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Essays On Healthy Aging From The Perspective Of A Health Production Function

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ESSAYS ON HEALTHY AGING FROM THE PERSPECTIVE OF A HEALTH PRODUCTION FUNCTION

by

NASIM BAGHBAN FERDOWS

DISSERTATION

Submitted to the Graduate School

Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2016

MAJOR: ECONOMICS

Approved By:

Advisor

Date

DEDICATION

To my loving husband and best friend Alireza,
and to my parents Maliheh and Mahmood.

ACKNOWLEDGMENTS

I have received support and encouragement from a great number of individuals. With this dissertation, my Ph.D. journey at Wayne State University is coming to an end. Working with Professor Gail Jensen Summers, my mentor, colleague, and friend has made this a thoughtful and rewarding endeavor. I would like to thank Gail for her invaluable support as my research project evolved from an idea to a complete study. I would like to thank Dr. Wassim Tarraf for his support, insightful ideas and guidance in the completion of this dissertation.

I would like to extend my appreciation to my other dissertation committee members, Dr. Jennifer Ward-Batts and Dr. Xu Lin and thank Dr. Li Way Lee, Dr. Allen Goodman and Dr. Peter Lichtenberg for their support. Last but not least, I am thankful to everyone who challenged me to improve during my time at WSU.

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CHAPTER 1. INTRODUCTION

There has been a dramatic increase in life expectancy in the US over the last century, partly because of advances in medical interventions for cardiovascular disease, and partly because of the relative success of public programs focused on improving the lives of older adults (DHHS 2016). In the US today life expectancy at birth is 78.7 years, which is up from 68.2 years in 1950 and 47.3 years in 1900 (CDC 2016). However, this increase in lifespan does not necessarily imply that declines in physical health, functioning, and cognition, which often come with advancing age, have been reduced. For this reason, understanding and promoting “healthy aging” in later life has become a public health priority. 65⁺

This dissertation examines the determinants of healthy aging in later life through the lens of a “health production function.” A health production function describes the relationship between different levels of health and the inputs (or building blocks) needed to produce those levels of health (Folland, Goodman et al. 2007). In agreement with current paradigms in gerontology, we view aging as a lifelong process. Each individual is shaped by their personal history, e.g., by the events and circumstances of their lives, from childhood up through the present (e.g., (Schulz and Heckhausen 1996, Pruchno, Heid et al. 2015)). Using nationally representative data from the 2010 Health and Retirement Survey (HRS) on 9,478 non-institutionalized Americans, ages 65 and older, we estimate a production function for healthy aging and then examine the direct and indirect effects of various life course inputs.

We specify and fit a recursive simultaneous equations model, in which we examine: (1) the effects of early life circumstances on healthy aging in later life, including both their direct effects and any indirect effects that occur through the mediating variables of educational attainment, income, and wealth, (2) the effects of lifestyle and health habits on healthy aging,

and (3) the contribution of proxy variable for biological characteristics related to healthy aging, (4) whether and how healthy aging and its determinants differs between men and women.

Following this Introduction, Chapter 2 reviews relevant prior research on the determinants of healthy aging, as well as the closely related construct of successful aging. Chapter 3 describes the calculation of the direct and indirect effects of variables in a recursive-form health production function. These effects are derived for two different situations: first, when the outcome measure is continuous and then when the outcome measure is a discrete measure. In Chapter 4 the first section reports estimates the health production function, and estimates of the direct and indirect effects of childhood measures for all adults ages 65 and older. The second section of Chapter 4 examines whether the production function differs for men and women. The third section of this Chapter examines the health production function for the discrete outcome measure. Finally, Chapter 5 concludes this dissertation.

This study is innovative in several ways. First, it proposes a new strategy for operationalizing the concept of healthy aging and then demonstrates its usefulness. Specifically, in this dissertation we propose that healthy aging can be defined as a continuous variable, one that measures the *degree* to which an individual meets healthy aging criteria, as an alternative to the discrete (0,1) indicator for healthy aging that earlier studies have used. We show that when this continuous measure is implemented with data from the Health and Retirement Study (HRS), reasonable findings result. Second, this study examines how various factors determined in different periods of an individual's life contribute to healthy aging. In particular, explicit models are estimated for various adulthood pathways that link early-life influences to later life health. In the model we develop there are three pathways -- education, income, and wealth -- through which early-life influences indirectly affect healthy aging. Third, this study demonstrates that

men and women differ, not only in their health production functions, but in the particular pathways through which early-life influences indirectly affect their level of healthy aging.

CHAPTER 2. LITERATURE REVIEW

2.1. Healthy and Successful Aging

Since Rowe and Kahn (1987) first developed their typologies of aging a multitude of terminologies, definitions, and empirical conceptualizations of “successful aging” and its derivative concepts have been put forth and examined (Depp and Jeste 2006, Martinson and Berridge 2015). As originally conceived, successful aging encompassed a low probability of disease and disease-related disability, high cognitive and physical functioning, and active engagement with life (Rowe and Kahn 2015). Since then, many have proposed to rethink, adjust, or expand the concept, offering both normative and empirical critiques. We believe that the more descriptive and less normative label of “healthy aging,” which we adopt in this paper, provides an appropriate framework for modeling the contribution of various developmental and life course factors on physical and cognitive health and functioning in later life. Unlike previous studies that use a discrete measure to operationalize healthy aging, we view healthy aging as a continuum, thus steering away our findings and interpretations from a focus on what Schafer and Ferraro (2012, p. 112) describe as the “elite group” of healthy agers.

2.2. Aging as a Lifelong Process

Aging is a lifelong process, and so too is healthy aging in later life. It may be influenced by events and circumstances that have occurred over the individual’s lifetime; from childhood up through to the present. This idea has been highlighted in prior studies, such as Schulz & Heckhausen (1996), Hendricks (2012), and Pruchno et. al. (2015). According to Hendricks (2012), the adoption of a life course perspective is about examining the effects of biological, developmental (including social and psychological factors), historical and geographical factors. Thus, a life course perspective of healthy aging needs to consider developmental influences that

are launched prior to birth (genetics), childhood influences, environmental conditions, early and late adulthood achievements, as well as the individual's current health behaviors.

Available empirical evidence suggests that health and longevity likely have biological roots. Glatt, Chayavichitsilp et al. (2007) found that genetics contribute substantially to successful aging and that successful aging tends to run in families. They suggested that several specific genes are likely involved. Prior studies have also highlighted the importance of early life development to health and aging outcomes, including *in utero* characteristics (Sayer, Cooper et al. 1998, Kuh, Bassey et al. 2002) and childhood circumstances. In their research, Doom and Kasl (1998) examine the effects of parental longevity on mortality using a sample of Australian older adults ages 70 and over. They use parental ages at death as a proxy for parental longevity and for the few respondents who reported having a living parent at the time of the survey they use current parental ages. They find that Parental ages at death were not associated with mortality for either men or women.

Early life conditions and experiences have been shown to influence cognitive development (Jefferis, Power et al. 2002) and educational achievement among young adults (Case, Fertig et al. 2005) earnings, physical health, disease avoidance, and mental health among adults in midlife (Currie and Stabile 2003, Schafer and Ferraro 2012, Friedman, Karlamangla et al. 2015), social and economic resources and lifestyle risks in adulthood (Ferraro, Schafer et al. 2015), and physical and mental health, ability to function, cognition, and mortality among older adults (Hayward and Gorman 2004, Luo and Waite 2005, Britton, Shipley et al. 2008, Case and Paxson 2008, Haas 2008).

A few studies have investigated the effects of early life characteristics on successful aging. Luo and Waite (2005) analyzed data from 1998 HRS to explore the impact of childhood

socioeconomic status (SES) and own SES as an adult on later life health status. They found that childhood SES and adult SES are both important determinants of health. Pruchno, Wilson-Genderson et al. (2010) analyzed data on adults, ages 50–74, who were living in New Jersey and found that successful aging is affected both by early influences, such as incarceration history, as well as one's contemporary characteristics, such as employment status, health behaviors, social support, and religiosity. Furthermore, the effects of early influences were attenuated upon adjustment for these contemporary characteristics. More recently, Pruchno and Wilson-Genderson (2014) report that within this same sample of adults, early life characteristics, particularly education and incarceration history, are also strong predictors of being able to continue-to-age-successfully over a four year period. Studies conducted outside the US provide additional evidence of linkages between one's characteristics in early life and ability to age successfully in later life (Britton, Shipley et al. 2008, Brandt, Deindl et al. 2012, Hurst, Stafford et al. 2013).

There is also research that suggests that achievements in young adulthood and midlife, such as level of education and economic success (e.g, income and wealth), can partially compensate for the effects of disadvantageous childhood characteristics (González, Tarraf et al. 2013, Friedman, Karlamangla et al. 2015). Yet these studies did not examine childhood's indirect effects through these variables. This gap in the literature is important because socioeconomic characteristics have been consistently highlighted as some of the most challenging and persistent risk factors for health problems, disability, and mortality (Adler, Boyce et al. 1994, Adler and Newman 2002, Adler and Rehkopf 2008). Some have found that socioeconomic characteristics have interesting effects variability (Chen and Miller 2012) which is likely due to antecedent circumstances. As such they can, even among disadvantaged groups, protect against

or predispose to negative physiologic and other health processes. In this paper we explicitly model the mediating role of these factors, particularly with respect to childhood circumstances.

Current health behaviors have also been linked to successful aging (Pruchno and Wilson-Genderson 2012, Sabia, Singh-Manoux et al. 2012). Specific studies have highlighted the importance of not smoking (Burke, Arnold et al. 2001, Depp and Jeste 2006, Pruchno, Hahn et al. 2012) and drinking alcohol in moderation (Kaplan, Huguette et al. 2008). Other studies have linked excessive body weight (Singh-Manoux, Sabia et al. 2014, Jackson, Dobson et al. 2015) to negative patterns of aging, and several have emphasized the importance of avoiding sedentary living for successful aging in later life (Shaw and Agahi 2014) (Hamer, Lavoie et al. 2014, Blodgett, Theou et al. 2015, Schwingel, Sebastião et al. 2016). Studies also suggest that positive health habits in later life may be able to offset the effects of negative early and midlife influences (Pruchno, Wilson-Genderson et al. 2010, Schafer and Ferraro 2012). The strength of the associations uncovered in these studies underscores the value of health initiatives that seek to promote better health habits among older adults.

CHAPTER 3. DESIGN AND METHODS

This chapter theoretically defines a health production function for healthy aging, and describes the methods for estimating and interpreting the “total effect,” the “direct effect,” and the “indirect effects” of variables in the model. We first examine these for the case of a continuous outcome variable, and then examine these for a discrete outcome variable.

