CENTER for RETIREMENT RESEARCH at BOSTON COLLEGE

WILL SURVIVORS OF THE FIRST YEAR OF THE COVID-19 PANDEMIC HAVE LOWER MORTALITY?

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Abstract

The mortality burden of the COVID-19 pandemic was particularly heavy among older adults, racial and ethnic minorities, and those with underlying health conditions. These groups are known to have higher mortality rates than others even in the absence of COVID. Using data from the 2019 *American Community Survey*, the 2018 *Health and Retirement Study,* and the 2020 National Vital Statistics System, this paper estimates how much lower the overall mortality rate will be for those who lived through the acute phase of the early pandemic after accounting for this selection effect of those who died from COVID. Such selection may have implications for life insurance and annuity premiums, as well as assessments of the financial standing of Social Security – if the selection is large enough to substantially alter projected survivor mortality.

The paper found that:

- 10-year mortality rates, absent direct COVID deaths and long COVID, will likely be lower in 2021 than anticipated in 2019.
- However, these differences are small, ranging from a decline of 0.4 percentage points for people in their 60s to 1 percentage point for those in their 90s.
- The small difference is in spite of the fact that COVID mortality was, indeed, very selective, with mortality declines exceeding half the maximum possible declines, holding total COVID deaths constant, for every age group.

The policy implications of the findings are:

- That declines in mortality due to COVID selection likely will not impact overall population mortality substantially enough to affect Social Security cost projections.
- Any impact of selection effects on Social Security costs will likely be swamped by ongoing mortality increases directly attributable to acute and long COVID.

Introduction

The COVID-19 pandemic has claimed over a million American lives, with half of that toll occurring in the year between March 2020 and March 2021. The burden was particularly heavy among older adults, racial and ethnic minorities, and those with underlying health conditions (Dyer et al. 2020; Alsan, Chandra, and Simon 2021; Ruhm 2021). These groups are known to have higher mortality rates than others even in the absence of COVID, potentially limiting the years of life lost to the pandemic.[1] What has not been as thoroughly explored is the implication of this selection effect for the mortality rates of those who survived the pandemic. This paper estimates how much lower the overall mortality rate will be for those who lived through the acute phase of the early pandemic after taking into account the selection effect of those who died from COVID. Such selection may have implications for life insurance and annuity premiums, as well as assessments of the financial standing of Social Security – if the selection is large enough to substantially alter projected survivor mortality relative to pre-COVID expectations.

The analysis uses the *American Community Survey* (ACS) of 2019 and the *Health and Retirement Study* (HRS) of 2018 to estimate the demographic and health distributions, respectively, of the over-60 2019 population. The *National Vital Statistics System* (NVSS) data from 2020 are then used to analyze deaths, by cause, in 2020 and, by extrapolation, early 2021. These data are combined to arrive at an estimated distribution of the April 2021 population by gender, race, ethnicity, and health status.

Based on this adjusted distribution, new life tables by gender are calculated, and compared with the pre-COVID life tables. These estimates are made under the *counterfactual* assumption that COVID will not directly impact mortality going forward either through new infections or long COVID. This assumption is adopted since it provides the most conservative estimate from the perspective of Social Security's finances.

The comparison of pre- and post-COVID life tables reveals that COVID mortality was, indeed, very selective. However, despite the large death toll from COVID, the share of older adults who died during the first year of the pandemic was not enough to substantially alter mortality rates in the next few years. Moreover, COVID mortality was less selective among the older population than among the younger cohorts.

[1] For racial gradients in mortality, see Wettstein et al. (2021).

The rest of the paper proceeds as follows. The next section provides the background for the analysis. The third and fourth sections describe the data and methodology. The fifth section presents the results. The final section concludes that COVID victims were very concentrated in otherwise high-mortality populations; however, the scale of COVID deaths was such that this selection leads to only modest reductions in projected future mortality.

Background

The COVID pandemic was an enormous shock to all aspects of life, including mortality. To date, over a million Americans (and many millions more around the world) have died of COVID.[2] This toll is evidenced by the many deaths clearly attributable to COVID, as well as even higher excess mortality over the past two years.[3]

COVID deaths were not random. Some groups of people were more likely to be exposed to COVID, and some groups, conditional on exposure, were more likely to suffer severe consequences. In particular, Black and Hispanic individuals were more likely to come in contact with COVID in the early months of the pandemic (Hooper, Nápoles, and Pérez-Stable 2020; Sarkar et al.2021). Meanwhile, for those contracting COVID, the disease was more dangerous to those with certain preexisting health conditions and to older individuals (Imam et al. 2020; Harrison et al. 2020). Specifically, the Centers for Disease Control (CDC) noted seven categories of chronic health conditions that are associated with elevated risk from COVID: cancer, cerebrovascular disease, diabetes, heart disease, kidney disease, lung disease, and obesity.

With the exception of Hispanics, the groups most at risk from COVID were also more likely to die within a given time period than other groups even in the absence of COVID. Mortality was higher among Black than among white Americans through 2019 (Wettstein et al. 2021). Mortality rates also, of course, rise with age and are higher among individuals with a large range of health problems, particularly those that lead to increased risk of COVID mortality (Raghavan et al. 2019; Zucker et al. 2017; Soedamah-Huthu 2006; Badar et al. 2015; Lowe et al. 1998; Flegal et al. 2013; Mannino et al. 2003; Pedone 2010; Razmara et al. 2017; Ikeda et al. 2009; Florez-Perdomo et al. 2020; Ketchandji et al. 2009; Schonberg et al. 2011; Tu et al. 2018).

[2] World Health Organization (2022).
[3] See, for example, Mulligan and Arnott (2022).

The implication of elevated COVID mortality among otherwise high-mortality groups is that fewer members of those groups are likely to have survived into late 2021, and survivors of the pandemic's first year are likely to have lower non-COVID mortality.

Such survivor selection might have implications for academic and practical forecasts of mortality in the coming years. To be sure, the overwhelming impact of the pandemic has been to increase mortality rates since 2019; however, a *second order* effect of selection may mitigate mortality increases once the acute phase of the pandemic has passed. For researchers, life insurers, and pension providers, looking beyond the direct effects of COVID on mortality to these second-order effects is necessary for determining expected mortality trajectories, setting life insurance and annuity premiums, and determining appropriate funding levels for life-contigent policies. Furthermore, correctly attributing any mortality decline in future years to this acceleration of deaths is necessary for understanding the rate of improvement in life expectancy due to more permanent factors, such as medical innovation, in assessing longer-term trends.

