AN ABSTRACT OF THE THESIS OF

Chenkai Wu for the degree of Master of Science in Human Development and Family Studies presented on June 1, 2015

Title: The Relationship between Retirement Timing and Mortality: A Population-Based Longitudinal Study among Older Adults in the United States.

Abstract approved:____

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Retirement is one of the most important transitional events in later life. Despite a large body of research examining the impacts of retirement on health, questions still remain regarding the relationship between retirement timing and subsequent health and survival. Previous research examining the existence, direction, and magnitude of the relationship between retirement timing and health has produced mixed results and is limited by a number of issues including inconsistency in the definition and measurement of retirement and retirement timing, lack of large-scale nationally representative data, and insufficient adjustment for the healthy worker survivor bias and other confounding factors. Using data from the Health and Retirement Study (HRS), a population-based longitudinal study comprising a nationally representative sample of U.S. adults aged 50 years and over, this study aimed to examine the distribution and predictors of retirement timing and to gain an in-depth understanding of its impacts on longevity. The average age at retirement for healthy retirees, individuals who did not consider health was an important reason to retire, was 64.9 years (*SD* = 3.8 years), with younger generation and individuals with more wealth resources retiring earlier. Unhealthy retirees, individuals who reported health was an important reason to retire, on average, retired approximately half year earlier than healthy retirees (64.3 vs. 64.9). Among healthy retirees, retirement timing was strongly related to survival, with a one-year increase in age at retirement associated with an 11% lower risk of all-cause mortality (95% CI: 8%, 15%). Relationship between retirement timing and mortality was not conditional on socio-demographics including birth cohort, gender, race/ethnicity, education, wealth, occupation, and marital status. Results were similar for unhealthy retirees. Together, these findings provide insight to the relationship between retirement timing and subsequent health outcomes in older adults. In addition, these results indicate the need for future research that aims to develop a better understanding of the mechanisms underlying the relationship between retirement timing and longevity. Furthermore, such research could elucidate important criteria for evaluating the labor market policies that aim to increase retirement age to promote extended working life.

The Relationship between Retirement Timing and Mortality: A Population-Based Longitudinal Study among Older Adults in the United States

by
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A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented June 1, 2015
Commencement June 2015

Master of Science thesis of Chenkai Wu presented on June 1, 2015.

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Chenkai Wu, Author

ACKNOWLEDGEMENTS

First and foremost I would like to express my deepest appreciation to Dr. Robert Stawski and Dr. Michelle Odden for their tremendous mentorship, encouragement, and support during the process of writing this thesis. Without their continued guidance and persistent help this thesis would not have been possible.

I would also like to thank Dr. Adam Branscum for his insightful ideas and suggestions that made a huge contribution to the statistical methods used in this work. Many thanks also to Dr. Richard Settersten for his contributions as committee member. Your thoughts, suggestions, and feedback on this work have been incredibly invaluable.

Thank you to all my friends and family, especially my parents, Qi Zhu and Ming Wu, who have supported me emotionally, mentally, and financially.

Finally, special thanks to my wife, Qingqing Zhang, for her continued support, encouragement, and love over the past ten years.

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Chapter 1: Introduction

1.1. General Background

Retirement, typically defined as the time when people permanently withdraw from the workforce, is one of the most important transitional life events in later life that impacts financial resources, daily activities, family relations, and social network (Doyle, McKee, Rechel, & Grundy, 2009; Wang, Henkens, & van Solinge, 2011). Over the past several decades, workers have tended to retire at younger ages in the United States (U.S.) as well as most of the other developed countries in the world (Behncke, 2012; Börsch-Supan & Jürges, 2006; Gendell, 2001). According to Social Security Administration data, the average retirement age declined from 68.5 to 62.6 years for men and from 67.9 to 62.5 years for women in the U.S. from 1950 to 2000 (Gendell, 2001). This average retirement age was approximately 2.5 years earlier than the institutionally expected retirement age at which an individual is entitled to claim full Social Security retirement benefits in the U.S.

This trend towards early retirement is primarily driven by changes in the public pension systems that provide strong incentives for workers to exit early from the workforce and increased availability of private pensions (Blundell, Meghir, & Smith, 2002; Gruber & Wise, 2008). The substantial decline in retirement age, which partly determines the length of working life and the duration of retirement, lowers the ratio of workers per retiree, which, in turn, might result in an unsustainable Social Security system (Gendell, 2001; Wiatrowski, 2001). Additionally, a number of other ongoing demographic trends in the U.S. including decline in mortality and fertility rates, prolonged life expectancy, and delayed entry into the workforce of young adults, create a shrinking working population that may not be able to produce sufficient financial support for a rapidly growing retired population (Leibfritz, 2002; Vaupel & Loichinger, 2006). In order to recover the worker-to-retiree ratio to an economically optimal range and thus to help ease the fiscal pressure on the public pension system, policymakers have pressed for increasing retirement age and extending working lives of the elderly. Many governments have enacted policies to encourage extended working life by reducing the early retirement incentives, postponing the eligible age for claiming public pension, and increasing or eliminating the mandatory retirement age (Cooke, 2006; Leibfritz, 2002; Schils, 2008). In the U.S., the retirement age eligible for claiming full Society Security benefits has been gradually increased from 65 to 67 years for people born 1937-1960, and the early retirement benefits individuals can claim at age 62 have been reduced (McGee & Wegman, 2004).

1.2. Problem Statement

The rationale behind these policies encouraging older workers to retire later as well as their anticipated economic implications has been extensively discussed (Burtless, 2013; John, 2010; Munnell & Sass, 2009). However, the potential health consequences of the current trend towards early retirement and foreseeable trend towards delayed retirement in the near future have received little empirical attention. Therefore, it is critical and timely to develop a better understanding of whether and how retirement timing impacts retirees’ subsequent health. Unlike other health measures such as, mental health (Calvo, Sarkisian, & Tamborini, 2013; Mojon-Azzi, Sousa-Posa, & Widmer, 2007), self-rated general health (Coe & Lindeboom, 2008; Coe & Zamarro, 2011), chronic conditions (Behncke, 2012; Westerlund et al., 2010), physical limitations (Neuman, 2008), and health behaviors (Calvo, 2014), longevity has received considerably less attention. Where the effects of retirement timing on longevity have been examined, the research has primarily focused on European populations. Since the retirement age eligible for claiming a full pension in the U.S. has been gradually increased to ensure the financial viability of the Social Security system, more research is needed in order to have a better understanding of the health consequences of prolonged working live and delayed retirement for U.S. adults. More importantly, findings from previous studies of retirement timing and longevity have been mixed. A number of studies reported higher mortality in early retirees compared to those who exit the workforce around the institutionally normative age (i.e. on-time retirees) (Bamia, Trichopoulou, & Trichopoulos, 2008; Waldron, 2001; Wallman et al., 2006), whereas others found no differences in longevity between early and on-time retirees (Hernaes, Markussen, Piggott, & Vestad, 2013; Litwin, 2007; Tsai, Wendt, Donnelly, de Jong, & Ahmed, 2005) or even a lower mortality among individuals retiring early (Brockmann, Müller, & Helmert, 2009). In a large-scale study of retirement in Greece, Bamia et al. (2008) found that retiring later was related to a lower risk of all-cause mortality. In contrast, Brockmann et al. (2009) observed a beneficial effect of early retirement on longevity among a sample of insured German older workers. Additionally, Litwin's (2007) study compared mortality between early and on-time retirees using a representative sample of older Jewish Israelis; the results showed that people who exit the workforce early did not have either higher or lower mortality relative to those who retired on time. In sum, to date, there has been no consensus reached on the existence, direction, and magnitude of the relationship between retirement timing and longevity.

The inconsistencies of existing findings may be partly attributable to the methodological limitations of prior research. One major methodological limitation is how to adequately account for the healthy worker survivor bias (Kühntopf & Tivig, 2012). Considerable research has shown that health status is one of the most important indicators of early transition into retirement (Alavinia & Burdorf, 2008; Butterworth et al., 2006; Pransky, Benjamin, & Savageau, 2005;

Rice, Lang, Henley, & Melzer, 2011); workers in poor health are more likely to retire early than healthy workers. Health is also strongly associated with longevity, with individuals in worse health status having a shorter life span. Therefore, pre-retirement health status is a confounder of the relationship between retirement timing and longevity; the observed adverse effects of early retirement on longevity may be spurious.

Knowledge of the potential impacts of retirement timing on longevity is also limited by the use of non-representative samples. For example, professional German fire fighters (Wagner et al., 2006), rubber tire workers (Haynes, McMichael, & Tyroler, 1978), and employees in a U.S. petroleum and petrochemical company (Tsai et al., 2005) have been previously studied. People with different occupations may have different retirement patterns, which undermines the comparability of the results across studies. In addition, study populations of different origins potentially have distinct socially, culturally, and institutionally expected retirement ages, leading to inconsistent classifications of early, on-time, and late retirement (Kuhn, Wuellrich, & Zweimüller, 2010; Litwin, 2007; Tsai et al., 2005). As a consequence, early retirees identified in one study could be classified as on-time or even late retirees in other studies.

Another potential reason for these discrepant findings is the differences between study populations and analytic strategies. First, no consensus has been reached on the operational definition of retirement, which is critically important to empirical studies of retirement timing and mortality (Shim et al., 2013). Second, mixed findings may be due to varying approaches used for defining and categorizing early, on-time, and late retirement. For example, in Litwin's study (2007), women who retired between the ages of 50 and 59 and men who retired between the ages of 60 and 64 were defined as early retirees while women who retired after age 60 and men who retired after age 65 were identified as on-time retirees. In contrast, Tsai et al. (2005)

defined workers who retired at age 55 or 60 as early retirees and those who retired at age 65 as on-time retirees. Third, the ambiguous findings reported could also result from the fact that previous studies focused on populations of various origins (e.g. Greece, Norway, Germany, U.K, and U.S.) that have substantially distinct cultural beliefs and social norms towards work, retirement, and public pension systems. Consequently, delayed retirement may be indeed associated with better survival in some countries while related to worse survival in others.

Since little attention has been devoted to examining whether and how retirement timing might influence longevity and highly diverging findings are reported, continued research in this area is necessary to provide a better understanding of the impacts of retirement timing on longevity. Gaining insights about whether there exists an optimal time to retire to preserve longevity has important implications for post-retirement quality of life and trajectories of health conditions among older adults who represent a rapidly growing population both domestically and globally. In addition, understanding the existence, direction, and magnitude of the relationship between retirement timing and longevity may elucidate important criteria for evaluating the current policies that aim to encourage older workers to retire later and to stay in the workforce longer.

1.3. Purpose of the Present Study

The purposes of the present study were to provide a detailed description of retirement timing among U.S. older adults and, more importantly, to gain an in-depth understanding of its impacts on longevity in order to answer the intriguing question: Is there an optimal time to retire for preserving longevity? The specific aim was to examine the relationship between the timing of retirement and mortality in individuals who reported health was not important for retirement (healthy retirees) and those who considered health an important reason to retire (unhealthy retirees). The life course perspective (Elder, 1974; Elder, 1994) was utilized to lay the theoretical underpinning of the present study and to formulate the study hypotheses. From a life course perspective, transition into retirement occurring within a culturally and institutionally expected range of ages would produce better survival outcome in comparison to transitions occurring off the social timetable (Szinovacz & Davey, 2004; van Solinge & Henkens, 2007). Therefore, it was expected that on-time retirees would have better survival outcome than both early and late retirees.

1.4. Data for the Current Study

The aims of the present study were to explore the distribution and predictors of retirement timing among U.S. older adults and to investigate its association with longevity. In an attempt to achieve these goals and to overcome the major methodological limitations of previous research, data from the Health and Retirement Study (HRS), a population-based longitudinal study comprising a national representative sample of over 10,000 U.S. adults aged ≥ 50 years in 1992, were used.

Data from the HRS are ideal for answering the main research questions of this study for the following four reasons. First, most study participants enrolled in the initial HRS cohort (target population of this study) aged at least 50 years at baseline (1992/1993) and most of the participants had experienced transition into retirement by the end of the study, which allows for rigorous examination of the association between retirement timing and mortality. Second, the HRS includes comprehensive socio-demographic, lifestyle, and health information, allowing for adjustment for a wide range of potential confounders. Third, the HRS contains a variable indicating whether health was an important factor influencing decision about when to retire, providing a unique opportunity to account for the healthy worker survivor bias that largely undermined the validity of previous studies addressing the similar research questions. Fourth, the HRS has a nationally representative sample with a considerable size, which helps enhance the generalizability of the study results.

