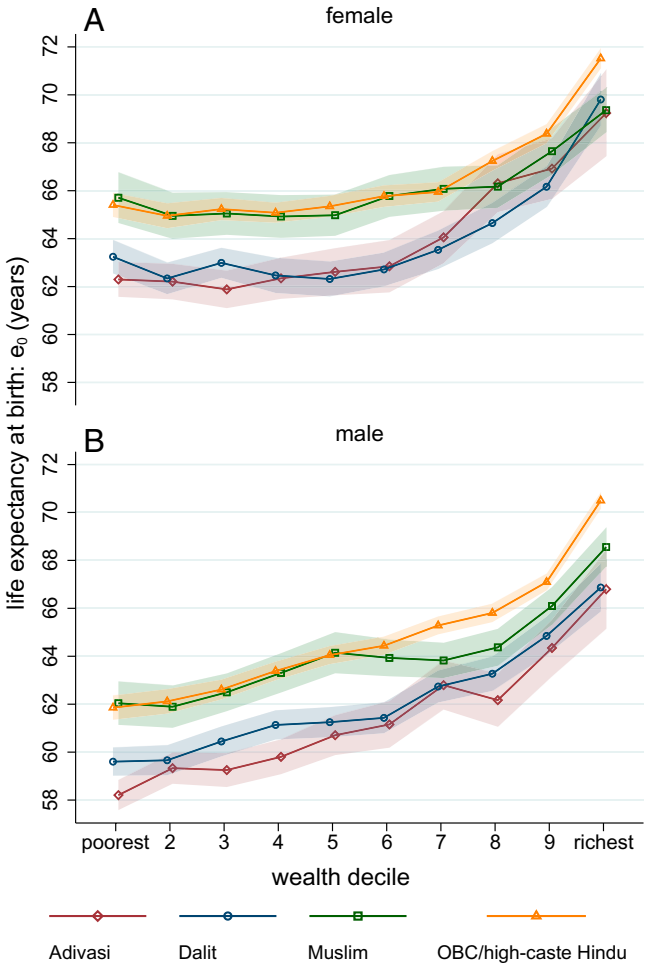

Fig. 5. Life expectancy by household wealth: lower life expectancy at birth among Dalits and Adivasis at all levels of wealth. Wealth decile are deciles of a wealth index constructed using a PCA of household assets and house infrastructure. Life expectancy estimates for each wealth decile, sex, and social group are calculated using standard life table procedures. (*A*) Estimates for female life expectancies and (*B*) male life expectancies. Estimates use sample weights. The shaded areas around the lines represent 95% confidence intervals calculated using a cluster-bootstrap procedure. Source: AHS 2010 to 2011 (19).

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 women, Adivasi women, and Dalit men; 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

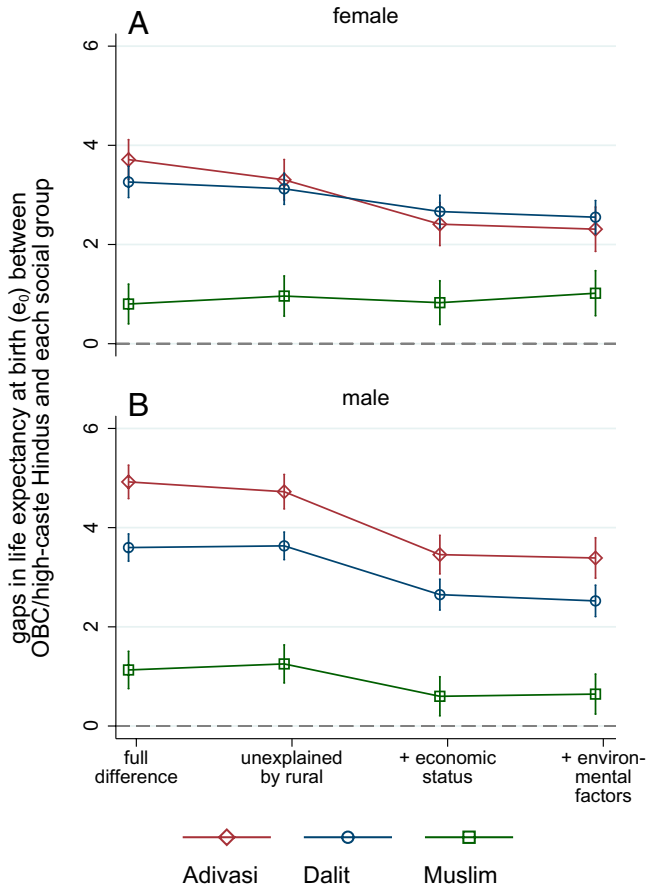

Fig. 6. Demographic reweighting: unaccounted-for gaps in life expectancy (years) between OBC/high-caste Hindus and marginalized groups. Marginalized groups are reweighted to reflect the same distribution of characteristics as among OBC/high-caste Hindus in three ways. (*A*) Estimates for females and (*B*) estimates for males. "Full difference" shows the full life expectancy gap between OBC/high-caste Hindus and marginalized social groups (HC e_0 − Adivasi e_0, 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 (29).

