SOCIETY OF ACTUARIES

Mortality and Longevity

Mortality by Socioeconomic Category in the United States

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Executive Summary

Since around 1980, geographic and socioeconomic disparities in survival have been growing in the United States. An enhanced understanding of the differences in mortality patterns across subgroups of the population is essential for addressing the needs of the American public. While geographic and racial/ethnic variations in mortality are well documented, studies of socioeconomic differences have been lagging in the United States, in part because of data limitations. Though information about education and occupation is theoretically included on the death certificate, it is often missing or incomplete, especially for women and for retirees. Furthermore, income —a key indicator of socioeconomic status—is not available. Studies of socioeconomic differences in mortality have thus had to rely on surveys linked to the National Death Index that are typically too small to provide robust results.

This study applies a different approach. Building on methodology initially developed in the United Kingdom, we construct a series of mortality indicators for groupings of U.S. counties based on their socioeconomic characteristics as measured by county-wide variables on education, occupation, employment, income and housing price and quality.

Using data from the Census Bureau, the Socioeconomic Index is calculated for each data year and for each county. Counties are then ranked based on their Socioeconomic Index Scores (SISs), weighted by their population size in each corresponding year, and stratified into ten (deciles[1]) groups of roughly equal population size. Because the relative position of each county on the socioeconomic scale changes from one data year to another, the composition of each decile is not fixed over time and counties are allowed to move across deciles. For each year of the analysis, age-specific mortality rates are calculated separately for males and for females for each county grouping (decile), as well as for the United States as a whole. The resulting mortality rates are used to construct complete life tables by sex, year and decile.

The main findings of the study are:

- **Growing socioeconomic inequalities in mortality**

In 1982, life expectancy at birth ranged from 68.9 years to 73.0 years for men and from 77.4 and 79.0 years for women across all deciles, a difference of 4.1 years and 1.6 years, respectively, between the lowest and highest deciles. In 2018, it ranged from 73.0 to 80.2 years for men and from 78.8 to 84.6 years for women, and the difference reached 7.2 years and 5.8 years, respectively. Mortality declines gradually from one decile to the next, with some interweaving among the third to fifth deciles and among the sixth to eighth deciles (Figure 1).

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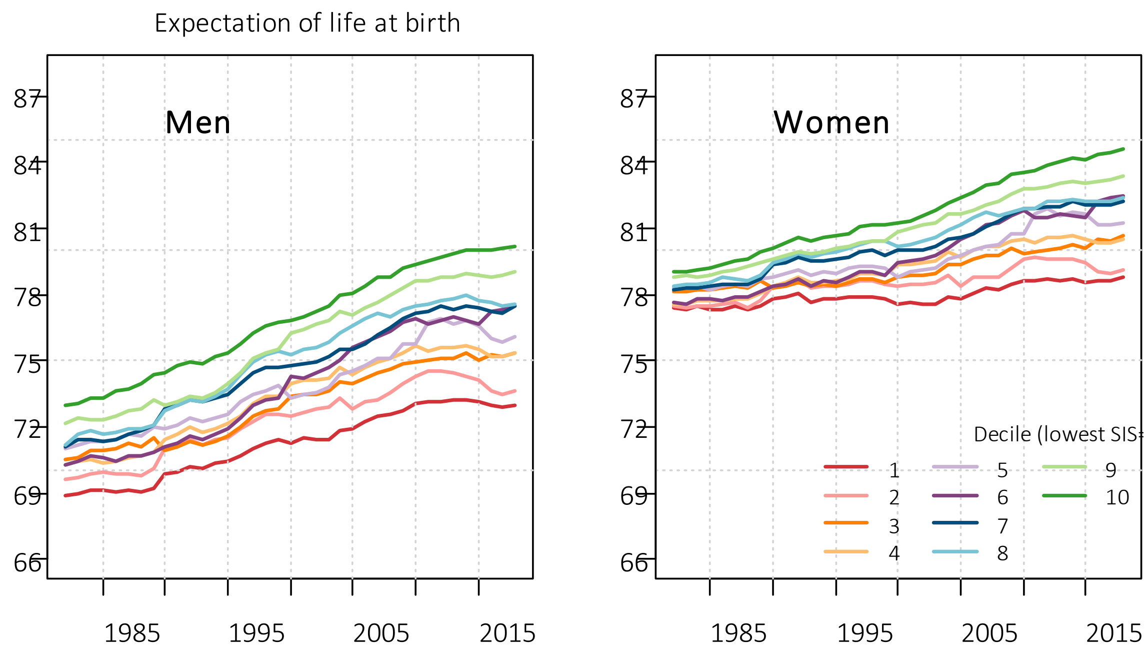
[1] The same calculations were performed for all counties grouped into quintiles. Results are very similar to the analysis by deciles, though trends are smoother and the range of mortality values across the county groupings is smaller.

Figure 1.
EXPECTATION OF LIFE AT BIRTH (IN YEARS) BY SOCIOECONOMIC DECILE FOR EACH SEX, 1982–2018



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

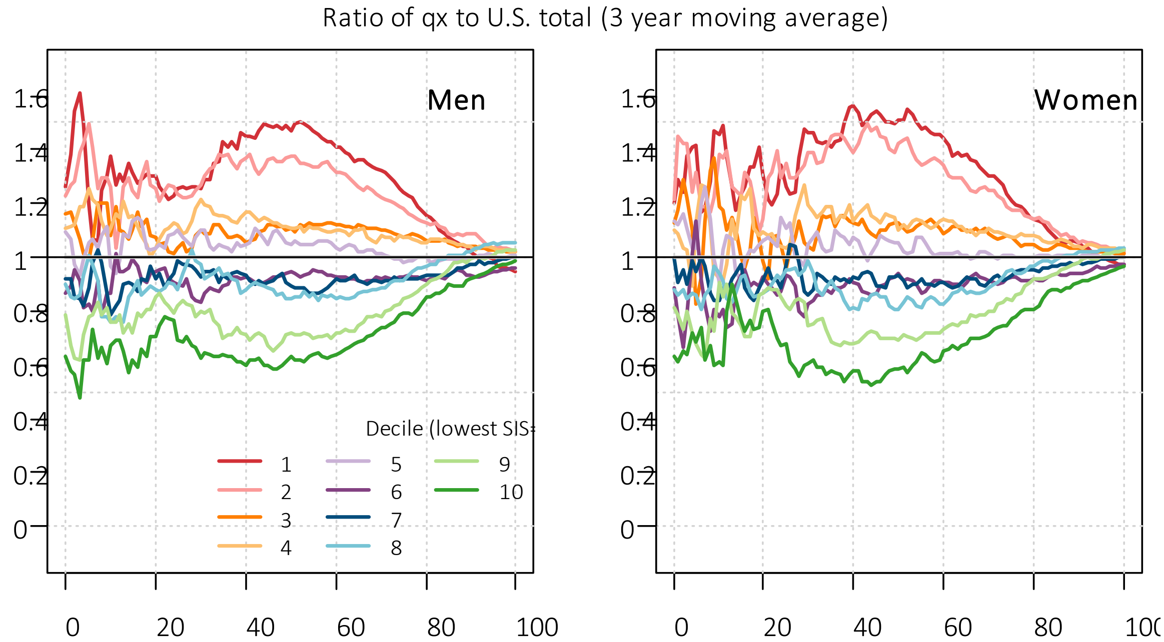
- **Largest disparities among the young**

The ratio of the probabilities of dying[2] in every decile to the U.S. average shows that disparities are largest for children and for adults between the ages of 40 and 60, with nearly mirror images for each sex. At these ages, compared to the U.S. average in 2018, the probabilities of dying are 40 to 50 percent higher in the counties with the lowest SISs and lower in the counties with the highest SISs, which corresponds to a ratio of nearly 2:1 between the two extreme deciles in terms of the risks of death (Figure 2). The excess (or deficit) declines to around 10 percent at ages 80 and above.

[2] Demographers distinguish between mortality rates (the number of deaths over a period of time, typically one year, divided by the corresponding population, or person-years lived) and probabilities of death (the proportion of individuals who survive over a given age interval among all those alive at the beginning of the age interval). However, in this report, for the sake of fluidity, we will use one or the other denomination indifferently when discussing the probabilities of dying (designated by the notation q_x, or ${}_nq_x$, where x represents the age at the beginning of the interval and n, the length of the age interval —e.g., ${}_5q_0$ corresponds to the probability of dying, or the proportion dying, before their fifth birthday among all children born alive).

Figure 2

RATIO OF THE PROBABILITIES OF DYING (q_x) IN EACH DECILE TO THE U.S. TOTAL, EACH SEX, 2018 (%)

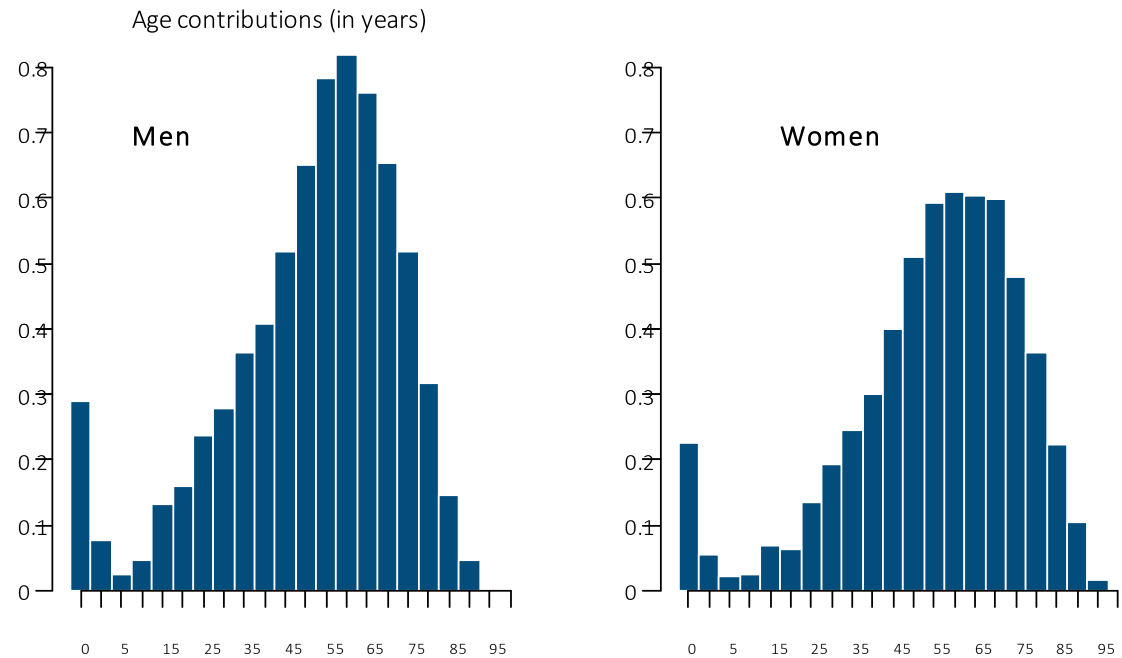


Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

However, mortality rates are relatively low below age 50 and large differences in small rates have less of an impact on overall survival than small differences in large rates. This explains why about half of the gap in life expectancy at birth between the first and 10th deciles is attributable to differences in mortality at ages 55 and above (Figure 3).

Figure 3

AGE CONTRIBUTIONS TO THE DIFFERENCE IN LIFE EXPECTANCY AT BIRTH BETWEEN THE 10TH AND FIRST DECILE, EACH SEX, 2018



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

- **A deterioration of recent trends for all**

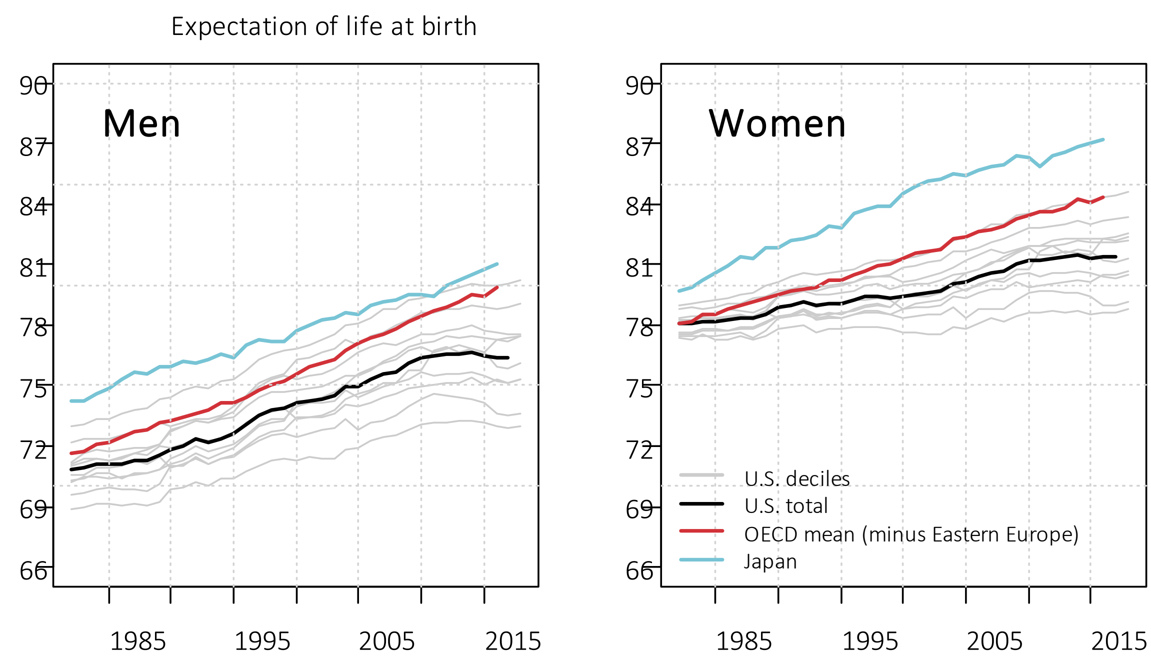
Between 2010 and 2014, life expectancy at birth stabilized in the United States and it declined during the period 2014–2017. The most recent year of data (2018) shows a slight uptick in survival. Our analysis indicates that the deteriorating trend has affected all population deciles except for the 10 percent with the highest SISs. It also shows that mortality reversals were most pronounced in the first two deciles (the 20 percent with the lowest SISs), for whom there was no increase in the length of life over the ten-year period between 2008 and 2018 for both men and women. In the 20 percent counties with the highest SISs (i.e., in the ninth and 10th deciles), mortality continued to decline but at a much slower rate than before 2010.