1.5. Thesis Structure

The remainder of the thesis was structured as follows. In Chapter 2, a broad survey of literature was discussed followed by a presentation of methodological limitations and inconsistencies in analytic strategy of previous research, introduction of the theoretical framework, and statement of study questions and corresponding hypotheses. Then, data source, inclusion and exclusion criteria for the analytic sample, operational definitions as well as measures of analytic variables, and statistical analysis were presented in Chapter 3. Results were shown and discussed in Chapter 4. In Chapter 5, general discussion of the study results and contributions, implications, and limitations of the present study were presented. In Chapter 6, general conclusions were presented.

Chapter 2: Literature Review

2.1. Distribution and Predictors of Retirement Timing

As mentioned earlier, retirement age has steadily declined since the late 20th century in many industrialized countries (Behncke, 2012; Börsch-Supan & Jürges, 2006; Gendell, 2001). This trend towards early retirement along with the dramatic demographic changes such as decline in mortality and fertility rates, prolonged life expectancy, and delayed entry into the workforce of young adults has post serious fiscal threats to the public pension systems (Leibfritz, 2002; Vaupel & Loichinger, 2006). Consequently, policymakers in these countries have pressed for policies to delay retirement age in order to alleviate the growing financial pressure facing the Social Security system (Munnell & Sass, 2009). One pre-condition for the success of these political endeavors is a clear understanding of why people retire at a certain age (Kubicek, Korunka, Hoonakker, & Raymo, 2010). Over the past few decades, researchers have invested a considerable amount of effort into identifying predictors that influence the retirement decision concerning when to retire in order to help policymakers identify specific ways to promote extended working life among older workers, with most attention has been given to personal socio-demographic factors and pre-retirement health status (e.g. Beehr, 1986; Feldman, 1994; Kubicek et al., 2010; Mein et al., 2000; Oakman & Wells, 2013).

The most widely studied socio-demographic predictors of retirement timing include birth cohort, gender, marital status, and financial resources (e.g. Adams, 1999; Flippen & Tienda, 2000; Talaga & Beehr, 1989). Birth cohort is an important characteristic that has demonstrated a strong relationship with retirement timing, with persons born later retiring at younger ages (Adams, 1999; Brux, 2010; Gendell, 2001). Gender has been typically included as a potential predictor of retirement timing in prior studies, though its association with retirement timing is ambiguous (Adams, 1999; Beehr, Glazer, Nielson, & Farmer, 2000; Talaga & Beehr, 1995). Marital status is an additional factor that is associated with when individuals choose to retire (Gustman & Steinmeier, 1984; Henkens & Tazelaar, 1997; Szinovacz & DeViney, 2000). Prior research shows that married persons retire earlier than unmarried ones, and spouses having close relationship and a high level of marriage satisfaction are more likely to retire early. Financial resources are another personal factor that is strongly related to retirement timing; financially disadvantaged persons are more likely to exit the labor force late (Beehr et al., 2000; Green, 2006). In addition, Adams (1999) showed that persons reporting lower level of satisfaction with income retired later. An exception to prior research relating favorable financial situation to early retirement is a study conducted by Wolfson et al. (1993) utilizing administrative data from the Canadian Pension Plan. They found that high-income Canadian workers were more likely to retire late.

In addition to these, a considerable amount of research has examined the effects of pre-retirement health on retirement timing. Many studies have found poor health to be an important determinant of early retirement (e.g. Butterworth et al., 2006; Dwyer & Mitchell, 1999; Mein et al., 2000). For example, using data from the HRS, Dwyer and Mitchell (1999) found that U.S. male workers in poor self-rated health retired 1-2 years earlier than those in good health. In addition, in a more recent study, Rice et al. (2011) found that older U.K. workers who reported depressive symptoms or mobility limitations were more likely to retire early. However, there are several exceptions showing no association of poor health and early retirement (Beehr et al., 2000; Burkhauser, Couch, & Phillips, 1996). Beehr et al. (2000) indicated that neither self-rated health nor spouse-rated health was predictive of retirement timing based on a small sample of employees of a western state in the U.S. In another study of U.S. workers, Burkhauser et al.

(1996) found that the percent of reporting poor health status was approximately the same for male workers who claimed Social Security benefits at age 62 and for those who took pensions later.

However, the wide majority of prior studies have focused on the predictors of early retirement, with rare attention given to late retirement. This overlooks the possibility that predictors of early retirement may not explain why individuals choose to retire late. In addition, a number of previous studies investigating the determinants of retirement timing rely on small or homogeneous samples, making it difficult to generalize the study findings and to compare the results across studies (e.g. Beehr et al., 2000; Mein et al., 2000). In light of these limitations, continued research using representative data and focusing on not only early retirement, but also late retirement is necessary to improve our understanding of the predictors of retirement decision about when to retire.

The present study, which is based on a nationally representative sample and contains data on a wide range of socio-demographic, lifestyle, and health-related characteristics, aimed to provide a detailed description of the distribution and predictors of retirement timing among U.S. older adults. Having a better understanding of the distribution and predictors of retirement timing allows us to examine potential subgroup variations in retirement timing.

2.2. Relationship between Retirement Timing and Longevity

A number of studies, spanning from different scientific disciplines, including gerontology, sociology, public health, and economics, have investigated the relationship between retirement timing and longevity. However, existing studies in this field have yielded conflicting findings and have focused mostly on the impacts of early retirement on longevity. A number of studies found that early retirement has a detrimental effect on longevity (Bamia et al., 2008; Carlsson, Andersson, Michaëlsson, Vågerö, & Ahlbom, 2012; Kuhn et al., 2010; Kühntopf & Tivig, 2012; Wagner et al., 2006). In contrast, a large-scale German study reported a beneficial effect of early retirement on longevity (Brockmann et al., 2009). Alongside these studies that suggest early retirement is either detrimental or beneficial for longevity, several studies found no association of retirement timing with longevity (Hernaes et al., 2013; Litwin, 2007; Tsai et al., 2005).

2.2.1. Detrimental Effects of Retiring Early on Longevity

Waldron (2001) examined the association of retirement timing with mortality among a sample of male U.S. residents who had lived to age 65 by comparing life expectancy among five subgroups of retirees with different retirement ages[1]. The results showed that men who retired between the ages of 62 and 65 died sooner in comparison to those who retired at age 65 or older, after adjusting for age, race/ethnicity, education, and marital status. The findings suggest that there was a positive relationship between retirement age and life expectancy, with early retirement associated with a shorter life span.

Qualitatively similar findings are also reported in studies using different populations. Bamia et al. (2008) investigated the association of retirement timing with mortality, using a nationally representative sample of Greek participants aged 20-86 years. Among retirees, 5-year increase in retirement age was related to a 10% lower risk of all-cause mortality. The results suggest that retiring later was associated with a lower risk of death. In this Greek study, the healthy worker survivor bias was acknowledged and addressed by excluding individuals who reported having a pre-retirement medical diagnosis of chronic conditions (e.g. stroke, cancer, coronary heart disease). Another study finding a detrimental effect of retiring early on survival is Kuhn et al (2010), who used an instrumental variables approach to estimate the causal effect of

[1] 62 years to 62 years and 3 months, 62 years and 3 months to 62 years and 11 months, 63 years to 64 years, 64 years to 65 years, and 65 years or older

early retirement on mortality among a sample of blue-collar workers aged ≥ 50 years at enrollment. Early retirees were defined as workers who met certain eligibility criteria and were allowed to retire up to 3.5 years earlier than those who were ineligible. They found that early retirement was associated with an increased risk of death before age 67 for males. However, the effects of early retirement on long-term survival were not examined due to the limitations of the data. Moreover, in a recent Swedish study, Carlsson et al. (2012) examined the relationship between retirement timing and mortality using participants who were born 1930-1945 and healthily employed one year prior to retirement. Findings showed that men who retired between the ages of 61 and 63 had a significantly higher risk of mortality compared to those who retired between 64-66 and 67-69.

In addition to these, two studies of Germans found detrimental effects of retirement early. Kühntopf and Tivig (2012) examined the relationship between retirement age and mortality among all German old-age and disability pensioners. Results revealed that, among men who retired before age 65, retirement age was positively associated with remaining life expectancy at age 65. Early retirees who died before age 65 were excluded to account for the healthy worker survivor bias. However, this approach implicitly assumes that early retirees deceased before age 65 were forced to leave labor force due to health-related reasons and all healthy early retirees would live at least to the age of 65. Therefore, it is questionable whether this strategy was sufficient to address the healthy worker survivor bias. Additionally, Wagner et al. (2006) studied the association of retirement age with mortality among a cohort of 4,640 professional German fire fighters. A higher mortality was reported among fire fighters who exit the workforce relatively early than those who retired within a normative age range.

There are two possible explanations for these findings suggesting that early retirement is a risk factor for mortality. First, early retirement is associated with poorer post-retirement health outcomes such as declined cognitive abilities (Rohwedder & Willis, 2010), low perceived health (Alavinia & Burdorf, 2008), low level of satisfaction and happiness (Börsch-Supan & Jürges, 2006), and increased number of days in hospital (Barban, Svensson, Billari, de Luna, & Lundholm, 2012), which may lead to increased risk of mortality. Second, prolonged working life is associated with greater financial and social resources (Munnell & Sass, 2009; Quinn, Cahill, & Giandrea, 2011; Taylor & Bengtson, 2001), potentially leading to improved health and survival.

2.2.2. Beneficial Effects of Retiring Early on Longevity

In contrast, beneficial effects of early retirement on longevity are reported in a prospective study with a sample of over 120,000 German participants who were insured members of a compulsory German health insurance fund (Brockmann et al., 2009). After controlling for socio-demographics as well as health condition indexed by the number of days spent in hospital within 2 years prior to retirement, Brockmann and others found that workers who permanently left the workforce early (between the ages of 55 and 60) and healthy had improved survival outcome in comparison to those retiring between the ages of 61 and 65. The investigators suggest that extended pension payments and low-level stress may have been responsible for the reduced risk of mortality among employees who left the labor force early and healthy. However, it is worth mentioning that the study findings showing beneficial effects of early retirement on longevity have not been replicated in other cohorts.

2.2.3. No Effects of Retirement Timing on Longevity

In addition to aforementioned studies suggesting that retiring early either improves or worsens survival, a few other studies have found that retirement timing was not associated with longevity (e.g. Hernaes et al., 2013; Litwin 2007). In an early study of over 3,000 U.S. rubber tire workers, Haynes et al. (1978) compared the death rates between retirees who exit the workforce between the ages of 62 and 64 (early retirees) and those who retired at age 65 (on-time retirees) over a 5-year study period. They found no significant difference in survival between early and on-time retirees, after adjusting for socio-demographic characteristics and pre-retirement health status. Analogous findings were presented in another more recent U.S. study comparing post-65 mortality between petrochemical workers who retired at age 60 (early retirees) and those who retired at age 65 (on-time retirees) (Tsai et al., 2005). Old workers who retired early at 60 did not have significantly higher mortality compared to those who exit the workforce at the institutionally expected retirement age in the U.S.

The view that retirement timing is not associated with mortality is also supported by evidence found in studies conducted in other social and cultural contexts. In a study of Israelis, Litwin (2007) compared 7-year mortality between men who retired between the ages of 50 and 64 and women who retired between the ages of 50 and 59 with men who retired at age 65 or over and women who retired at age 60 or above. Findings suggest that workers who retired early did not have significantly different mortality rates compared to those who retired late, adjusting for socio-demographic characteristics and reasons to retire. Similarly, in a study of Norwegians, Hernaes et al. (2013) found no association between retirement timing and mortality, using accessibility to early retirement program in Norway as an instrument for retirement to deal with the healthy worker survivor bias. Early retirees were defined as individuals who participated in an early retirement pension scheme (i.e. contractual pension) in Norway and were therefore entitled to claim a state pension earlier than the mandatory retirement age (i.e. 67). One possible explanation for these findings suggesting retirement timing has no impacts on longevity is that retirement timing does not independently add any additional value for predicting survival, after taking into account all socio-demographic, lifestyle, and health-related factors that are associated with both retirement timing and longevity.

2.2.4. Effects of Late Retirement on Longevity

The vast majority of studies on retirement timing have focused on the health consequences of early retirement because previous research has primarily focused on European populations, who are mandatorily required to retire at a certain age (e.g. 67 for Norwegian) (European Commission, 2009). Participants included in these studies, in general, did not have the flexibility to retire later than the mandatory retirement age. In contrast, minimal empirical evidence for the effects of late retirement on longevity is available. The present study aimed to expand existing research by investigating the impacts of both early and late retirement on longevity by using a nationally representative sample of U.S. middle-aged and older workers who have a more flexible retirement arrangement due to the complete abolition of mandatory retirement in the U.S. since 1986 (von Wachter, 2002).