In the United States, observable SES characteristics explain about three-quarters of the life expectancy gap between Black and White Americans (11). In the AHS states, they explain less than half. We find that the unexplained gaps are about half a year for Muslim men; 1 y for Muslim women; more than 2 y for Adivasi women, Dalit women, and Dalit men; and more than 3 y for Adivasi men.

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.

Data Availability. AHS data are available at Zenodo (https://zenodo.org/record/6062984#.YgmCoUntyUk). Replication files are available at Zenodo (https://zenodo.org/record/6067096).

ACKNOWLEDGMENTS. For helpful comments and suggestions, we are grateful to two anonymous referees, the Population Association of America's 2021 Dorothy S. Thomas Award selection committee, Monica Alexander, Samuel Arenberg, Casey Breen, Karthik Rao Cavale, Diane Coffey, Irma Elo, Dennis Feehan, Nathan Franz, Michael Geruso, Sonal Gihara-Sharma, Michel Guillot, Rajeev Kumar, Kiran Kumbhar, Leigh Linden, Nazar Khalid, Kanika Sharma, Dean Spears, Nikkil Sudharsanan, Megan Reed, Amit Thorat, Atheendar Venkataramani, and Tom Vogl. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant DGE-1610403. This research was also supported by Grant P2CHD042849, Population Research Center, and by Grant T32HD007081, Training Program in Population Studies, both awarded to the Population Research Center at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, and by a National Institute of Child Health and Human Development Training grant at the University of California, Berkeley, T32HD007275. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the official views of the NSF or the NIH. Additional support was provided by the International Union for the Scientific Study of Population Civil Registration and Vital Statistics Fellowship.