The potential impact of survivor selection is particularly important for Social Security. As one of the largest providers of life-contingent payments in the world, forecasting mortality rates in the near- and long-term is essential to understanding the sufficiency of funding streams for the program. In particular, since the Old-Age and Survivors Insurance (OASI) program's costs increase when mortality declines, the heavy death toll of the last few years has had a beneficial impact on program finances. However, the program's actuaries are already looking ahead to the effects on their life tables in the coming years. The acceleration of deaths of otherwise high-mortality individuals due to the pandemic may require new life tables to be estimated.[4]

Of course, if COVID-19 continues to account for many deaths in the next few years despite widespread vaccination, future mortality will not decline as much, if at all. Similarly, if survivors of COVID-19 have elevated mortality risk due to further health complications, like "long COVID," that too would increase mortality.[5] While both these effects would improve OASI's finances, the analysis here assumes that they are negligible in order to provide a *conservative* estimate of future improvement in mortality from the perspective of OASI.

[4] The new life tables will be relevant for projections over the next decade or so. The decomposition of trends to COVID-19 vs. more permanent changes can inform longer-term projections of mortality that rely on long-run trends in mortality decline (U.S. Social Security Administration 2015).
[5] For example, see Li et al. (2021).

A further limitation of the analysis lies in the availability of timely data. Two main constraints are relevant here: data on deaths and data on the joint distribution of health conditions and demographic characteristics in the population. The next section describes the data used in the analysis and its limitations.

Data

Our analysis rests on three main data sources: the ACS, the HRS, and the NVSS. The 2019 ACS is used to estimate the demographic distribution of the population on the eve of the pandemic – the share of those over 60 that fall into each category defined by the intersection of gender, race, ethnicity, and 10-year age bins. Similarly, the 2018 wave of the HRS is used to estimate the health distributions of the 2019 population – the share of each demographic group that has each of the relevant chronic health conditions accounted for in the analysis.

In choosing which health conditions to include, the analysis is guided by two imperatives: 1) health conditions must be disproportionately affected by COVID; and 2) they must be measurable in the HRS. To determine the former, the set of chronic conditions starts with those cited by the CDC as of March 2021 (CDC 2021) as increasing the risk of severe illness from COVID.[6] These conditions are then further restricted to those that are asked about in the HRS.

The following set of conditions meet these two criteria: cancer, cerebrovascular disease, diabetes, heart disease, lung disease, and obesity.[7] Moreover, while comorbidities are common, to maintain sufficient sample sizes of demographic-health conditions cells, individuals with multiple conditions are assigned to the one with the highest risk of COVID mortality.

In the case of both the ACS and HRS, the years chosen reflect the final survey years unambiguously prior to the pandemic. For the ACS, this choice does not seem to entail much risk for error, since at best more timely data would have covered just the first two months of 2020 (assuming a pandemic start date of March 2020). However, in the case of the HRS, the two-year gap between survey waves leads to some potential inaccuracy in the estimated disease profile of the population if that profile changed substantially between 2018 and early 2020.

[6] These are conditions that the CDC defines as "having a published meta-analysis or systematic review or completing the CDC systematic review process. The meta-analysis or systematic review demonstrates a conclusive increase in risk for at least one severe COVID-19 outcome."

[7] Since March 2021, some conditions have been added to the CDC list that are not included in the analysis at this stage. In particular, mental health conditions (such as mood disorders) and neurological conditions (such as dementia) are not included in the analysis but could be incorporated in future work.

To examine whether the extrapolation of disease prevalence from 2018 to 2020 might bias estimates, Figure 1 displays the time trends in these conditions since 1992 (the first wave of the HRS). For ease of exposition, these trends are calculated for the full over-60 population, rather than by demographic subgroups. The figure shows that changes in the prevalence of these conditions have been fairly modest year-to-year, at least since 2006. Consequently, the analysis proceeds under the assumption that the 2018 chronic condition distribution is a close approximation of the early 2020 distribution.

Figures 2a and 2b display the estimated distribution of health conditions by gender and age group on the eve of the pandemic.[8] The patterns in the figure illustrate some of the issues present in the remainder of the analysis. First, the shorthand of "healthy" is used to describe individuals who report having none of the enumerated chronic health conditions; however, such individuals may well have other conditions not included in this analysis. They may even have some of the conditions that are considered, but not be aware of them (e.g., undiagnosed diabetes).

Second, the age trends and gender differences in the prevalence of the various conditions demonstrate the importance of accounting for the joint distribution of health and demographic groups. Unsurprisingly, the healthy group's size declines with age in both genders, but women tend to be healthier in any given age category. Similarly, heart disease is more common among men at all ages, while obesity prevalence is similar across genders. Finally, some of the trends by age are likely due to survivors being selected to be healthier; however, some are an artifact of the assignment of individuals to a single condition when they have comorbidities. For example, diabetes does not likely decline with age so much as it is supplanted by more life-threatening conditions, which tend to arise among those with diabetes.

The goal of this exercise is to characterize the over-60 U.S. population after the first year of the pandemic. Thus far, this population has been characterized in terms of its demographic and health distribution as of 2019. To take the extra step of estimating the population composition in 2021, the 2020 NVSS is used to analyze deaths, by demographic group and cause of death, in 2020 and, by extrapolation, early 2021. The NVSS, accessed through the WONDER

[8] The analysis uses an even finer partition of the population, with health conditions estimated by age, gender, race, and ethnicity; see Figure 3. However, for the purposes of describing the pre-pandemic population, a more aggregated partition with larger sample sizes allows for a more accurate discussion of broad trends.

database, records all deaths in the United States based on death certificates. Because deaths are reported with a lag, the analysis relies solely on 2020 data to estimate deaths in each demographic-health group through the March 2020-March 2021 period. The precise method for this analysis is described in the next section.

Methods

The analysis has three conceptual parts: 1) to characterize the 2019 population of older adults by their demographics and health conditions; 2) to adjust this estimated population for COVID-19 and non-COVID-19 deaths in 2020 and early 2021, in proportion to the demographics and health conditions identified, resulting in a predicted late 2021 population; and 3) to analyze the impact of selection in COVID deaths on life tables for the estimated late-2021 population relative to pre-pandemic expectations.

Characterizing the 2019 Population

The first part, estimating the distribution of the population over age 60 in 2019 into demographic-health cells, is straightforward. Demographic groups, indexed by g, are defined by the intersection of gender, race, ethnicity, and 10-year age bins starting at 60. The size of each group is estimated from the 2019 ACS.

Next, the share of each group g suffering from each of the relevant chronic health conditions, indexed by h, is estimated based on the HRS. The "healthy" group, with none of these conditions, is denoted by $h=1$. The resulting partition of the population into cells defined by demographics and health is shown in Figures 3a-3d, which are, themselves, a more detailed breakdown of the simplified distribution displayed in Figure 2.