3.1. Health Production Function in a Continuous Outcome Model

Assume HA_i is a measure of the extent to which individual i is aging healthy. We view HA_i as the output of a health production function, produced by childhood health and socioeconomic status, biological factors, in terms of parent’s longevity, adult achievements in terms of education attained, and current characteristics, such as household income, wealth, health habits and pertinent demographics. In addition to the direct effects of these factors on healthy aging, the indirect effects of childhood factors that operate through education, income, and wealth are also of interest. More formally, following Grossman (1972), HA is viewed as the output of a health production function:

$$HA_i = f (BL_i, C_i, Edu_i, Inc_i, W_i, HB_i, Z_i) \quad (1)$$

where i indexes the individual, HA_i is a measure of the extent to which an individual is aging healthy, BL_i is a set of biological factors referring to mother’s and father’s longevity, C_i is a set of childhood characteristics, Edu_i is education attained, Inc_i is income, W_i is wealth, HB_i is a set of health habits / lifestyle variables, and Z_i is a vector of other explanatory variables in the model.

The challenge for estimating the effects of each variable on HA is that some of these variables likely influence mediating variables, so they may have an indirect effect on healthy aging through these channels, as well. Thus, it is critical to account for both the direct and

indirect effects to generate an unbiased assessment of their overall influence. For example, childhood characteristics likely influence education attained, and income and wealth likely depend on childhood characteristics as well as education. To address this possibility, we adopt a simultaneous equations model, one that allows for estimating both the direct effects of each variable on HA and any indirect effects that operate through the mediators of education, income, and wealth. More formally, our model incorporates equations for these mediators:

$$Edu_i = E [C_i, X_i] \quad (2)$$

$$Inc_i = I [C_i, E(C_i, X_i), X_i] \quad (3)$$

$$W_i = W [C_i, E(C_i, X_i), X_i] \quad (4)$$

Figure 1 conceptually illustrates this model, which has a naturally recursive structure. Childhood conditions, such as childhood SES, influence own education, typically in young adulthood. Own education and childhood characteristics then partly determine achievements in midlife, such as income and wealth. In later life healthy aging depends on all of these factors. The key insight here is that education, income, and wealth are all mediating variables for the effects of childhood on later life outcomes. Therefore, it is critical to account for these indirect pathways to obtain an unbiased estimate of the overall influence of the childhood factors. Considering these indirect pathways and considering equations (2)-(4), the health production function in equation (1) can also be described as follows:

$$HA_i = f \{BL_i, C_i, E(C_i, Z_i), I[C_i, E(C_i, Z_i), Z_i], W[C_i, E(C_i, Z_i), Z_i], HB_i, Z_i\} \quad (5)$$

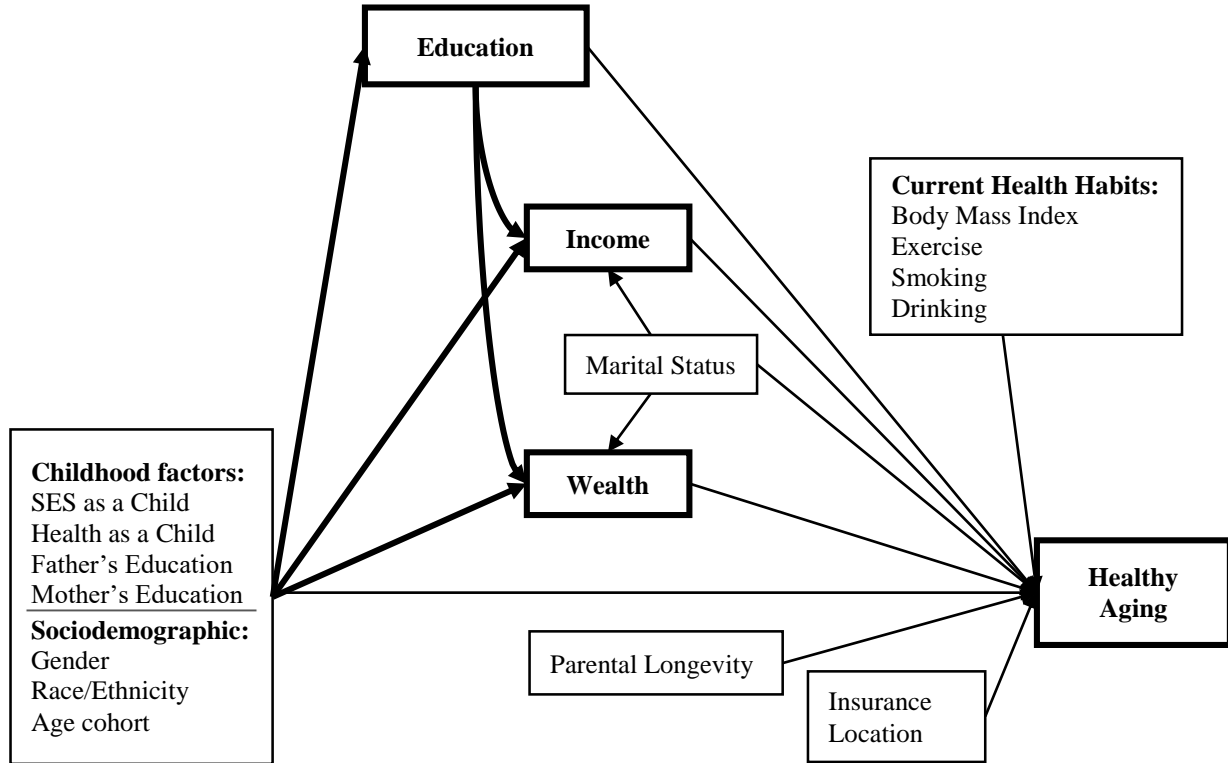


Figure 1- The association between childhood factors and healthy aging in later life is mediated by educational attainment, income and wealth, controlling for other determinants of healthy aging throughout the life span.

The full associations between childhood and healthy aging should account for these indirect effects through the mediators. Considering these indirect pathways, the health production function in equation (5) can also be estimated as follows:

$$HA_i = \gamma^0 + \gamma^{bl}BL_i + \gamma^c C_i + \gamma^{edu}E(C_i, Z_i) + \gamma^{inc} I(C_i, E(C_i, Z_i), Z_i) + \gamma^{wl}W(C_i, E(C_i, Z_i), Z_i) + \gamma^{hb}HB_i + \gamma^z Z_i + \varepsilon_i \quad (6)$$

3.1.1. Direct and Indirect Effects in a Continuous Outcome Model

The direct association between each childhood variable C_i and healthy aging is γ^c , and this is what the prior literature conventionally estimates as the association between childhood factors and healthy aging controlling for mid and later-life circumstances. The indirect and total

effects of C that operates through early and mid-life mediators are shown by the full set of derivatives of healthy aging to C_i in equation (7):

$$\frac{\partial HA_i}{\partial C_i} = \frac{\partial f}{\partial C_i} + \left[\frac{\partial f}{\partial Edu_i} + \frac{\partial f}{\partial Inc_i} \frac{\partial I}{\partial Edu_i} + \frac{\partial f}{\partial W_i} \frac{\partial W}{\partial Edu_i} \right] \frac{\partial E}{\partial C_i} + \frac{\partial f}{\partial Inc_i} \frac{\partial I}{\partial C_i} + \frac{\partial f}{\partial W_i} \frac{\partial W}{\partial C_i} \quad (7)$$

The first term in equation (7) estimates the direct effects of C_i and HA_i , described previously as γ^c . The second term in equation (7) estimates the indirect effects of childhood circumstances that operate through education. The third and fourth terms are the indirect effects that operate through income and wealth respectively. To calculate the terms in equation (7), models that predict education, income and wealth should also be estimated. Beginning with education, it can be estimated as follows:

$$Edu_i = \alpha^0 + \alpha^c C_i + \alpha^z Z_i + e_i \quad (8)$$

where the α 's are the parameters to be estimated, e.g. α^c estimates the effects of childhood on educational attainment, e_i denotes the error term.

Since income and wealth are considered as being dependent on childhood characteristics as well as education, they can be estimated as follows:

$$Inc_i = \delta^0 + \delta^c C_i + \delta^{edu} E(C_i, Z_i) + \delta^z Z_i + \mu_i \quad (9)$$

$$W_i = \beta^0 + \beta^c C_i + \beta^{edu} E(C_i, Z_i) + \beta^z Z_i + \omega_i \quad (10)$$

Where δ 's and β 's estimate the effects of C_i on income and wealth, respectively and μ_i and ω_i denote the error term.

Considering equations (7) - (10), the total effects of each childhood factor on healthy aging can be described as follows:

$$\frac{\partial HA_i}{\partial C_i} = \gamma^c + [\gamma^{edu} + \gamma^{inc} \delta^{edu} + \gamma^{wl} \beta^{edu}] \alpha^c + \gamma^{inc} \delta^c + \gamma^{wl} \beta^c \quad (11)$$

Equation (11) reveals that the total effect of each childhood factor is the sum of a direct effect of that factor on healthy aging, γ^c , and three indirect effects, one that operates through education, $[\gamma^{edu} + \gamma^{inc}\delta^{edu} + \gamma^{wl}\beta^{edu}]\alpha^c$, another that operates through income, $\gamma^{inc}\delta^c$, and a third that operates through wealth, $\gamma^{wl}\beta^c$.

3.1.2. Statistical analysis

Equations (6) and (8) through (10) are specified as linear regressions for HA, years of education, log(income), and log(wealth). The logarithmic transformations for income and wealth correct for skewness in the distribution of these measures. In order to obtain unbiased estimates, we adopt a simultaneous equation (SUR) model, allowing the error terms, ε_i , e_i , μ_i and ω_i to be correlated. SUR recognizes that random shocks in childhood, which are not directly observed in the data, might influence downstream life outcomes. Models are estimated using Maximum Likelihood methods in MPLUS version 7.4 (Muthen & Muthen, 2015). After estimating the model, the direct, indirect, and total effect of each childhood characteristic on HA are calculated once for the whole sample and once separately for men and women. Standard errors for all estimates are calculated by bootstrapping with the number of iterations set at 10,000. Additionally, all reported estimates account for the complex design of the HRS including appropriate sampling weights to ensure correct inferences and allow our findings to generalize to the population of non-institutionalized Americans in 2010, ages 65 and older.

3.2. Health Production Function in a Discrete Outcome Model

When healthy aging (HA) is measured as a (0,1) outcome, the health production function takes the following form instead of equation (1):

$$Prob(HA_i = 1) = \Phi(BL_i, C_i, Edu_i, Inc_i, W_i, HB_i, Z_i) \quad (12)$$

where i indexes the individual, HA_i is a dichotomous variable indicating whether he or she satisfies the criteria for healthy aging (1 if yes, 0 otherwise), $\Phi(\cdot)$ is the normal cumulative density function, BL_i is a set of biological factors referring to mother's and father's longevity, C_i is a set of childhood characteristics, Edu_i is education attained, Inc_i is income, W_i is wealth, HB_i is a set of health habits/lifestyle variables, and Z_i is a vector of other explanatory variables.