2.3. Methodological Limitations and Inconsistencies

Contradictory findings regarding the existence, direction, and magnitude of the relationship between retirement timing and mortality in older adults are arguably, in part, result from the methodological limitations of prior research.

The first major methodological limitation is the scarcity of studies sufficiently addressing the healthy worker survivor bias, that is, the possible reverse causal relationship between retirement timing and health (Calvo et al., 2013). It has been well documented that poor physical or mental health is a leading reason for older workers to retire early (Butterworth et al., 2006; Mein et al., 2000; Waldron, 2001); poor pre-retirement health status may be partly, or even primarily, responsible for the observed association of retirement timing with mortality. Hernaes et al. (2013) did not account for the reasons why workers retired early and thus did not distinguish individuals who retired due to health-related reasons from retirees who exit the workforce due to non-health-related reasons in the analysis because such information was not available in the data set. Tsai et al. (2005) excluded early retirees who retired at age 55 or 60 and died before the age of 65 from the study and only compared the post-65 mortality between early retirees (retired at age 55 or 60) and on-time retirees (retired at age 65) in an attempt to address the healthy worker survivor bias. However, the validity of their findings largely relies on a untested assumption that all early retirees who were not alive at age 65 retired due to health-related reasons and all early retirees who exit the workforce due to non-health-related reasons did not die before the age of 65. Similarly, Kühntopf and Tivig (2012) compared the remaining life expectancy at age 65 between early retirees who received old-age or disability pensions before age 65 and on-time retirees who received old-age pensions at age 65 to control for the healthy worker survivor bias, assuming individuals who were able to reach age 65 did not retire due to health-related reasons. However, the study design may still suffer from the healthy worker survivor bias because disability pensioners who retired before age 60 due to severe physical limitations were included in the sample. The current study addressed the healthy worker survivor bias by taking reasons to retire (i.e. whether health was an important reason to retire or not) into account in examining the effects of retirement timing on mortality.

The second limitation of previous studies of retirement timing and longevity arises from using non-representative samples. Wagner et al. (2006) found that early retirees had a higher mortality compared to on-time retirees using a sample of professional German fire fighters. As pointed out by the authors, fire fighters represent a highly specialized occupation with a hugely different retirement pattern as compared to workers with other types of occupation. The generalizability of the findings was therefore largely undermined. In addition, since female fire fighters were extremely rare and thus excluded from the analysis, the implications of the results were further limited. Similar issues were present in several other studies, in which rubber tire workers (Haynes et al., 1978), blue- collar workers (Kuhn et al., 2010), and employees in a U.S. petroleum and petrochemical company (Tsai et al., 2005) have been the target study populations. In the present study, data from the HRS, which is comprised of a large and nationally representative sample of U.S. residents with various job types and varying social background and healthy conditions were used to avoid problems introduced by using non-representative samples and to ensure the generalizability of the study results.

In addition to the two major methodological limitations documented above, considerable differences in research methodology across existing studies add another layer of difficulty in studies of retirement timing and mortality. The present study aimed to deal with two methodological inconsistencies in the literature concerning 1) the definition and measurement of retirement timing, and 2) the classification of retirement timing.

First, inconsistencies in operational definition and measurement of retirement timing are one important reason why findings regarding the effects of retirement timing on mortality are mixed. A few studies have defined retirement age based upon substantial changes in earning patterns. In Carlsson et al. (2012) study, the retirement age is identified as the difference between birth year and the first year at which an individual having more than 80% of the total personal income from retirement benefits. One potential limitation of this operational definition of retirement age is the difficulty to distinguish permanently retired people from partially retired people who experience a substantial decrease in the proportion of earnings from work while still work part-time. In a study of Norwegians (Hernaes et al., 2013), year of birth and the last month of work without any retirement pensions or benefits received were used to identify retirement age. Besides, instrumental variables approach also has been used to determine retirement age. In a study of Austrians, Kuhn et al. (2010) used the eligibility status for the Regional Extended Benefit Program (REBP), which allows blue-collar workers to exit from the labor force up to 3.5 years earlier than ineligible workers, as an instrument for retirement age. Use of an instrumental variables strategy allows the analysis to sufficiently account for the healthy worker survivor bias; however, a major disadvantage of the instrumental variables approach used in this Austrian study is that measurement error is inevitable unless all eligible workers for the REBP would indeed exit from the workforce early and none of the ineligible workers would choose to retire early. Moreover, several other studies have utilized individuals' self-reported retirement status to quantify retirement age. For example, Bamia et al. (2008) identified participants' retirement status and retirement age through the use of self-reported date of retirement recorded in a lifestyle questionnaire. Because measurement error in retirement age would be largely minimized with the use of self-reported retirement status and retirement age, self-reported retirement age was used to identify individuals' retirement age in the present study, in which detailed information on retirement status, retirement age, and reasons for retirement are readily available.

The second methodological inconsistency arises with regard to the absence of consensus on the classification of retirement timing. Because socially and institutionally normative retirement age varies across countries, occupations, and demographics (e.g. gender), early/late retirement, which is defined as permanent withdrawal from the workforce earlier/later than a specified age, has been classified differently in studies conducted in different social, cultural, and policy contexts (e.g. Kuhn et al., 2010; Litwin, 2007; Tsai et al., 2005). Consequently, individuals qualified as early retirees in one study is likely to be identified as on-time or even late retirees in other studies. Lack of such consistency may partly explain the contradictory findings from studies of retirement timing and mortality. Tsai et al. (2005) qualified early retirees as persons who retired exactly at age 55 or 60 and compared their survival outcome with that of on-time retirees who retired at age 65. It showed that on-time retirees had decreased mortality over the study period than early retirees who retired at age 55, while there was no difference found in mortality between on-time retirees and those who retired at 60. The definition of early retirement is likely to influence the nature of the effect of retiring early on mortality. In contrast, some studies have defined early retirees as persons who retired at any ages prior to a specified normative retirement age (e.g. 65). For example, Kuhn et al. (2010) considered men who retired before age 65 and women who retired before age 60 early retirees[1]. In an Israel study, Litwin (2007) defined early retirees as men who retired between the ages of 60 and 64 and women who retired between the ages of 50 and 59 due to the difference in eligible age for retirement pensions between men and women in Israel.

In this U.S. cohort study, no attempt was made to set cutoff ages for defining early, on-time, and late retirement because there is no mandatory retirement age for U.S. workers and they therefore have high level of flexibility with regard to retirement timing. In addition, most of these cutoff points used previously are arbitrary and may be of low validity for identifying early and late retirees. Alternatively, the present study treated retirement timing as a continuous variable and explored potential nonlinear relationships between retirement timing and mortality by having a quadratic term of retirement timing (i.e. retirement timing^2) in the statistical models. Retirement timing was also categorized into early, on-time, and late retirement based on cutoff

[1] 60 and 65 are statutory retirement ages for Austrian men and women, respectively.

ages derived from data-driven approaches (see details in Chapter 3) to assess the robustness of the study findings to different classifications of retirement timing.

2.4. Theoretical Framework: the Life Course Perspective

Transition into retirement and the effects of retirement on health in later life can be best understood through the lens of the life course perspective (Elder, 1974; Elder, 1994), which has developed rapidly over the past several decades and has become a major theoretical framework in the study of human development across life span. The life course perspective posits that an individual's life course is comprised of a sequence of age-linked transitions (e.g. transition into adolescence, transition into parenthood) that are embedded in a broader cultural, social, and historical context (Katz, Peace, & Spurr, 2012). The life course perspective underscores the role of personal history and social circumstances in shaping the life transitions and their consequences on physical, mental, and social well-being (Moen, 1996; Settersten, 2003). In addition, the life course perspective emphasizes the role of timing in the association between a life transition and subsequent health and well-being. Individuals' expectations and beliefs about the most appropriate timing to retire with regard to post-retirement health and quality of life are largely shaped by cultural and institutional norms as well as the expectations of other members from the same birth cohort (Hagestad & Neugarten, 1985; Moen, 1996). Van Solinge and Henkens (2007) argue that retirees are aware of their own positions in the social and cultural timetable and are likely to describe themselves as on-time versus off-time retirees. Retirees who experience transition into retirement off the social and institutional timetable (i.e. either before or after the normative retirement age) are more likely to perceive retirement as involuntary and forced (Szinovacz & Davey, 2004), receive less support from peers who retire within the institutionally expected age range, and have more stress (van Solinge & Henkens, 2007) than those who retire on time. Therefore, workers who choose to retire around the institutionally anticipated ages are expected to have better survival and lower mortality than those who retire off the cultural, social, or institutional timetable. The present study attempted to resolve the conflicting empirical findings regarding the nature of the association of retirement timing with mortality by approaching retirement from the life course perspective, which has served as the main theoretical framework for several studies addressing the similar research questions (e.g. Calvo & Sarkisian, 2011; Calvo et al., 2013).

2.5. Research Questions and Hypotheses

The primary goals of the present study were to explore the distribution and predictors of retirement timing and to investigate its impacts on mortality. This study sought to answer the following question: Is there an optimal time to retire for preserving longevity? Examining the impacts of retirement timing on mortality using a representative sample and rigorous analytic strategies would lead to greater clarity on the existence, direction, and magnitude of the relationship between retirement timing and health in later life. In addition, gaining insights about whether and how retirement timing has impacts on retirees' longevity can also provide important information regarding the post-retirement quality of life and health trajectories. Furthermore, findings of this study may potentially elucidate important criteria for evaluating the current labor force policies that aim to delay retirement to promote longer working life. According to the life course perspective, off-time transition into retirement is generally more difficult to deal with than transition occurring on time. It was thus hypothesized that on-time retirees would have better survival outcome and lower mortality in comparison to both early and late retirees; there would exist an inverted U-shaped relationship between retirement timing and longevity.

Chapter 3: Methods

3.1. Study Participants

3.1.1. Introduction of the HRS

The HRS is a biennial longitudinal study of a nationally representative multistage area probability sample of households in the contiguous U.S. of non-institutionalized residents that started in 1992 and have data available through 2010. The HRS is primarily funded by the U.S. National Institute on Aging (NIA) and is designed, administered, and managed by the Institute for Social Research at the University of Michigan (Karp, 2007). The primary goal of the HRS is to describe changes in life patterns through the transition into retirement of middle-aged and older adults in the U.S. by collecting considerable amount of information about their health conditions, family network, social relations, financial situation, and employment status (Juster & Suzman, 1995). The baseline assessment of the initial HRS cohort was conducted from 1992 to 1993 and a total of 12,654 respondents (7,704 households) aged ≥ 50 years were included. Beginning in 1998, a separate study called Assets and Health Dynamics among the Oldest Old (AHEAD), which was initially conducted in 1993 and consisted of 8,222 elderly born in 1923 and earlier (AHEAD cohort), was merged with the HRS into a single interview schedule and a single data set. In 1998, two additional birth cohorts including participants born 1924-1930 (Children of the Depression [CODA] cohort) and 1942-1947 (War Babies [WB] cohort) were incorporated into the HRS to fill the generational gap between the HRS cohort and the AHEAD cohort. Additionally, the Early Baby Boomer (EBB) cohort (born 1948-1953) and the Mid Baby Boomer (MBB) cohort (born 1954-1959) were added into the HRS in 2004 and 2010, respectively. The assessment schedule of each of the six birth cohorts available in the HRS was shown in Table 1. Further details about the recruitment strategies, designs, and sampling approaches of the HRS have been extensively documented elsewhere (Heeringa & Connor, 1995).

In the present study, the original HRS data were combined with the RAND HRS data to facilitate the process of data management. The RAND HRS data is a subset of the original HRS data with more organized versions of wealth and income variables, created by RAND Center for the Study of Aging in an attempt to make the original HRS data easier to work with for researchers.