Adjusting the Population for Deaths in March 2020-March 2021

The base population from the first step is then adjusted to account for two types of attrition: non-COVID and COVID mortality in the first year of the pandemic, between March 2020 and March 2021. Fundamentally, these data are from the NVSS. However, death records in the NVSS list the demographics of the decedent, but not what health conditions they may have had. Thus, assumptions must be made in assigning deaths to each demographic-health cell.

Specifically, three kinds of deaths need to be accounted for: deaths of causes related directly to each of the COVID-relevant chronic health conditions; all other non-COVID deaths; and deaths directly attributable to COVID. Each kind of death is handled differently. Particular care is given to assigning COVID deaths, since this categorization is at the root of the analysis.

Assigning Non-COVID Deaths

First, deaths of causes directly linked to the chronic conditions of interest must be allocated to the different demographic-health groups. The intuition here is that deaths determined to be caused by, for example, heart disease, are more likely to occur among individuals with known heart conditions than among the general population. Furthermore, the pandemic seems to have exacerbated many causes of death that are not directly related to COVID, and so accounting for specific changes in non-COVID causes of death during the pandemic may be important in accurately forecasting who is alive after the pandemic's first year.

To account for this intuition, the analysis assumes that individuals in each cell who die from any cause corresponding to the listed conditions come first out of the individuals with that condition. For example, if among Black men ages 60-70 there were 100 cancer-related deaths and 500 people with cancer, all cancer-related deaths would be assumed to come from that group. If, instead, there were only 50 people with cancer, then all 50 would be assumed to have died of cancer, while the remaining 50 would be assumed to have come from the other health-condition groups, according to their relative baseline size.

In practice, this latter case of "excess" deaths spilling over into other categories is rare. This outcome almost exclusively happens in either the 90-99 age groups or the "other" race group due to small sample sizes of these groups in the HRS. Appendix Table A1 documents precisely which groups experience this situation.

All other causes of death (e.g., accidents) are treated much as chronic-condition-related deaths that exceed their demographic-health group size. That is, within a demographic group, such deaths are assigned to all the health groups in proportion to their size, implicitly assuming an equal hazard of death for all health groups within a demographic cell. While this assumption is no doubt incorrect, it is the most agnostic position to take.

Assigning COVID Deaths to Demographic-Health Cells

To determine which demographic-health group is assigned each COVID death in the NVSS, the following procedure is adopted. First, for each chronic health condition, a literature review was conducted to find the COVID mortality risk relative to a healthy individual. Thus, for example, a person with diabetes has a 56-percent higher risk of death from COVID than a healthy individual, according to Williamson et al. (2020).[9]

Table 1 lists the studies included in the literature review. The table lists, for each health condition, the COVID mortality hazard ratios implied by the study for individuals with the condition relative to healthy individuals. The table further details the country and age ranges of the study sample and any additional notes and assumptions made to arrive at a single relative hazard number.

The bolded studies are those that were ultimately chosen to determine the COVID mortality risk associated with each condition. In making this choice, preference was given first to studies in the United States. Barring that, studies in OECD countries were preferred. Finally, in case multiple studies remained after the application of these criteria, the ones with a population age range most closely approximating the over-60 population of interest were selected.

Next, the number of COVID deaths in 2020 in each group *g* were acquired from the NVSS. These deaths were then allocated between the health-conditions *h* within *g* based on *h*'s relative risk of dying from COVID-19, compared to the "healthy" population. This process assumes the risk of *getting* COVID is independent of health status, but allows the risk to vary by demographics. The procedure thus accounts for the documented elevated risk of COVID exposure by race and ethnicity.

Specifically, the allocation of deaths to health conditions within a demographic group is accomplished by solving the following system of equations:

$$d^g = \sum_h^H d_h^g$$

$$d_h^g = \frac{n_h^g}{n_1^g} * x_h * d_1^g, h = 2, \dots, H,$$

[9] Averaged over the different HbA1c levels examined in that study.

where d^g is the number of COVID deaths in group g; d_h^g is the number of deaths within each health category h within group g (the main variables to be solved for); n_h^g is the share of group g in the h health category; and x_h is the relative mortality risk of the h category relative to $h=1$.

Overall, this procedure for assigning all deaths by their cause to each demographic-health group yields an estimate of the number of people in each health status of each demographic group who are still alive by the end of 2020. As data for 2021 may not yet be complete, the 2020 mortality rates are extrapolated to the first quarter of 2021. That is, each health-demographic type is assumed to lose one quarter as many people in Q1 of 2021 as in all of 2020. The resulting population as of April 1, 2021 is then the base population for the rest of the analysis.

Estimating the Mortality Rates of the Forecasted 2021 Population

The previous steps yield a forecasted April 2021 population, with a best-guess estimate of the distribution of that population into demographic-health cells. The final step is to estimate the mortality of this forecasted population. The difficulty here is estimating the mortality rates of different demographic-health types.

Rather than estimating the rates directly based on small sample sizes in the HRS (particularly for minority groups at advanced ages with relatively rare health conditions), the analysis once more relies on the medical literature. A second review of the literature was undertaken to arrive at hazard rates for individuals with the chronic conditions of interest relative to healthy individuals. The results of this review are in Table 2, which is laid out similarly to Table 1.

With relative hazards in hand, these relative probabilities of death can then be applied to the estimated population of each (g,h) type, adjusting the mortality rate for the full group g from existing 2019 life tables by the hazard ratio for the h health condition. All that is required is the baseline mortality probability of group g.

This baseline 2019 probability of death for each group g is estimated in a manner similar to Wettstein et al. (2021). That is, using the NVSS for the numerator and the ACS for the denominator, non-parametric death rates for each age are estimated. These rates are then fitted with a Gompertz-Makeham function using nonlinear least squares. For the purpose of this

analysis, this function is fitted only to ages 60 and older.[10] Using these fitted values, 10-year age bin mortality rates are calculated.

One final hurdle must be overcome, which is that the mortality rates observed in the population of each group g are composites of the mortality in each subgroup *(g,h)*. The mortality hazard rates from the medical literature give hazards relative to "healthy" individuals. So the mortality of rates of individuals in group g who have none of the chronic conditions, that is, groups *(g,1)*, must be found.

To do so, the overall mortality rate of g is made to conform to the rate resulting from aggregating the rates of all the health conditions within g by solving for the mortality rate of healthy group g-individuals. That is, the mortality of healthy individuals in g, m_1^g, is solved for in the equation: $m_0^g = \sum_1^H W_h^g m_h^g$, where m_0^g is the overall mortality rate of group g and W_h^g is the share of g with condition h.

Finally, new forecasted life tables for men and women can be generated by aggregating the estimated population of each (g,h) type up to the full population by gender and age group. Here, the mortality of each gender-age type is the weighted average of mortality for all the *(g,h)* types comprising the gender-age group, where the weights are given by the forecasted size of each *(g,h)* type.