- **An increasing gap with other high-income democracies**

The recent deterioration in mortality rates has increased the gap between the United States and other comparable countries (high-income democracies). However, even before the 2010 change in trends, the United States experienced slower progress in survival than other OECD countries and only the highest decile has been on par with the average level of life expectancy at birth exhibited in these countries (Figure 4). Compared to Japan, the world leading country in the length of life for women, even the U.S. population in the highest socioeconomic decile is lagging behind and the gap is particularly large for women. Relative to the average life expectancy in Japan in 2018 (the last data point for Japan), life expectancy for the 10 percent of Americans in counties with the highest SISs was 1.1 years shorter for men and 2.8 years shorter for women.

Figure 4

TRENDS IN LIFE EXPECTANCY AT BIRTH IN U.S. DECILES AND THE U.S. AS A WHOLE COMPARED WITH JAPAN AND THE AVERAGE FOR OTHER OECD COUNTRIES*, EACH SEX, 1982–2018



*Excluding Eastern European countries as well as Mexico and Turkey.

Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

To conclude, there is a clear gradient in mortality across county groupings based on selected social and economic characteristics with progressively higher rates of survival in each successive decile. The gradient increased progressively during the study period (1982–2018). It is more pronounced for men than for women and more pronounced for children and adults below age 60 years. It also appears that only the 10 percent of Americans in counties with the highest Socioeconomic Index Scores live longer than the average inhabitant of other OECD democracies and even the highest decile of Americans has a shorter expected lifetime than the average Japanese. Though it is too early to evaluate the effect of the major shock induced by the ongoing COVID-19 pandemic on mortality disparities in the United States, there is no reason to believe that 2020 will inaugurate a closing of the gap between the least and most affluent Americans.

Section 1: Introduction

There has been increasing actuarial interest in better understanding socioeconomic differences in mortality patterns in the recent past to enhance models and methods used in practice and, more specifically, to refine survival forecasts and mortality improvement models. Beyond the insurance industry, inequalities in mortality are of great importance to the American public and policy makers in general due to issues of socioeconomic inequities. Since around 1980, geographic and socioeconomic disparities in survival have been growing in the United States as indicated by a Congressional Budget Office study (Manchester and Topoleski, 2008; also see Ezzati et al., 2008). As we have demonstrated in previous work, inequalities in access to material resources have slowed down the progress in life expectancy for the U.S. population as a whole and they have contributed to the increasing gap in survival with other high-income democracies (Wilmoth, Boe, and Barbieri, 2011).

The specific objective of this study is to construct a set of detailed life tables by socioeconomic category across all U.S. counties for all years since 1999, the first year when mortality data are readily available in the appropriate format for this purpose. The results of this study are expected to:

- Enhance mortality information available to actuaries in the insurance, reinsurance and retirement plan industries
- Help to monitor changes in socioeconomic variations in mortality
- Provide a baseline for policy makers to evaluate future changes
- Create a way to evaluate the impact of interventions to reduce inequalities
- Improve our understanding of the mechanisms driving growing disparities in mortality in the United States.

Section 2: Background Research

Interest in developing composite measures of material and social well-being originates from the 1970s and 1980s, when the British government was looking for ways to better allocate resources under various aid programs (Townsend, 1987). In the most recent decade or so, this area of research has exhibited renewed interest due to the rise in socioeconomic disparities in mortality in many high-income countries, including the United States (see an extensive and recent review of the literature in Mitra and Brucker, 2019).

These disparities are associated with both income (or poverty) and education (see for instance Case and Deaton, 2015, Currie and Schwandt, 2016a and 2016b, and Chetty et al., 2017 for some much publicized research findings). Studies based on multidimensional indices of what is most commonly labelled "deprivation" (as they reflect access to material, social, and symbolic resources) have tended to develop their own index, depending on the field of application (economics, public policy, public health, actuarial studies, etc.) and available data. Few of these studies have specifically looked at the impact of area-level socioeconomic characteristics on mortality, with the notable exception of a string of articles by Singh (2002, 2003 and 2006) in which he showed that the increase in the mortality differentials across geographic areas during the 1980s and 1990s was due to slower mortality declines in more deprived areas. The idea of studying mortality variations in subgroups of the population based on a composite index measured at the U.S. county level is also behind several articles by Murray and his colleagues but their research only takes income and race into account, ignoring the effects of education and other socioeconomic factors (Danaei et al., 2010; Murray et al., 2005 and 2006). Similarly, Currie and Schwandt looked at mortality by groupings of counties ranked by their Poverty Index only (2016a and 2016b). All this literature is based on data available before 2010, and thus does not reflect the deceleration of mortality improvement that occurred after 2010 in the United States.

The Census Bureau has recently developed a new Multidimensional Deprivation Index (MDI) as a more comprehensive measure of well-being than its existing Poverty Index (Glassman, 2019). Like the Poverty Index, the

MDI is based on income, but it includes five additional dimensions measuring other aspects of well-being: education, health, economic security, housing quality and neighborhood characteristics. The Census Bureau's index suffers from two drawbacks for our purpose. First, the Census Bureau MDI partly relies on data from the County Health Rankings and Roadmaps, which is not available for years before 2013. Second, like in many studies measuring deprivation, the Census Bureau combines socioeconomic characteristics with individual health information. More specifically, it relies on the American Community Survey respondents' answers to questions about disability to construct a predicted measure of health status. Because our goal is to analyze the relationship between area-level socioeconomic position and area-level mortality, including health-related factors into the calculation of our index would create issues of circularity since health and mortality are so closely related.

After reviewing the merits of existing methods to measure area-level socioeconomic characteristics as a composite index, we determined that the best course of action was to follow Singh's approach (Singh, 2002, 2003 and 2006). Singh has investigated the use of a large array of socioeconomic indicators and statistical techniques to construct his multidimensional index. The indicators were selected because of their theoretical relevance. Singh progressively narrowed down the indicators to a set of 11 variables describing social and economic characteristics of the population (Table 1). He explored the use of three alternative statistical techniques to construct a single index from these variables, namely principal component analysis, principal factor analysis, and maximum likelihood factor analysis. He found that all three methods yielded very similar results, with the principal component analysis providing the highest reliability coefficient (on Cronbach's alpha test). He also applied his method on several different subsets of the population and at different geographic levels (census tracts, ZIP codes and counties) with very consistent results across all subsets. He performed separate analyses using data from the 1970, 1980, 1990 and 2000 censuses and obtained very similar factor loadings in terms of their magnitude and the relative weight of each variable, and very high correlations between the indices for each pair of censuses (0.89 or above).

Table 1
SOCIOECONOMIC VARIABLES IN SINGH'S 2006 ARTICLES

Socioeconomic variables	
1.	Percentage of the population 25 years and above with less than nine years of education
2.	Percentage of the population 25 years and above with at least a high school diploma
3.	Percentage of the population 16 years and above employed in white collar occupations
4.	Unemployment rate for the population 16 years and above
5.	Median family income
6.	Ratio of total households with less than $10,000 family income to those with greater than or equal to $50,000 family income a year
7.	Percentage of families below the federal poverty level
8.	Median home value
9.	Median gross rent
10.	Percentage of housing units without a telephone
11.	Percentage of housing units without complete plumbing

The advantages of following Singh's approach are that: 1) it saves time since Singh has experimented and tested multiple methods and sets of variables before settling down on a specific one; 2) it guarantees that the data necessary for the method implementation are available for the 1980, 1990 and 2000 censuses (used by Singh) and thus, that it is possible to extend the study back to the 1980s when the necessary (restricted) mortality data have been obtained; and 3) it provides a useful source of validation for our calculations.

The basic idea behind Principal Component Analysis

The purpose of Principal Component Analysis (PCA) is to summarize the information in a dataset of individuals described by multiple intercorrelated variables. PCA is used to reduce the initial set of variables into a smaller set of new variables, called factors, dimensions, or principal components, while preserving as much information about the diversity in the initial dataset as possible. The principal components are built from a linear combination of the original variables. The process may somewhat sacrifice accuracy but it considerably increases simplicity.

The analysis follows three steps:

1) Standardization of the range of the initial variables so that each one contributes equally to the analysis, independently from its initial range and original nature (e.g., percent population; median dollar values; etc...) across all observations. This is done by normalizing each variable, i.e., centering on the mean and dividing by the standard deviation.

2) Construction of a covariance matrix, pairing all variables two by two, to determine which variables are most correlated and, thus, contain redundant information.

3) Creation of new variables as linear combinations of the initial variables so that the new variables (the principal components) are uncorrelated and as much of the information from the initial variables is retained into as few components as possible. The components are successively constructed so that the first component captures the maximum amount of redundant information as possible from these initial variables and each successive component is orthogonal to the previous one.

Section 3: Construction of the Socioeconomic Index

A Socioeconomic Index Score (SIS) was computed for each U.S. county following Singh's approach and using data from the 1980, 1990 and 2000 censuses as well as from the 2005–2009 through 2014–2018 American Community Surveys (ACS). The SIS represents an average for the county as a whole and only takes heterogeneity into account by including information on income inequalities within each area among the variables on which the SIS is based. Another related issue stems from the wide disparities in population size across all U.S. counties. The average size of all U.S. counties in 2018 is around 100,000 people, ranging from a mere 75 people in Kalawao County (Hawaii) to 10 million in Los Angeles County (California). It would have been much better to compare areas with similar sizes but we are dependent on the data, which are only available at the county level. To avoid the large year-to-year fluctuations in either socioeconomic variables or mortality in very small counties, we aggregated those together within each state or to a larger neighboring county with the closest socioeconomic characteristics and population density so that each county or county aggregate represents at least 10,000 people. Aggregates were also constructed to maintain consistency for counties that split or merged over the study period. The county aggregates were fixed throughout the study period (1982–2018).

Note regarding the American Community Survey

The American Community Survey (ACS) is a nationwide representative survey that collects and produces information on social, economic, housing, and demographic characteristics from a locally representative sample of 3.5 million households every year. The ACS is managed by the U.S. Census Bureau. It was designed to replace the long census form that was administered to 2 percent of all U.S. households at each census (every ten years) so as to collect more detailed information in addition to that on the short census form (administered to all U.S. households). The purpose of the ACS is to allow the Census Bureau to collect a continuous stream of socioeconomic and demographic information about the country's population. ACS data are available as 1-year or 5-year estimates. The 1-year estimates reflect the most current data, but they have larger margins of error than 5-year estimates and they are not available for areas with fewer than 65,000 people. 5-year estimates are available for all geographies. Since the median size of the 3,100 or so U.S. counties is 25,000 people, only the ACS 5-year estimates can be used for the calculation of SIS. The first 5-year ACS estimates were released by the Census Bureau in 2010 for the 2005–2009 period (thus centering on year 2007). The most recent 5-year ACS data are available for the years 2014–2018. ACS data can thus be used to construct the SIS for each of these periods (2005–2009, 2006–2010, 2007–2011 … and 2014–2018).

We first extracted all necessary statistics from the three censuses and all 5-year ACSs to compute the indicators described in Table 2 for all U.S. counties. The 11 variables used were exactly the same as Singh's with one exception: the ACS did not include the information necessary to compute the same measure of income disparity. We thus created our own measure of income inequality as the ratio of the average income in the lowest quintile of the population to the average income in the highest quintile.

Table 2
THE 11 VARIABLES USED IN OUR ANALYSIS

Socioeconomic variables
1. Percentage of the population aged 25 and over with less than 9 years of education
2. Percentage of the population aged 25 and over with at least a high school education
3. Percentage of the population aged 16 and over employed in a white collar occupation
4. Unemployment rate for the population 16 years and over
5. Median household income
6. Ratio of the average household income in the lowest quintile to the average household income in the highest quintile
7. Percentage of the population below the federal poverty threshold
8. Median home value for owner occupied units
9. Median gross rent for rental units
10. Percentage of housing without a telephone
11. Percentage of housing without complete plumbing

Information on the distribution of all counties on each of the variables is presented for each census year and ACS period in Appendix A.

We ran a principal component analysis (PCA) using both the STATA and R software (using the FactoMineR computer package) to ensure that the results were identical. The PCA was implemented with as many components (also called factors, or dimensions in the literature) as there are variables (11). One of the outputs, the eigenvalues, indicates how much of the overall variance (variability in the data) is stored in each principal component (Table 3). By design, the first component accounts for the largest share of the overall variance, with the other components successively accounting for a smaller and smaller share of the variance. In our analysis, the first component accounts for around 60 percent of the overall variance for the 1980, 1990 and 2000 censuses data but less than 50 percent for all ACS years, i.e., 47 percent in the data corresponding to the first time period (2005–2009) and between 44 and 45 percent for all other time periods (2006–2010 through 2014–2018). These values correspond closely to Singh's. The second component accounts for 11–16 percent of the overall variance and the other components, 10 percent or less. The first four components account for about 80 percent of total variability in any one period (closer to 90 percent in the three censuses), with the remaining six components accounting for progressively smaller amounts.