3.1.2. Analytic Sample

This study focused on the initial HRS cohort because 1) it has the most waves of data (up to 10 assessments) among six cohorts of the HRS for tracking the occurrence of transition into retirement and death events, 2) other study cohorts are comprised of individuals who are either too young or too old, providing limited information on their transition to and through retirement, and 3) the initial HRS cohort was assessed specifically for examining retirement. The analytic sample was first limited to 8,756 participants who 1) reported their age and were 50-62 years old at baseline (i.e. born 1931-1941), 2) were primary interview respondents (i.e. data were not obtained from a proxy respondent), and 3) had at least 1 valid assessment over the 18-year study period in addition to the baseline measurement (i.e. participants who were only assessed at baseline were excluded). The assessment at each wave was considered valid for an individual if he/she was alive and was the primary survey respondent. The analytic sample was further restricted to 4,092 participants who reported being working at baseline (1992/1993) and had experienced transition into retirement by the end of the study. Moreover, because both occupation type and pre-retirement health status may be important determinants of when individuals decide to retire, 524 individuals whose occupation information was unavailable and

454 individuals who did not report whether health was an important reason for them to retire were excluded. Additional 158 individuals who were lost to follow-up in the same year when they reported being completely retired (i.e. observed survival time since retirement was 0) were also excluded, resulting in 2,956 eligible participants (final analytic sample).

In order to appropriately account for the impacts of pre-retirement health status on the association of retirement timing with mortality, the analytic sample (*n* = 2,956) was stratified into two subgroups: healthy and unhealthy retirees, based on a question, “Whether poor health was very important, moderately important, somewhat important, or not important reason for retirement?” Individuals who answered “not important at all” were classified as healthy retirees, while individuals who chose one of the other three answers (i.e. very important, moderately important, or somewhat important) were considered unhealthy retirees. Consequently, the final analytic sample consisted of 1,934 healthy retirees (from 1,782 households) with 967 males (50.0%), 1,628 White (84.2%), 1,487 (76.9%) being married, and an average age of 55.5 years (*SD* = 3.0 years), and 1,022 unhealthy retirees (from 922 households) with 457 males (44.7%), 775 White (75.8%), 666 (65.2%) being married, and an average age of 55.1 years (*SD* = 3.1 years). Detailed baseline characteristics of the final analytic sample stratified by whether health was an important reason to retire (i.e. healthy retirees vs. unhealthy retirees) were presented in Table 2. Primary analyses of this study focused on the healthy retirees (*n* = 1,934); unhealthy retirees (*n* = 1,022) were included in the secondary analyses.

3.2. Measures

3.2.1. Outcome

The primary outcome in this study was time (in years) from date of birth to the time of death from any cause. By the end of the study, 234 (12.1%) healthy and 262 (25.6%) unhealthy retirees had died, respectively. For those who did not die over the entire study period, the outcome variable was time (in years) from date of birth to the time of last follow-up. Mortality was ascertained based on a single variable, available in HRS Tracker file, recording participants' year of death taken from an exit interview or a spouse/partner's core interview. Information on mortality was available up to year 2011.

3.2.2. Predictor

Retirement. Retirement status was ascertained according to a question asking respondents in each wave: "At this time do you consider yourself partly retired, completely retired, or not retired at all?" An individual was defined as retired if they responded, "completely retired".

Retirement timing. Retirement timing was defined as age when an individual, for the first time over the study period, reported being completely retired. In the HRS, some individuals reported having experienced multiple transitions between working and retirement. Such multiple transitions were ignored. This strategy was consistent with prior research that used the HRS data to investigate the effects of retirement timing on physical and emotional health in older adults (Calvo et al., 2013).

3.2.3. Covariate

To account for potential confounders, socio-demographic, lifestyle, and health-related variables were included in the multivariate analyses of retirement timing and mortality. All covariates were measured at baseline (1992/1993) to minimize the impacts of missing data.

Socio-demographic characteristics. Socio-demographic covariates included birth cohort, gender, race/ethnicity, marital status, education, wealth, and occupation. Birth cohort was defined as year of birth. Female was considered reference group for gender. Race/ethnicity was dichotomized into non-Hispanic white and non-white (reference group) including non-Hispanic Black, other Hispanics, and other races. Marital status was dichotomized as married and other marital status (reference group). Education was originally measured in years of self-reported highest grade of school or year of college, and was then categorized as less than high school (reference group), high school, and more than high school. Wealth, defined as total assets excluding the net value of living place, was classified into 4 categories (minimum-25th percentile, 25th percentile-median, median-75th percentile, and 75th percentile-maximum), with the lowest wealth category being a reference group. Occupation type was ascertained by self-reported job title and was collapsed into 3 major occupational sectors: blue-collar occupations (including farming, forestry, fishing, mechanics and repair, construction trade and extractors, operators, and members of Armed Forces), white-collar occupations (including managerial specialty operation, professional specialty operation and technical support), and service occupations (including sales, clerical/administrative support, food preparation, protection service, personal service, and private household, cleaning and building service). White-collar occupations were considered a reference group.

Lifestyle and health-related characteristics**.** Smoking status was assessed categorically as one of three possible responses, former smoker, current smoker, and never-smoker (reference group). Alcohol use was dichotomized as drinker and never-drinker (reference group). Physical activity, defined as participation in light physical activity such as walking, dancing, gardening, golfing, bowling, and so on, had two categories: 3 or more times a week and less than 3 times a week (reference group). Body mass index (BMI) was calculated by dividing self-reported weight in kilograms by self-reported height in meters squared, and was classified as underweight (BMI < 18.5), normal (BMI = 18.5-24.9), overweight (BMI = 25.0-30), and obese (BMI > 30). Due to small cell size in the underweight category, BMI was further collapsed into underweight/normal (reference group), overweight, and obese categories. Self-rated health was reverse coded with 5 (highest score) indicating the most positive rating of health (1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent). Medical history was indexed by a simple count of the total number of physician-diagnosed health conditions experienced prior to the study baseline (1992/1993). Health conditions considered included hypertension, diabetes, cancer, lung disease (asthma excluded), heart problems (e.g. heart attack, angina), congestive heart failure, stroke, arthritis/rheumatism, and psychiatric problems.

3.3. Statistical Analysis

The statistical analysis of this study included several stages and began with a description of the baseline characteristics for both healthy and unhealthy retirees; means and standard deviations for continuous variables and counts and percentages for categorical variables were summarized. Then, mean values of baseline characteristics were compared across healthy and unhealthy retirees using a t-test for continuous variables and a chi-squared test for categorical variables.

In Stage 2, descriptive statistics of retirement age for healthy retirees including mean, standard deviations, median, and range were first obtained. Then, a series of bivariate analyses were conducted to compare mean retirement age across socio-demographic, lifestyle, and health-related variables for healthy retirees. A multiple linear regression was subsequently run to explore the simultaneous contributions of multiple predictors to retirement age among healthy retirees.

In Stage 3, the unadjusted association of retirement age with mortality among healthy retirees was examined using the Cox proportional hazards model (Cox, 1972), a widely used statistical approach for modeling time-to-event outcomes (e.g. time to death). Retirement age and its squared term (i.e. retirement age^2) were the primary predictors of the model. The purpose of including a quadratic term of retirement age in the Cox proportional hazards model was to test the study hypothesis that on-time retirees had a lower risk of death compared to early and late retirees. The quadratic term was included for multivariable Cox proportional hazards models if it was associated with mortality at a statistical significance level of $p < .05$.

In Stage 4, socio-demographics including birth cohort, gender, race/ethnicity, marital status, education, and wealth, lifestyle variables including smoking status, alcohol use, and physical activity, and health-related variables including BMI, self-rated health and chronic conditions were entered into the Cox proportional hazards model as covariates to estimate the adjusted hazard ratios (HRs) for the risk of mortality per one year increase in retirement age. Subsequently, multiplicative interaction terms between retirement age and socio-demographics (e.g. retirement age × gender) were included in the multivariable model and tested for statistical significance using a Wald chi-squared test. Insignificant interaction terms ($ps \geq .05$) were excluded from the final model. Proportionality of hazards, an important assumption of the Cox proportional hazards model, was evaluated by testing for a statistically significant none-zero linear relationship between scaled Schoenfeld residuals and survival time. A statistically significant non-zero linear relationship indicated a violation of the proportional hazards (PH) assumption. The significance level was set at $\alpha = 0.01$ to take multiple testing into account. Interaction terms between survival time and variables violating the PH assumption were created to evaluate the consequences of assumption violations.

In Stage 5, survival analyses were repeated with retirement timing classified as a three-level categorical variable (early, on-time, and late retirees) to evaluate whether the study findings were robust to different classifications of retirement timing. Two categorization methods were used with one using the first and the third quartiles of retirement age as cutoffs and another using mean retirement age minus one standard deviation and mean retirement age plus one standard deviation as cutoffs.

Sensitivity analyses were conducted in Stage 6 to evaluate the robustness of the association of retirement age with mortality to different definitions of healthy retirees. Survival analyses were repeated using two alternative definitions of healthy retirees with one incorporating participants who reported health was a somewhat important reason to retire into the category of healthy retirees and another considering participants who reported health was a somewhat important reason or moderately important reason to retire healthy retirees (i.e. only participants who reported health was an very important reason to retire were not considered healthy retirees).

In Stage 7, secondary analyses including exploring the distribution and predictors of retirement age for unhealthy retirees, testing whether health was an important reason to retire (yes/no) moderated the association of retirement age with mortality, and stratifying analyses across healthy and unhealthy retirees were performed.

In order to reduce collinearity between linear and quadratic terms in the models and to improve interpretation of the statistical results, retirement timing, as defined by age at retirement, was centered at 65 years (i.e. institutionally expected retirement age in the U.S.) and birth cohort was centered at 1931 (i.e. birth year of the youngest cohort in this study). Robust standard errors were used to account for the nested data structure of the HRS (i.e. participants were nested within households). All statistical analyses were conducted using Stata 13.1 (StataCorp, College

Station, TX) and SAS software, version 9.4 (SAS Institute, Cary, NC). All statistical tests were two-sided.

Chapter 4: Results

4.1. Baseline Characteristics of Study Sample

A total of 1,934 healthy retirees, individuals who reported health was not an important reason to exit the workforce and a total of 1,022 unhealthy retirees, individuals who considered health was an important part of their decision about retirement timing were included. Compared to unhealthy retirees, healthy retirees were older, more often male and white, more educated, and more likely to be married (*ps* < 0.01, Table 2). They were also more likely to be white-collar workers and had more wealth resources than unhealthy retirees (*ps* < 0.01). In addition, healthy retirees were more likely to be involved in physical activity, less likely to smoke, had a lower BMI and a lower prevalence of chronic conditions, had a better self-rating of health, and had lower risk of death over the study period in comparison to unhealthy retirees (*ps* < 0.01). Overall, healthy retirees had more advantaged socio-demographic and health profiles compared with unhealthy retirees.

4.2. Distribution and Predictors of Retirement Timing

The distribution of retirement age for healthy retirees was approximately normally distributed with a majority of the individuals retiring around the age of 65 (Figure 2). The mean and median retirement age for healthy retirees was 64.9 years ($SD = 3.8$ years) and 64.7 years, respectively (Table 3). For healthy retirees, the range of retirement age was 53.3-78.0 years, suggesting a considerable variation in retirement age.

The distribution of unhealthy retirees' retirement age was similar to that of healthy retirees (Figure 2). Compared to healthy retirees, unhealthy retirees exit the workforce significantly earlier ($p < 0.001$), with an average retirement age of 64.3 years ($SD = 4.1$ years)

(Table 4). However, the difference in average retirement age was only marginally statistically significant, after correcting for potential confounders ($p = 0.06$).

In both bivariate and multivariate analyses examining predictors of retirement age among healthy retirees, mean differences in retirement age were negligible (all mean differences were < 1 year) across almost all included socio-demographic, lifestyle, and health-related characteristics (Table 3 and Table 5). Two notable exceptions were birth cohort and non-housing wealth. For birth cohort, there was a clear positive trend between late birth year and early retirement for individuals born 1931-1941 (Figure 3). The marginal mean retirement age declined from 67.6 to 62.7 years in a decade. The direction and the magnitude of the relationship between birth year and retirement age remained almost unchanged, after adjustment for other covariates (β: -0.47, 95% CI: [-0.52, -0.41], $p < 0.001$) (Table 5). Individuals born in 1941, on average, retired 4.7 years earlier than those born 10 years earlier in 1931, independent of the effects of other contributors. In addition, healthy retirees who were in the highest wealth category (i.e. upper quartile), on average, permanently exit the workforce 1 year earlier compared to those who were in the lowest wealth category (i.e. lower quartile) (β: -1.00, 95% CI: [-1.47, -0.48], $p < 0.001$), adjusting for other factors (Table 5).

Similarly, the patterns of retirement age did not differ substantially across most of the predictors for unhealthy retirees. Two socio-demographic factors, birth cohort and non-housing wealth, were found to be significantly associated with retirement age (Table 5); individuals born earlier and with less financial resources retired later. Unlike healthy retirees, two health measures, the number of chronic conditions and self-rated health were found to be significantly associated with retirement age among unhealthy retirees, with individuals having more chronic conditions and poorer self-perceived health retiring earlier (Table 5).