As noted earlier, education may depend on childhood characteristics, and income and wealth may depend on childhood characteristics and education. Considering these indirect pathways and considering equations (2) through (4) above, the health production function in equation (12) can also be described as follows:

$$Prob(HA_i = 1) = \Phi \{BL_i, C_i, E(C_i, Z_i), I[C_i, E(C_i, Z_i), Z_i], W[C_i, E(C_i, Z_i), Z_i], HB_i, Z_i\} \quad (13)$$

The full associations between childhood and the probability of healthy aging should account for these indirect effects through the mediators. Considering these indirect pathways, the health production function in equation (12) can also be estimated as follows:

$$Prob(HA_i = 1) = \gamma^0 + \gamma^{bl}BL_i + \gamma^c C_i + \gamma^{edu}E(C_i, Z_i) + \gamma^{inc} I(C_i, E(C_i, Z_i), Z_i) + \gamma^{wl}W(C_i, E(C_i, Z_i), Z_i) + \gamma^{hb}HB_i + \gamma^z Z_i + \varepsilon_i \quad (14)$$

3.2.1. Direct and Indirect Effects in a Discrete Outcome Model

The total effect of each childhood factor on the probability of healthy aging is shown by the derivative of the probability of healthy aging with respect to C_i . Assuming $\Phi(\cdot)$ follows a normal distribution, differentiating equation (1) yields:

$$\frac{\partial Prob(HA_i=1)}{\partial C_i} = \phi(\cdot) \times \left\{ \frac{\partial \Phi}{\partial C_i} + \left[\frac{\partial \Phi}{\partial Edu_i} + \frac{\partial \Phi}{\partial Inc_i} \frac{\partial I}{\partial Edu_i} + \frac{\partial \Phi}{\partial W_i} \frac{\partial W}{\partial Edu_i} \right] \frac{\partial E}{\partial C_i} + \frac{\partial \Phi}{\partial Inc_i} \frac{\partial I}{\partial C_i} + \frac{\partial \Phi}{\partial W_i} \frac{\partial W}{\partial C_i} \right\} \quad (15)$$

The first term in equation (15), $\emptyset(\cdot) \times \frac{\partial \Phi}{\partial C_i}$, estimates the direct effects of C_i and HA_i , described previously as γ^c . The second term in equation (15) estimates the indirect effects of childhood circumstances that operate through education. The third and fourth terms are the indirect effects that operate through income and wealth respectively. To calculate the terms in equation (18), models that predict education, income and wealth should also be estimated. These indirect pathways have been introduced in section 3.2. Considering equations (7)-(10), the total effects of each childhood factor on the probability of healthy aging can be described as follows

$$\frac{\partial Prob(HA_i=1)}{\partial C_i} = \emptyset(\cdot) \times \{ \gamma^c + [\gamma^{edu} + \gamma^{inc} \delta^{edu} + \gamma^{wl} \beta^{edu}] \alpha^c + \gamma^{inc} \delta^c + \gamma^{wl} \beta^c \} \quad (16)$$

Equation (16) reveals that the total effect of each childhood factor is the sum of a direct effect of that factor on healthy aging, $[\emptyset(\cdot) \times \gamma^c]$, and three indirect effects, one that operates through education, $[\emptyset(\cdot) \times [\gamma^{edu} + \gamma^{inc} \delta^{edu} + \gamma^{wl} \beta^{edu}] \alpha^c]$, another that operates through income, $[\emptyset(\cdot) \times \gamma^{inc} \delta^c]$, and a third that operates through wealth, $[\emptyset(\cdot) \times \gamma^{wl} \beta^c]$.

3.2.2. Statistical analysis

For the continuous measure of healthy aging we adopt a linear multivariate regression model for healthy aging and linear regression models for education, log(income), and log(wealth). For the discrete measure of healthy aging we instead adopt a multivariate probit model for healthy aging and linear regression models for education, log(income), and log(wealth). In both set-ups, since the error terms across these equations, ε_i , e_i , μ_i and ω_i , may be correlated, we adopt a seemingly unrelated regressions (SUR) model (Roodman 2011). SUR recognizes that random shocks in childhood, which are not directly observable in the data, might also influence downstream life outcomes. After estimating each model, we calculate the direct, indirect, and total effects of childhood characteristics on the probability of healthy aging, along

with estimates of their standard errors (using the “delta method” (Oehlert 1992; Feiveson 1999)). To ensure our findings generalize to the population of non-institutionalized Americans, ages 65 and older, all estimates are weighted using the sampling weights provided on the public-use HRS data files.

3.3. Data

We analyze data from the 2010 HRS and RAND HRS (RAND HRS data, 2010). The HRS is an ongoing nationally representative survey of older Americans and their spouses. Many HRS participants have been interviewed every other year since 1992. The survey is quite broad and collects extensive data on the health and functioning of participants, as well as their demographic characteristics, income and financial assets, and other data. The RAND HRS is a clean, user-friendly version of the HRS with derived measures for total annual income, wealth, and other key variables, and RAND Corporation makes it publicly available to researchers.

We focus on HRS respondents ages 65 or older in 2010, and exclude respondents who are missing information on key variables. Our sample consists of 9,478 older adults, ranging in age from 65 to 101 with a mean age of 75.4 years old, 42% of our sample are men and 58% are women.

3.4. Measurement of Variables

3.4.1. Dependent Variable (Healthy Aging) as a Continuous Measure:

We define an index variable to measure healthy aging (HA). HA_i is the average standardized score individual i achieves in four domains: (a) presence/absence of major diseases, measured over nine medical conditions (high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, arthritis, and depression), (b) presence/absence of disability, measured over five activities of daily living (ADLs) (walking across a room, dressing,

bathing/showering, eating, and getting in/out bed) and five instrumental ADLs (using a telephone, taking medication, handling money, shopping, and preparing meals), (c) level of physical functioning, measured with regard to seven different tasks (walking one block, walking several blocks, climbing one flight of stairs, climbing several flights of stairs, lifting or carrying items weighing more than 10 lbs., stooping, kneeling or crouching, and pulling or pushing large objects), and (d) level of cognition, measured by the score obtained on the Telephone Interview of Cognitive Status (TICS), a reliable and validated measure of cognitive function (Ofstedal 2005). More specifically, we define HA_i to be the continuous variable:

$$HA_i = (Z_i^a + Z_i^b + Z_i^c + Z_i^d)/4 \quad (17)$$

where Z_i^a , Z_i^b , Z_i^c and Z_i^d are individual i 's standardized scores in domains (a), (b), (c), and (d), respectively, and where each score is measured so that higher values reflect better achievement in that domain. Z_i^a is the total number of medical conditions (summed over the six listed above) for which individual i reported being disease-free, minus the sample mean of that tally, divided by the tally's standard error. Z_i^b is the total number of ADLs and IADLs (summed over the ten listed above) for which individual i reported being disability-free, minus the sample mean of that count, divided by the count's standard error. Z_i^c and Z_i^d are similarly defined as the standardized scores achieved in domains (c) and (d), respectively.

Standardizing the Z_i^k 's facilitates interpreting both their values and the value of HA_i . A value of zero indicates that individual is at the sample mean. A value of one indicates they are one standard deviation above the mean on that measure, whereas a value of minus one indicates they are one standard deviation below the mean. HA_i measures the average score individual i achieves across all four domains, and higher values correspond to healthier aging. An individual's healthy aging score is measured in units of standard deviation from the sample

mean, so HA will have both negative and positive values. Notice that different individuals whose underlying scores for the four domains happen to be close will have values for HA_i that are also close. This is a desirable property for an index of healthy aging, but it is lacking in the simple (0,1) indicators that earlier studies have adopted. Notice also that our definition for HA_i does not account for active community engagement. We chose to omit this domain because in the HRS there are too many instances of missing data on measures of engagement, and because recent work suggests social measures should be kept separate (Kullgren, McLaughlin et al. 2012, Hodge, English et al. 2013).

3.4.2. Dependent Variable (Healthy Aging) as a Discrete Measure:

An older adult is considered a healthy ager if, in 2010, he/she had: (a) no major disease (cancer, chronic lung disease, diabetes, heart problems, stroke, or depression), (b) no disability on five activities of daily living (walking across a room, dressing, bathing/showering, eating, and getting in/out bed), (c) high physical functioning, meaning no more than one difficulty with seven tasks (walking one block, walking several blocks, climbing one flight of stairs, climbing several flights of stairs, lifting or carrying items weighing more than 10 lbs., stooping, kneeling or crouching, and pulling or pushing large objects), and (d) achieved a median-or-better score on the Telephone Interview of Cognitive Status (TICS), a reliable and validated measure of cognitive function (Ofstedal, 2005). Our definition of healthy aging does not account for active community engagement since recent work suggests social measures should be kept separate from a health-based conception of successful aging (McLaughlin, 2012; Hodge et. al, 2013).

3.4.3. Covariates

To measure biological factors we include two proxy measures, mother's and father's longevity, each measured as the parent's age at death. For the small sample of individuals with a living parent we instead assign the current age of the parent as a measure of parent's longevity.

Childhood characteristics include father's education and mother's education, each categorized as, "at least high school," "less than high school," or "not reported," self-rated childhood SES, categorized as "above-average," "average or varying," or "below-average," and self-rated childhood health, categorized as "excellent," "very good," "good," "fair" or "poor."

Educational attainment is measured by years of education, and both income and wealth are measured by their natural logarithm.

Current health habits include 1) current body mass, categorized as, "underweight or normal," "overweight," or "obese," 2) level of weekly exercise, categorized as "never," "1-3 times a month," "once a week," "more than once a week," or "every day," 3) smoking status, categorized as "never," "former smoker," or "current smoker," and 4) alcohol consumption, categorized as "never," "not at risk," "at low risk," or "at high risk." (Based on the NIAA definition of at-risk drinking).

Other explanatory variables in all equations include age, gender, marital status, race/ethnicity, type of health insurance, and geographic Census region.

3.5. Sensitivity Analysis

It is possible that the variables measuring health behaviors in the production function are potentially endogenous, i.e., correlated with the disturbance. If so, that introduces potential bias in the estimated regression parameters. In order to overcome this problem, the health production function was re-estimated by treating health behaviors as another mediator in the production

function. In this analysis, health behavior is introduced as an index measure, compounded of all the four measures of; drinking habits, smoking habits, body mass index and exercise (ranged from 0 to 10) into one index measure ranged between zero and ten. The health behavior index measure was treated as a continuous measure and entered as a mediator in the health production function estimation. This model was estimated for years 2010 and 2012 separately to assess whether the results are consistent over time.

Including cognitive functioning in the outcome may bias the results because cognitive functioning in late life may be directly caused by cognitive functioning in early life and which can be a source of endogeneity and bias the results. Thus, additional set of sensitivity analyses was undertaken using slight variations in the definition of healthy aging by excluding cognitive functioning from the definition of successful aging.