Table 3

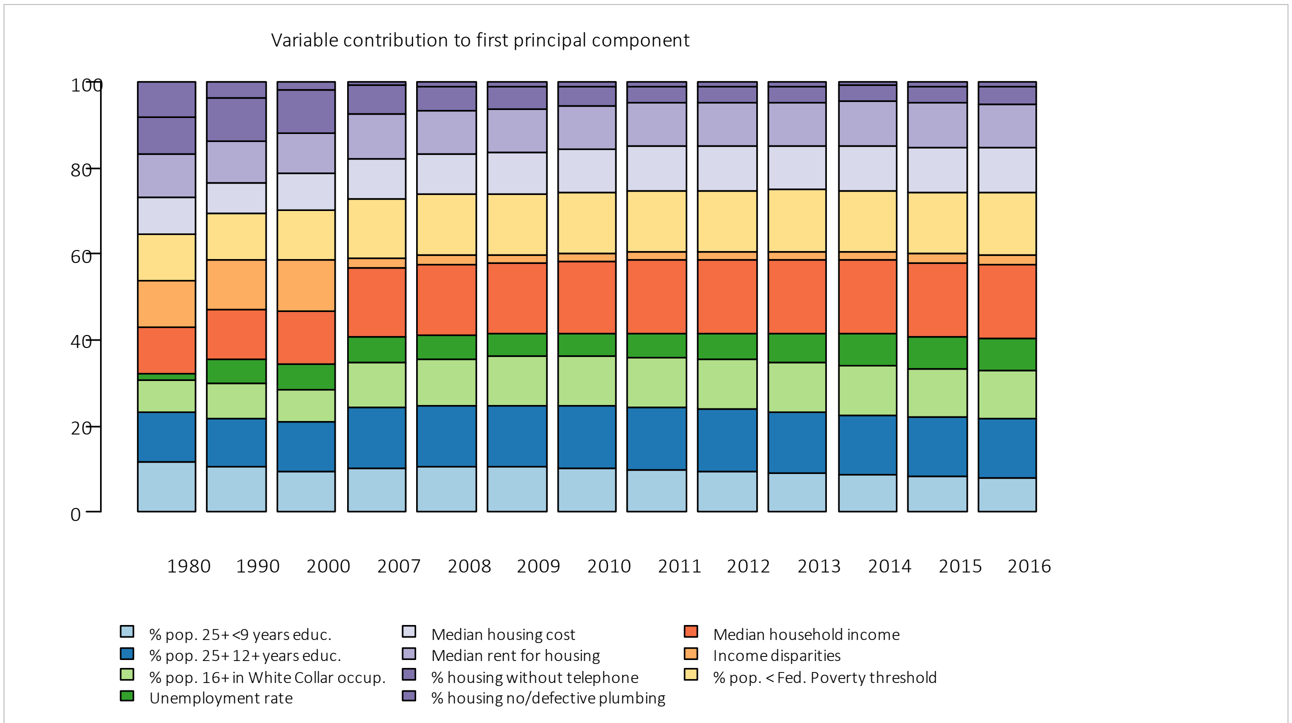
PERCENTAGE OF THE VARIANCE STORED IN EACH PRINCIPAL COMPONENT (PC)

Year/Period	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
1980	62.5	10.9	7.7	6.2	3.3	2.9	2.3	1.6	1.3	0.9	0.4
1990	61.3	13.1	7.3	6.5	3.1	2.9	2.3	1.5	0.9	0.7	0.4
2000	59.1	12.3	8.9	6.9	3.9	3.2	2.3	1.2	1.1	0.6	0.4
2005–2009	47.2	15.8	9.1	8.4	6.8	5.6	2.9	1.8	1.1	0.8	0.5
2006–2010	46.7	16.3	9.2	8.3	7.0	5.9	2.8	1.6	1.1	0.8	0.5
2007–2011	46.0	16.5	9.4	8.5	7.1	6.0	2.7	1.5	1.1	0.8	0.5
2008–2012	45.5	16.5	9.4	8.6	7.0	6.4	2.6	1.5	1.1	0.8	0.5
2009–2013	44.9	16.4	9.4	9.0	7.4	6.3	2.7	1.6	1.1	0.8	0.5
2010–2014	44.8	16.5	9.4	9.2	7.3	6.1	2.7	1.5	1.1	0.8	0.5
2011–2015	44.7	16.4	9.8	9.2	7.3	5.6	2.8	1.7	1.1	0.8	0.5
2012–2016	44.6	16.1	10.2	9.1	7.5	5.1	3.0	1.9	1.1	0.8	0.5
2013–2017	44.8	16.4	10.4	9.3	7.3	4.7	2.9	1.8	1.1	0.8	0.5
2014–2018	44.8	16.6	10.5	9.3	7.2	4.6	2.9	1.8	1.1	0.8	0.5

Another interesting output is the list of variable contributions. Variable contributions indicate the role played by each variable in the construction of each component. In Table 4 below, we show how each variable contributes to the first component in each time period (indexed by the mid-point of each period for the ACS). A similar table is presented for the next three main principal components in Appendix B. Figure 5 illustrates how variable contributions to the first principal component (PC1) change over time.

Figure 5

CONTRIBUTIONS OF THE 11 SOCIOECONOMIC VARIABLES TO THE FIRST PRINCIPAL COMPONENT (PC1) IN EACH CENSUS YEAR AND ACS TIME PERIOD (INDEXED BY THE MID-POINT YEAR)



Overall, changes are very gradual. For census years 1980, 1990 and 2000, seven of the 11 variables contribute nearly equally (with small variations around 10–12 percent). Those are the education variables (the shares of the population with less than nine years and with a high school diploma), the income and poverty variables (median household income, income disparities and proportion below the poverty threshold), and two of the housing variables (median rent and share of households without a telephone). Starting with the ACS, the contribution of three of these variables increases markedly: the proportion with a high school diploma, the proportion below the poverty threshold and, to a larger extent, the median household income, so that in the 2014–2018 ACS, these three variables together contribute over 45 percent to the first component. The contribution of the other four variables diminishes consistently over time, i.e., the proportion of the population with less than nine years of education (from around 11.5 percent in 1980–2000 to 8 percent in 2014–2018), the proportion of households without a telephone (from 9–10 percent to 4 percent), and, especially, income disparities (from 11–12 percent to around 2 percent). The contribution of all remaining variables either increased slightly (proportion in white collar occupations, from 7–8 percent in 1980–2000 to around 11 percent in 2014–2018; the unemployment rate, from around 6 percent in 1990 and 2000 to 7.5 percent in 2014–2018; and the median housing cost, from around 8 percent to 10 percent), declined (proportion of housing units with no or defective plumbing, from 8 percent to around 1 percent), or remained stable throughout the study period (median rent, around 10 percent).

Note that a small contribution to the first principal component could mean either that the variable does not discriminate across the units of observation (e.g., if it has very similar values, whether high or low, in every U.S. county) or that it is not linearly correlated with those variables most contributing to the first principal component, in which case they would contribute more to other components. This latter situation is most notable for income inequalities which contribution to the second principal component is the largest for years 2007 and beyond (25–27 percent), albeit negligible before that, which suggest that the prevalence of income inequality is independent from the general level of education and from the mean household income in any given county. By contrast, the proportion of housing units with no or incomplete plumbing system does not appear to meaningfully discriminate among counties: its contribution is only significant starting with the third principal component, which accounts for around 10 percent of the overall variance.

The role each variable plays in the construction of the second to fourth components is described in Appendix B. The second principal component is driven mostly by income inequality (contributing for about 25 percent starting in the 2000s but less than 2 percent in prior census years), median home value (for 15–17 percent) and median gross rent (around 17–18 percent). While the variable contributions to the construction of the first two components are quite stable over the 2000s and 2010s (though not so much for prior years), they vary a lot, albeit usually gradually, across the whole time period for the next two components. Note however that, as aforementioned and to follow Singh's approach, we only use the information provided by the first component to construct the SIS.

The variable coefficients, another standard output of PCA, are also called factor loadings or correlations (i.e., correlations between each variable and the factors). Overall, the correlations we obtained are very close from one year or period to the next, as well as to those calculated by Singh (Appendix C), except for income disparity, which was not defined in precisely the same way in Singh's and in our study.

Table 4

VARIABLE CONTRIBUTIONS TO THE FIRST COMPONENT BY CENSUS YEAR AND ACS PERIOD (INDEXED BY THE MID-CALENDAR YEAR)

Variable	Census			ACS time period (indexed by mid-calendar year)									
	1980	1990	2000	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
% pop. 25+ <9 years educ.	11.6	10.6	9.5	10.3	10.4	10.4	10.2	9.9	9.5	9.1	8.7	8.3	8.1
% pop. 25+ 12+ years educ.	11.6	11.2	11.5	13.9	14.2	14.4	14.4	14.4	14.3	14.1	13.9	13.7	13.5
% pop. 16+ in White Collar occupations	7.5	8.0	7.4	10.7	11.1	11.4	11.6	11.8	11.6	11.4	11.6	11.4	11.5
Unemployment rate	1.3	5.7	5.9	5.7	5.6	5.2	5.3	5.5	6.0	6.8	7.2	7.4	7.5
Median household income	10.8	11.7	12.4	16.1	16.3	16.6	16.9	17.2	17.2	17.2	17.2	17.1	17.1
Income disparities	11.1	11.3	12.0	2.2	2.3	2.0	2.0	1.7	1.8	2.0	1.9	2.2	2.3
% pop. < Fed. poverty threshold	10.9	11.0	11.5	14.0	14.2	14.2	14.2	14.2	14.2	14.3	14.3	14.4	14.5
Median home value	8.5	6.9	8.5	9.4	9.4	9.7	10.0	10.4	10.4	10.3	10.4	10.3	10.2
Median rent for housing	10.1	9.7	9.5	10.2	9.8	9.8	9.9	10.1	10.0	10.0	10.3	10.4	10.3
% housing without telephone	8.6	10.1	10.0	6.7	5.9	5.4	4.6	3.9	4.0	3.8	3.6	3.9	4.1
% housing with no/defective plumbing	8.0	3.7	1.7	0.8	0.9	1.0	1.0	1.0	0.9	0.9	0.9	1.0	1.0

The correlations on the first principal component were used to construct the SIS for each county. First, the values for each county and for each variable were normalized by subtracting their mean over all counties and dividing by the standard deviation as in the first step of the PCA. Standardization is necessary because of variations in the unit in which the variables are measured (i.e., percentages vs. dollar values) and in the range of values across variables measured by the same unit. Without standardization, variables with the largest ranges in values will dominate over those with small ranges, which would bias the results. The next step is to multiply the standardized value for each variable in each county by the corresponding coefficient from the first principal component. The resulting figures are then summed up over all 11 variables for each individual county. To follow Singh and for the sake of comparison, we again transformed the result into a standardized index by setting the mean of the index to 100 and its standard deviation to 20. This final index is our Socioeconomic Index. A Socioeconomic Index Score (SIS) was calculated for each county and time period.

Section 4: Distribution of All U.S. Counties within Socioeconomic Categories

National deciles were created by ranking all U.S. counties based on their SISs from lowest to highest and by stratifying them into 10 groups based on subsequent ranking. Counties were weighted by their population so that each decile represents approximately 10 percent of the U.S. population (over 30 million people in 2018), with the first decile designating the 10 percent population in the counties with the lowest SISs and the 10th decile, the 10 percent population in the counties with the highest SISs. Tabulations of the SISs and the percentages of the population along each of the dimensions used to construct the score for each county and each census year or ACS period are published together with the other study outputs. Similar calculations were performed for county quintiles. All figures in the report were reproduced for the quintiles and are presented in Appendix D.

Note that there is some instability in the county ranking over time: more than half of all counties change decile from one census year to the next and between 14 and 20 percent from an ACS period to the next (Table 5). In the vast majority of cases (70–80 percent from one census year to the next and 98–99 percent from one ACS period to the next), the changes are to the decile just above or just below. Over the whole study period (from 1980 through 2014–2018), 60 percent of all counties have changed decile.

Table 5

PROPORTION OF COUNTIES SWITCHING DECILE BETWEEN EACH SUCCESSIVE CENSUS OR ACS AND OVER SELECTED TIME PERIODS

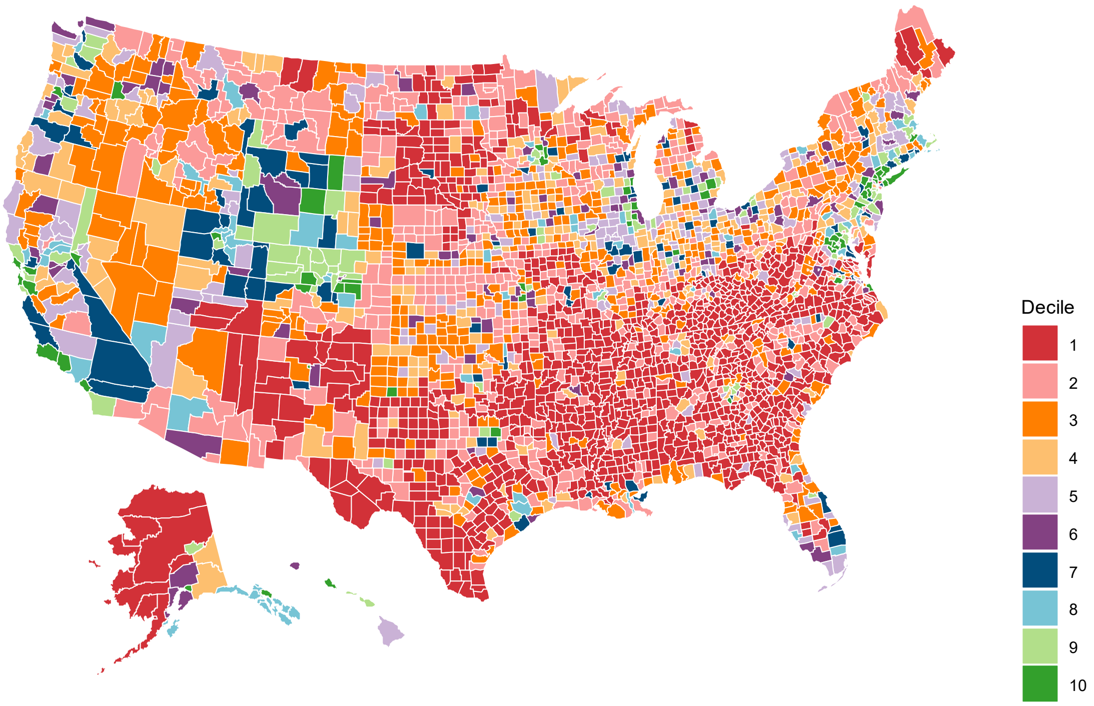
Time period	Number of deciles skipped														
	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	All
From 1980 to 1990	0.0	0.2	0.3	1.4	6.3	22.1	53.3	11.7	3.6	0.9	0.2	0.0	0.0	0.0	100.0
From 1990 to 2000	0.0	0.0	0.1	0.1	0.6	6.9	53.6	27.9	8.5	1.9	0.3	0.0	0.0	0.0	100.0
From 2000 to 2005	0.0	0.0	0.0	0.4	2.8	14.8	57.3	19.8	4.2	0.7	0.0	0.0	0.0	0.0	100.0
From 2005–2009 to 2006–2010	0.0	0.0	0.0	0.0	0.0	5.3	80.3	14.0	0.4	0.0	0.0	0.0	0.0	0.0	100.0
From 2006–2010 to 2007–2011	0.0	0.0	0.0	0.0	0.0	6.6	82.2	11.0	0.2	0.0	0.0	0.0	0.0	0.0	100.0
From 2007–2011 to 2008–2012	0.0	0.0	0.0	0.0	0.0	5.6	82.1	12.2	0.2	0.0	0.0	0.0	0.0	0.0	100.0
From 2008–2012 to 2009–2013	0.0	0.0	0.0	0.0	0.1	6.5	84.8	8.5	0.1	0.0	0.0	0.0	0.0	0.0	100.0
From 2009-–2013 to 2010–2014	0.0	0.0	0.0	0.0	0.1	6.4	85.8	7.4	0.3	0.0	0.0	0.0	0.0	0.0	100.0
From 2010–2014 to 2011–2015	0.0	0.0	0.0	0.0	0.1	7.2	85.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0
From 2011–2015 to 2012–2016	0.0	0.0	0.0	0.0	0.2	10.1	84.6	5.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0
From 2012–2016 to 2013–2017	0.0	0.0	0.0	0.0	0.0	7.8	84.8	7.2	0.1	0.0	0.0	0.0	0.0	0.0	100.0
From 2013–2017 to 2014–2018	0.0	0.0	0.0	0.0	0.1	13.3	80.9	5.7	0.0	0.0	0.0	0.0	0.0	0.0	100.0
From 1980 to 2005–2009	0.1	0.2	0.6	1.7	5.7	13.1	43.0	18.3	9.1	5.0	1.6	1.1	0.4	0.1	100.0
From 2005–2009 to 2014–2018	0.0	0.0	0.0	0.4	1.5	14.5	59.5	19.9	3.0	0.9	0.2	0.0	0.0	0.0	100.0
From 1980 to 2014–2018	0.0	0.3	0.8	2.3	5.1	13.5	38.9	18.0	9.8	5.8	3.1	1.6	0.4	0.2	100.0

The maps below show how counties are geographically distributed by socioeconomic decile at the beginning (1980), in the middle (2000) and at the end (2014–2018) of the study period (Figure 6). The predominance of counties colored in red on the maps reflects the fact that counties with the lowest scores (i.e., in the first decile) are typically small in terms of population. In 2014–2018 for instance, there were 690 counties in the first decile but only 57 in the 10th decile.