4.3. Retirement Timing and Mortality

Among healthy retirees, retirement age was significantly associated with all-cause mortality in the unadjusted Cox proportional hazards model with only linear term for retirement age included (HR: 0.89, 95% CI: [0.86, 0.92], $p < 0.001$) (Model A in Table 6). Retiring one year later was associated with an 11% lower risk of all-cause mortality. The addition of a quadratic term for retirement age (retirement age^2) did not add significantly to the unadjusted model or alter the hazard ratio associated with the linear term for retirement age (Model B in Table 6). Additionally, the effect of the quadratic term was extremely small (HR: 0.99, 95% CI: [0.99, 1.00]). These results, together, did not provide strong evidence to support a quadratic relationship between retirement timing and mortality. Therefore, the quadratic term for retirement age was not retained in further analyses.

The association of retirement age with all-cause mortality for healthy retirees remained statistically significant, after adjusting for socio-demographic, lifestyle, and health-related covariates (Model C in Table 6). For healthy retirees, retiring one year later, on average, was associated with an 11% decrease in risk of all-cause mortality (HR: 0.89, 95% CI: [0.85, 0.93], $p < 0.001$), after adjustment for potential confounders. Based on the chi-squared tests for PH assumption, there was no strong evidence suggesting the PH assumption was violated for any of the covariates in the adjusted model ($ps \geq 0.01$; $p = 0.38$ for global test). Model including interaction terms for two variables (i.e. retirement age and self-rated health) that marginally violated the PH assumption ($ps = 0.01$) with survival time (i.e. time-varying covariates) was fitted, but it did not perform substantially better compared to the model without time-varying covariates ($\Delta AIC = -9.4$; $\Delta BIC = 1.7$). In addition, the primary results and conclusions of the original multivariable Cox proportional hazards model remained virtually unchanged (full results not shown). The adjusted association of retirement age and all-cause mortality for healthy retirees did not differ between important socio-demographics including birth cohort, gender, race/ethnicity, education, occupation, wealth, and marital status (p-values for interactions > 0.05).

To assess whether the relationship between retirement timing and all-cause mortality was robust to different definitions of retirement timing, multivariable survival analyses were repeated for healthy retirees with retirement timing classified as a three-level categorical variable (early, on-time, and late retirees). Two categorization approaches were utilized with one based on quartiles of retirement age and another based on mean and standard deviation of retirement age. Using quartiles as cutoff ages, 466, 985, and 483 individuals were classified as early (< 62.4 years), on-time (62.4-67 years), and late retirees (> 67 years), respectively. Using mean minus one standard deviation and mean plus one standard deviation as cutoff ages, 252, 1385, and 297 individuals were classified as early (< 61.1 years), on-time (61.1-68.7 years), and late retirees (> 68.7 years), respectively. Results of both analyses consistently showed that late retirees had a significantly lower risk of all-cause mortality than on-time retirees, whereas early retirees had a significantly higher risk of death from any cause in comparison to on-time retirees, adjusting for covariates (Models A-B in Table 7).

Results of the Cox proportional hazards model including both healthy and unhealthy retirees showed that unhealthy retirees had a significantly higher risk of all-cause mortality than healthy retirees (HR: 1.84, 95% CI: [1.51, 2.27], $p < 0.001$) (Model A in Table 7), while the association of retirement age and all-cause mortality did not vary across healthy and unhealthy retirees (p-value for interaction, > 0.05) (Model B in Table 8). In addition, results of the Cox proportional hazards model with only unhealthy retirees included indicated that, after adjustment for potential socio-demographic, lifestyle, and health-related confounders, retiring 1 year later was associated with a 9% lower risk of all-cause mortality for unhealthy retirees (HR: 0.91, 95% CI: [0.88, 0.94], $p < 0.001$) (Table 9), which was similar to that of healthy retirees.

4.4. Sensitivity Analyses

The estimates of the association of retirement age with all-cause mortality among healthy retirees were robust against different operational definitions of healthy retirees. When both participants who responded “health was not an important reason at all for retirement” and “health was a somewhat important reason for retirement” were classified as healthy retirees, retiring 1 year later was associated with an 11% lower risk of all-cause mortality (HR: 0.89, 95% CI: [0.86, 0.93], $p < 0.001$) (Model B in Table 10). Similarly, when only individuals who responded “health was a very important reason to retire” were not considered healthy retirees, retiring 1 year later was related to a 10% decrease in all-cause mortality (HR: 0.90, 95% CI: [0.87, 0.92], $p < 0.001$) (Model C in Table 10).

Chapter 5: Discussion

The current study had two overall goals. The first goal was to provide a detailed description of retirement timing and to explore socio-demographic, lifestyle, and health-related predictors of retirement timing in a nationally representative sample of U.S. middle-aged and older adults. Results showed that the average retirement age was slightly below 65 for healthy retirees, individuals who considered health was not important to retire. Unhealthy retirees, individuals who reported health was an important part of their decision to retire, retired approximately half year earlier than healthy retirees (64.3 vs. 64.9). In addition, there was considerable variation in retirement timing for both healthy and unhealthy retirees. Moreover, birth cohort and wealth were significantly associated with retirement timing, with younger generation and wealthier individuals retiring earlier. Other socio-demographic, lifestyle, and health-related characteristics were not strongly predictive of when an individual retired, except that, among unhealthy retirees, those with poorer self-rated health and more chronic conditions retired earlier. The second goal was to identify the existence, direction, and magnitude of the relationship between retirement timing and mortality among U.S. adults, while at the same time trying to overcome some methodological limitations of previous studies. The study findings suggest that, in both healthy and unhealthy retirees, retirement timing was significantly associated with all-cause mortality, after adjustment for a wide range of confounders. However, there was a linear association between retirement timing and mortality in U.S. adults; retirees who exit the workforce around the institutionally expected age (i.e. 65) had a significantly lower risk of mortality than early retirees, whereas on-time retirees had a significantly higher risk of mortality compared to late retirees with prolonged working lives. These findings did not provide evidence to support the study hypothesis suggesting an inverted U-shaped relationship between retirement timing and mortality.

5.1. Distribution and Predictors of Retirement Timing

The average retirement age for U.S. healthy retirees born 1931-1941 was 64.9 years, which is approximately the same as the age eligible for claiming full Social Security benefits. The retirement age for healthy retirees spanned from 53.3 to 78.0 years with one-quarter of the individuals retiring before age 62.6 and one-quarter of the individuals retiring after age 67.0, suggesting considerable variation in retirement age. U.S. workers seemed to have a high degree of flexibility over decisions about when to retire, which may be attributable to the lack of a mandatory retirement age in the U.S. These descriptive results need to be interpreted cautiously because only individuals who were working at baseline (1992/1993) and had retired by the end of the study (2010/2011) were included in the analytic sample; individuals who retired at either very young (e.g. age of 45) or very old ages (e.g. age of 85) were excluded.

Birth cohort was shown to have the strongest effect on retirement timing. Younger generation tended to retire at younger ages, with the average retirement age decreasing by 4.7 years in a decade (i.e. 1931-1941). This finding is consistent with a prior report indicating, among the HRS cohort (born 1931-1941), older workers are more likely to expect to stay in the workforce after reaching the age of 62 or 65 (Pienta & Hayward, 2002). However, the study result was inconsistent with several previous studies showing that the average retirement age for U.S. men has stabilized or even increased over the past 30 years (Burtless & Quinn, 2000; Munnell, 2011). This discrepancy may be due to several reasons. For example, in the present study, the average retirement age was defined as the arithmetic mean age at which individuals retired, whereas the average retirement age was defined as the age at which 50% of the individuals exit the labor force (i.e. median) in some previous studies (e.g. Burtless & Quinn, 2000; Munnell, 2011). Additionally, the analytic sample of this study is restricted to individuals who were working at baseline (1992/1993) and had completely retired by the end of the study (2010/2011). Older cohorts are therefore more susceptible to selection bias in this study. For example, individuals born in 1931 were excluded from the analyses if they retired between the ages of 51 and 61 years (i.e. not working at baseline), whereas individuals born in 1941 were included in the analyses if they retired between the ages of 51 and 61 years (i.e. working at baseline). Moreover, in the present study, retirement timing was defined as the age at which an individual, for the first time over the study period, reported being completely retired. This approach may lead to measurement errors of retirement timing because some individuals reported having experienced multiple transitions between working and retirement.

Non-housing wealth is another personal factor that was significantly associated with retirement timing, with individuals having more favorable financial situation retiring at younger ages. This finding has been confirmed in several studies showing workers with more wealth resources were more likely to take an early retirement (Kim & Feldman, 1998; Kubicek et al., 2010). As Feldman (1994) suggested, individuals with a better financial well-being are more likely to retire early because they have accrued sufficient financial resources to maintain their standard of living during retirement and to improve their engagement in more meaningful and valued post-retirement leisure activities.

The other socio-demographic, lifestyle, and health-related factors were found to have no significance as predictors of when to retire for individuals who reported health was not an important reason for retirement. These findings were inconsistent with prior research indicating that individuals who were married and had low grade of employment were more likely to retire early (Mein et al., 2000). Differences between study populations (e.g. policy, cultural belief) and analytic strategies (e.g. inclusion criteria, definitions of retirement, statistical models) may, at least partially, account for this discrepancy. In addition, the present study focused on predictors of retirement timing (considered a continuous variable), whereas prior research has mostly focused on determinants of early retirement (typically treated as a binary indicator) with little attention being paid to late retirement. Furthermore, conclusions drawn in this study, which used a population-based cohort of U.S. middle-aged and older adults born 1931-1941, may not be generalizable to other birth cohorts or populations with different social and cultural backgrounds. Compared to healthy retirees, unhealthy retirees, on average, retired approximately half year earlier (64.3 vs. 64.9). This finding, though inconclusive, provides partial support for findings of previous research showing U.S. male workers in poorer self-rated health retired earlier (Dwyer & Mitchell, 1999).

Although a wide range of socio-demographic, lifestyle, and health-related factors were used to predict retirement timing, the linear regression models only explained 14.8% and 23.3% of the total variability of retirement timing (mostly by birth cohort) for healthy and unhealthy retirees, respectively; the majority of the variation in retirement timing was left unexplained. These findings highlight the idea that decision about when to retire is highly complex and potentially influenced by a variety of family-related factors (e.g. marital satisfaction) and job-related factors (e.g. job satisfaction) that were not considered in this study (Dave, Rashad, & Spasojevic, 2006; Feldman, 1994; Kubicek et al., 2010; Oakman & Wells, 2013). Future research should continue to identify specifically how individual-, family-, environmental-, and policy-level factors influence this decision-making process in a more dynamic way.

5.2. Relationship between Retirement Timing and Mortality in Healthy Retirees

The findings of this study showed that retirement timing significantly impacts longevity in healthy retirees, individuals who did not consider health an important reason to retire, independent of socio-demographic, lifestyle, and health-related factors. There was a strong linear relationship between retirement timing and mortality, with retiring 1 year earlier associated with an 11% higher risk of death. These findings were consistent with prior studies that have found early retirement was associated with an increased risk of mortality (Bamia et al., 2008; Carlsson et al., 2012; Kuhn et al., 2010; Kühntopf & Tivig, 2012; Wagner et al., 2006; Waldron, 2001; Wallman et al., 2006). The present findings indeed provided stronger evidence of the beneficial health effects of working longer into later life, because 1) this study used a sample with high levels of socio-demographic heterogeneity and 2) few prior studies have sufficiently accounted for the healthy worker survivor bias that may seriously distort the observed association of retirement timing with mortality. In addition to examining early retirement and its association with mortality, the current study also examined the health effects of delayed retirement by using a sample of U.S. middle-aged and older adults who have a high level of flexibility in retirement arrangement with regard to when to retire. The results suggest that healthy retirees had a substantially lower risk of death compared to individuals whose transition into retirement occurring on time or earlier.

Findings on the linear relationship between retirement timing and mortality, however, only offers partial support to the study hypothesis of a U-shaped relationship indicating on-time retirees having lower risk of death than both early and late retirees. Individuals retiring later were shown to have a lower, rather than higher, risk of mortality compared to retirees who completely retired around the institutionally expected age (i.e. 65), contrary to what the study hypothesis suggests. The most probable explanation for this discrepancy is that late retirees may consider their transition into retirement “on schedule” rather than “off schedule” and deem themselves as on-time retirees rather than off-time retirees. This may be especially true for the target population of this study, who live in the U.S., a country that has a strong working oriented culture. In this sense, social and cultural norms may actually encourage late retirement for U.S. workers; retiring late may be socially and culturally acceptable or even desirable. Given the fact that prior research has only documented retirees who exit the workforce earlier than the expected retirement age are more likely to perceive retirement as involuntary and forced than those who retired on time (van Solinge & Henkens, 2007), future research is urgently needed to examine whether individuals perceive retirement transitions that take place later than the institutionally expected age as “on time” or “off time”.