CHAPTER 4. RESULTS

4.1. Results for all Adults, Ages 65 and Older in the Continuous Outcome Model

Descriptive statistics and definitions for all variables are reported in the Appendix A1 table. Regression parameters for the estimated production function for healthy aging are reported in Appendix A2 table, along with parameter estimates for the models specified for education, income, and wealth. Our main interest in these equations centers on what they imply about the marginal effects of variables set during different periods of an individual's life.

We begin with the effects of childhood measures. Each childhood characteristic can affect *HA* both directly and indirectly through the mediators. Table 1 reports the marginal product of each childhood characteristic on *HA*, derived using equation (5). The first three columns report the indirect effects of childhood characteristics through education, income, and wealth, the fourth column reports their direct effects, and the last column reports their total effects, or "marginal products."

Our results indicate that childhood characteristics have significant effects on healthy aging, particularly with respect to an individual's childhood SES, childhood health, and parental education. First, compared to having had average childhood SES, having had a poor childhood SES lowers a healthy aging score by 0.08 ($p < 0.01$), a reduction equivalent to 0.13 standard deviations. This decrease partly reflects a poor childhood SES's indirect influence on healthy aging through lower educational attainment (-0.02 ; $p < 0.01$). Second, reporting very good or excellent childhood health, as opposed to good childhood health, raises a healthy aging score by 0.072 ($p < 0.01$) and 0.153 ($p < 0.01$), respectively, or by 0.12 and 0.25 standard deviations, respectively. The higher healthy aging scores are partly attributable to better educational attainment

Table 1: Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among Adults Ages 65+ (N=9,180).

Childhood Factors (C_j)	Indirect through Education (E)	+ Indirect through Income (I)	+ Indirect through Wealth (W)	+ Direct	= Total
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.039*** (0.005)	0.002 (0.002)	0.003 (0.004)	-0.031 (0.024)	0.012 (0.025)
Below average	-0.02*** (0.003)	0.001 (0.001)	-0.001 (0.002)	-0.06*** (0.017)	-0.08*** (0.016)
<u>Childhood Health</u> ^b					
Excellent	0.034*** (0.004)	0.002* (0.001)	0.009*** (0.003)	0.107*** (0.02)	0.153*** (0.02)
Very Good	0.018*** (0.004)	0.000 (0.001)	0.009*** (0.003)	0.044* (0.025)	0.072*** (0.023)
Fair	0.006 (0.008)	0.000 (0.002)	0.000 (0.005)	-0.025 (0.035)	-0.019 (0.036)
Poor	0.003 (0.01)	-0.009** (0.004)	-0.02** (0.008)	-0.107* (0.061)	-0.132** (0.063)
<u>Parental Education</u> ^c					
Father Less than high school	-0.035*** (0.003)	-0.004*** (0.002)	-0.004* (0.002)	-0.008 (0.016)	-0.052*** (0.016)
Mother Less than high school	-0.04*** (0.004)	-0.004*** (0.001)	-0.002 (0.002)	-0.012 (0.014)	-0.057*** (0.014)

Reference Groups: ^aaverage, ^bgood, ^cmore than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

(0.018; $p < 0.01$ and 0.034; $p < 0.01$) and greater wealth accumulation (0.009; $p < 0.01$ and 0.009; $p < 0.01$) that arises from having had better childhood health. Third, having a high school educated mother or father raises a healthy aging score by 0.057 ($p < 0.01$) and 0.052 ($p < 0.01$), increases equivalent to 0.09 and 0.08 standard deviations, respectively. The effects of parental

(both father's and mother's) education are significantly enhanced through their indirect effects on a person's own education, and to a lesser extent income.

These findings highlight that the total effects of childhood arise from both childhood's indirect effects through the mediators and direct effects on healthy aging. If we had instead ignored the indirect effects of these characteristics and focused only on direct effects, a practice widely adopted in previous studies, we would have underestimated the effects of childhood. In other words, ignoring indirect effects in this model leads to estimates that are downwardly biased.

Table 2 reports the marginal effects of childhood factors on the socioeconomic attainment mediators, holding constant other model covariates. Our results indicate that these childhood factors are linked substantially to a person's educational prospects, and to differing degrees income and wealth. First, reported years of education is enhanced by better childhood SES and diminished when childhood SES was below average. Additionally, a person's own education is significantly enhanced by better childhood health and deflated by lower parental education. Second, poor health and lower paternal and maternal education significantly decrease levels of reported income. Finally, reported wealth is positively associated with very good and excellent childhood health and negatively related to poor health. The strong and consistent effects of childhood factors on education in particular provide another clear signal of the importance of accounting for indirect effects when examining healthy aging.

Table 2: Effects of Childhood Characteristics on Educational Attainment (E), Income (I), and Wealth (W) among Adults Ages 65+, Expressed as Partial Derivatives (N=9,180).

Childhood Factors (C_j)	$\frac{\partial E}{\partial C_i}$	$\frac{\partial I}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$
<u>Childhood Socioeconomic Status</u> ^a			
Well off	0.944*** (0.123)	0.044 (0.049)	0.067 (0.113)
Poor	-0.485*** (0.06)	0.034* (0.02)	-0.029 (0.054)
<u>Childhood Health</u> ^b			
Excellent	0.84*** (0.091)	0.054** (0.026)	0.245*** (0.079)
Very Good	0.45*** (0.086)	0.01 (0.023)	0.23*** (0.072)
Fair	0.149 (0.183)	-0.007 (0.052)	-0.003 (0.138)
Poor	0.073 (0.249)	-0.198*** (0.075)	-0.519** (0.218)
<u>Parental Education</u> ^c			
Father Less than high school	-0.868*** (0.081)	-0.103*** (0.027)	-0.096* (0.056)
Mother Less than high school	-0.986*** (0.078)	-0.088*** (0.03)	-0.042 (0.052)

Reference Groups: Reference Groups: ^a average, ^b good, ^c more than high school. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Table 3 reports the total marginal effect on healthy aging scores of characteristics set at different times in a person's life. First, we find evidence for linking the longevity of one's father (0.023; p<0.01) and mother (0.031; p<0.01), our proxies for having "genes for longevity," to healthy aging. Second, we find that socioeconomic characteristics determined between childhood

Table 3: Marginal Products of Selected Inputs for Healthy Aging among Adults Ages 65+, Evaluated at the Sample Mean (N=9,180).

		MPs	(Std. Err)
<u>Biological Factors</u>			
Parental Longevity ^a	Father	0.023**	(0.011)
	Mother	0.031***	(0.011)
<u>Childhood Factors</u>			
Childhood Socioeconomic Status ^b	Well off	0.012	(0.025)
	Poor	-0.08***	(0.016)
Childhood Health ^c	Excellent	0.153***	(0.02)
	Very good	0.072***	(0.023)
	Fair	-0.019	(0.036)
	Poor	-0.132**	(0.063)
Parental Education ^d	Father Less than high school	-0.052***	(0.016)
	Mother Less than high school	-0.057***	(0.014)
<u>Early and Mid-Adulthood</u>			
Education		0.041***	(0.002)
Income		0.044***	(0.009)
Wealth		0.038***	(0.004)
<u>Current Health Behaviors</u>			
Smoking ^f	Former smoker	-0.082***	(0.015)
	Current smoker	-0.073***	(0.027)
Body Mass Index ^g	Underweight	-0.058	(0.061)
	Overweight	-0.047***	(0.01)
	Obese	-0.191***	(0.016)
Physical Activity ^f	Every day	0.309***	(0.033)
	More than once a week	0.252***	(0.013)
	Once a week	0.247***	(0.016)
	1-3 times a month	0.252***	(0.017)
Alcohol Consumption ^f	At most once a week	0.115***	(0.015)
	More than once a week	0.144***	(0.011)

Reference Groups: ^aParent did not survive average life expectancy, ^baverage, ^cgood, ^dmore than high school, ^fnever, ^gnormal. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference

from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey. Marginal products for other inputs in the healthy aging production function, which are not reported here, are available from the authors upon request.

and late life contribute to healthy aging. Education, income, and wealth are all positively associated with healthy aging scores, with marginal effects of 0.041 ($p<0.01$), 0.044 ($p<0.01$), and 0.038 ($p<0.01$), respectively, or in terms of standard deviation increases of 0.2, 0.07, and 0.16, respectively.

Current health habits, however, have the strongest effects on healthy aging, according to our estimates. Former and current smokers have healthy aging scores that are 0.082 ($p<0.01$) and 0.073 ($p<0.01$) lower, or in terms of standard deviation, 0.13 and 0.12 lower compared to their counterparts who never smoked. Being overweight or obese lowers a healthy aging score by 0.047 ($p<0.01$) and 0.191 ($p<0.01$), respectively, or by 0.08 and 0.31 standard deviations, relative to people reporting normal weights. Seniors who exercise also score substantially higher on our healthy aging index. Every level of reported physical activity is better compared to being sedentary. Exercising daily (0.309; $P<0.01$) is best for healthy aging, followed by multiple times weekly (0.252; $P<0.01$), once a week (0.247; $P<0.01$), and 1-3 times monthly (0.252; $P<0.01$). The increases in units of standard deviation associated with these exercise regimens are 0.50, 0.41, 0.40, and 0.41, respectively. Lastly, seniors who typically drink at most once a week and those who drink more than once a week have healthy aging scores that are 0.115 ($p<0.01$) and 0.144 ($p<0.01$) higher than the scores of abstainers. These effects translate into scores that are 0.19 and 0.23 standard deviations higher than the abstainer category.

Figure 2 graphically depicts the total marginal effects of different factors throughout the life span. It reveals another intriguing finding of our model. Comparing the absolute magnitude (in standard deviation terms) of the marginal products of variables determined in different periods of one's life, current health habits tend to have the largest effects on healthy aging, the achievements of adulthood have the next largest effects, and childhood characteristics have the smallest effects. (Parental longevity effects are statistically insignificant.) Stated differently, the closer the time period to the present, the more important that characteristic is to healthy aging.