Two crucial assumptions are made at this point: first, that COVID deaths among older adults are negligible after April 1, 2021. Second, that having had COVID and survived does not substantially increase the rate of any of the listed health conditions or of all-cause mortality; that is, "long COVID" has a negligible effect on mortality in the older population. These rosy assumptions are clearly incorrect, but they provide a conservative estimate of the potential improvement in mortality rates as a result of COVID eliminating the least healthy.

Results

The process outlined above yields gender-specific life tables for the U.S. population ages 60 and over. Table 3 shows these life tables for men and women in panel A and B, respectively. To put the new estimates in context, Column 3 shows the 10-year mortality rate implied by

[10] Restricting the ages targeted by the nonlinear least squares to over 60 yields 10-year mortality rates that are much closer to those implied by published Social Security Administration life tables than using the full range of ages in fitting the function.

published Social Security Administration (SSA) life tables from 2019. Column 4 shows the 10-year mortality rate estimated through the Gompertz-Makeham approach, without adjusting for any of the deaths observed in practice during 2020-2021, COVID or otherwise. Column 5 shows the forecasted mortality rate accounting for the selection deaths that took place during the first year of the pandemic.

Before turning to the main result regarding mortality in a post-COVID environment, comparing the SSA life table to the pre-COVID life table estimated in this analysis provides a baseline of what the methods here might have predicted in the absence of COVID. The two sets of numbers are very close, although the estimates in this analysis are consistently slightly lower than the SSA numbers. Thus, the remainder of the discussion will take the initial estimates from the current analysis as the baseline, so as not to overestimate any reduction in mortality due to COVID by choosing different methods for computing pre-COVID mortality.

The main result apparent in Table 3 is that mortality rates should be expected to be modestly lower post-COVID than what had been expected before the pandemic. The differences are not large, but they are particularly striking in the oldest age groups, where for both men and women a 1-percentage point decline in 10-year mortality is expected due to the selection of mortality during the pandemic's first year.

How large is the estimated reduction in mortality? To give it a proper scale, the estimated decline in mortality can be compared with the maximum possible declines that might have been observed based on overall mortality in 2020-2021. Column 6 of Table 3 shows the predicted life table that would result if, instead of assigning 2020 COVID deaths to the demographic-health groups from which they were most likely drawn based on relative hazard rates, COVID deaths were instead mechanically deducted from the *(g,h)* groups with the highest mortality rates overall. Thus, if COVID mortality were *as selective as possible*, given the total number of actual COVID deaths, Column 6 shows what mortality rates would be by age.

Naturally, the mortality rates in Column 6 are always lower than Column 5, although for younger ages these differences are not apparent after rounding. To focus in on these differences, Figure 4 shows the *change* in 10-year mortality (in red), and the *maximal potential change* (in gray). The figure shows that, as might be expected, absolute declines in mortality increase with age, largely because mortality in general rises sharply with age. Furthermore, pandemic

mortality was very selective: mortality declines are more than half of the maximal possible decline at all ages.[11]

However, a more nuanced finding is that the reduction in mortality as a share of the maximal possible reduction declines with age: for those in their 60s, around 80 percent of the maximal mortality reduction is forecasted to actually take place. In contrast, for those in their 90s only about 50 percent (for men) and 60 percent (for women) of the possible decline is likely to be realized. This pattern implies that COVID was selective in its victims of all ages – but more selective among younger ages, where the most frail were much more likely to succumb than at older ages, where COVID death was relatively likely to happen to all members of the cohort.

Conclusion

COVID took a heavy toll in the United States. The populations that bore the brunt of mortality from COVID were not random; instead, minorities were more likely to be infected and, conditional on infection, older adults andthose with certain chronic health conditions were more likely to suffer severe illness and death.

A consequence of COVID mortality selection is that those who lived through the pandemic are a slightly different population than those who entered the pandemic. The differences lie in both demographic and health condition distributions. Survivors of the first year of the pandemic are therefore less likely to be members of some of these high-mortality groups. This selection might have resulted in a lower mortality rate for the next few years than would have prevailed if the pandemic had not taken place.

This analysis shows that while, directionally, the selection effect is likely to reduce mortality in the near future, the magnitude of the impact of selection on near-term mortality rates is modest. Mortality is anticipated to decline by around one percentage point among those ages 90-99, and less at younger ages.

In addition, the assumptions made in the analysis were conservative from the perspective of OASI's finances. In particular, the analysis assumed that COVID will not directly cause higher mortality going forward and that long COVID will not be associated with elevated

[11] Note that, had COVID mortality been completely random, *no* decline in mortality relative to pre-COVID forecasts would be expected.

mortality risk in the future. Both these assumptions are clearly optimistic. In conjunction with the small impacts that selection among survivors of the first year of the pandemic might have on mortality, we are likely to continue observing above-trend mortality in the next few years.

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Table 1. *Selected Literature on COVID Mortality Hazard Ratios*

Study	Health condition	HR	Country	Age range	Notes
Williamson, E.J., et al. (2020)	***Diabetes***	***1.56***	***UK***	***18+***	***Averaged over HbA1c levels***
Zhu, Lihua, et al. (2020)	Diabetes	1.49	China	18-75	
Woolcott, Orison O., (2021)	Diabetes	1.49	Mexico	20+	HR by 10 year age groups, 1.41 is for 60-69.
Williamson, E.J., et al. (2020)	***Chronic Heart Disease***	***1.17***	***UK***	***18+***	
Gu, Tian, et al. (2020)	Coronary Heart Disease	4.2	China	24-94	
Williamson, E.J., et al. (2020)	***Obesity***	***1.24***	***UK***	***18+***	***Averaged over obesity classes***
Zeng, Jing, et al. (2021)	Obesity	2.54	China	18+	HR (>=65 year old): 3.89 HR(<65 years): 1.53
Hajifathalian, Kaveh, et al. (2020)	Obesity	1.15	USA	18+	Relative Risk, New York City, 770 patients, 29 May
Nakeshbandi, Mohamed, et al. (2020)	Obesity	1.4	USA	18+	Relative Risk ; New York City, 504 patients only. 1.2 for women
Aveyard, Paul, et al. (2021)	***Lung Disease***	***60-79: 1.5 80+:1.04***	***UK***	***20+***	***Averaged over COPD and asthma***
Rabbani, Golam, et al. (2021)	Lung Disease	1.9	China, UK, US	18+	3.13 RR ; meta-analysis
Williamson, E.J., et al. (2020)	***Stroke***	***2.16***	***UK***	***18+***	
Pranata, Raymond, et al. (2020)	Cerebrovascular Disease	2.38	N/A	40+	
Williamson, E.J., et al. (2020)	***Cancer***	***1.16***	***UK***	***18+***	***Averaged over diagnosis timing (includes hematological and nonhematological)***
Khoury, Emma, et al. (2022)	Cancer	1.69	28 countries	35-74	
ElGohary, Ghada, et al. (2020)	Cancer	3.32	China, Spain, USA	10 to 94	Averaged from the RR of all studies from meta analysis
Mangone, Lucia, et al. (2021)	Cancer	1.39	Italy	<50 and >79	Incidence Rate Ratio