In contrast, study findings on the impacts of retirement timing on longevity support the “psychosocial-materialist” hypothesis suggesting that retiring later is associated with better health outcomes because employment is a key component of individuals’ personal social identity and provides them with substantial personal, financial, and psychosocial resources (Calvo et al., 2013). This “psychosocial-materialist” hypothesis is supported by an empirical study showing that retirement leads to increased difficulties in mobility and daily activities, increased likelihood of developing chronic conditions, and decline in mental health (Dave et al., 2006). They suggest that the presence of poor health outcomes may be postponed in workers retiring at an older age because retirement is a stressful life event associated with a decline in physical functioning and an increased risk of morbidity. In addition, Morris et al. (1994) showed that individuals who retired due to non-health-related reasons had a significantly higher risk of death compared to those who were continuously employed. From the role enhancement perspective, individuals who permanently withdraw from the labor force and their career jobs are susceptible to perceptions of loss of work role, which may lead to anxiety, feeling of dissatisfaction, psychological stress, and depression (Bossé, Aldwin, Levenson, & Ekerdt, 1987; Elwell & Maltbie-Crannell, 1981; Kim & Moen, 2002). Moreover, continued work later in life might help maintain older workers' post-retirement standard of living (Quinn et al., 2011) and is associated with greater financial and social resources (Munnell & Sass, 2009; Taylor & Bengtson, 2001), which may lead to improved health and survival. These findings, together, suggest that prolonged working life and delayed transition into retirement may represent a gain in personal and social resources and maintain the physical and mental health status by delaying the date at which these functions start to decline. This statement may be particularly true for working oriented countries, in which work is highly valued and considered an important component of individuals' lives (Oakman & Well, 2013).

5.3. Relationship between Retirement Timing and Mortality by Socio-demographics

An exploratory analysis was conducted in this study to evaluate the robustness of the relationship between retirement timing and mortality in socio-demographic subgroups. There was no evidence that the effects of participants' retirement timing on mortality were conditional on their important socio-demographic characteristics including birth cohort, gender, race/ethnicity, education level, occupation, wealth, and marital status, suggesting that the beneficial effect of retiring late on longevity is universal across different socio-demographic profiles. These findings were in line with previous studies reporting an increased risk of mortality associated with retiring early among certain sub-populations (e.g. men, fire fighters, blue-collar workers) (Kuhn et al., 2010; Wagner et al., 2006; Waldron, 2001). For instance, Wagner et al. (2006) found early retirement was a risk factor for mortality among a sample of German professional fire fighters. In addition, using data of American male workers, Waldron

(2001) showed early retirement was detrimental for longevity. However, caution must be exercised in the interpretation of these findings because little prior research has explicitly examined the potential subgroup variations in the association of retirement timing with mortality. In addition, only two-way interactions were considered in this study; it is therefore possible that the observed positive association of retirement timing with survival is attenuated or even inverted in subgroups with specific socio-demographic profiles (e.g. high-order interactions). For example, the detection of differential effects of retirement timing on mortality for younger White males in comparison to older non-White females would require a four-way interaction between retirement timing, gender, birth cohort, and race/ethnicity. Furthermore, this study may have been underpowered to detect interactions between retirement timing and multiple socio-demographics because large sample size is typically needed to identify statistically significant interaction terms; however, as the estimates of the interactions were consistently close to the null (i.e. hazard ratios being 1.0), it is unlikely that this study has failed to find subgroup variations in the relationship between retirement timing and mortality. Future research should continue to investigate the moderating role of socio-demographics as well as other types of variables in the association of retirement timing with longevity as well as other health outcomes in order to better understand potentially different pathways by which retirement timing contributes to influence later life health.

5.4. Relationship between Retirement Timing and Mortality in Unhealthy Retirees

One unique methodological contribution of this study is that it compared the effects of retirement timing on mortality between healthy and unhealthy retirees, in an attempt to reduce bias introduced by the healthy worker survivor bias. Analyses exclusively focusing on unhealthy retirees showed a strong linear relation between retirement timing and mortality. For unhealthy retirees, retiring 1 year later corresponded with a 9% lower risk of death, which was analogous to that for healthy retirees. Unhealthy retirees did not appear different from healthy retirees with respect to the direction and the magnitude of the relationship between retirement timing and mortality. No evidence was shown for the interaction between retirement timing and whether health was an important reason to retire, implying that retiring later was associated with a lower risk of death and high survival for both healthy and unhealthy retirees. Healthy worker survivor bias did not seem to have a huge impact on the association of retirement timing with mortality in this study; however, future research should continue to address this issue, especially when disability pensioners who retired early due to serious health problems are part of the study population.

Pooled survival analyses including both healthy and unhealthy retirees showed unhealthy retirees had a higher risk of death compared to healthy retirees, which may be related to the fact that unhealthy retirees were more socioeconomically disadvantaged, less likely to engage in healthy behavior, and had worse health status than healthy retirees (Table 2). This finding partially supports the conclusions from the study by Wagner et al. (2006), suggesting that retirees who exit the workforce due to disability (unhealthy retirees) had a significantly higher risk of death than non-disability retirees (healthy retirees). Higher risk of mortality among persons who retired due to health-related reasons was also found in different study populations (Morris, Cook, & Shaper, 1994; Olsen & Jeune, 1979; Quaade, Engholm, Johansen, & Møller, 2002).

5.5. Strengths and Implications

The present study had several substantive and methodological strengths that are worth mentioning. First, this study had a large sample size and used a nationally representative population-based cohort with rich information on potential socio-demographic, lifestyle, and health-related confounders, which provides more internally valid and generalizable results. Second, this study was able to sufficiently and rigorously account for the potential reverse causal relationship between retirement timing and health by restricting the sample of the primary analysis to individuals who did not consider health was an important reason to retire. Separating effects of retirement timing from effects of retirement motivation is necessary to identify the unique contribution of retirement timing to mortality (Litwin, 2007). Third, in addition to the main effect of retirement timing on mortality, this study examined socio-demographic differences in patterns of the relationship between retirement timing and mortality, and found the association of retirement timing with mortality did not vary by birth cohort, gender, race/ethnicity, education, wealth, occupation, or marital status. Fourth, unlike previous studies that have mostly focused on early retirement, this study contributed to the retirement literature by using the HRS data to examine the health consequences of not only early retirement, but also late retirement. Finally, this study had a relatively long follow-up period (up to 18 years), allowing the investigation of the impacts of retirement timing on long-term survival and providing sufficient number of death events to achieve adequate statistical power.

The findings from this study have important implications for policies concerning labor market, retirement, and later life health. In the context of rising longevity, aging population retiring earlier, and young adults delaying entry into the workforce, policymakers have pressed for policy changes encouraging delayed retirement age for claiming full retirement benefits to alleviate the huge financial pressure facing Social Security, which is currently underfunded (John, 2010; Munnell & Sass, 2009). In addition to the economic and social impacts of delaying retirement age, which has been extensively discussed and studied (Burtless, 2013; John, 2010; Munnell & Sass, 2009), it is critically important to take the health consequences of retirement timing into account for policy evaluation. This study suggests that late retirement has a substantial beneficial effect on longevity and early retirement is associated with an increased risk of mortality. In this sense, reducing early retirement benefits, providing social and economic incentives to prolong working life, and enacting policies that aim to postpone retirement may be beneficial for individuals' health and be desirable for society as a whole.

5.6. Limitations and Directions for Future Research

This study is not without limitations. First, this study focused exclusively on retirement timing and mortality, which tells us little about the impacts of retirement timing on trajectories of health conditions and quality of life after retirement, and thus precludes further examination of the underlying mechanisms of the positive linear relationship between retirement timing and mortality observed in this study. Future research should investigate the possible mechanisms by which retirement timing impacts longevity in order to have a better understanding of the relationship between retirement timing and post-retirement health trajectories. Future research is also needed to focus on post-retirement changes in lifestyle (e.g. social relations) and health behaviors (e.g. physical activity), which might explain why retiring later is associated with better survival outcome (Dave et al., 2006).

Second, the present study only examined widely used socio-demographic, lifestyle, and health behavioral characteristics as predictors of retirement timing. Decisions about when to permanently exit the workforce are complex, multifactorial, and formulated over years (Ekerdt, Kosloski, & DeViney, 2000). Recent studies have documented the importance of psychological factors such as marital satisfaction, job satisfaction, job control, and social cohesion at work in understanding individuals' decisions about when to retire (Kubicek et al., 2010; Oakman & Wells, 2013). Future research is therefore needed to expand the scope of the present study by focusing on pre-retirement psychosocial characteristics of family and work as predictors of when people choose to retire.

Third, as shown earlier, unhealthy retirees, individuals who reported health was an important reason to retire had substantially disadvantaged socio-demographic and health profiles than healthy retirees, individuals who did not consider health was an important reason for retirement (Table 2); however, the question (i.e. is health an important reason for retirement) used in this study to define healthy and unhealthy retirees does not necessarily identify whether their health was the major reason for them to retire or not. Given the fact that decision about when to retire is multifactorial and complex, it is possible that individuals who considered health was an important reason to retire indeed exit the workforce due to a variety of reasons other than poor health.

Fourth, the findings of this study may not be generalizable to other birth cohorts (born outside the 1931-1941 period) because either earlier or later birth cohorts may not share the same behaviors, cultural beliefs, and attitudes towards work and retirement with the studied birth cohort (Litwin, 2007). Future research should include other birth cohorts available in the HRS to identify whether the association of retirement timing and mortality observed in this pre-baby-boomer cohort (i.e. HRS cohort) is invariant across birth cohorts, especially the baby-boomer cohort which has started to retire and will substantially influence the population-level retirement patterns in the near future (Humpel, O'Loughlin, Wells, & Kendig, 2009). Similarly, future research needs to investigate the effects of retirement timing on mortality in other countries that may have different political, economic, social, and cultural context, to evaluate nation-level variation.

Finally, although analyses in this study adjusted for a wide range of potential confounders, some residual confounding could still exist in this observational study. Future research needs to account for more confounders such as marital satisfaction and job satisfaction to obtain a more valid estimate of the impacts of retirement timing on mortality.

Chapter 6: Conclusion

The present study adds to the literature in several important ways. First, this study contributes to a greater understanding of the distribution and determinants of retirement timing for individuals who did consider health was an important reason to retire (i.e. unhealthy retirees) and those did not (i.e. healthy retirees). Second, this study provides a better understanding of the impacts of retirement timing on longevity. Results indicated a strong linear relationship between retirement timing and mortality among U.S. adults, with retiring later associated with a lower risk of mortality, independent of socio-demographic, lifestyle, and health-related characteristics. Third, by exploring the moderating role of important socio-demographics the current study finds that the association of retirement timing and mortality was invariant across different socio-demographic subgroups. Fourth, by using a sample with comprehensive information on socio-demographics, health behaviors, and employment status and stratifying the analyses by healthy and unhealthy retirees, this study was able to appropriately address some major methodological limitations facing previous research.

In general, this study is a distinct addition to the retirement literature by its attempt to extend the research through a methodologically rigorous investigation of retirement timing and its association with longevity. The findings in this study can help inform future research that aims to explain the mechanisms explaining the relationship between retirement timing and mortality and to better understand the post-retirement trajectories of health conditions in old age. These findings may also elucidate important criteria for evaluating the current labor market policies that aim to delay retirement and promote extended working life.