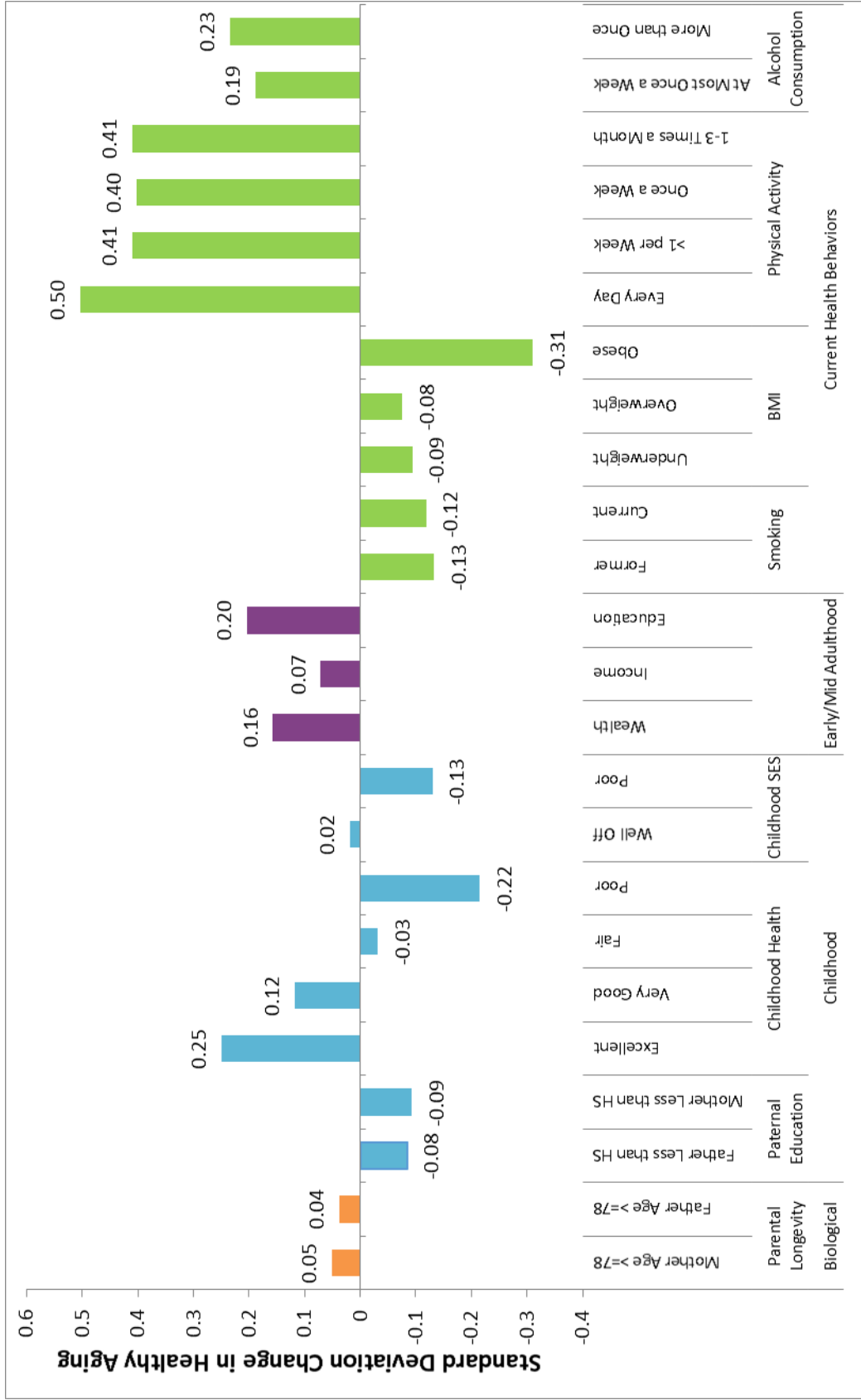


Figure 2. Total marginal effects of different factors throughout the life span.
 Note: The marginal product for a discrete variable can be interpreted as the average change in healthy aging scores, measured in units of standard deviation, given that characteristic relative to the reference group. The marginal product for a continuous variable can be interpreted as the average change in healthy aging scores, measured in units of standard deviation, given a change of one standard deviation in that continuous variable.

4.1.1. Discussion

This section of the dissertation has estimated a health production function for adults ages 65 and older with inputs that span throughout the whole life cycle, and has estimated both the direct and indirect effects of childhood circumstances. Three broad findings emerge from this part of the study. First, favorable childhood characteristics have positive implications for healthy aging. Second, the effects of childhood factors are manifested both directly and indirectly through early- and mid-adulthood socioeconomic achievement. Third, current positive health behaviors are substantial contributors to healthy aging, and their effects are comparatively larger than the effects of early life factors.

4.2. Results for Men and Women separately, Ages 65 and Older in the Continuous Outcome Model

In this section of the dissertation we estimate separate health production function for men and women. Descriptive statistics for the sample by gender group are provided in Appendix B1 and Appendix B2 tables. This table shows how men and women are acting differently in terms of health behaviors. Generally speaking, it reveals that women tend to have healthier habits related to alcohol consumption, smoking and their body mass. A higher percentage of men are overweight, compared to women, whereas the percentage of men doing any exercise is higher than it is among women. The percentage of at high or low risk drinker men is higher than women and the percentage of ever being a smoker is much higher for men. In Supplementary Table 4, all the regression parameters are reported along with parameter estimate for education, income, and wealth. Our main interest in these equations centers on the marginal effects of early life variables.

Tables 4 and 5 reports the effects of childhood circumstances on healthy aging scores among women and men, respectively. In each of these tables, the first three columns report the specific indirect effects of each childhood characteristic, i.e., that operate through education, income, and wealth. The fourth column reports the direct effect of each characteristic on healthy aging score, and the last column reports the total marginal effect of each characteristic. All marginal effects are calculated at the sample means for women and men, respectively.

Interestingly, we see that early life circumstances have no direct association with healthy aging for men but there are several direct associations for women. There are more indirect associations between childhood factors and healthy aging scores for women compared to men, but the indirect effects that operate through education are larger in magnitude than they are for men.

The results for women, reported in Table 4, reveal that an above-average childhood SES indirectly raises a woman's later-life healthy aging score through education by 0.031. In contrast, a below-average childhood SES indirectly lowers a woman's healthy aging score through education by -0.017, whereas it increases that score through income by 0.002. The direct and total aggregate effects of childhood SES are significant for women who had below-average childhood SES. In this case, a woman's healthy aging score declines directly by -0.074, while the total decrease in her healthy aging score is -0.090. Excellent health as a girl as opposed to good health indirectly raises her healthy aging score by 0.025, 0.004 and 0.011 through education, income and wealth respectively, and it directly raises her score by 0.138 with the total effect of 0.178, which is the highest total effect among all the childhood factors.

Table 4. Specific Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among Women Ages 65+, Year 2010 (N=5,822)

Childhood Factors (C_j)	Indirect through			Direct	Total
	Education(E)	Income(I)	Wealth(W)		
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.031*** (0.006)	0.001 (0.003)	0.005 (0.004)	-0.050 (0.031)	-0.012 (0.033)
Below average	-0.017*** (0.003)	0.002* (0.001)	-0.001 (0.002)	-0.074*** (0.021)	-0.090*** (0.020)
<u>Childhood Health</u> ^b					
Excellent	0.025*** (0.004)	0.004* (0.002)	0.011*** (0.003)	0.138*** (0.020)	0.178*** (0.021)
Very Good	0.016*** (0.004)	0.001 (0.002)	0.009*** (0.003)	0.059** (0.027)	0.085*** (0.028)
Fair	0.006 (0.010)	0.001 (0.002)	0.003 (0.006)	-0.048 (0.046)	-0.038 (0.048)
Poor	0.000 (0.012)	-0.010** (0.004)	-0.018* (0.010)	-0.063 (0.077)	-0.091 (0.077)
<u>Parental Education</u> ^c					
Father More than high school	0.029*** (0.003)	0.004* (0.002)	0.006** (0.003)	0.010 (0.019)	0.049** (0.020)
Mother More than high school	0.035*** (0.005)	0.004*** (0.002)	0.000 (0.003)	0.022 (0.020)	0.061*** (0.021)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Table 5. Specific Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among Men Ages 65+, Year 2010 (N=4,138)

Childhood Factors (C_j)	Indirect through			Direct	Total
	Education(E)	Income(I)	Wealth(W)		
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.041*** (0.008)	0.002 (0.003)	-0.003 (0.007)	-0.005 (0.033)	0.035 (0.035)
Below average	-0.017*** (0.005)	0.001 (0.001)	0.000 (0.002)	-0.021 (0.022)	-0.036 (0.022)
<u>Childhood Health</u> ^b					
Excellent	0.038*** (0.007)	0.001 (0.002)	0.004 (0.005)	0.044 (0.027)	0.087*** (0.025)
Very Good	0.016** (0.006)	0.000 (0.002)	0.005 (0.005)	0.024 (0.026)	0.044* (0.024)
Fair	0.004 (0.013)	-0.002 (0.003)	-0.006 (0.008)	0.024 (0.053)	0.020 (0.052)
Poor	0.004 (0.020)	-0.005 (0.006)	-0.010 (0.014)	-0.102 (0.071)	-0.112 (0.074)
<u>Parental Education</u> ^c					
Father More than high school	0.036*** (0.006)	0.003 (0.002)	0.000 (0.003)	0.018 (0.022)	0.057** (0.023)
Mother More than high school	0.038*** (0.006)	0.004** (0.002)	0.004 (0.003)	0.011 (0.022)	0.056** (0.023)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Having very good health as a girl also has positive effects on her healthy aging score, both directly and indirectly. The indirect effects, which operate through education and wealth, are 0.016 and 0.009, respectively, with direct and total effects of 0.059 and 0.085, respectively. In contrast, if her childhood health was reported as fair there are no effects of her childhood health, and if her childhood health was reported as poor there are negative effects through income by -0.010 and through wealth by -0.018. Having a father with at least a high school education compared to less than high school education also indirectly raises a woman's healthy aging score through education by 0.029, through income by 0.004 and through wealth by 0.006. The total effect of an educated father on a woman's healthy aging score is 0.049. Having an educated mother also has positive effects with stronger indirect effects through education and stronger total effects compared to an educated father. An educated mother indirectly raises a woman's healthy aging score through education by 0.035 and through income by 0.004, with a total effect of 0.061.

The key results for men are reported in Table 5. The results indicate that an above-average childhood SES indirectly raises a man's healthy aging score through education by 0.041 and a below-average childhood SES indirectly lowers his healthy aging score through education by -0.017. Excellent childhood health, as opposed to good, indirectly raises a man's healthy aging score through education by 0.038. The total effect of excellent childhood health for males is 0.087 and it is the highest total effects among all the childhood factors. Experiencing very good health as a boy increases his healthy aging score indirectly through education by 0.016, with the total effect being 0.044. In contrast, there are no effects of having fair or poor childhood health on a man's healthy aging score. Having a high school educated mother and father both positively influence a man's healthy aging score by 0.056 and 0.057, respectively, which are

enhanced through their indirect effect on his educational attainment by 0.036 for an educated father and a slightly higher effect, 0.038, for an educated mother. The indirect effects of parental education through income are only significant for an educated mother, which increases the man's healthy aging score by 0.004.

These indirect effects of childhood exist because childhood has a strong direct association with own years of education, and education has a strong positive association with income (0.096 for women and 0.084 for men) and wealth (0.269 for women and 0.184 for men), as shown in Tables 6 and 7. Table 6 pertains to women, Table 7 to men.

Education, income and wealth strongly and positively relate to the healthy aging scores of both women and men (Appendix B3 and Appendix B4 tables). For example, the partial derivatives of the healthy on education, income and wealth for women are 0.022, 0.045 and 0.031, respectively, while for men they are 0.030, 0.034 and 0.032, respectively.