Table 2. *Selected Literature on All Cause Mortality*

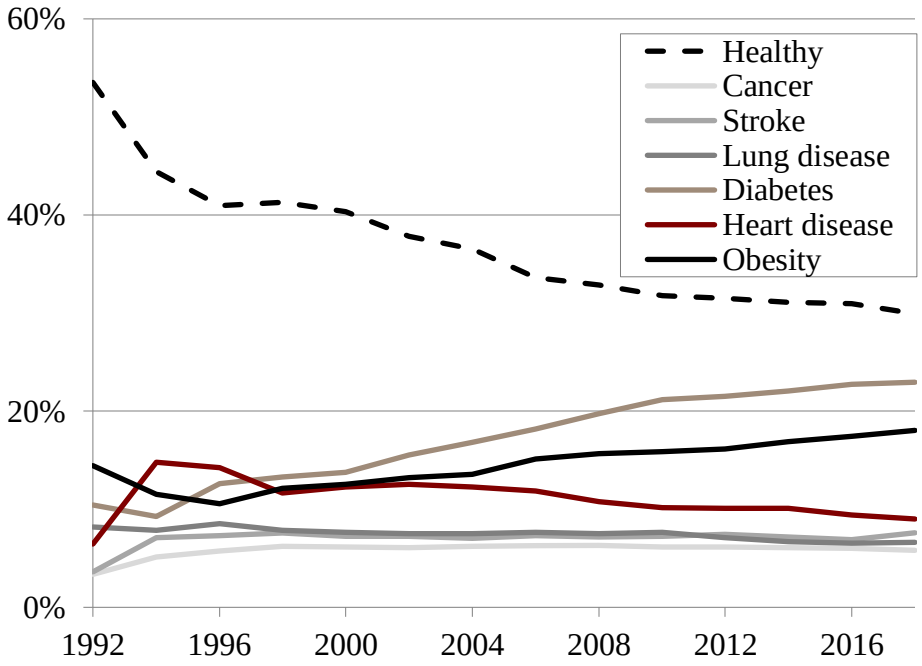
Study	Health condition	HR	Country	Age range	Notes
Raghavan, Sridharan, et al. (2019)	***Diabetes***	***1.29***	***USA***	***Mean age 65***	
Zucker, Inbar, et al. (2017)	Diabetes	1.38	Israel	35+	
Soedamah-Huthu, S.S. (2006)	Type 1 Diabetes	1.6-3.8	UK	35-+	By age group, and gender
Badar, Athar A., et al. (2015)	***Coronary Artery Disease***	***1.3***	***USA***	***60+***	***CAD/Angina***
Lowe, Lynn, et al. (1998)	Cardiovascular Disease	1.34	USA	40-64	HR for women with CVD is 1.45
Flegal, Katherine M., et al. (2013)	***Obesity***	***1.18***	***10+ countries including the US***	***24-80***	***Meta-analysis***
Mannino, D.M., et al. (2003)	***Lung Disease***	***1.53***	***USA***	***25-74***	***Averaged over severity of COPD***
Pedone, Claudio. (2010)	mild COPD	1.26	Italy	65+	
Razmara, Ali, et al. (2017)	***Stroke***	***1.57***	***USA***	***65-74***	
Ikeda, Ai, et al. (2009)	Acute Ischemic Stroke	2.01	Japan	40-69	1.83 for men & 1.74 for women with strokes
Florez-Perdomo et al. (2020)	Cerebrovascular Disease	2.78	China & Italy	30-80	
Ketchandji, Melanie, et al. (2009)	***Prostate Cancer***	***1.35***	***USA***	***66-84***	***Averaged over stages of prostate cancer***
Schonberg, Mara A., et al. (2011)	***Breast Cancer***	***1.41***	***USA***	***67+***	***Averaged over stages of breast Cancer***
Tu, Huakang, et al. (2018)	Cancer	1.5	Taiwan	18+	Risk of Cancer Death

Table 3. *10-year Mortality Rates, SSA 2019 Life Tables versus Post-COVID Adjustments*

Gender	Age group	SSA	Initial rate	Adjusted	Maximum possible effect
M	60-69	14.7%	14.6%	14.6%	14.6%
M	70-79	29.6	29.2	29.1	29.0
M	80-89	63.1	61.9	61.5	61.2
M	90-99	94.3	94.9	93.8	92.7
F	60-69	9.2	9.2	9.2	9.2
F	70-79	21.7	20.8	20.7	20.7
F	80-89	53.1	51.4	51.0	50.9
F	90-99	90.1	91.4	90.3	89.6

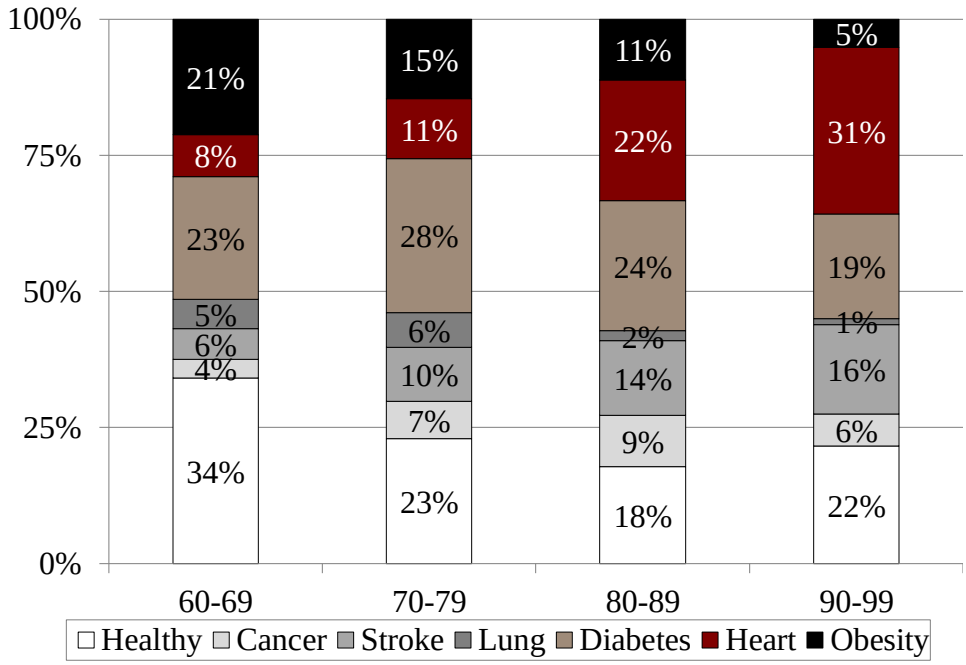
Sources: SSA (2019); and authors' calculations.