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Figure 1. Flow chart of participants excluded from the study

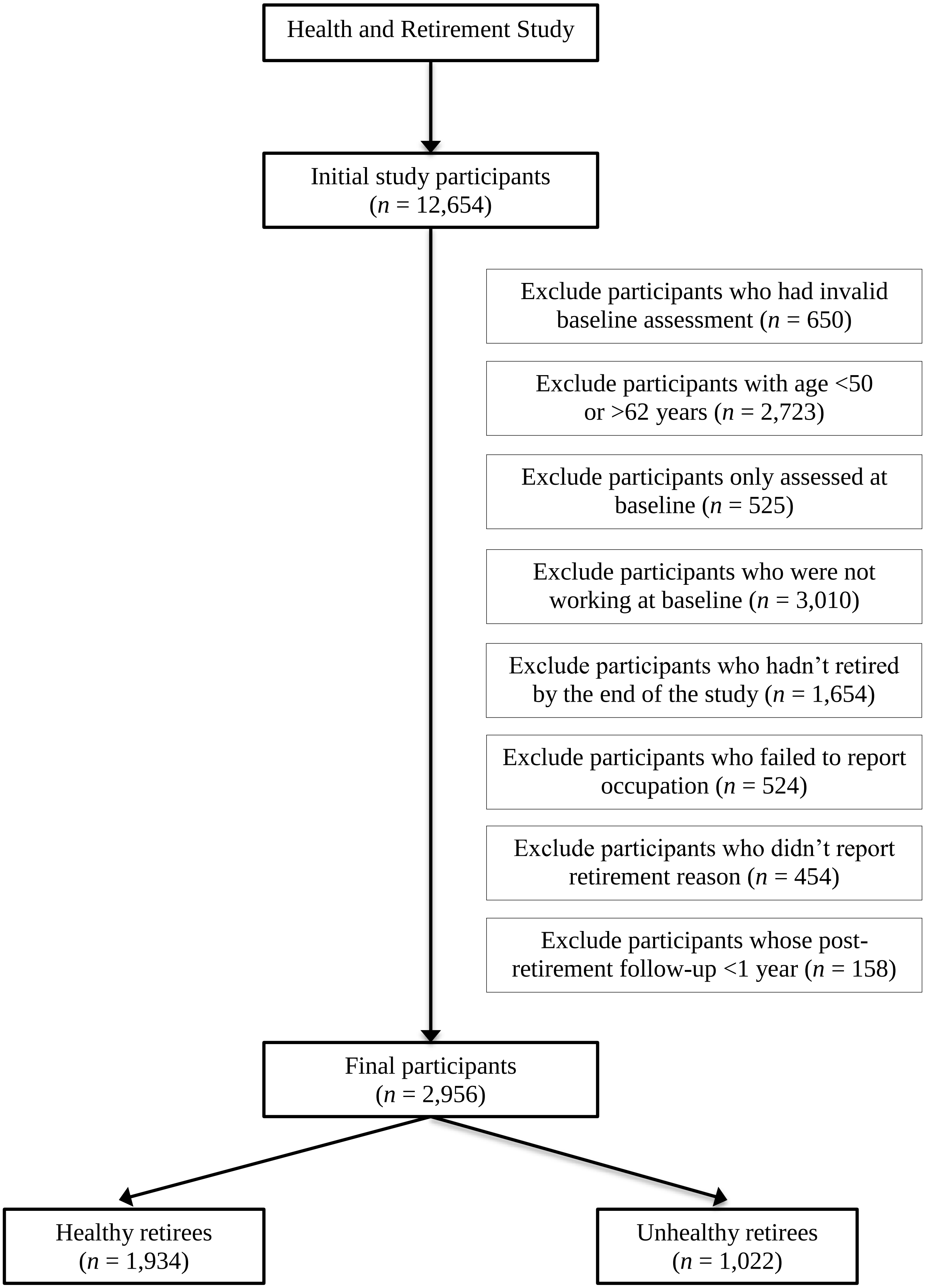

Figure 2. Distribution of retirement age for both healthy and unhealthy retirees

Figure 3. Average retirement age by birth cohort for both healthy and unhealthy retirees

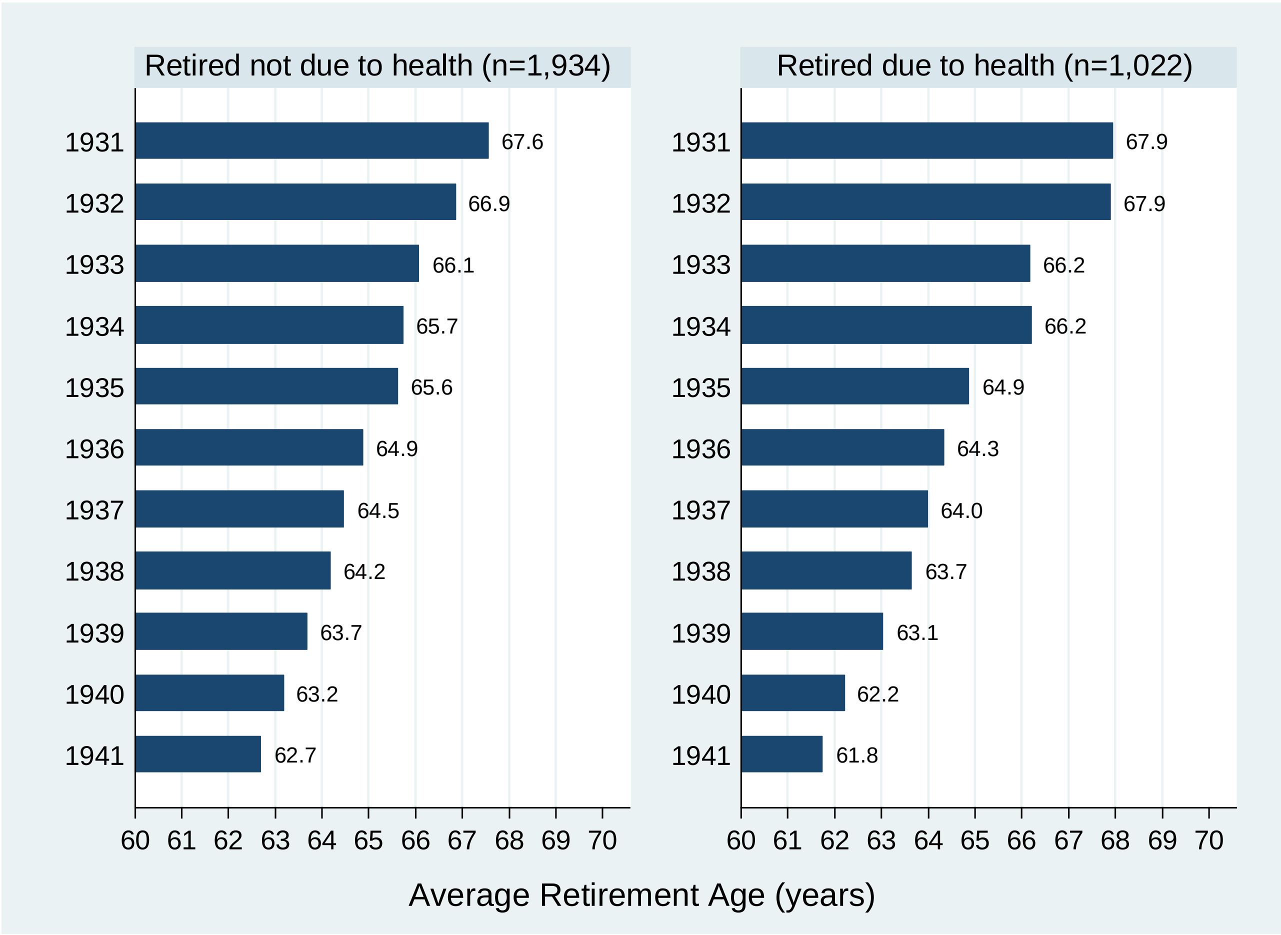

Table 1. Diagram of assessment schedule of each of the six cohorts in the HRS

	Year											
Cohort	1992	1993	1994	1995	1996	1998	2000	2002	2004	2006	2008	2010
HRS[a]	x		x		x	x	x	x	x	x	x	x
AHEAD[b]		x		x		x	x	x	x	x	x	x
CODA[c]						x	x	x	x	x	x	x
WB[d]						x	x	x	x	x	x	x
EBB[e]									x	x	x	x
MBB[f]												x

Note.

x indicates assessment is available

[a] HRS: Health and Retirement Study cohort

[b] AHEAD: Assets and Health Dynamics among the Oldest Old cohort

[c] CODA: Children of the Depression cohort

[d] WB: War Baby cohort

[e] EBB: Early Baby Boomer cohort

[f] MBB: Mid Baby Boomer cohort

Table 2. Baseline characteristics of the study sample

	Healthy retirees (*n* = 1,934)	**Unhealthy retirees (*n* = 1,022)**	
	Mean ± SD or Count (%)		p-value[a]
Male	967 (50.0%)	457 (44.7%)	**
White (vs. non-white)	1628 (84.2%)	775 (75.8%)	***
Age	55.5 ± 3.0	55.1 ± 3.1	***
Education			***
< High school	307 (15.9%)	285 (27.9%)	
High school	1092 (56.4%)	562 (55.0%)	
> High school	535 (27.7%)	175 (17.1%)	
Married (vs. others)	1487 (76.9%)	666 (65.2%)	***
Non-housing wealth			***
Min – 1st quartile	405 (20.9%)	351 (34.3%)	
1st quartile - median	472 (24.4%)	262 (25.6%)	
Median – 3rd quartile	498 (25.8%)	251 (24.6%)	
3rd quartile - max	559 (28.9%)	158 (15.5%)	
Occupation			***
White-collar	680 (35.2%)	231 (22.6%)	
Service	756 (39.1%)	446 (43.6%)	
Blue-collar	498 (25.8%)	345 (33.8%)	
Smoking			***
Never-smoker	754 (39.0%)	337 (33.0%)	
Former	756 (39.1%)	373 (36.5%)	
Current	424 (21.9%)	312 (30.5%)	
Alcohol use (yes)	1307 (67.6%)	622 (60.9%)	***
Frequent exercise	1041 (53.8%)	498 (48.7%)	**
BMI			***
Underweight/normal	728 (37.6%)	282 (27.6%)	
Overweight	843 (43.6%)	422 (41.3%)	
Obese	363 (18.8%)	318 (31.1%)	
Self-rated health	3.9 ± 0.9	3.3 ± 1.1	***
Chronic conditions	0.93 ± 0.92	1.51 ± 1.17	***
Death	234 (12.1%)	262 (25.6%)	***

Note. [a] Two-sample t-test for continuous variables and χ^2 test for categorical variables

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 3. Descriptive statistics of retirement age for healthy retirees

	Retirement Age (years)		
	Mean ± SD	Median	Range
Overall	64.9 ± 3.8	64.7	53.3 – 78.0
Socio-demographics			
Female	65.2 ± 3.9	64.9	53.3 – 76.8
Male	64.7 ± 3.7	64.5	55.0 – 78.0
Non-white	65.2 ± 3.4	65.0	55.6 – 74.7
White	64.9 ± 3.8	64.6	53.3 – 78.0
< High school	65.3 ± 3.6	65.3	55.8 – 77.0
High school	64.8 ± 3.8	64.4	53.3 – 78.0
> High school	64.8 ± 3.8	64.8	55.2 – 75.3
White-collar	64.8 ± 3.9	64.7	55.2 – 75.9
Service	65.1 ± 3.8	64.8	53.3 – 78.0
Blue-collar	64.8 ± 3.6	64.4	55.0 – 77.0
Wealth (min – 25^{th})	65.2 ± 3.7	65.1	53.3 – 78.0
Wealth (25^{th} – median)	65.2 ± 3.8	65.0	55.5 – 76.3
Wealth (median – 75^{th})	64.8 ± 4.0	64.3	55.0 – 76.8
Wealth (75^{th} - max)	64.5 ± 3.6	64.3	54.9 – 75.5
Not married	65.5 ± 4.0	65.3	55.6 – 76.5
Married	64.8 ± 3.7	64.5	53.3 – 78.0
Health-related factors			
Current smokers	64.9 ± 3.8	64.6	54.9 – 76.5
Former smokers	64.7 ± 3.6	64.6	55.0 – 76.8
Never-smokers	65.1 ± 3.9	64.7	53.3 – 78.0
Non-drinkers	65.1 ± 3.7	64.8	55.6 – 75.9
Drinkers	64.8 ± 3.8	64.6	55.3 – 78.0
Infrequent exercise	64.9 ± 3.8	64.7	53.3 – 78.0
Frequent exercise	64.9 ± 3.8	64.6	55.2 – 76.8
BMI (obese)	65.0 ± 4.0	64.6	55.8 – 78.0
BMI (high)	64.8 ± 3.6	64.5	53.3 – 75.5
BMI (normal/ underweight)	65.0 ± 3.9	64.8	54.9 – 77.0