Figure 7 shows which counties changed decile from the beginning to the end of the study period and over how many decile they shifted. Counties which socioeconomic ranking deteriorated between 1980 and 2014–2018 are located in three broad areas of the U.S.: along the West Coast (in Oregon and California in particular); in an area at the corner of Utah, Colorado and Wyoming; and South of the Great Lakes, in Wisconsin, Michigan and North of Illinois, Indiana and Ohio. By contrast, the situation improved for many counties in the North Central part of the country (in the Dakotas, Nebraska and Minnesota) as well as in the Northeast (in Maine, New Hampshire, and Vermont). Keeping the county ranking fixed over the study period by using only the SISs calculated from the 1980 census data would have created increasingly heterogeneous groupings (deciles) which would have complicated the interpretation of mortality differentials.

Figure 6a

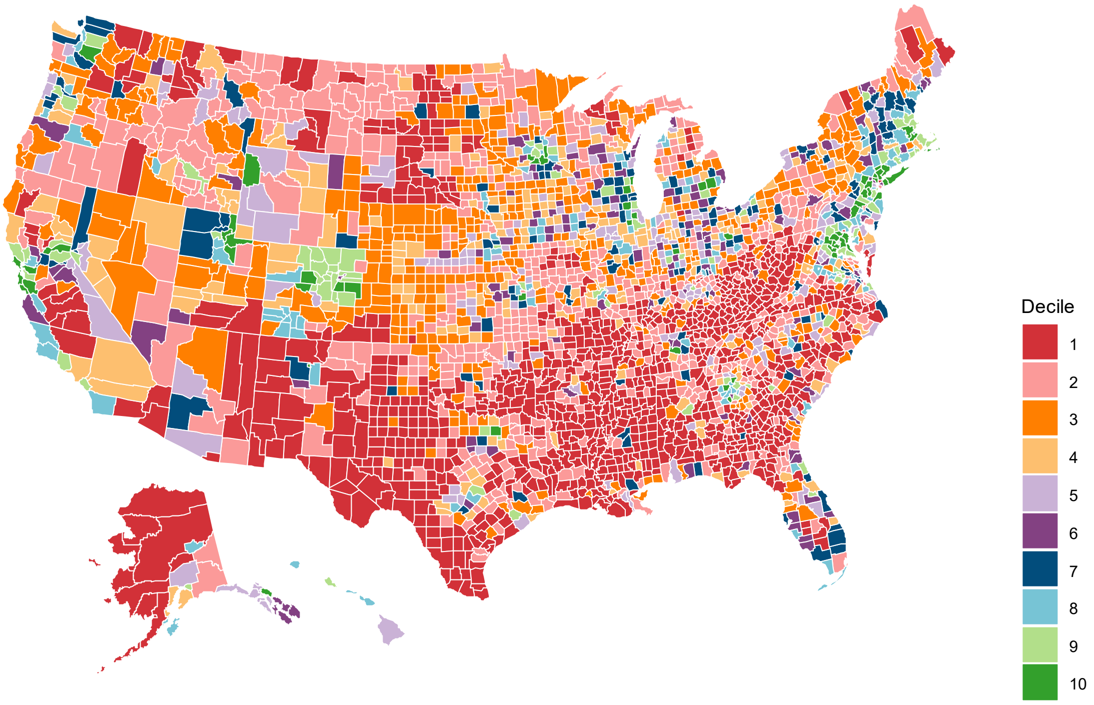
COUNTIES BY SOCIOECONOMIC DECILE (WEIGHTED BY POPULATION), 1980



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Figure 6b

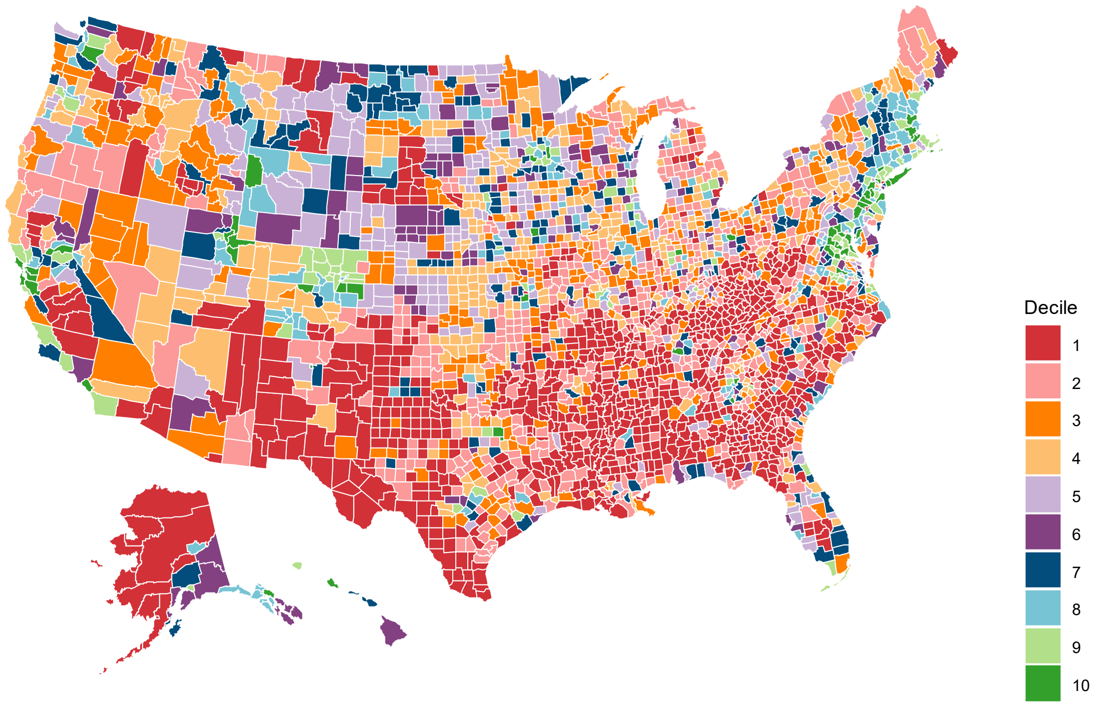
COUNTIES BY SOCIOECONOMIC DECILE (WEIGHTED BY POPULATION), 2000



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent in counties with the highest SISs.

Figure 6c

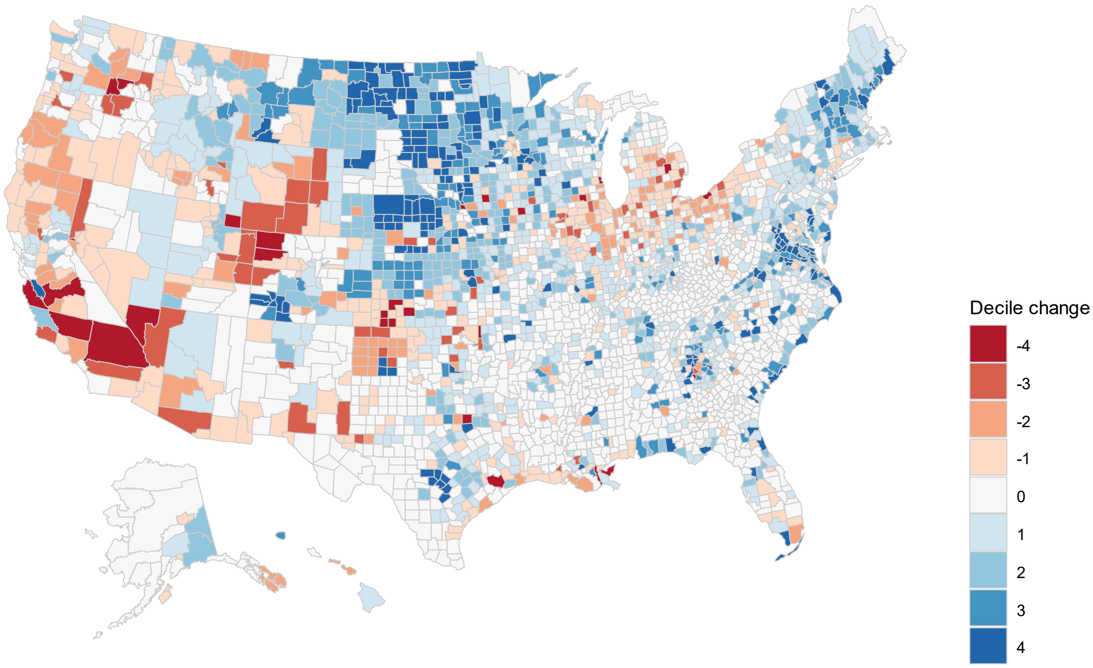
COUNTIES BY SOCIOECONOMIC DECILE (WEIGHTED BY POPULATION), 2014–2018



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Figure 7

CHANGE IN COUNTY DECILE BETWEEN 1980 AND 2014–2018



Note: Negative (red and orange) values designate counties which relative socioeconomic position deteriorated over the study period while positive (blue) values designate counties which socioeconomic position improved.

Section 5: Mortality by Socioeconomic Decile

To construct a lifetable series by decile, we used restricted mortality data from the National Center for Health Statistics, obtained through a Data User Agreement. Information is available for U.S. death certificates at the individual level and includes sex, age at last birthday in single years and county of residence for all calendar years since 1982. In combination with county-level population data from the Census Bureau for the corresponding years, we calculated mortality rates and, from those, complete life tables for all years from 1982 to 2018, using the Human Mortality Database methods and computer code (Wilmoth et al., 2017). One of the originalities of the HMD Methods Protocol is to implement an algorithm derived from Kannisto to smooth rates at ages 90+ years in order to more accurately estimate the underlying mortality curve at high ages. We validated our results by aggregating both the death counts and the population counts over all deciles and compared the results with the Human Mortality Database (HMD) lifetable series for the United States as a whole. Consistency between the two types of data series was found to be perfect for the life expectancy at birth and other ages and for mortality rates by single year of age.

5.1 GROWING INEQUALITIES IN MORTALITY

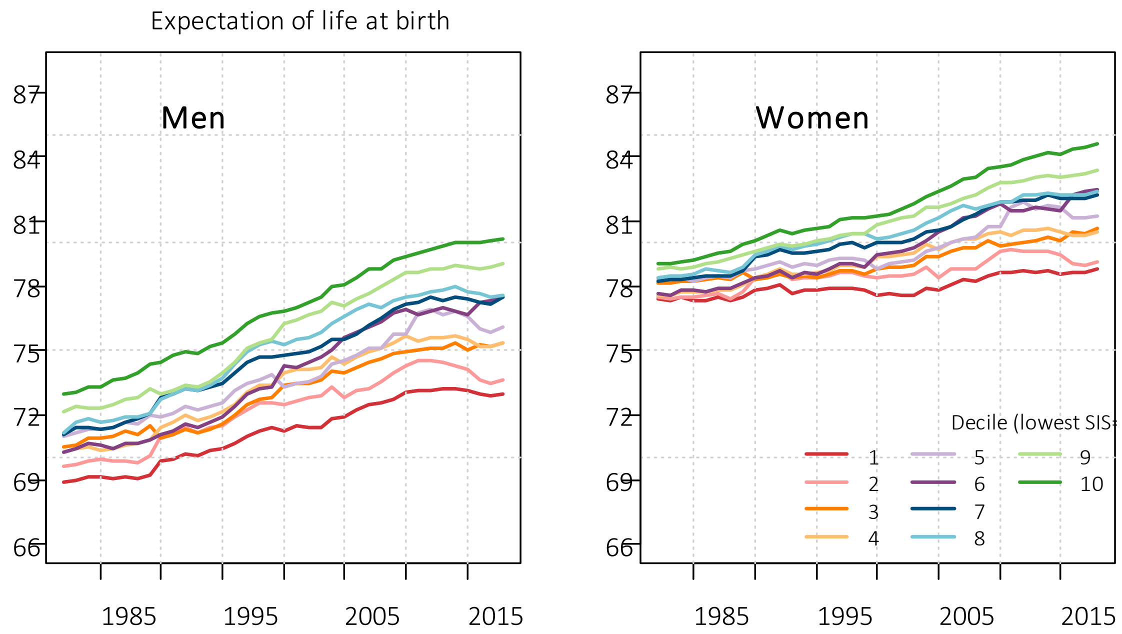
Figure 8 shows trends in life expectancy at birth by decile for each sex. The figure shows a clear mortality gradient from one decile to the next at the bottom and at the top of the distribution with some crossovers for deciles three through eight. It also indicates that mortality disparities have increased progressively since 1982. In 1982, life expectancy at birth ranged from 68.9 years to 73.0 years for men and from 77.4 and 79.0 years for women across all deciles. In 2018, it ranged from 73.0 to 80.2 years for men and from 78.8 to 84.6 years for women. The difference between the two extreme deciles increased from 4.1 to 7.2 years for men and from 1.6

to 2.7 years for women during the study period. The gap between the lowest and highest deciles is smaller but increased faster for women than for men (Table 6).