Figure 1. *Distribution of Health Conditions for 60+ in HRS, 1992-2018*



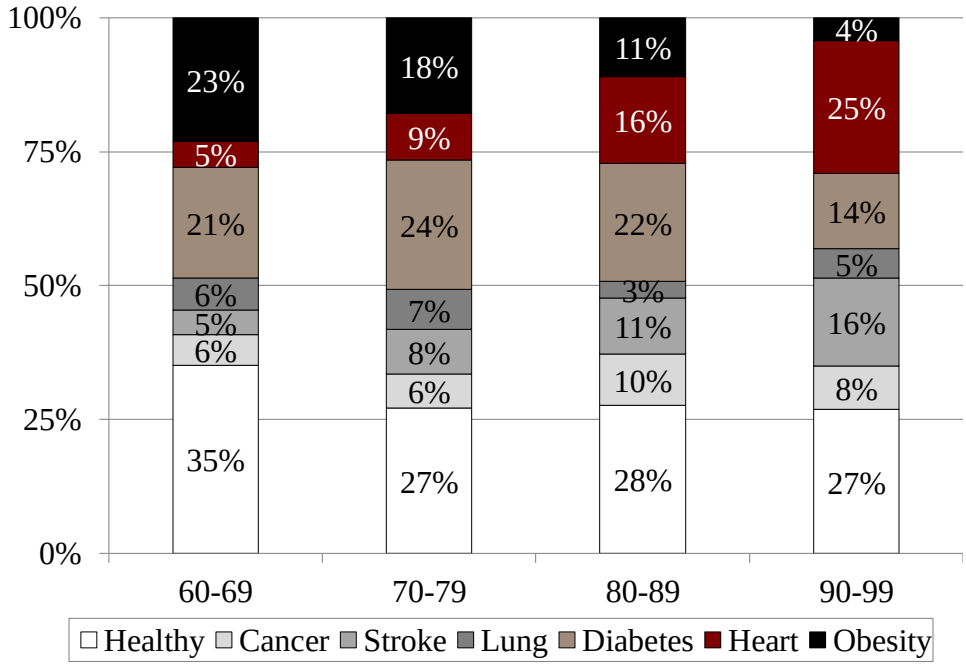
Source: Authors' calculations from University of Michigan, *Health and Retirement Study* (HRS) (1992-2018).

Figure 2a. *Distribution of Health Conditions by Age Group for Men*



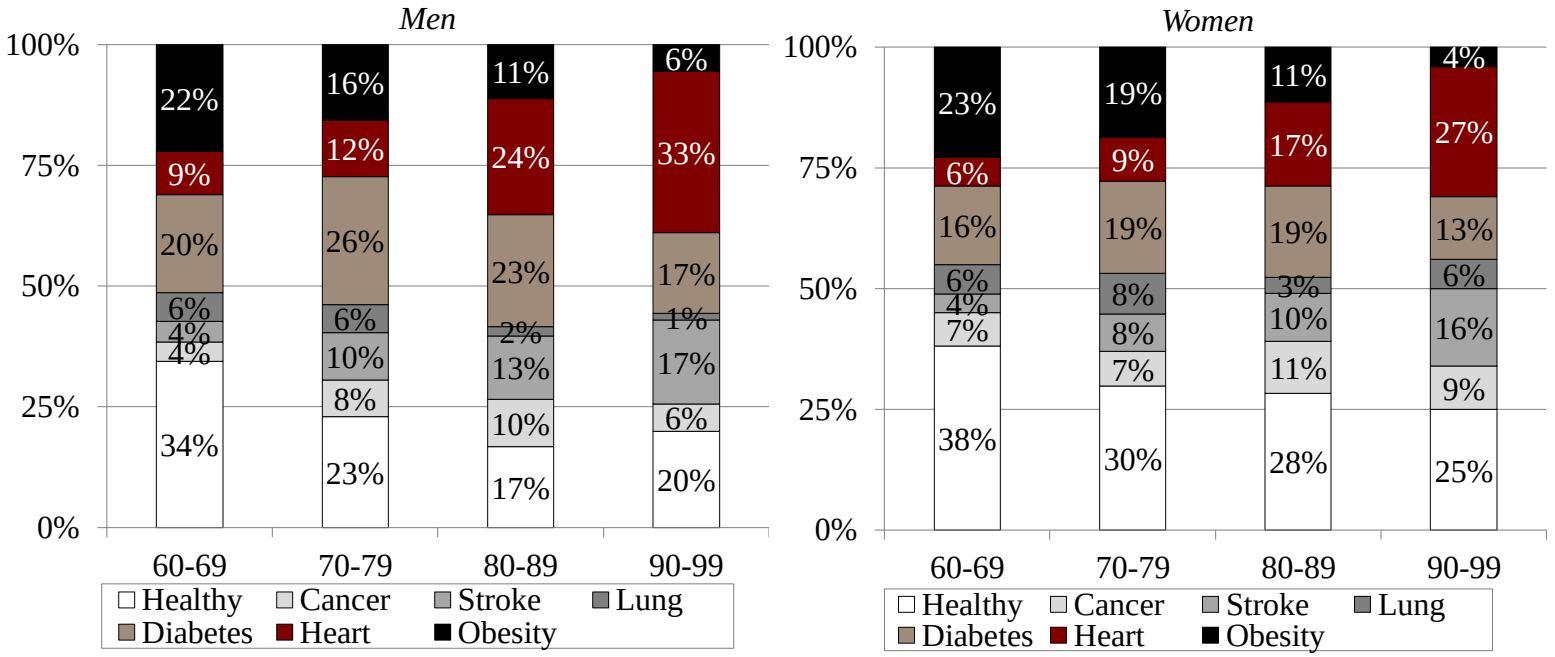
Source: HRS (2018).