1. D. R. Williams, J. A. Lawrence, B. A. Davis, Racism and health: Evidence and needed research. *Annu. Rev. Public Health* **40**, 105–125 (2019).
2. J. C. Phelan, B. G. Link, Is racism a fundamental cause of inequalities in health? *Annu. Rev. Sociol.* **41**, 311–330 (2015).
3. A. Deaton, Commentary: The convoluted story of international studies of inequality and health. *Int. J. Epidemiol.* **31**, 546–549 (2002).
4. D. Tabutin, B. Masquelier, Mortality inequalities and trends in low-and middle-income countries, 1990-2015. *Population* **72**, 221–296 (2017).
5. B. R. Ambedkar, *Annihilation of Caste: With a Reply to Mahatma Gandhi* (University of Columbia, 1937).
6. V. Xaxa, Tribes as indigenous people of India. *Econ. Polit. Wkly.* **34**, 3589–3595 (1999).
7. Sachar Committee, *Social, Economic and Educational Status of the Muslim Community of India* (Prime Minister's High-Level Committee, Cabinet Secretariat, Government of India, 2006).
8. S. B. Desai *et al.*, *Human Development in India* (Oxford University Press, New York, 2010).
9. S. Thorat, K. S. Neuman, *Blocked by Caste: Economic Discrimination in Modern India* (Oxford University Press, 2012).
10. A. Case, A. Deaton, Health and wealth among the poor: India and South Africa compared. *Am. Econ. Rev.* **95**, 229–233 (2005).
11. M. Geruso, Black-white disparities in life expectancy: How much can the standard SES variables explain? *Demography* **49**, 553–574 (2012).
12. I. T. Elo, Social class differentials in health and mortality: Patterns and explanations in comparative perspective. *Annu. Rev. Sociol.* **35**, 553–572 (2009).
13. N. Saikia, P. Kulkarni, Data for research into health inequality in India. *Econ. Polit. Wkly.* **51**, 111–116 (2016).
14. S. J. Clark, A general age-specific mortality model with an example indexed by child mortality or both child and adult mortality. *Demography* **56**, 1131–1159 (2019).
15. A. C. Cameron, D. L. Miller, A practitioner's guide to cluster-robust inference. *J. Hum. Resour.* **50**, 317–372 (2015).
16. T. A. Moultrie *et al.*, *Tools for Demographic Estimation* (International Union for the Scientific Study of Population, 2013).
17. Government of India. Annual Health Survey Dataset 6062984. Zenodo. https://zenodo.org/record/6062984#.YgmCoUntyUk. Deposited 13 February 2022.
18. Office of the Registrar General, *Census of India 2011: Household Listing Operations* (Office of the Registrar General and Census Commissioner, Indian Census Bureau, India, 2011).
19. Office of the Registrar General and Census Commissioner of India, *SRS Based Abridged Life Tables 2007-2011* (Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, New Delhi, India, 2013).
20. I. M. Timaeus, Measurement of adult mortality in less developed countries: A comparative review. *Popul. Index* **57**, 552–568 (1991).
21. Office of the Registrar General and Census Commissioner of India, *SRS Statistical Report 2007* (Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, New Delhi, India, 2009).
22. Office of the Registrar General and Census Commissioner of India, *SRS Statistical Report 2008* (Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, New Delhi, India, 2010).
23. Office of the Registrar General and Census Commissioner of India, *SRS Statistical Report 2009* (Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, New Delhi, India, 2011).
24. International Institute for Population Sciences–IIPS/India and ICF. National Family Health Survey NFHS-4, 2015-16. https://www.dhsprogram.com/methodology/survey/survey-display-355.cfm. Accessed 10 January 2018.
25. A. Gupta, N. Sudharsanan, Large and persistent life expectancy disparities among India's social groups. SocArXiv. doi:10.31235/osf.io/hu8t9 (2020).
26. P. Gerland, UN population division's methodology in preparing base population for projections: Case study for India. *Asian Popul. Stud.* **10**, 274–303 (2014).
27. S. H. Preston, I. T. Elo, Q. Stewart, Effects of age misreporting on mortality estimates at older ages. *Popul. Stud.* **53**, 165–177 (1999).
28. D. Cutler, A. Deaton, A. Lleras-Muney, The determinants of mortality. *J. Econ. Perspect.* **20**, 97–120 (2006).
29. D. Coffey, D. Spears, *Where India Goes: Abandoned Toilets, Stunted Development and the Costs of Caste* (Harper Collins, 2017).
30. L. Cai *et al.*, Estimation of multi-state life table functions and their variability from complex survey data using the SPACE Program. *Demogr. Res.* **22**, 129–158 (2010).
31. E. Arias, J. Xu, United States life tables, 2015. *National Vital Statistics Reports* **67** (2018).
32. A. M. Saabneh, Arab-Jewish gap in life expectancy in Israel. *Eur. J. Public Health* **26**, 433–438 (2016).
33. S. Bhalotra, C. Valente, A. van Soest, The puzzle of Muslim advantage in child survival in India. *J. Health Econ.* **29**, 191–204 (2010).
34. M. Gomes *et al.*, Nationwide mortality studies to quantify causes of death: Relevant lessons from India's million death study. *Health Aff. (Millwood)* **36**, 1887–1895 (2017).
35. International Institute for Population Sciences and ICF, *India National Family Health Survey NFHS-4 2015-16* (International Institute for Population Sciences and ICF, Mumbai, India, 2017).
36. R. Thimmaiah, V. Poreddi, R. Ramu, S. Selvi, S. B. Math, Influence of religion on attitude towards suicide: An Indian perspective. *J. Relig. Health* **55**, 2039–2052 (2016).
37. M. N. Srinivas *et al.*, *Caste in Modern India and Other Essays* (Asia Publishing House, 1962).
38. S. Gogoi, P. J. Saikia, Sharing and exchanging: Understanding common grounds in northeast India. *Asian Ethn.* **21**, 22–38 (2020).
39. Registrar General and Census Commissioner of India, *Compendium of India's Fertility and Mortality Indicators, 1971–2013* (Government of India, 2013).
40. J. Drèze, A. Sen, *An Uncertain Glory: India and Its Contradictions* (Princeton University Press, 2013).
41. A. Maharatna, Fertility, mortality and gender bias among tribal population: An Indian perspective. *Soc. Sci. Med.* **50**, 1333–1351 (2000).
42. V. Xaxa, Women and gender in the study of tribes in India. *Indian J. Gend. Stud.* **11**, 345–367 (2004).
43. A. D. P. Chiavegatto Filho, H. Beltrán-Sánchez, I. Kawachi, Racial disparities in life expectancy in Brazil: Challenges from a multiracial society. *Am. J. Public Health* **104**, 2156–2162 (2014).
44. B. Phillips *et al.*, Mortality trends in Australian Aboriginal peoples and New Zealand Māori. *Popul. Health Metr.* **15**, 25 (2017).
45. B. Kamble, *The Prisons We Broke* (Orient Blackswan, 1990).
46. O. Valmiki, A. P. Mukherjee, *Joothan: An Untouchable's Life* (Columbia University Press, 2008).
47. S. George, Reconciliations of caste and medical power in rural public health services. *Econ. Polit. Wkly.* **54**, 43–50 (2019).
48. B. R. Ambedkar, *Ranade, Gandhi & Jinnah* (Columbia University, 1943).