These growing inequalities could result either from 1) a deterioration in the health status of individuals in the lowest decile, possibly combined with an acceleration of improvement in the survival odds of the population in the highest decile, or 2) from selective migration across county borders, with an increasing geographic concentration of the population by income and education. There is a large body of literature that has, indeed, demonstrated an increase in income segregation at the neighborhood level since about 1975 (see for instance a seminal article by Massey and Fischer, 2003; as well as Danziger and Gottschalk, 1995; Levy, 1998; U.S. Bureau of the Census, 2002; Phillips, 2002). It would be useful to better understand how the rising geographic concentration of the population by socioeconomic status has contributed to increasing disparities in mortality within the U.S. population but additional data would be necessary for such an analysis.

Figure 8

EXPECTATION OF LIFE AT BIRTH (IN YEARS) BY SOCIOECONOMIC DECILE FOR EACH SEX, 1982–2018



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Table 6

LIFE EXPECTANCY AT BIRTH IN THE FIRST AND 10TH DECILES FOR EACH YEAR AND SEX, AND DIFFERENCE BETWEEN THE FIRST AND 10TH DECILES, 1982-2018

Year	Men			Women			Both sexes		
	1st decile	10th decile	Diff.	1st decile	10th Decile	Diff.	1st decile	10th decile	Diff.
1982	68.9	73.0	4.1	77.4	79.0	1.6	73.1	76.1	3.0
1983	69.0	73.1	4.1	77.3	79.0	1.7	73.1	76.2	3.1
1984	69.1	73.3	4.2	77.5	79.1	1.6	73.3	76.3	3.1
1985	69.1	73.3	4.2	77.3	79.2	1.9	73.2	76.4	3.2
1986	69.1	73.6	4.5	77.3	79.4	2.1	73.1	76.6	3.5
1987	69.1	73.8	4.6	77.5	79.5	2.1	73.3	76.8	3.5
1988	69.1	73.9	4.9	77.3	79.6	2.3	73.1	76.9	3.7
1989	69.2	74.4	5.1	77.5	79.9	2.5	73.3	77.3	4.0
1990	69.8	74.4	4.6	77.8	80.1	2.3	73.8	77.4	3.6
1991	69.9	74.8	4.8	77.9	80.4	2.5	73.9	77.7	3.8
1992	70.2	74.9	4.7	78.0	80.6	2.6	74.1	77.9	3.8
1993	70.1	74.9	4.8	77.6	80.5	2.8	73.8	77.8	4.0
1994	70.4	75.2	4.8	77.8	80.6	2.8	74.0	78.0	4.0
1995	70.4	75.4	4.9	77.8	80.7	2.9	74.1	78.1	4.1
1996	70.7	75.8	5.1	77.9	80.8	2.9	74.3	78.4	4.1
1997	71.0	76.3	5.2	77.9	81.1	3.1	74.5	78.8	4.3
1998	71.3	76.6	5.3	77.9	81.2	3.3	74.6	79.0	4.4
1999	71.4	76.7	5.3	77.8	81.2	3.4	74.6	79.1	4.5
2000	71.3	76.8	5.5	77.6	81.3	3.7	74.4	79.2	4.7
2001	71.5	77.0	5.5	77.6	81.4	3.7	74.6	79.3	4.7
2002	71.4	77.2	5.9	77.6	81.6	4.0	74.5	79.5	5.1
2003	71.4	77.5	6.1	77.5	81.8	4.3	74.5	79.8	5.3
2004	71.8	78.0	6.2	77.9	82.2	4.3	74.8	80.2	5.4
2005	71.9	78.1	6.2	77.8	82.4	4.6	74.9	80.3	5.5
2006	72.2	78.4	6.1	78.1	82.6	4.6	75.1	80.6	5.5
2007	72.5	78.8	6.3	78.3	83.0	4.6	75.4	81.0	5.6
2008	72.5	78.8	6.3	78.2	83.0	4.9	75.4	81.0	5.7
2009	72.8	79.2	6.5	78.4	83.4	5.0	75.6	81.4	5.8
2010	73.1	79.4	6.3	78.7	83.6	4.9	75.9	81.6	5.7
2011	73.2	79.5	6.4	78.6	83.6	5.0	75.9	81.7	5.8
2012	73.2	79.7	6.5	78.7	83.9	5.2	75.9	81.9	6.0
2013	73.2	79.9	6.7	78.6	84.0	5.4	75.9	82.0	6.1
2014	73.3	80.0	6.8	78.7	84.2	5.5	76.0	82.2	6.3
2015	73.1	80.0	6.9	78.6	84.2	5.6	75.8	82.2	6.3
2016	73.0	80.0	7.0	78.6	84.3	5.7	75.8	82.2	6.5
2017	72.9	80.1	7.1	78.6	84.4	5.8	75.7	82.3	6.6
2018	73.0	80.2	7.2	78.8	84.6	5.8	75.8	82.5	6.6

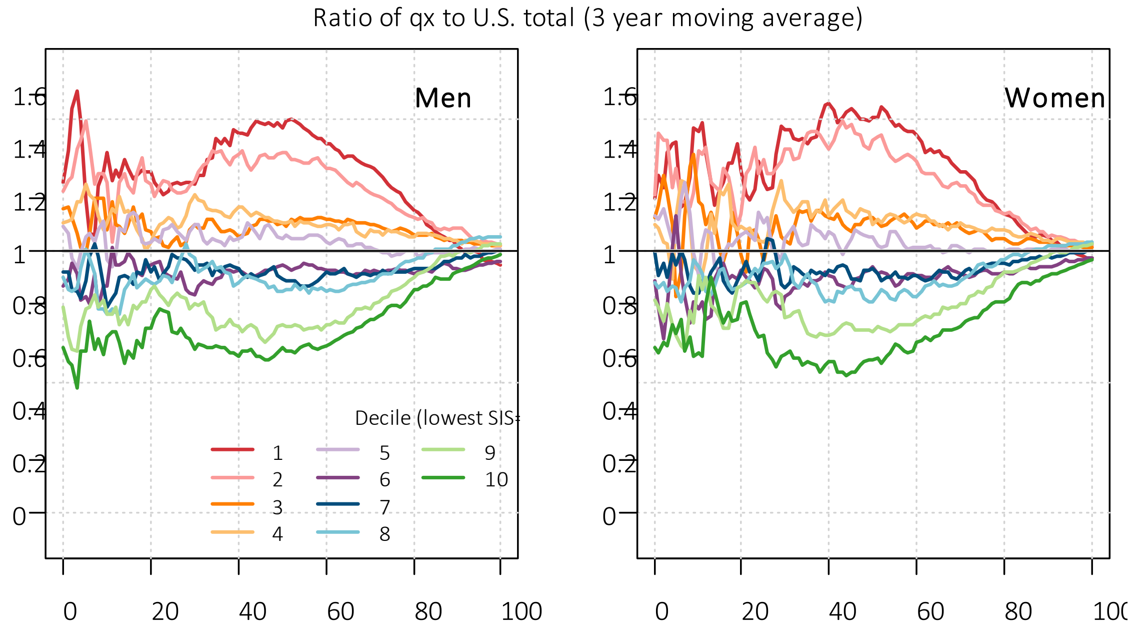
Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

5.2 LARGEST DISPARITIES AMONG THE YOUNG

For both men and women, the ratio of the mortality rates in every decile to the U.S. average shows that disparities are largest for children and for adults between the ages of 40 and 60 years, after which they progressively diminish to reach a very low level at ages above 80 years (see Figure 9 for an illustration with 2018 data). Mortality rates around age 45–50 years are 50 percent higher in the lowest decile and 50 percent lower in the highest decile compared to the U.S. average but the excess (or deficit) declines to around 10 percent at age 80 years. This pattern could result from increasing selection of the most robust individuals with age in the lowest deciles as premature mortality removes the frailest from the population.[3] Disparities appear to be slightly more pronounced for women than for men in 2018.

Figure 9

RATIO OF THE PROBABILITIES OF DYING (q_x) IN EACH DECILE TO THE U.S. TOTAL, EACH SEX, 2018 (%)



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Inequalities in mortality below age 45 appear to have increased until around 2000 when they reached a plateau. They have increased continuously since 1982 for both sexes between the ages of 45 and 85 years as showed on Figure 10 below, which represents trends in the ratio of mortality for selected indicators in the first to 10th deciles. The level of mortality in the highest decile relative to the lowest decile fluctuated between 50 and 70 percent for men between the ages of 0 and 5 ($_5q_0$), 5 and 25 ($_{20}q_5$), and 25 and 45 ($_{20}q_{25}$) over the study period. The pattern for women is very similar, except for larger disparities at ages 25-45 during the 2010s (with a ratio of 40 percent).

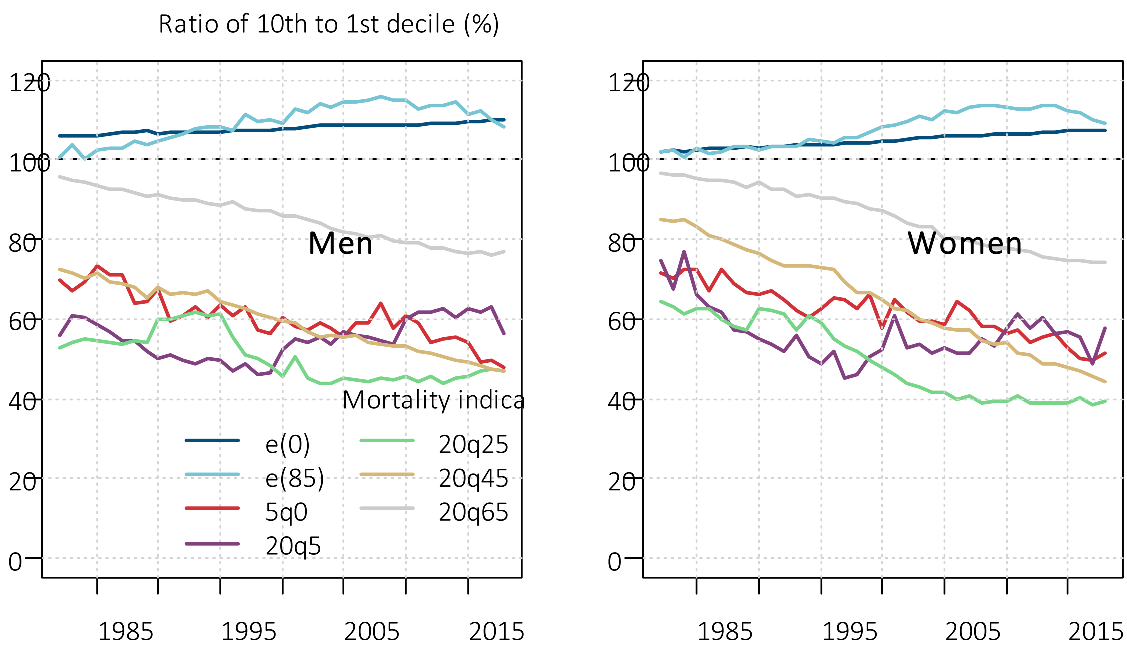
Mortality between the ages of 45 and 65 ($_{20}q_{45}$) declined much faster for those in the 10th decile compared to those in the first decile. While the rate for the former was about 75 percent of the latter for men and 85 percent for women in 1982, it was only 45 percent for men and 40 percent for women (less than half) in 2018. Mortality

[3] See the seminal article by Vaupel, Manton and Stallard, 1979 for a demonstration of how heterogeneity in population frailty can create this kind of pattern.

in the next age group ($_{20}q_{65}$) followed a similar trend though differences between the extreme deciles are not as pronounced: the ratio declined from around 95 to 75 percent for both men and women. The ratio in the expectation of life at age 85 (e_{85}) increased until the late 2000s (reflecting an increase in disparities), when it started declining slowly up to our most recent data point (2018). The combined impact of these trends on the expectation of life at birth has been a fairly continuous increase in inequality in line, as reflected by the slightly increasing ratio for the expectation of life at birth (e_0).

Figure 10

RATIO OF THE 10TH TO THE FIRST DECILE FOR SELECTED MORTALITY INDICATORS* BY SEX



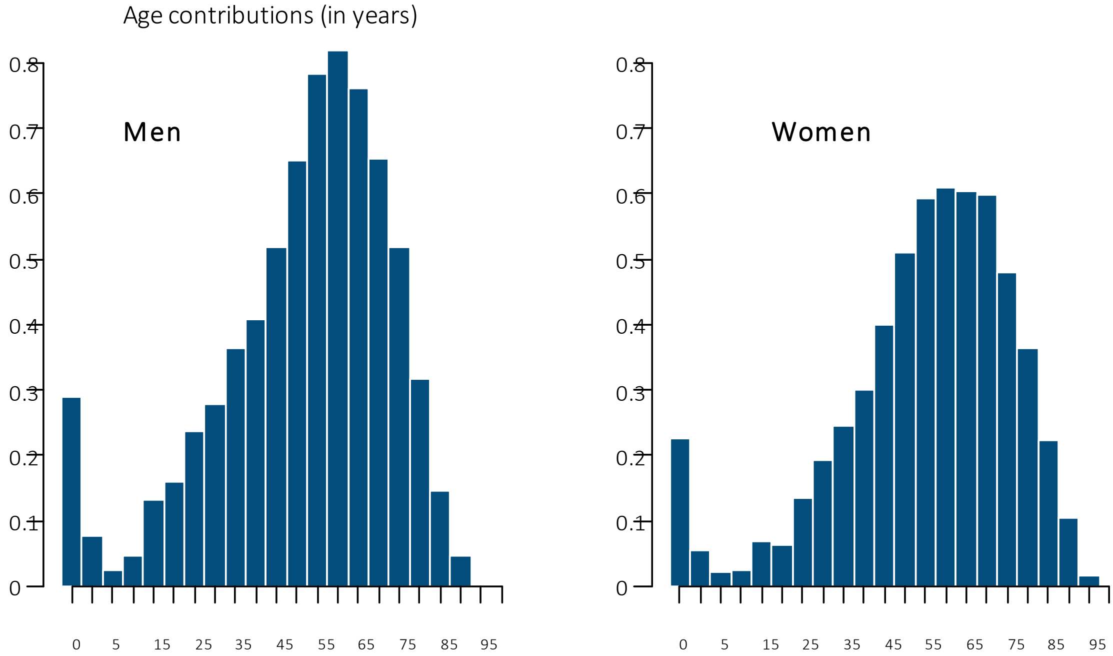
*e(0) = expectation of life at birth; e(85) = expectation of life at age 85; 5q0 = the probability of dying between birth and exact age 5; 20q5 = the probability of dying between exact age 5 and exact age 25; 20q25 = the probability of dying between exact age 25 and exact age 45; 20q45 = the probability of dying between exact age 45 and exact age 65; 20q65 = the probability of dying between exact age 65 and exact age 85 (see note 2 earlier for a definition of the probabilities of dying).

Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

In spite of the fact that the mortality gap between the two extreme deciles is largest among adults around the age of 50 years, most of the difference in the length of life is attributable to mortality disparities around the ages of 55 to 70 years (Figure 11). This is because mortality rates are relatively low for young adults, increasing quickly after age 60–65 years or so, and large differences in low rates have less of an impact on overall mortality than small differences in high rates. Ages above 55 years contribute more than half of the difference in life expectancy at birth between the two extreme deciles for both men (56 percent) and women (62 percent).

Figure 11

AGE CONTRIBUTIONS TO THE DIFFERENCE IN LIFE EXPECTANCY AT BIRTH BETWEEN THE FIRST AND 10TH DECILE, EACH SEX, 2018



Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

5.3 A DETERIORATION OF RECENT TRENDS FOR ALL

In 2010, life expectancy at birth stopped improving in the U.S. and it declined during the period 2014–2017 at the national level, though the most recent year of data (2018) shows a slight uptick in survival. Our analysis indicates that the deteriorating trend has affected all population deciles of both sexes (Figure 8). For the most affluent segment of the population (i.e., in the highest decile), mortality reached a plateau after 2014: life expectancy at birth only gained 0.1 year for men and 0.2 for women, while it declined for both men and women in the lowest decile, by 0.4 and 0.1 years, respectively (from 73.3 to 72.9 years for men and from 78.7 to 78.6 years for women) with no progress since 2010 (Table 7). Though life expectancy increased for all groups between 2017 and 2018, the COVID-19 pandemic makes it likely that 2020 will, again, see an increase in mortality in at least some segments of the population, both from the virus itself and from its social and economic fallout.

Table 7

YEARS OF LIFE GAINED IN EACH DECILE AND FOR THE U.S. AS A WHOLE OVER SELECTED TIME PERIODS BY SEX

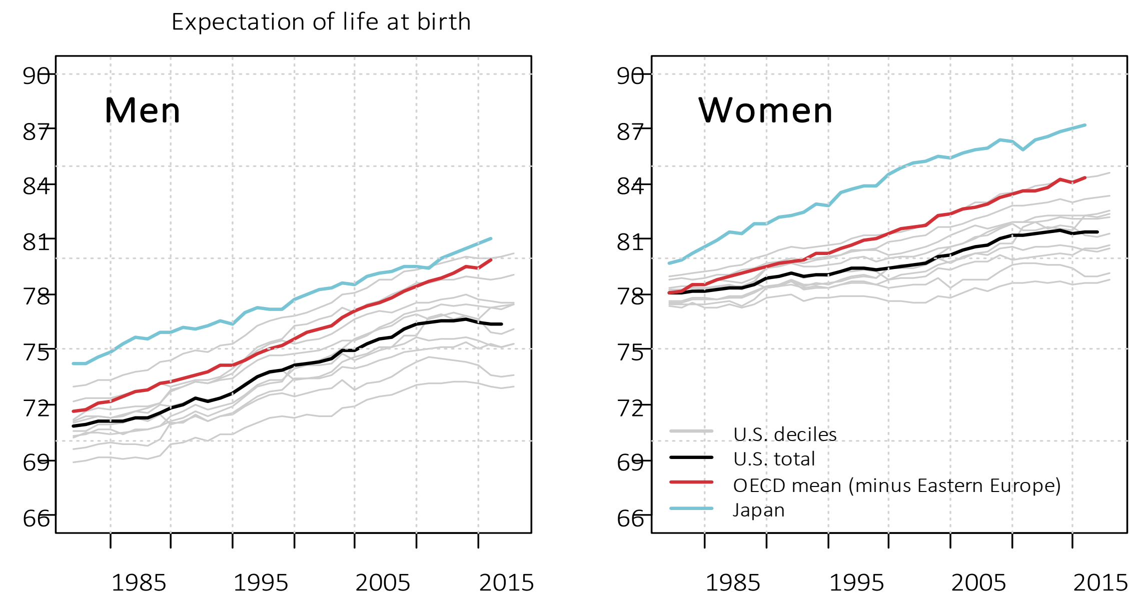
Decile	Men				Women			
	2002–2006	2006–2010	2010–2014	2014–2018	2002–2006	2006–2010	2010–2014	2014–2018
1	0.9	0.8	0.2	-0.3	0.5	0.6	0.0	0.1
2	0.3	1.2	0.0	-0.7	0.3	0.9	0.0	-0.5
3	0.8	0.8	0.4	0.0	0.7	0.3	0.4	0.4
4	0.5	1.0	0.0	-0.4	0.6	0.5	0.1	-0.1
5	1.2	1.0	1.0	-0.7	0.9	0.7	1.0	-0.5
6	1.4	1.1	-0.1	0.7	1.1	1.1	-0.3	0.9
7	0.8	1.3	0.3	0.0	0.7	1.1	0.3	0.0
8	1.3	0.6	0.4	-0.4	1.1	0.4	0.4	0.1
9	0.8	1.2	0.3	0.1	0.7	1.0	0.3	0.2
10	1.1	1.0	0.7	0.2	1.1	0.9	0.7	0.4
U.S. Total	0.9	1.0	0.3	-0.1	0.8	0.8	0.3	0.1

5.4 AN INCREASING GAP WITH OTHER HIGH-INCOME DEMOCRACIES

To provide some context to socioeconomic variations in mortality in the United States, we compared trends in life expectancy at birth in each of the ten deciles with those in the OECD countries (Figure 12). Eastern European countries as well as Mexico and Turkey are excluded from the comparison to include only countries similar to the U.S. in terms of their level of economic development and political systems. We also show trends in Japan (included in the OECD countries), which has record high level of survival for women.

Figure 12

TRENDS IN LIFE EXPECTANCY AT BIRTH IN U.S. DECILES AND THE U.S. AS A WHOLE COMPARED WITH JAPAN AND THE AVERAGE FOR OTHER OECD COUNTRIES*, EACH SEX, 1982–2018



*Excluding Eastern European countries as well as Mexico and Turkey.

Note: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Figure 12 shows that the only Americans living as long as their OECD counterparts are those in the highest decile for both men and women. It also shows that both Japanese men and women enjoy longer lives than even the most affluent Americans. In 2017, the last year for which we have comparable data, life expectancy at birth reached 79.7 years in the selected OECD countries, 80.1 years in the highest U.S. decile and 81.1 years in Japan for men, and 84.2, 84.4 and 87.3 years, respectively, for women (Table 8). Furthermore, the flattening of the curve in the U.S. suggests that even Americans in the highest decile might soon live shorter lives than their average OECD counterparts (at least for men).

Table 8

LIFE EXPECTANCY AT BIRTH BY SEX IN THE FIRST AND 10TH DECILES, IN THE U.S. AS A WHOLE, IN JAPAN AND IN THE OECD*

Year	Men					Women				
	1st decile	10th decile	U.S. Total	OECD*	Japan	1st decile	10th decile	U.S. Total	OECD*	Japan
1982	68.9	73.0	70.8	71.6	74.3	77.4	79.0	78.1	78.1	79.7
1983	69.0	73.1	71.0	71.7	74.3	77.3	79.0	78.1	78.2	79.8
1984	69.1	73.3	71.1	72.1	74.6	77.5	79.1	78.2	78.5	80.3
1985	69.1	73.3	71.1	72.2	74.9	77.3	79.2	78.2	78.5	80.6
1986	69.1	73.6	71.1	72.4	75.3	77.3	79.4	78.3	78.8	81.0
1987	69.1	73.8	71.3	72.7	75.7	77.5	79.5	78.4	79.0	81.4
1988	69.1	73.9	71.3	72.8	75.6	77.3	79.6	78.3	79.2	81.3
1989	69.2	74.4	71.6	73.1	76.0	77.5	79.9	78.6	79.3	81.8
1990	69.8	74.4	71.9	73.3	76.0	77.8	80.1	78.9	79.5	81.9
1991	69.9	74.8	72.0	73.4	76.2	77.9	80.4	79.0	79.7	82.2
1992	70.2	74.9	72.3	73.6	76.1	78.0	80.6	79.2	79.8	82.3
1993	70.1	74.9	72.2	73.8	76.3	77.6	80.5	78.9	79.9	82.5
1994	70.4	75.2	72.4	74.2	76.6	77.8	80.6	79.1	80.2	82.9
1995	70.4	75.4	72.6	74.1	76.4	77.8	80.7	79.1	80.3	82.8
1996	70.7	75.8	73.1	74.4	77.0	77.9	80.8	79.2	80.5	83.5
1997	71.0	76.3	73.6	74.8	77.3	77.9	81.1	79.4	80.7	83.7
1998	71.3	76.6	73.8	75.0	77.2	77.9	81.2	79.4	80.9	83.9
1999	71.4	76.7	73.9	75.2	77.2	77.8	81.2	79.4	81.0	83.9
2000	71.3	76.8	74.1	75.6	77.7	77.6	81.3	79.4	81.3	84.5
2001	71.5	77.0	74.3	75.9	78.0	77.6	81.4	79.5	81.6	84.9
2002	71.4	77.2	74.4	76.1	78.3	77.6	81.6	79.6	81.7	85.2
2003	71.4	77.5	74.5	76.3	78.4	77.5	81.8	79.7	81.8	85.3
2004	71.8	78.0	75.0	76.8	78.6	77.9	82.2	80.1	82.2	85.5
2005	71.9	78.1	75.0	77.0	78.5	77.8	82.4	80.1	82.4	85.4
2006	72.2	78.4	75.3	77.4	78.9	78.1	82.6	80.4	82.6	85.7
2007	72.5	78.8	75.5	77.5	79.1	78.3	83.0	80.6	82.7	85.9
2008	72.5	78.8	75.7	77.8	79.2	78.2	83.0	80.6	82.9	86.0
2009	72.8	79.2	76.1	78.1	79.5	78.4	83.4	81.0	83.2	86.4
2010	73.1	79.4	76.3	78.3	79.5	78.7	83.6	81.1	83.3	86.3
2011	73.2	79.5	76.4	78.6	79.4	78.6	83.6	81.2	83.5	85.9
2012	73.2	79.7	76.5	78.8	79.9	78.7	83.9	81.3	83.6	86.4
2013	73.2	79.9	76.5	79.1	80.2	78.6	84.0	81.3	83.8	86.6
2014	73.3	80.0	76.6	79.4	80.5	78.7	84.2	81.4	84.1	86.8
2015	73.1	80.0	76.4	79.4	80.8	78.6	84.2	81.3	84.0	87.0
2016	73.0	80.0	76.3	79.6	81.0	78.6	84.3	81.3	84.2	87.2
2017	72.9	80.1	76.3	79.7	81.1	78.6	84.4	81.4	84.2	87.3
2018	73.0	80.2	76.5	-	81.3	78.8	84.6	81.5	-	87.4

*Excluding Eastern European countries as well as Mexico and Turkey. *Note*: The first decile represents the 10 percent of the population in counties with the lowest SISs and the 10th decile represents the 10 percent of the population in counties with the highest SISs.

Section 6: Conclusion

Our study found a clear gradient in mortality across county groupings based on selected social and economic characteristics with progressively higher rates of survival in each successive decile of affluence. As shown here and as demonstrated by the detailed life tables by socioeconomic decile, calendar year and sex published together with this report, differentials in mortality across socioeconomic deciles increased during the study period (1982–2018). Mortality disparities are more pronounced for men than for women, as well as for children and adults below the age of 60 compared to persons above that age. An analysis of the causes of death involved in the varying levels of disparity by sex and age would help identify the factors driving these patterns. It also appears that only the 10 percent of Americans in counties with the highest SISs live longer than the average inhabitant of other OECD democracies and even they live less than the average Japanese.

Though it is too early to evaluate the effect of the major shock induced by the ongoing COVID-19 pandemic on mortality disparities in the United States, there is no reason to believe that 2020 will inaugurate a closing of the gap between Americans in the lowest and highest socioeconomic deciles. We will monitor the situation as new data become available, trusting that the mortality series made available together with this report will provide a useful resource to actuaries for improving their estimates of mortality for insured populations as well as for refining their mortality improvement models.

We hope that, in addition, the results of this study extends beyond the insurance community and will be useful to the public and to policy makers in their efforts to reduce inequalities in mortality in the U.S. population, a public health priority of the U.S. government as described in the Healthy People 2030 initiative.