Figure 2b. *Distribution of Health Conditions by Age Group for Women*



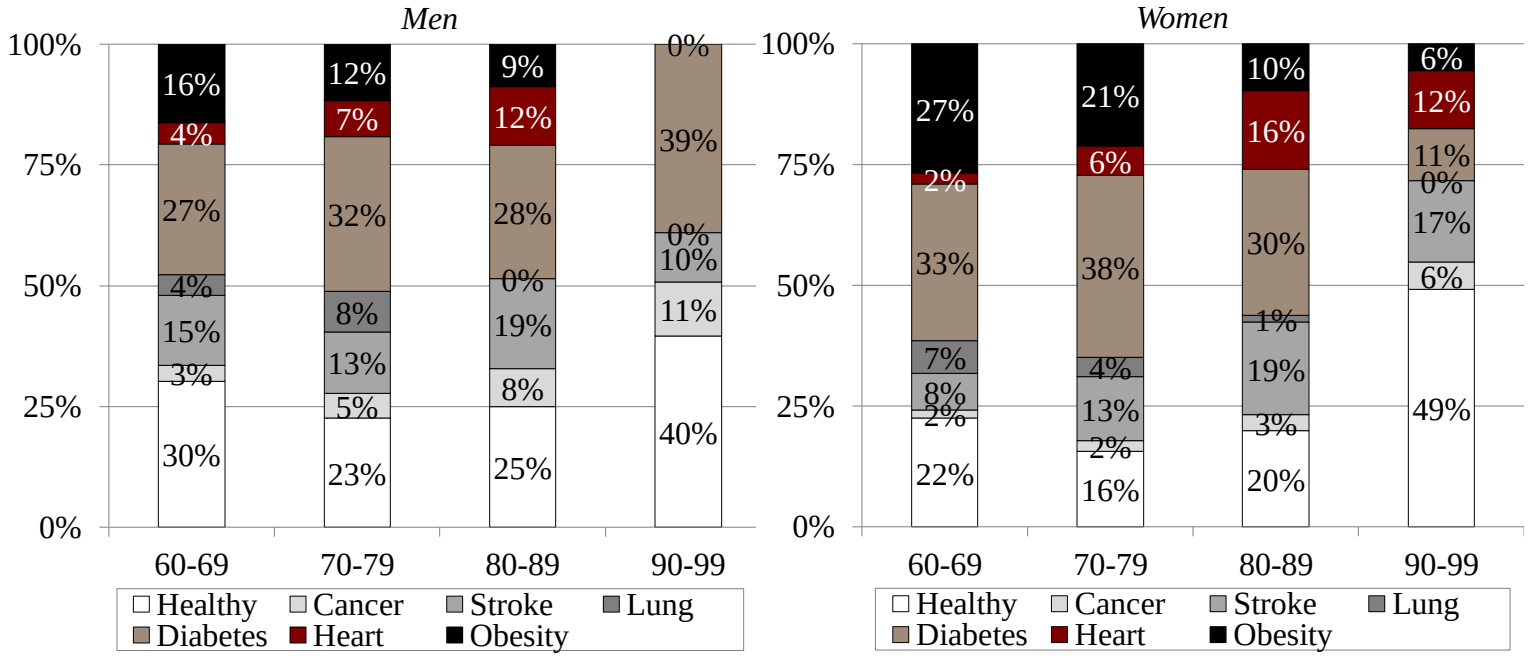
Source: HRS (2018).

Figure 3a. *Distribution of Health Conditions by Age Group for Whites*



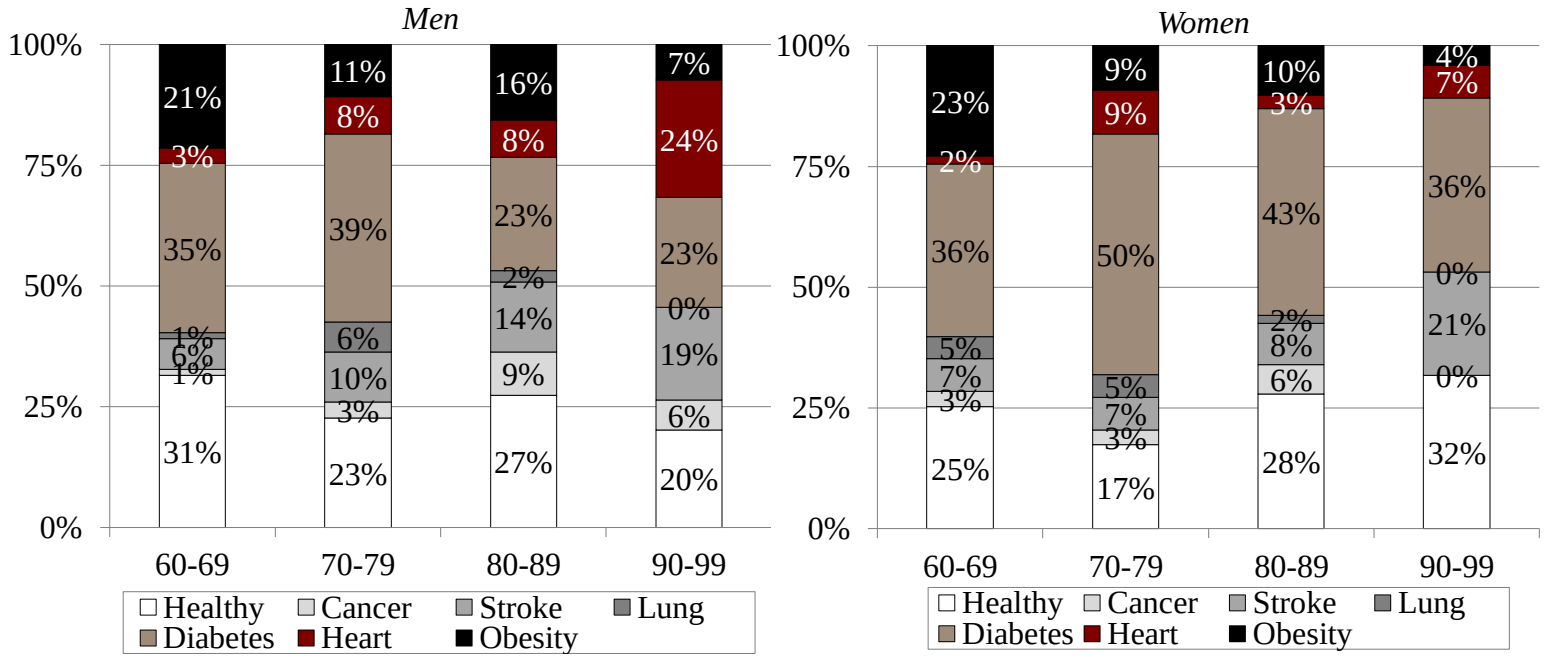
Source: HRS (2018).