Table 4. Descriptive statistics of retirement age for unhealthy retirees

	Retirement Age (years)		
	Mean ± SD	Median	Range
Overall	64.3 ± 4.1	63.8	54.7 – 79.4
Socio-demographics			
Female	64.5 ± 4.1	64.3	54.7 – 78.2
Male	64.1 ± 4.2	63.5	55.0 – 79.4
Non-white	64.7 ± 4.1	64.3	54.8 – 77.1
White	64.2 ± 4.2	63.7	54.7 – 79.4
< High school	64.4 ± 4.0	64.1	54.8 – 76.2
High school	64.3 ± 4.2	63.6	54.7 – 79.4
> High school	64.4 ± 4.2	64.0	54.8 – 76.5
White-collar	64.4 ± 4.1	64.0	54.8 – 75.9
Service	64.5 ± 4.2	64.0	54.7 – 79.4
Blue-collar	64.1 ± 4.2	63.5	55.0 – 78.2
Wealth (min – 25th)	64.3 ± 3.9	63.8	54.8 – 79.4
Wealth (25th – median)	64.6 ± 4.3	64.3	54.7 – 76.7
Wealth (median – 75th)	64.2 ± 4.2	63.6	55.6 – 76.4
Wealth (75th - max)	64.2 ± 4.4	63.9	55.0 – 77.1
Not married	64.6 ± 4.0	64.4	54.8 – 75.8
Married	64.2 ± 4.2	63.6	54.7 – 79.4
Health-related factors			
Current smokers	63.9 ± 4.1	63.3	54.8 – 77.1
Former smokers	64.6 ± 4.2	64.3	54.7 – 79.4
Never-smokers	64.5 ± 4.1	63.9	54.8 – 78.2
Never-drinkers	64.2 ± 4.1	63.9	54.7 – 79.4
Drinkers	64.8 ± 3.8	64.6	55.3 – 78.0
Infrequent exercise	64.3 ± 4.1	64.0	54.8 – 76.7
Frequent exercise	64.3 ± 4.2	63.8	54.7 – 79.4
BMI (obese)	64.0 ± 4.2	63.6	54.8 – 78.2
BMI (high)	64.6 ± 4.1	64.0	55.0 – 79.4
BMI (normal/ underweight)	64.4 ± 4.1	63.8	54.7 – 76.4

Table 5. Linear regressions for retirement age for both health and unhealthy retirees

	Healthy retirees (*n* = 1,934)		**Unhealthy retirees (*n* = 1,022)**	
Variable	β	95% CI	β	95% CI
Intercept	68.93	[67.81, 70.05]	67.82	[66.42, 69.22]
Birth cohort	-0.47***	[-0.52, -0.41]	-0.62***	[-0.70, -0.54]
Male (vs. female)	-0.20	[-0.57, 0.16]	-0.16	[-0.72, 0.40]
White (vs. non-white)	-0.03	[-0.48, 0.42]	-0.25	[-0.83, 0.33]
Education (ref. < high school)				
High school	-0.09	[-0.58, 0.40]	0.17	[-0.38, 0.72]
> High school	0.06	[-0.57, 0.68]	0.37	[-0.49, 1.24]
Married (vs. others)	-0.36	[-0.76, 0.04]	-0.37	[-0.89, 0.15]
Non-housing wealth				
1st quartile - median	-0.27	[-0.76, 0.23]	-0.08	[-0.70, 0.54]
Median – 3rd quartile	-0.58*	[-1.09, -0.08]	-0.55	[-1.22, 0.12]
3rd quartile - max	-1.00***	[-1.47, -0.48]	-0.90*	[-1.65, -0.14]
Occupation (ref. white-collar)				
Service	-0.05	[-0.48, 0.38]	-0.03	[-0.70, 0.64]
Blue-collar	-0.26	[-0.78, 0.26]	-0.22	[-0.96, 0.52]
Smoking (ref. never-smokers)				
Former	-0.26	[-0.64, 0.11]	0.04	[-0.53, 0.61]
Current	-0.12	[-0.57, 0.33]	-0.31	[-0.90, 0.28]
Alcohol use (yes)	-0.04	[-0.39, 0.31]	-0.35	[-0.83, 0.12]
Frequent exercise (yes)	-0.09	[-0.41, 0.23]	-0.05	[-0.51, 0.41]
BMI (ref. normal/underweight)				
Overweight	-0.14	[-0.49, 0.22]	0.33	[-0.25, 0.91]
Obese	0.04	[-0.44, 0.53]	-0.02	[-0.64, 0.61]
Self-rated health	-0.05	[-0.25, 0.15]	0.40***	[0.16, 0.63]
Chronic conditions	-0.13	[-0.31, 0.05]	-0.24*	[-0.46, -0.03]

Note. CI = confidence interval for β. Standard errors adjusted for clustering. Birth cohort was centered at 1931.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 6. Association of retirement age with mortality

	Healthy retirees (n = 1,934)						
	Model A (unadjusted)		Model B (unadjusted)		Model C (adjusted)		p-value[a]
	HR [95% CI]	p-value	HR [95% CI]	p-value	HR [95% CI]	p-value	
Retirement Age	0.89 [0.86, 0.92]	***	0.89 [0.86, 0.93]	***	0.89 [0.85, 0.92]	***	
Retirement Age^2			0.99 [0.99, 1.00]	>0.05			
Birth cohort					1.02 [0.96, 1.08]	>0.05	>0.05
Male					1.68 [1.23, 2.30]	***	>0.05
White (vs. non-white)					1.08 [0.73, 1.59]	>0.05	>0.05
Education (ref. < high school)							>0.05
High school					0.67 [0.46, 0.95]	*	
> High school					0.65 [0.40, 1.07]	>0.05	
Married (vs. others)					0.81 [0.59, 1.12]	>0.05	>0.05
Non-housing wealth (ref. <1st quartile)							>0.05
1st quartile - median					1.15 [0.80, 1.67]	>0.05	
Median - 3rd quartile					0.94 [0.62, 1.42]	>0.05	
3rd quartile - max					0.92 [0.60, 1.41]	>0.05	
Occupation (ref. White-collar)							>0.05
Service					0.95 [0.65, 1.38]	>0.05	
Blue-collar					0.97 [0.64, 1.46]	>0.05	
Smoking (ref. never-smokers)							
Former smokers					1.27 [0.90, 1.80]	>0.05	
Current smokers					2.61 [1.85, 3.69]	***	
Drinking (yes)					0.95 [0.70, 1.28]	>0.05	
Frequent exercise (yes)					1.02 [0.79, 1.33]	>0.05	
BMI (ref. normal/low)							
Overweight					0.87 [0.65, 1.17]	>0.05	
Obese					1.20 [0.84, 1.72]	>0.05	
Self-rated health					0.89 [0.76, 1.04]	>0.05	
Chronic conditions					1.22 [1.06, 1.41]	**	

Note. CI = confidence interval for hazard ratio. Standard errors adjusted for clustering. Retirement age was centered at 65. Birth cohort was centered at 1931. [a] p-values for interactions between retirement age and covariates. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 7. Association of retirement age with mortality (alternative analyses)

		Healthy retirees
		HR [95% CI]
On-time retirees (reference)	Model A	-
Early retirees		1.65 [1.10, 2.47]*
Late retirees		0.32 [0.20, 0.52]***
On-time retirees (reference)	Model B	-
Early retirees		1.51 [1.10, 2.07]*
Late retirees		0.43 [0.30, 0.61]***

Note. CI = confidence interval for hazard ratio. Standard errors adjusted for clustering. Socio-demographic measures (birth cohort, gender, race/ethnicity, education, marital status, wealth, and occupation), lifestyle measures (smoking status, alcohol use, physical activity), and health-related measures (BMI, self-rated health, and chronic conditions) were adjusted in Models A and B. Birth cohort was centered at 1931.

Model A: retirement age was categorized as early (< 62.6 years), on-time (62.6-67.0 years), and late (> 67.0 years) retirees using the first quartile and the third quartile as cutoffs.

Model B: retirement age was categorized as early (< 61.1 years), on-time (61.1-68.7 years), and late (> 68.7 years) retirees using mean minus one standard deviation and mean plus one standard deviation as cutoffs.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 8. Association of retirement age with mortality (both healthy and unhealthy retirees included)

	Hazard ratio [95% CI]	
	Model A	Model B
Retirement Age	0.90 [0.88, 0.92]***	0.90 [0.87, 0.93]***
Retired due to health	1.84 [1.51, 2.26]***	1.85 [1.51, 2.27]***
Retirement age × Retired due to health	-	1.00 [0.96, 1.05]
Birth cohort	1.02 [0.97, 1.06]	1.02 [0.97, 1.06]
Male	1.75 [1.41, 2.17]***	1.75 [1.41, 2.17]***
White (vs. non-white)	1.05 [0.82, 1.33]	1.05 [0.82, 1.33]
Education		
High school	0.79 [0.62, 0.99]*	0.79 [0.62, 0.99]*
>High school	0.90 [0.63, 1.28]	0.90 [0.63, 1.28]
Married (vs. others)	0.90 [0.72, 1.13]	0.90 [0.72, 1.13]
Non-housing wealth		
1st quartile - median	1.08 [0.84, 1.38]	1.08 [0.84, 1.38]
Median – 3rd quartile	0.92 [0.70, 1.21]	0.92 [0.70, 1.21]
3rd quartile - max	0.90 [0.66, 1.22]	0.90 [0.66, 1.22]
Occupation		
Service	1.12 [0.84, 1.48]	1.12 [0.84, 1.48]
Blue-collar	1.09 [0.81, 1.46]	1.09 [0.81, 1.46]
Smoking		
Former smokers	1.33 [1.04, 1.70]*	1.33 [1.04, 1.70]*
Current smokers	2.59 [2.03, 3.31]***	2.59 [2.03, 3.31]***
Drinking (yes)	0.90 [0.74, 1.10]	0.90 [0.74, 1.10]
Frequent exercise (yes)	0.86 [0.72, 1.04]	0.86 [0.72, 1.04]
BMI		
Overweight	0.96 [0.78, 1.19]	0.96 [0.78, 1.19]
Obese	1.12 [0.87, 1.44]	1.12 [0.87, 1.45]
Self-rated health	0.91 [0.82, 1.01]	0.91 [0.82, 1.01]
Health conditions (count)	1.16 [1.06, 1.27]***	1.16 [1.06, 1.27]***

Note. CI = confidence interval for β. Standard errors adjusted for clustering. Retirement age was centered at 65. Birth cohort was centered at 1931.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 9. Association of retirement age with mortality for unhealthy retirees

	Unhealthy retirees (*n* = 1,022)
	Hazard ratio [95% CI]
Retirement Age	0.91 [0.88, 0.94]***
Birth cohort	1.01 [0.96, 1.07]
Male (vs. female)	1.79 [1.33, 2.42]***
White (vs. non-white)	1.03 [0.76, 1.40]
Education	
High school	0.85 [0.65, 1.12]
>High school	1.21 [0.73, 1.99]
Married (vs. others)	0.98 [0.73, 1.33]
Non-housing wealth	
1st quartile - median	0.97 [0.69, 1.36]
median – 3rd quartile	0.90 [0.63, 1.30]
3rd quartile - max	0.91 [0.58, 1.43]
Occupation	
Service	1.29 [0.84, 2.00]
Blue-collar	1.18 [0.77, 1.82]
Smoking	
Former	1.37 [0.97, 1.93]
Current	2.54 [1.82, 3.56]***
Drinking (yes)	0.85 [0.65, 1.12]
Frequent exercise (yes)	0.74 [0.57, 0.96]*
BMI	
Overweight	1.07 [0.78, 1.47]
Obese	1.09 [0.77, 1.33]
Self-rated health	0.91 [0.80, 1.05]
Health conditions (count)	1.12 [1.00, 1.26]*

Note. CI = confidence interval for β. Standard errors adjusted for clustering. Retirement age was centered at 65. Birth cohort was centered at 1931.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 10. Association of retirement age with mortality (sensitivity analyses)

	Model A (*n* = 1,934)		**Model B (*n* = 2,143)**		**Model C (*n* = 2,342)**	
	HR [95% CI]	p-value	HR [95% CI]	p-value	HR [95% CI]	p-value
Retirement Age	0.89 [0.85, 0.92]	***	0.89 [0.86, 0.93]	***	0.90 [0.87, 0.92]	***

Note. CI = confidence interval for hazard ratio. Standard errors adjusted for clustering. Retirement age was centered at 65. Birth cohort was centered at 1931.

Model A: individuals who reported *health was not an important reason to retire* were classified as healthy retirees.

Model B: individuals who reported *health was a somewhat important reason* or *not an important reason to retire* were classified as healthy retirees.

Model C: individuals who reported *health was a somewhat important reason*, *a moderately important reason*, or *not an important reason to retire* were classified as healthy retirees.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.