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Appendix A

SUMMARY STATISTICS ON THE DISTRIBUTION OF ALL COUNTIES ON EACH VARIABLE FOR EACH CENSUS AND ACS PERIOD

	Minimum	1st quartile	Median	Mean	3rd quartile	Maximum
Percent population with less than 9 years of education						
1980	2.27	16.38	22.65	24.06	30.79	63.37
1990	1.14	8.78	12.84	14.08	18.25	56.33
2000	0.66	5.18	7.60	8.85	11.41	46.29
2007	0.35	3.87	5.68	6.82	8.74	38.15
2008	0.32	3.74	5.53	6.58	8.39	36.24
2009	0.40	3.61	5.33	6.35	8.10	37.28
2010	0.67	3.53	5.16	6.18	7.84	38.20
2011	0.58	3.39	4.99	5.99	7.55	37.71
2012	0.51	3.28	4.83	5.79	7.30	35.29
2013	0.49	3.17	4.63	5.59	7.06	35.56
2014	0.56	3.02	4.46	5.39	6.74	34.56
2015	0.43	2.87	4.29	5.18	6.47	34.65
2016	0.44	2.75	4.09	4.97	6.21	35.08
Percent population with at least a high school diploma						
1980	25.25	49.87	61.35	59.56	68.27	94.86
1990	31.56	62.21	71.62	69.83	77.19	94.71
2000	34.70	71.49	79.27	77.50	83.92	96.50
2007	46.51	77.80	84.09	82.54	88.01	98.74
2008	47.90	78.67	84.65	83.14	88.45	99.31
2009	46.32	79.38	85.10	83.70	88.90	98.61
2010	44.88	79.98	85.54	84.16	89.25	97.52
2011	44.97	80.36	85.86	84.57	89.57	97.43
2012	46.72	80.94	86.39	84.99	89.87	97.29
2013	46.28	81.41	86.80	85.43	90.23	97.55
2014	48.52	81.78	87.15	85.81	90.46	97.80
2015	48.84	82.51	87.51	86.22	90.84	97.96
2016	51.48	83.08	87.83	86.63	91.08	98.03
Percent adult 16+ years old in white collar occupations						
1980	22.34	36.07	40.97	42.58	47.76	81.08
1990	26.05	40.12	45.39	47.05	52.70	81.41
2000	25.62	36.91	40.80	41.83	45.55	78.38
2007	34.08	47.73	51.98	52.84	57.27	81.58
2008	29.05	48.24	52.28	53.26	57.57	82.01
2009	35.47	48.40	52.55	53.46	57.63	82.06
2010	33.78	48.56	52.70	53.50	57.47	82.85
2011	35.13	48.70	52.71	53.62	57.60	82.74
2012	34.97	48.71	52.60	53.58	57.56	83.47
2013	35.22	48.65	52.52	53.52	57.54	83.08
2014	34.34	48.64	52.55	53.54	57.66	83.30
2015	34.24	48.83	52.67	53.68	57.81	82.79

2016	30.48	47.64	51.68	52.65	56.73	82.77
Unemployment rate						
1980	1.42	4.99	6.72	7.07	8.72	27.53
1990	1.25	4.94	6.37	6.81	8.13	23.60
2000	1.63	4.25	5.46	5.88	6.95	21.84
2007	1.23	5.50	6.94	7.22	8.61	22.90
2008	1.32	5.94	7.52	7.83	9.32	23.02
2009	1.39	6.38	8.19	8.47	10.14	26.13
2010	1.15	6.78	8.66	8.99	10.86	26.05
2011	1.05	7.10	9.05	9.38	11.36	27.11
2012	1.24	6.67	8.60	8.88	10.78	26.69
2013	0.91	5.98	7.77	8.09	9.82	26.78
2014	1.12	5.36	7.01	7.31	8.83	26.83
2015	1.08	4.79	6.26	6.53	7.84	27.04
2016	0.75	4.30	5.62	5.91	7.10	23.67
Median household income (in $)						
1980	7,030	12,244	14,328	14,690	16,549	41,516
1990	9,809	20,326	23,537	24,726	27,760	76,566
2000	16,271	30,493	34,912	36,335	40,420	80,852
2007	23,620	45,764	52,193	54,217	60,259	129,326
2008	24,874	46,672	52,970	55,090	61,189	130,432
2009	25,808	47,537	54,213	56,451	62,715	133,556
2010	26,008	47,971	54,781	56,940	63,436	136,611
2011	25,995	48,013	55,167	57,248	63,712	139,244
2012	26,112	48,701	56,094	58,006	64,520	138,131
2013	24,877	49,076	56,584	58,499	65,071	140,838
2014	24,063	50,241	57,935	59,968	66,957	147,164
2015	24,698	52,011	60,182	62,279	69,430	150,962
2016	26,374	53,989	62,553	64,763	72,111	154,204
Income disparity[4]						
1980	5.55	47.59	76.68	95.26	124.19	529.78
1990	5.08	83.09	146.16	181.15	237.49	1611.18
2000	2.52	28.61	49.36	62.14	81.44	474.86
2007	6.28	10.42	11.83	12.44	13.71	106.17
2008	6.36	10.46	11.89	12.44	13.75	50.06
2009	6.61	10.60	11.94	12.57	13.81	40.68
2010	6.85	10.75	12.15	12.74	14.01	40.78
2011	7.21	10.93	12.33	12.94	14.18	40.14
2012	7.07	11.09	12.48	13.14	14.27	40.71

[4] Income disparity could not be computed in a consistent way over the study period due to a lack of comparable data in the census versus the ACS. For years 1980, 1990 and 2000, income inequality is measured as the ratio of the number of households with a median annual income below $5,000 to the number of households with a median annual income at $25,000 and above multiplied by 100. For years 2007 and beyond, income inequality is the ratio of the median annual income in the top households quintile to the bottom households quintile.

2013	7.18	11.22	12.69	13.37	14.50	54.88
2014	7.40	11.31	12.81	13.55	14.70	117.01
2015	7.42	11.37	12.89	13.61	14.84	83.09
2016	7.48	11.39	12.91	13.66	15.01	60.78
Percent individuals below the Federal poverty threshold						
1980	3.05	10.21	13.52	15.11	18.52	50.64
1990	2.18	10.77	14.67	16.12	20.12	59.98
2000	2.31	9.37	12.76	13.78	17.04	50.89
2007	2.83	10.96	14.66	15.31	18.70	46.86
2008	2.43	11.20	14.83	15.46	18.84	43.38
2009	3.45	11.52	15.27	15.85	19.25	43.18
2010	3.53	11.98	15.83	16.33	19.65	42.64
2011	3.63	12.41	16.13	16.76	20.23	43.53
2012	3.84	12.54	16.32	16.91	20.29	43.94
2013	4.02	12.40	16.22	16.81	20.29	45.04
2014	3.73	12.05	15.92	16.51	19.92	45.00
2015	3.04	11.68	15.50	16.08	19.36	46.45
2016	3.53	11.36	15.00	15.65	19.07	46.60
Median home value (in $)						
1980	10,000	27,500	32,500	37,522	45,000	200,000
1990	17,500	37,500	47,500	57,782	67,500	500,000
2000	20,800	60,100	77,350	85,739	97,100	497,000
2007	29,400	82,833	110,200	136,782	156,130	880,000
2008	31,400	85,450	113,800	139,824	159,550	868,000
2009	33,300	86,600	115,200	140,102	161,350	842,300
2010	33,900	87,600	115,905	138,579	160,500	827,300
2011	35,000	88,500	116,089	137,154	158,650	828,100
2012	38,100	89,200	116,300	137,235	158,450	838,400
2013	35,500	91,463	118,096	139,334	160,350	848,700
2014	33,600	93,400	120,800	142,667	164,400	871,500
2015	34,800	95,525	124,375	147,427	168,400	927,400
2016	33,800	99,016	128,100	153,617	174,400	1,009,500
Median gross rent (in $)						
1980	60	160	185	199	225	450
1990	175	275	325	335	375	875
2000	225	375	425	459	525	1,125
2007	293	517	587	630	695	1,487
2008	313	533	605	649	715	1,531
2009	337	555	627	674	746	1,604
2010	347	569	641	690	760	1,678
2011	379	582	655	704	775	1,733
2012	360	594	668	717	790	1,802
2013	351	596	672	722	793	1,827
2014	345	606	683	735	810	1,861
2015	356	625	702	757	832	1,973

2016	392	644	722	781	857	2,158
Percent housing units with no telephone						
1980	0.94	5.48	8.68	10.33	14.01	65.63
1990	0.50	4.31	7.10	8.35	11.33	59.67
2000	0.24	1.92	3.25	3.92	5.18	46.11
2007	0.44	3.12	4.35	4.91	6.04	37.29
2008	0.29	2.68	3.74	4.24	5.15	35.70
2009	0.11	2.26	3.04	3.50	4.14	30.66
2010	0.27	1.88	2.50	2.90	3.29	30.38
2011	0.31	1.90	2.46	2.84	3.17	30.47
2012	0.24	1.97	2.51	2.86	3.18	29.68
2013	0.34	2.02	2.52	2.84	3.14	31.37
2014	0.22	2.08	2.55	2.87	3.19	25.85
2015	0.37	1.91	2.38	2.66	2.96	21.68
2016	0.34	1.78	2.23	2.50	2.83	20.63
Percent housing units with incomplete plumbing						
1980	0.27	2.03	3.70	5.43	7.06	70.51
1990	0.00	0.76	1.48	2.34	2.85	64.80
2000	0.09	0.83	1.53	2.57	3.02	72.23
2007	0.00	0.28	0.47	0.66	0.77	27.27
2008	0.00	0.30	0.49	0.68	0.82	27.83
2009	0.00	0.31	0.50	0.71	0.86	25.31
2010	0.00	0.29	0.49	0.71	0.84	25.15
2011	0.00	0.27	0.45	0.66	0.75	23.60
2012	0.00	0.26	0.44	0.63	0.72	23.34
2013	0.00	0.25	0.41	0.60	0.69	23.70
2014	0.00	0.23	0.38	0.56	0.64	23.09
2015	0.00	0.24	0.38	0.57	0.66	22.95
2016	0.00	0.24	0.38	0.56	0.65	22.90

Appendix B

VARIABLE CONTRIBUTIONS TO THE 2ND, 3RD AND 4TH COMPONENTS BY ACS PERIOD

Variable	Census			ACS time period (indexed by mid-calendar year)									
	1980	1990	2000	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2nd principal component													
% pop. 25+ <9 years educ.	0.1	0.7	0.7	3.2	3.2	3.0	2.9	2.8	2.8	3.0	3.7	3.9	4.8
% pop. 25+ 12+ years educ.	0.5	0.6	0.1	2.1	2.3	2.4	2.4	2.5	2.4	2.4	2.7	2.7	3.2
% pop. 16+ White Collars	11.7	12.2	12.9	8.7	8.4	8.4	8.4	8.7	9.1	9.3	8.8	9.1	8.8
Unemployment rate	28.1	16.9	23.8	8.3	8.4	9.6	11.3	11.8	12.0	12.3	13.0	12.6	11.7
Median household income	0.6	3.3	2.6	2.4	2.1	1.7	1.4	1.1	1.0	1.1	1.3	1.5	1.8
Income disparities	0.6	0.6	1.8	25.1	26.0	25.4	25.7	27.3	27.9	27.4	26.0	26.9	26.3
% pop. < poverty threshold	4.8	5.7	8.3	6.2	6.2	6.3	6.7	7.7	7.9	7.6	7.1	7.0	6.6
Median home value	13.7	21.8	16.8	17.2	17.6	17.3	17.0	16.1	15.9	16.3	16.6	16.5	16.7
Median rent for housing	12.0	17.4	17.2	18.3	18.7	18.6	18.6	18.1	18.1	18.0	18.4	17.8	18.2
% housing without telephone	13.0	7.2	2.9	4.8	4.4	4.6	3.4	2.1	1.4	1.2	1.0	0.7	0.5
% housing with no/def. plumb.	14.8	13.8	12.9	3.5	2.6	2.6	2.4	1.9	1.5	1.3	1.4	1.4	1.5
3nd principal component													
% pop. 25+ <9 years educ.	1.7	15.6	17.6	0.0	0.7	0.1	0.7	6.2	22.2	38.2	38.0	37.6	37.3
% pop. 25+ 12+ years educ.	1.6	11.7	13.8	0.0	0.2	0.0	0.1	2.3	10.1	20.0	20.0	20.2	20.0
% pop. 16+ White Collars	5.6	13.9	0.0	2.5	3.2	1.8	2.5	3.4	4.4	3.7	3.6	4.0	4.5
Unemployment rate	66.0	24.2	2.0	2.3	0.8	0.0	0.2	0.6	1.9	1.5	2.1	2.3	3.4
Median household income	1.5	7.2	2.0	0.2	0.6	0.7	1.1	1.9	2.9	1.8	1.6	1.3	1.1
Income disparities	0.0	1.1	1.0	16.6	17.1	14.8	14.6	17.4	18.4	12.6	14.7	11.4	10.7
% pop. < poverty threshold	4.1	8.4	1.4	2.2	3.4	3.5	4.0	4.8	6.0	3.8	3.6	3.2	3.4
Median home value	5.2	4.9	6.7	0.3	0.9	0.4	0.9	2.6	4.9	4.7	4.3	3.9	3.4
Median rent for housing	1.5	1.7	5.1	0.7	1.5	0.7	1.3	3.4	6.0	6.1	5.4	4.9	4.0
% housing without telephone	9.8	0.8	0.0	0.4	1.1	9.2	13.0	7.2	1.1	6.4	6.0	7.2	5.9
% housing with no/def. plumb.	3.3	10.6	50.4	74.7	70.4	68.6	61.4	50.2	22.1	1.2	0.8	4.1	6.2
4th principal component													
% pop. 25+ <9 years educ.	8.4	9.5	10.6	33.6	34.3	35.8	36.8	31.7	16.6	0.1	0.0	1.0	1.4
% pop. 25+ 12+ years educ.	9.3	11.4	8.4	21.0	20.0	20.0	20.3	17.9	10.2	0.0	0.1	0.0	0.1
% pop. 16+ White Collars	22.1	1.1	16.4	5.2	4.0	3.9	2.8	1.4	0.1	1.1	0.9	1.0	0.9
Unemployment rate	0.5	0.8	11.5	2.9	3.4	3.0	2.5	1.1	0.2	0.5	0.6	1.2	1.1
Median household income	20.0	0.0	6.7	1.2	1.4	2.1	2.2	1.3	0.1	0.8	0.7	1.2	1.2
Income disparities	12.8	1.8	3.2	10.3	7.9	11.3	8.7	4.2	0.2	5.5	4.8	7.1	8.8
% pop. < poverty threshold	13.2	3.3	9.6	2.8	2.6	3.6	3.2	1.6	0.1	1.9	1.4	2.1	2.5
Median home value	0.2	9.0	3.5	8.6	6.6	6.4	5.0	3.2	0.8	0.6	0.4	1.0	1.0
Median rent for housing	3.1	1.5	2.0	5.2	4.8	5.6	5.2	3.7	1.0	0.6	0.4	0.8	0.9
% housing without telephone	0.8	0.0	4.2	4.4	4.4	2.3	3.8	11.1	18.5	14.7	12.2	16.3	17.0
% housing with no/def. plumb.	9.7	61.5	23.8	4.8	10.7	5.9	9.4	22.8	52.2	74.2	78.5	68.2	65.1

Appendix C

FACTOR LOADINGS (VARIABLE CORRELATIONS) FROM THE PCA RUN BY SINGH (2002) FROM THE 1970, 1980 AND 1990 CENSUS DATA AND BY US FROM 1980, 1990 AND 2000 CENSUS DATA.