Tables 8 and 9 report the gender-specific indirect, direct and total effects of all the lifespan factors used in this study. Table 8 is for women, Table 9 is for men. The indirect effects reported in each of these tables are the sum of all three indirect pathways that operate through education, income and wealth, as shown in the first column of Table 8 for women and the first column of Table 9 for men.

As Tables 8 and 9 show, almost all the combined indirect effects significantly influence healthy aging scores both for women and men. These results strengthen the idea of recognizing the importance of these indirect pathways when studying healthy aging and the lifelong factors that affect it. The gender-specific models also find that holding childhood characteristics constant, health habits, biological factors, demographics, and location also influence health at older ages. Parental longevity has a small positive influence on the healthy aging scores of both

Table 6: Partial Derivatives of Childhood Characteristics on Education, Income and Wealth for the sample of Women Ages 65+, Year 2010 (N=5,822)

Childhood Factors	$\frac{\partial E}{\partial C_i}$	$\frac{\partial I}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$	$\frac{\partial Inc}{\partial Edu}$	$\frac{\partial W}{\partial Edu}$
				0.096***	0.269***
				(0.006)	(0.015)
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.912***	0.030	0.170		
	(0.151)	(0.061)	(0.124)		
Below average	-0.48***	0.041*	-0.045		
	(0.078)	(0.024)	(0.072)		
<u>Childhood Health</u> ^b					
Excellent	0.730***	0.080**	0.363***		
	(0.104)	(0.037)	(0.101)		
Very Good	0.449***	0.022	0.303***		
	(0.104)	(0.033)	(0.100)		
Fair	0.165	0.015	0.092		
	(0.277)	(0.054)	(0.184)		
Poor	-0.007	-0.219**	-0.579*		
	(0.357)	(0.086)	(0.313)		
<u>Parental Education</u> ^c					
Father More than high school	0.828***	0.094**	0.183**		
	(0.104)	(0.040)	(0.076)		
Mother More than high school	1.001***	0.089**	-0.006		
	(0.096)	(0.036)	(0.085)		

Reference Groups: ^aaverage, ^bgood, ^cless than high school. *p<0.1, **p<0.05, ***p<0.01. The p-0value corresponds to a test of difference from zero. Standard errors were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Table 7: Partial Derivatives of Childhood Characteristics on Education, Income and Wealth for the sample of Men Ages 65+, Year 2010 (N=4,138)

Childhood Factors	$\frac{\partial E}{\partial C_i}$	$\frac{\partial I}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$	$\frac{\partial Inc}{\partial Edu}$	$\frac{\partial W}{\partial Edu}$
				0.084*** (0.009)	0.184*** (0.015)
<u>Childhood Socioeconomic Status</u> ^a					
Above average	1.068*** (0.198)	0.069 (0.075)	-0.108 (0.233)		
Below average	-0.439*** (0.114)	0.043 (0.029)	0.009 (0.062)		
<u>Childhood Health</u> ^b					
Excellent	1.000*** (0.155)	0.017 (0.047)	0.136 (0.139)		
Very Good	0.405*** (0.154)	-0.007 (0.050)	0.157 (0.142)		
Fair	0.098 (0.328)	-0.048 (0.082)	-0.188 (0.241)		
Poor	0.113 (0.505)	-0.157 (0.151)	-0.307 (0.453)		
<u>Parental Education</u> ^c					
Father More than high school	0.926*** (0.121)	0.098** (0.041)	0.007 (0.102)		
Mother More than high school	0.984*** (0.133)	0.122*** (0.041)	0.111 (0.098)		

Reference Groups: ^aaverage, ^bgood, ^cless than high school. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

men and women. Interestingly, a mother's longevity influences her daughter's health at older ages and a father's longevity influences a son's health at older ages. According to our estimates having better health habits tends to positively influence healthy aging scores both for men and women, and health habits have the strongest effects among all of the lifespan factors. As noted earlier, health habits appear to have stronger effects among women. Women who have never smoked have, on average, a healthy aging score that is 0.127 higher than that of current smokers, whereas former and current smokers are not significantly different in terms of their healthy aging scores. In contrast, smoking habits are unrelated to healthy aging scores among men. Being overweight or obese has negative consequences for healthy aging among both men and women, with stronger effects among women. Overweight women are healthier than obese women, with a healthy aging score that is 0.147 higher, on average, *ceteris paribus*. Normal weight and underweight women are also healthier than obese women, by 0.196, on average, while these differences across weight categories for males are 0.123 and 0.145, respectively.

The gender-specific findings also indicate that for both men and women, any level of exercise, even only exercising once to three times a month, significantly increases the one's chances of being healthy at older ages, and among all the health habits, exercise has the greatest impact on healthy aging scores. Exercising daily increases healthy aging scores by 0.320, on average, among women, and by 0.256, on average, among men when compared to not doing any exercise.

Interestingly, the effects of alcohol consumption are very different for men and women. Women who drink and are considered at low risk drinkers are significantly healthier than at-risk drinkers, with healthy aging score of 0.068, but there are no significant differences between the

Table 8. Combined Indirect, direct and Total Effects of all Inputs on Healthy Aging Scores among Women Ages 65+ (N=5,822).

Inputs	Combined Indirect† (S.E)	Direct	(S.E)	Total	(S.E)	
<u>Biological Factors</u> ^a						
Mother				0.001**	(0.0005)	
Father				0.0007	(0.001)	
<u>Childhood circumstances</u>						
Childhood SES ^b						
Above Average	0.038***	(0.008)	-0.049	(0.031)	-0.011	(0.033)
Below Average	-0.016***	(0.004)	-0.074***	(0.021)	-0.090***	(0.020)
Self-rated health as a child ^c						
Excellent	0.040***	(0.006)	0.138***	(0.019)	0.178***	(0.020)
Very Good	0.026***	(0.005)	0.059**	(0.027)	0.085***	(0.028)
Fair	0.009	(0.010)	-0.048	(0.046)	-0.039	(0.048)
Poor	-0.028*	(0.015)	-0.061	(0.077)	-0.089	(0.077)
Father's Education Level ^d						
Not reported	-0.022***	(0.008)	-0.041	(0.027)	-0.063**	(0.025)
More than high school	0.038***	(0.005)	0.010	(0.019)	0.048**	(0.020)
Mother's Education Level ^d						
Not reported	-0.031***	(0.010)	0.043	(0.040)	0.012	(0.040)
More than high school	0.038***	(0.006)	0.023	(0.020)	0.061***	(0.021)
<u>Mid and later life circumstances</u>						
Education	0.013***	(0.001)	0.022***	(0.004)	0.035***	(0.003)
Ln(income)					0.045***	(0.011)
Ln(wealth)					0.031***	(0.004)
<u>Current Health Habits</u>						
Smoking Habit ^f						
Former smoker					0.034	(0.032)

Never smoker					0.127***	(0.028)
Body Mass Index ^g						
Overweight					0.147***	(0.020)
Normal/underweight					0.196***	(0.019)
Level of Exercise ^f						
1-3 times a month					0.263***	(0.024)
Once a week					0.248***	(0.021)
More than once a week					0.242***	(0.019)
every day					0.320***	(0.046)
Drinking Habit ^f						
Low risk alcohol drinker					0.068**	(0.033)
Not at risk/non drinker					-0.048	(0.036)
<u>Socio-demographics</u>						
Age Cohort ^g						
75 - 84	-0.010*	(0.005)	-0.165***	(0.020)	-0.174***	(0.020)
85+	-0.010	(0.007)	-0.443***	(0.034)	-0.453***	(0.032)
Marital Status ^h						
Separated or divorced	-0.100***	(0.012)	0.027	(0.024)	-0.074***	(0.024)
Widowed	-0.064***	(0.009)	-0.001	(0.014)	-0.065***	(0.016)
Never Married	-0.096***	(0.014)	0.032	(0.047)	-0.064	(0.048)
Race / Ethnicity ^k						
African American	-0.077***	(0.008)	-0.080***	(0.028)	-0.157***	(0.029)
Hispanic	-0.172***	(0.020)	-0.063	(0.040)	-0.235***	(0.037)
Other	-0.033	(0.024)	-0.044	(0.056)	-0.077	(0.072)
Census Region ^m						
Midwest					-0.006	(0.021)
South					-0.043*	(0.023)
West					-0.044*	(0.023)
Insurance ^q						

Medicare & Medicaid	-0.223***	(0.040)
Medicare & Private	0.013	(0.018)
Other or No Insurance	-0.014	(0.045)

^a Parent's current age or age at death

Reference Groups: ^b about average, ^c good, ^d more than high school, ^f current, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q Medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

† Combined Indirect effects is the sum of the three indirect effects (education, income and wealth).

Table 9. Combined Indirect, direct and Total Effects of all Inputs on Healthy Aging Scores among Men Ages 65+ (N=4,138).

Inputs	Combined Indirect† (S.E)		Direct	(S.E)	Total	(S.E)
<u>Biological Factors</u> ^a						
Mother					0.0001	(0.001)
Father					0.001**	(0.001)
<u>Childhood circumstances</u>						
Childhood SES ^b						
Above Average	0.040***	(0.010)	-0.005	(0.033)	0.035	(0.034)
Below Average	-0.015***	(0.006)	-0.02	(0.022)	-0.035	(0.022)
Self-rated health as a child ^c						
Excellent	0.043***	(0.008)	0.043	(0.027)	0.087***	(0.025)
Very Good	0.020**	(0.009)	0.023	(0.026)	0.044*	(0.024)
Fair	-0.004	(0.016)	0.024	(0.053)	0.02	(0.052)
Poor	-0.011	(0.023)	-0.1	(0.071)	-0.11	(0.074)
Father's Education Level ^d						
Not reported	-0.035***	(0.010)	0.033	(0.033)	-0.002	(0.036)
More than high school	0.039***	(0.007)	0.017	(0.022)	0.057**	(0.023)
Mother's Education Level ^d						
Not reported	-0.059***	(0.010)	-0.025	(0.033)	-0.085**	(0.033)
More than high school	0.045***	(0.006)	0.011	(0.022)	0.056**	(0.023)
<u>Mid and later life circumstances</u>						
Education	0.009***	(0.002)	0.030***	(0.004)	0.039***	(0.003)
Ln(income)					0.034***	(0.012)
Ln(wealth)					0.032***	(0.006)
<u>Current Health Habits</u>						
Smoking Habit ^f						
Former smoker					-0.041	(0.034)
Never smoker					-0.004	(0.038)
Body Mass Index ^g						
Overweight					0.123***	(0.023)