Figure 3b. *Distribution of Health Conditions by Age Group for Blacks*



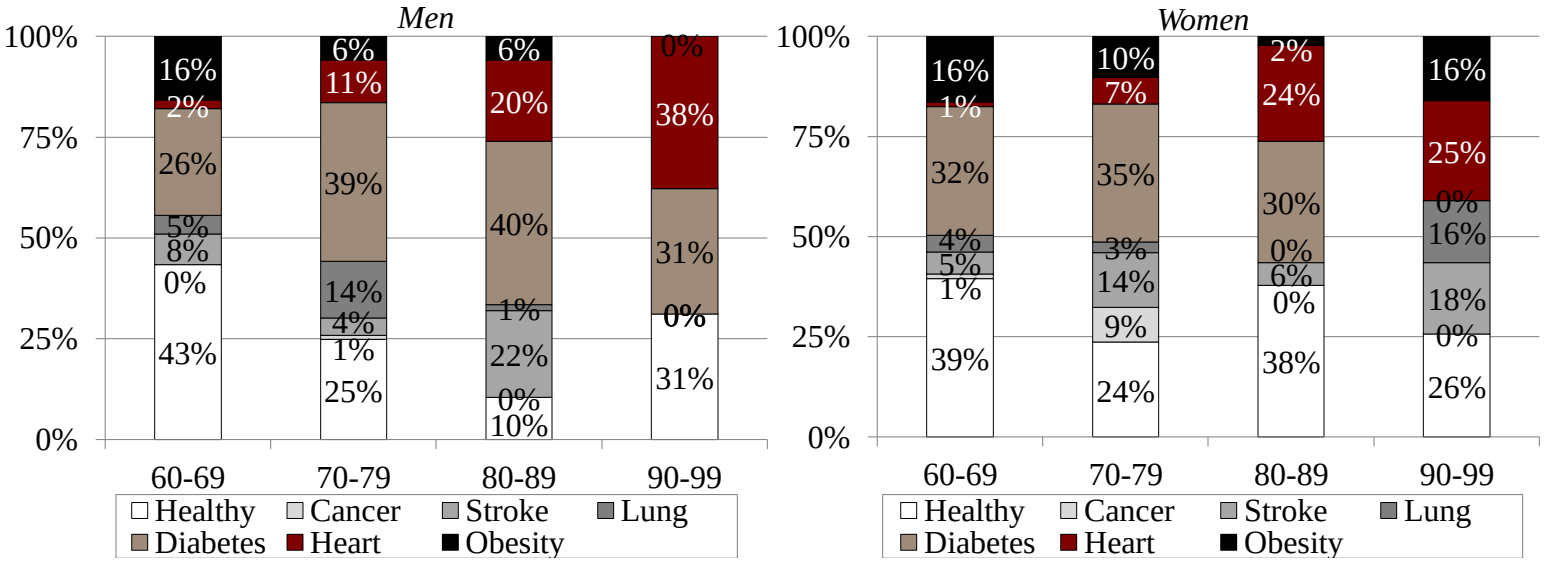
Source: HRS (2018).

Figure 3c. *Distribution of Health Conditions by Age Group for Hispanics*



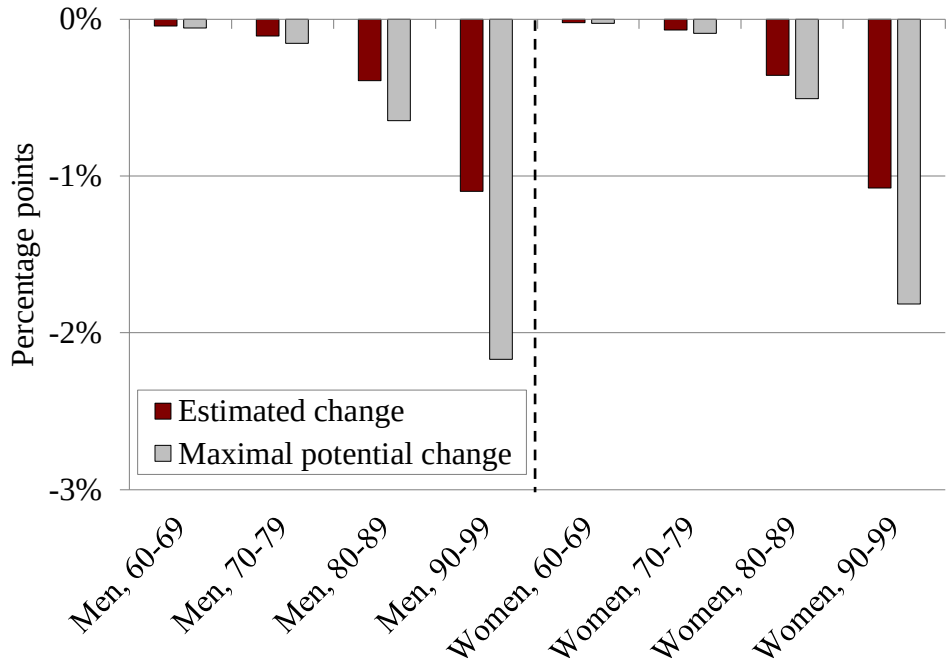
Source: HRS (2018).

Figure 3d. *Distribution of Health Conditions by Age Group for the Other Race Group*



Source: HRS (2018).

Figure 4. *The Change in 10-year Mortality, and the Maximal Potential Change*



Source: Authors' calculations.

Appendix

Appendix Table A1.

Age group	Demographic group	Cancer	Stroke	Lung	Diabetes	Heart	Obesity
60-69	White male	-	-	-	-	-	-
60-69	White female	-	-	-	-	-	-
60-69	Black male	-	-	-	-	-	-
60-69	Black female	-	-	-	-	-	-
60-69	Hispanic male	-	-	-	-	-	-
60-69	Hispanic female	-	-	-	-	-	-
60-69	Other male	X	-	-	-	-	-
60-69	Other female	-	-	-	-	-	-
70-79	White male	-	-	-	-	-	-
70-79	White female	-	-	-	-	-	-
70-79	Black male	-	-	-	-	-	-
70-79	Black female	-	-	-	-	-	-
70-79	Hispanic male	-	-	-	-	-	-
70-79	Hispanic female	-	-	-	-	-	-
70-79	Other male	-	-	-	-	-	-
70-79	Other female	-	-	-	-	-	-
80-89	White male	-	-	-	-	-	-
80-89	White female	-	-	-	-	-	-
80-89	Black male	-	-	X	-	-	-
80-89	Black female	-	-	-	-	-	-
80-89	Hispanic male	-	-	-	-	-	-
80-89	Hispanic female	-	-	-	-	-	-
80-89	Other male	X	-	-	-	-	-
80-89	Other female	X	-	X	-	-	-
90-99	White male	-	-	X	-	-	-
90-99	White female	-	-	-	-	-	-
90-99	Black male	-	-	X	-	X	X
90-99	Black female	-	-	X	-	-	-
90-99	Hispanic male	-	-	X	-	-	-
90-99	Hispanic female	X	-	X	-	-	-
90-99	Other male	X	X	X	-	-	-
90-99	Other female	X	-	-	X	-	-

Source: Authors' calculations.

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