Variable	Singh's study (2002)			HMD project		
	1970	1980	1990	1980	1990	2000
% pop. 25+ <9 years education	0.7924	0.8743	0.8319	0.8913	0.8437	0.7877
% pop. 25+ 12+ years education	-0.8862	-0.8730	-0.8569	-0.8940	-0.8681	-0.8651
% pop. 16+ White Collars	-0.6661	-0.6862	-0.7058	-0.7166	-0.7359	-0.6955
Unemployment rate	0.2115	0.2809	0.5749	0.3011	0.6222	0.6188
Median household income	-0.8975	-0.8923	-0.9029	-0.8616	-0.8883	-0.8973
Income disparities*	0.7810	0.7070	0.8438	0.8732	0.8727	0.8839
% pop. < poverty threshold	0.8524	0.8748	0.8700	0.8642	0.8624	0.8640
Median home value	-0.7245	-0.7626	-0.6601	-0.7660	-0.6834	-0.7434
Median rent for housing	NA	-0.8390	-0.7977	-0.8326	-0.8081	-0.7860
% housing without telephone	0.8480	0.7424	0.8013	0.7679	0.8271	0.8062
% housing with no complete plumbing	0.8766	0.7524	0.6502	0.7428	0.4999	0.3373

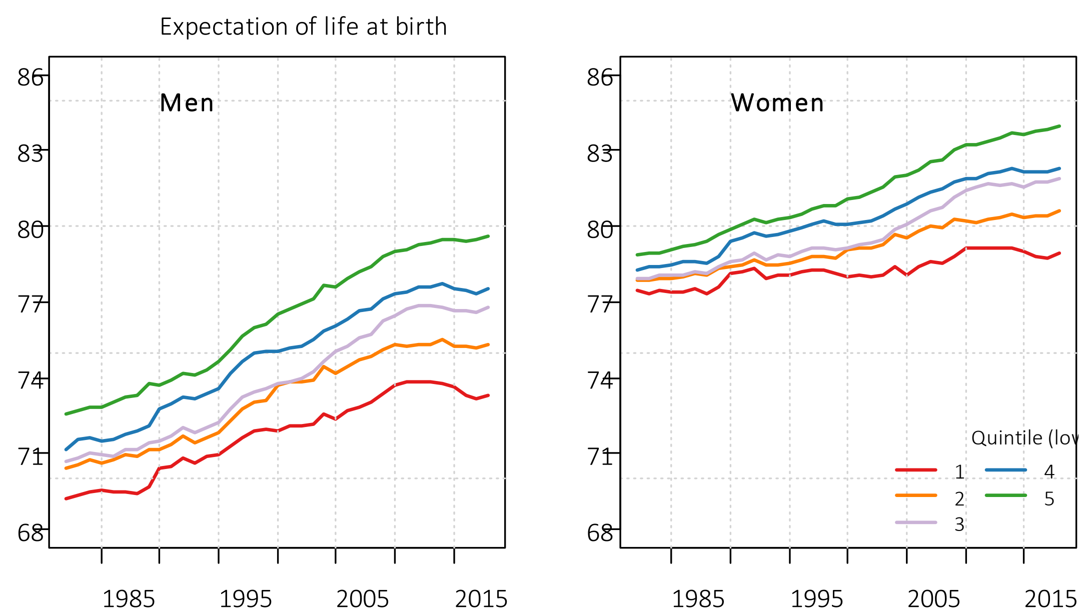
* Income disparity was not measured in the same way in Singh's study as in ours. In Singh's study, income disparity was defined as the ratio of the number of households with less than $10,000 income to the number of households with greater than or equal to $50,000 in 1990, the ratio of the number of households with less than $5,000 to the number of households with greater than or equal to $25,000 in 1980 and the ratio of the number of households with less than $3,000 to the number of households with greater than or equal to $15,000. We adapted this measure to the data available in the ACS for the sake of consistency. In our study, income disparity is measured by the ratio of the mean household income in the highest quintile to the mean household income in the lowest quintile.

Appendix D

Report Figures for County Quintiles

Figure D.1

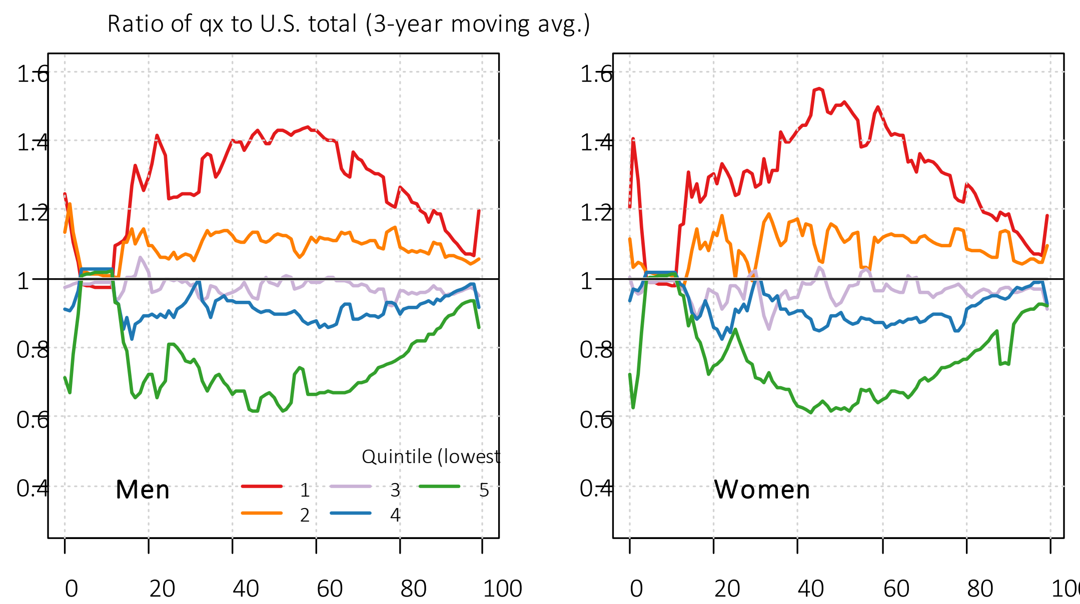
EXPECTATION OF LIFE AT BIRTH (IN YEARS) SOCIOECONOMIC QUINTILE FOR EACH SEX, 1982–2018



Note: The first quintile represents the 20 percent of the population in counties with the lowest SISs and the fifth quintile represents the 20 percent of the population in counties with the highest SISs.

Figure D.2

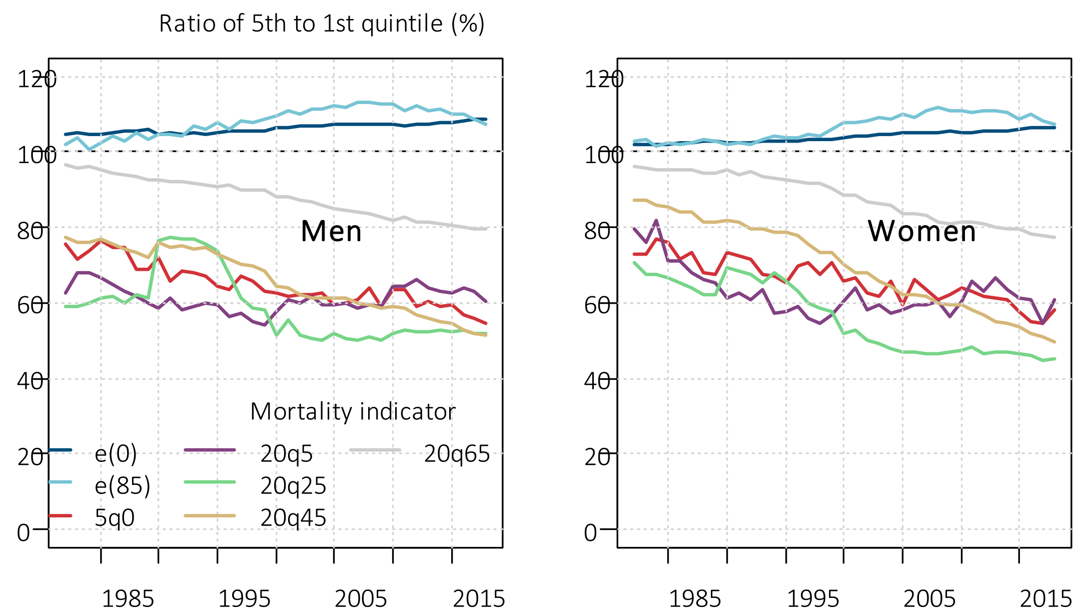
RATIO OF THE PROBABILITIES OF DYING (q_x) IN EACH QUINTILE TO THE U.S. TOTAL, EACH SEX, 2018 (%)



Note: The first quintile represents the 20 percent of the population in counties with the lowest SISs and the fifth quintile represents the 20 percent of the population in counties with the highest SISs.

Figure D.3

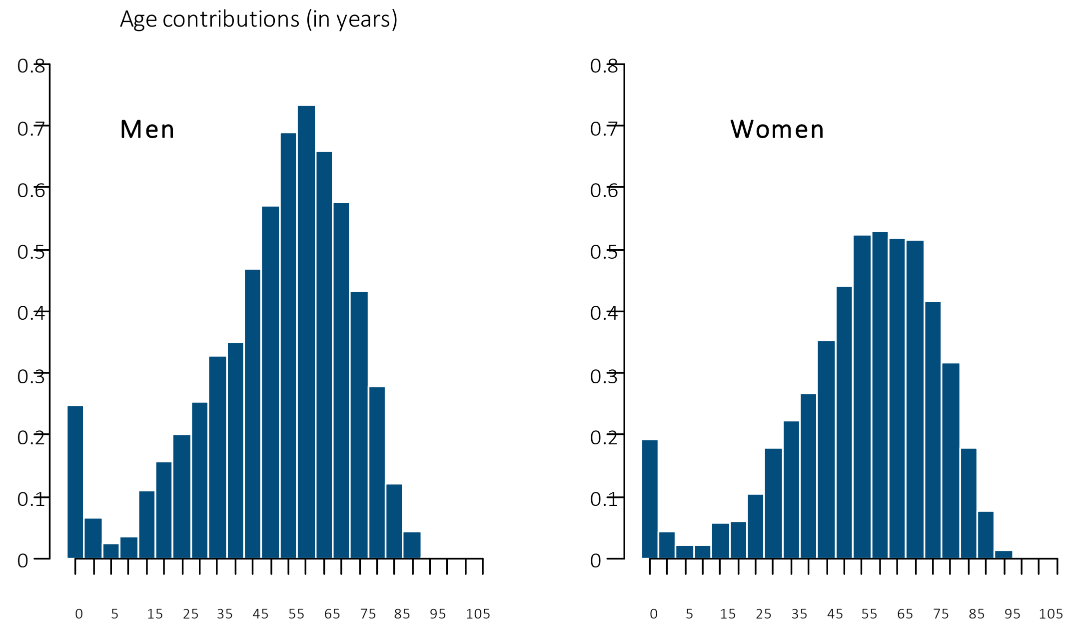
RATIO OF THE FIFTH TO THE FIRST QUINTILE FOR SELECTED MORTALITY INDICATORS BY SEX



Note: The first quintile represents the 20 percent of the population in counties with the lowest SISs and the fifth quintile represents the 20 percent of the population in counties with the highest SISs.

Figure D.4

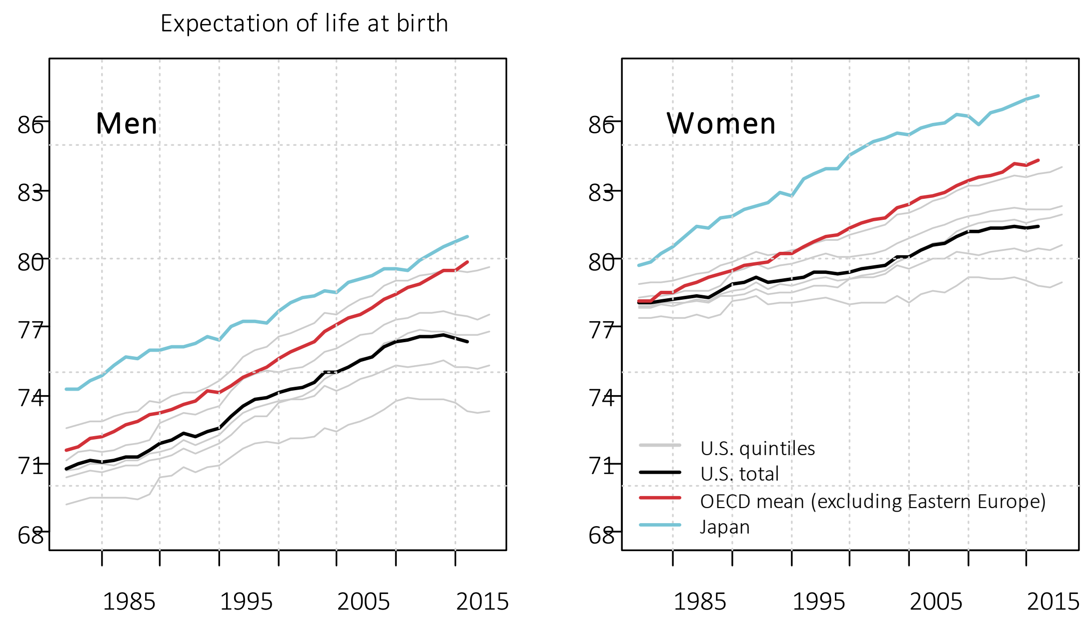
AGE CONTRIBUTIONS TO THE DIFFERENCE IN LIFE EXPECTANCY AT BIRTH BETWEEN THE FIFTH AND FIRST QUINTILE, EACH SEX, 2018



Note: The first quintile represents the 20 percent of the population in counties with the lowest SISs and the fifth quintile represents the 20 percent of the population in counties with the highest SISs.

Figure D.5

TRENDS IN LIFE EXPECTANCY AT BIRTH IN U.S. QUINTILES, THE U.S. AS A WHOLE, THE OECD* AND JAPAN, EACH SEX, 1982–2018



*Excluding Eastern European countries as well as Mexico and Turkey.

Note: The first quintile represents the 20 percent of the population in counties with the lowest SISs and the fifth quintile represents the 20 percent of the population in counties with the highest SISs.

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