Normal/underweight					0.145***	(0.027)
Level of Exercise ^f						
1-3 times a month					0.191***	(0.027)
Once a week					0.211***	(0.023)
More than once a week					0.211***	(0.020)
every day					0.256***	(0.040)
Drinking Habit ^f						
Low risk alcohol drinker					-0.015	(0.036)
Not at risk/non drinker					-0.134***	(0.034)
<u>Socio-demographics</u>						
Age Cohort ^g						
75 - 84	-0.007	(0.007)	-0.201***	(0.018)	-0.208***	(0.019)
85+	0.005	(0.009)	-0.382***	(0.033)	-0.377***	(0.033)
Marital Status ^h						
Separated or divorced	-0.066***	(0.013)	0.013	(0.033)	-0.053*	(0.031)
Widowed	-0.042***	(0.009)	-0.016	(0.032)	-0.058*	(0.033)
Never Married	-0.055***	(0.015)	0.101	(0.062)	0.046	(0.060)
Race / Ethnicity ^k						
African American	-0.092***	(0.012)	-0.044	(0.032)	-0.135***	(0.034)
Hispanic	-0.173***	(0.020)	0.057	(0.039)	-0.115**	(0.045)
Other	-0.032	(0.019)	0.033	(0.072)	0.001	(0.080)
Census Region ^m						
Midwest					-0.022	(0.020)
South					-0.047***	(0.017)
West					-0.005	(0.019)
Insurance ^q						
Medicare & Medicaid					-0.178***	(0.051)
Medicare & Private					0.015	(0.019)
Other or No Insurance					0.017	(0.051)

^a Parent's current age or age at death

Reference Groups: ^b about average, ^c good, ^d more than high school, ^f current, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q Medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were

calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

†Combined Indirect effects is the sum of the three indirect effects (education, income and wealth).

two groups among men. Men who never drink or are considered low-risk drinkers are given a score of -0.134 compared to the at-risk drinkers group, indicating that the never drinkers are less healthy than at-risk drinkers.

We also find that holding childhood characteristics and health behaviors constant, socio-demographics still affect one's chances of aging healthy, both directly and indirectly. African American women have a lower chances of aging healthy compared to white women. The indirect effect of being African American is -0.077, the direct effect is -0.080, and the total effect is -0.157. Among men the indirect effect of being African American is slightly larger than it is among women. Among men the indirect effect is -0.092, there is no direct effect, and the total effect of being African American is -0.135. Hispanics are also less healthy compared to whites, with an indirect effect of -0.172 and total effects of -0.235 for women and -0.173 and -0.155 for men, respectively.

The effects of marital status are almost the same for both sexes with all the indirect effects negatively affecting healthy aging, and no significant direct effects, and some total effects being significant. Healthy aging scores for separated or divorced women is indirectly affected by -0.100 while the total effect is -0.074, and these measure for men are -0.066 and 0.053, respectively. Never married men and women are indirectly and negatively affected but there are no total effects significant when we compared to currently married individuals.

In addition, the regional measures show that women from the South and West are less healthy than women from the North by -0.043 and 0.044, respectively. Men from the South are less healthy than men from the North by -0.047. And the results for the insurance measure indicates that both men and women who carry Medicaid coverage (in addition to Medicare) have

healthy aging score that are lower by -0.223 among women and -0.178 among men, compared to women and men who only have Medicare.

4.2.1. Discussion

This section of this dissertation has reported on separate production functions for men and women. It has discussed how the direct, indirect, and total effects of childhood circumstances on healthy aging vary between men and women, and also discussed gender-based differences in the effects of current health behaviors and socio-demographics. The results suggest that men and women produce healthy aging differently; thus, their production functions differ.

Five Broad findings emerge from this study: First, our results support the theory of indirect effects. Almost all the combined indirect effects significantly influence healthy aging scores both for women and men. This strengthens the argument that researchers should consider these indirect pathways when studying healthy aging. Better childhood conditions improve socioeconomic status in adulthood and thus indirectly promote longevity. This statement applies to having been raised under favorable economic conditions, having had excellent or very good childhood health, and having had a better-educated father. The associations between childhood characteristics and healthy aging are indirect, they operate through the education choices made as a young adult, and through income and wealth, which is typically accumulated steadily over one's working years. This finding is consistent with other studies that consider the indirect pathways through mid-life mediators to estimate the effects of childhood factors on survival and longevity (Shen and Zeng, 2014; Hayward and Gorman, 2004). Because education income and wealth all positively affect healthy aging, they transmit the imprint of childhood circumstances onto healthy aging in later life. These results are readily visible using the lens of a recursive SUR

model, which facilitates decomposing the effect of each childhood variable into its indirect and direct effects. Thus, our findings suggest previous studies of the effects of childhood on successful aging as an older adult, that have not taken into account these indirect pathways, likely underestimated the effects of childhood characteristics because they ignored potential indirect effects through mediators such as education and wealth.

Second, the direct and indirect effects of childhood conditions are stronger for women than they are for men. Among men, childhood conditions are only indirectly affecting healthy aging and there are no direct effects of childhood. Among women both the indirect and some direct effects of childhood conditions significantly affect healthy aging in later life. For almost all the childhood circumstances the effects are larger and more often significant among women.

Third, current health behaviors have the greatest impact on healthy aging scores among all the lifespan variables, both among men and women. However, the effects of current health behaviors are larger in magnitude among women. For example, in later life smoking and heavy drinking negatively affect women's health but do not appear to have negative effects on men's health. One possible explanation is that this is due to selection effects, i.e., men who have survived long enough to appear in this sample are from the advantaged group of men in terms of health.

Fourth, some socio-demographic characteristics significantly affect healthy aging scores, e.g., marital status, race, ethnicity and location. Although marital status does not have a direct effect on healthy aging scores, it indirectly affects health at advanced ages, which makes the total effects significant for both males and females. Married individuals have a better chance of aging healthy. Controlling for all the lifespan factors and considering the indirect pathways, Whites have a better chances of aging healthy compared to African Americans and Hispanics.

Finally, our findings underscore the value of taking a life-cycle approach to study health and functioning in later life. Because childhood experiences are associated with education and economic achievements in adulthood, childhood's effects are transmitted onto outcomes in late life through effects on these mediators. This suggests that investments in programs that reduce childhood poverty or improve childhood nutrition and health are likely to also improve healthy aging in later life. The benefits of such initiatives extend well beyond childhood.

4.3. Results for all Adults, Ages 65 and Older in the Discrete Outcome Model

When the measure of healthy aging is changed to the discrete (0,1) measure defined in Chapter 3, the proportion of healthy agers in the sample is 0.126. Descriptive statistics for the total sample, and by healthy aging group are provided in Appendix C7 table.

Table 10 reports our key findings upon estimating the health production function using this discrete measure. The first three columns report the indirect effects of each childhood characteristic, i.e., that operate through education, income, and wealth. The fourth column reports the direct effect of each characteristic on the probability of healthy aging, and the last column reports the total marginal effects. All effects are calculated at the sample mean. Interestingly, for this measure of healthy aging, the model suggests that early life circumstances have no direct effects on healthy aging, but have several indirect effects through education and wealth. An above-average childhood SES indirectly raises the probability of healthy aging through education by 0.014 and through wealth by 0.005, whereas a below-average childhood SES indirectly lowers that probability through education by -0.007 and through wealth by -0.003.

Table10: Direct, Indirect, and Total Effects of Childhood Characteristics on the Probability of Healthy Aging (n=8,212)

Childhood Factors (C_j)	Indirect			Direct	Total
	Education	Income	Wealth		
Childhood Socioeconomic Status ^a					
Above Average	0.014** (0.0068)	0.002 (0.0021)	0.005** (0.0026)	-0.055 (0.0428)	-0.033 (0.0413)
Below Average	-0.007** (0.0035)	-0.001 (0.0009)	-0.003* (0.0017)	-0.034 (0.0248)	-0.044* (0.0255)
Childhood Health ^b					
Excellent/Very Good	0.010** (0.0046)	0.004 (0.0027)	0.009*** (0.0035)	0.035 (0.0305)	0.058* (0.0309)
Fair/ Poor	0.000 (0.0025)	0.000 (0.0015)	-0.004 (0.0029)	0.017 (0.0503)	0.014 (0.0513)
Parental Education ^c					
Father	0.013** (0.0059)	0.005 (0.0035)	0.007*** (0.0029)	0.032 (0.0274)	0.057** (0.0286)
Mother	0.013** (0.0060)	0.005 (0.0038)	0.003* (0.0017)	0.003 (0.0261)	0.024 (0.0252)

Reference Groups: ^aaverage, ^bgood, ^c more than high school. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero.

Standard errors are calculated using delta method, using Taylor series approximation and reported in parenthesis.

Besides, childhood characteristics, education, income, and wealth, the health production function included indicators for age, race, gender, marital status, insurance, location, self-rated current health status, recent changes in health habits and interactions of these variables. All of the marginal effects reported in this table account for these interaction terms.

Table11: Partial Derivatives of Childhood Characteristics on Education, Income and Wealth (n=8,212)

Childhood Factors	$\frac{\partial E}{\partial C_i}$	$\frac{\partial I}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$
Childhood Socioeconomic Status ^a			
Above Average	0.990*** (0.1391)	-0.017 (0.0497)	0.043 (0.1119)
Below Average	-0.476*** (0.0646)	0.018 (0.0203)	-0.039 (0.0504)
Childhood Health ^b			
Excellent/Very Good	0.692*** (0.0750)	0.060** (0.0241)	0.277*** (0.0824)
Fair/ Poor	0.028 (0.1710)	-0.015 (0.0470)	-0.182 (0.1295)
Parental Education ^c			
Father	0.875*** (0.0751)	0.069** (0.0332)	0.168** (0.0665)
Mother	0.873*** (0.0849)	0.096*** (0.0289)	-0.039 (0.0645)

Reference Groups: ^aaverage, ^bgood, ^c more than high school. *p<0.1,**p<0.05,***p<0.01. The p-value corresponds to a test of difference from zero.

Standard errors are calculated using delta method, using Taylor series approximation and reported in parenthesis.

Besides, childhood characteristics, education, income, and wealth, the health production function included indicators for age, race, gender, marital status, insurance, location, self-rated current health status, recent changes in health habits and interactions of these variables. All of the marginal effects reported in this table account for these interaction terms.

The total aggregate effect of childhood SES is significant for below-average childhood SES. In this case, the probability of healthy aging declines by -0.044, or from 0.126 to 0.082. Excellent or very good health as a child indirectly raises the probability of healthy aging through education by 0.01 and through wealth by 0.009, with a total effect on the probability of healthy aging of 0.058, a rise from 0.126 to 0.184. In contrast, fair/poor childhood health indirectly lowers the probability of healthy aging through wealth by -0.004, but the total effect is not statistically significant.

Having a father with at least a high school education also indirectly raises the probability of healthy aging through education by 0.013 and through wealth by 0.007. The total effect of an educated father is a 0.057 increase in the probability of healthy aging, or from 0.126 to 0.183. Having an educated mother also has positive effects but not as strong. An educated mother indirectly raises the probability of healthy aging through education by 0.013 and through wealth by 0.003. Yet the total effect of a mother's education is not statistically significant.

These indirect effects of childhood exist because childhood has strong direct effects on own years of education, and because childhood and education together have strong positive effects on income and wealth. (See Table 11.) Education and wealth strongly and positively relate to the probability of healthy aging. For example, the partial derivatives of the probability of aging healthy on education and wealth are 0.037 ($p=0.034$) and 0.051 ($p=0.005$), respectively. In contrast, the partial derivative of the probability of aging healthy on income, while positive, is not significant (0.077 ($p=0.134$)). This helps explain why childhood had no indirect effects on healthy aging through income.

We also find that holding childhood characteristics constant, health habits, demographics, and location also affect the probability of healthy aging. Details regarding these results are available from the author upon request.

4.3.1. Discussion

This section of this dissertation has reported estimates of the health production function when a (0, 1) indicator of healthy aging is adopted instead of the continuous measure used in the previous two analyses. A multivariate probit model was estimated for the probability of aging healthy, and estimates were reported for the direct and indirect effects of childhood circumstances, and for the marginal effects of mid-life factors and current health habits.

Four broad findings emerge when this specification is used. First, favorable childhood conditions have significant positive implications for healthy aging after age 65. This statement applies to having been raised under favorable economic conditions, having had excellent or very good childhood health, and having had a better-educated father. Second, the effects of childhood characteristics on healthy aging are indirect. They operate through the education choices made as a young adult, and through wealth, which is typically accumulated steadily over one's working years. Because education and wealth both positively affect healthy aging, they transmit the imprint of childhood circumstances onto healthy aging in later life. In contrast, the direct effects of childhood on healthy aging are negligible. These results are readily visible using the lens of a recursive SUR model, which facilitates decomposing the effect of each childhood variable into its indirect and direct effects. Third, if our findings are correct, they suggest previous studies of the effects of childhood on successful aging as an older adult likely underestimated the effects of childhood characteristics because they ignored potential indirect effects through mediators such as education and wealth. Finally, our findings underscore the value of taking a life-cycle

approach to study health and functioning in later life. Because childhood experiences have effects on education and economic achievements in adulthood, childhood's effects are transmitted onto outcomes in late life through effects on these mediators. This suggests that investments in programs that reduce childhood poverty or improve childhood nutrition and health are likely to also improve healthy aging in later life. The benefits of such initiatives extend well beyond childhood.

4.4. Sensitivity Analysis

A number of sensitivity analyses were conducted to check the robustness of key findings from the first analysis, which was the main analysis of this dissertation. Recall, it used the continuous measure of healthy aging and estimated a single health production function for men and women combined. In the first sensitivity analysis current health behaviors were treated as a fourth mediating variable in that model. In a second sensitivity analysis the health production function was re-estimated for both years 2010 and 2012. The estimation results for these additional analyses are reported in Appendix D1 through Appendix D5 tables. Based on the results we found no evidence of any indirect effects of childhood characteristics through health behaviors, but the three other indirect pathways -- education, income and wealth -- continued to show significant indirect effects which were almost the same as when the model considered health behaviors as simple covariates. The results for both years 2010 and 2012 were also almost identical to the results based on 2010 alone. The model with the two years of data was also re-estimated with individuals who died between the two waves being excluded, and the results were identical to the previous results.

In a third sensitivity analysis the definition of healthy aging was altered. Specifically, an individual's score on cognitive functioning was excluded from the definition of an individual's

healthy aging score. The results of this analysis are reported in Appendix E1 and Appendix E2 tables. When this alternative definition of healthy aging was used, the key results did not substantially change, although there were some changes in the magnitude of various effects.

Another set of analysis has been carried to estimate the health production function, considering the direct and indirect effects of childhood factors and a life-span approach, based on three different age groups; the young-old, old and old-old group. Based on the results, reported in Appendix F1 through Appendix F3 tables, there are small variations in the magnitude of the effects of childhood factors, while the directions of the effects are the same.

CHAPTER 5. DISCUSSION AND CONCLUSIONS

This dissertation has used a health production function framework to examine the associations between healthy aging in later life and childhood, mid-life, and current characteristics. A variety of inputs that span an individual's lifetime were considered as potential determinants of healthy aging. Various formulations of the model were estimated, and in each case the central focus was on quantifying the direct and indirect effects of early life factors on healthy aging in later life. After estimating each model the direct, indirect, and total effects of childhood circumstances on healthy aging were derived. The analysis was based on the idea that health at older ages may depend on circumstances surrounding one's childhood and also on the choices each individual makes in the early and mid-stages of their life. If correct, the total effect of childhood circumstances on healthy aging could be larger than the amount that has been reported in prior studies.

The findings from this dissertation underscore the value of adopting a life span approach to study healthy aging among older adults. The results indicate that childhood experiences have important effects on educational choices and economic achievements in adulthood. The effects of childhood are then transmitted onto outcomes in late life through their effects on these mediators.

An important implication of these relationships is that investments in programs that reduce childhood poverty or improve childhood nutrition and health are likely to eventually improve educational attainments and household wealth, as well as prospects for healthy aging in later life. Thus, the benefits of such initiatives likely extend well beyond childhood and well into the future. Finally, because we find that a senior's current health habits are so important to healthy aging, current and emerging programs for older adults aimed at improving health habits,

such as exercising, achieving a healthy weight, and being smoke-free are likely to translate into healthier aging among older adults.

At a technical level this study proposed and then implemented a new measure of healthy aging, as an alternative to using a discrete (0,1) indicator for whether an individual meets healthy aging criteria. The measure proposed is a continuous measure of the *degree to which* an individual is healthy across a range of domains. We found that this alternative measure of healthy aging not only has a useful interpretation, when analyzed empirically the results obtained were reasonable.

A key finding is that advantageous childhood conditions give rise to healthier aging after age 65. Multiple hypotheses linking early life course characteristics to health in older age and mortality outcomes have been posited. For example, disadvantageous socioeconomic and health circumstances can negatively influence biological mechanisms (e.g., through stress) and predispose individuals to accelerated aging (Evans and Kim 2012, Gruenewald, Karlamangla et al. 2012, Friedman, Karlamangla et al. 2015). These circumstances can also modify the trajectories for social and economic success and further increase susceptibility to negative health outcomes. When measurable, these social and economic conditions are usually modeled as confounders, or controlled for, in current examinations of health and aging studies. However, socioeconomic attainments in midlife have the potential to either accelerate or decelerate the effects of early life conditions. The model developed in this dissertation explicitly allows for these indirect pathways. Our findings not only substantiate previously published results; they update the evidence using more precise estimates of these relationships.

Concordant with previous work we find that being raised under average or above-average socioeconomic conditions (as opposed to poor conditions), having had very good or excellent

childhood health (as opposed to good health), and having had a high school educated mother or father (as opposed to parents with less than a high school education) significantly raises healthy aging scores in later life.

Yet we also find that accounting for indirect effects contributes to these results. This suggests that previous research, which examined the relationships between childhood conditions and aging outcomes, may have underestimated childhood's effects, as none of these studies considered the potential for additional indirect effects through mediating variables, such as education, income, and wealth. Our results indicate that measures of childhood circumstances operate differentially through adulthood achievement indicators, particularly by influencing educational choices made as a young adult, and wealth, which is typically accumulated over one's working years. Because education and wealth both positively affect healthy aging, they transmit the imprint of childhood circumstances onto healthy aging in late life.

Our models also suggest that a senior's current health behaviors likely have the greatest impact on healthy aging, with effects larger than those of childhood and biological factors. In other words, even though our model reveals that factors from all parts of life are relevant to healthy aging, it suggests that the current health behaviors of an individual likely matter the most.

There are several limitations to the present study that should be mentioned. First, we have examined the determinants of healthy aging, which strictly speaking differs from successful aging as conceptualized by Rowe and Kahn (1987). Operationally, the difference is that healthy aging ignores active social engagement whereas successful aging does not. Because the HRS obtained many non-responses to its questions on social engagement we chose to focus on healthy aging. Additional studies of the determinants of both successful aging and healthy aging based

on other data would help to enhance our understanding of the implication of analyzing one and not the other. Second, this study used self-reported data, both to define healthy aging and to measure variables in the model. Although self-reported health has been shown to be a valid and reliable measure of overall health, less is known about the accuracy of self-reported incidence of diseases, functioning on activities of daily living, self-reported health habits and body weight

APPENDIX A- FULL MODEL (ALL ADULTS AGES 65 AND OLDER)

Appendix A1: Variable Definitions and Descriptive Statistics for the Sample of Adults Ages 65+ (N=9,478).

	<u>Definition</u>	Mean/ %	SE / N
<u>Dependent variables</u>			
Education	years of education (1-17+)	12.65	0.08
Income	annual household income	54542.31	1783.18
Wealth	Wealth	557338.00	28335.76
Healthy Aging		0.15	(0.010)
major disease	high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, arthritis, and depression	2.61	(0.020)
disabilities	Activities of daily living, difficulty: walking across a room, dressing, bathing/ showering, eating, and getting in/out bed /Instrumental activities of daily living , difficulty: using the phone, taking medication, managing money, shopping for grocery, preparing meals	0.63	(0.021)
ADL/IADL			
physical functioning	walking one block, walking several blocks, climbing one flight of stairs, climbing several flights of stairs, lifting or carrying items weighing more than 10 lbs., stooping, kneeling or crouching, and pulling or pushing large objects	2.30	(0.033)
cognitive functioning	Telephone Interview of Cognitive Status (TICS)	21.41	(0.095)
<u>Childhood circumstances</u>			
Father's Education Level			
At least high school	(reference category)	30.42 %	2699
Less than high school		56.61 %	5512
Not reported		12.96 %	1267
Mother's Education Level			
At least high school	(reference category)	36.20 %	3182

Less than high school		55.04 %	5415
Not reported		8.77 %	881
self-rated health as a child			
Excellent		52.18 %	4812
Very good		24.75 %	2372
Good	(reference category)	16.96 %	1684
Fair		4.62 %	463
Poor		1.50 %	145
Self-rated SES as a child			
Above average		6.52 %	550
Average or varying	(reference category)	62.52 %	5842
Below average		30.97 %	3061
<u>Health Habits</u>			
Smoking Habit			
Never smoker	(reference category)	42.91 %	4072
Former smoker		48.51 %	4556
Current smoker		8.59 %	797
Body Mass Index			
underweight	BMI < 18.5	1.49 %	144
Normal	18.5 < BMI < 25 (reference category)	31.36 %	2932
Overweight	25 < BMI < 30	39.24 %	3602
Obese	BMI > 30	27.92 %	2682
Level of weekly exercise			
Every day		2.39 %	231
More than once weekly		20.43 %	1837
Once a week		8.29 %	783
1-3 times a month		7.72 %	717
Never	(reference category)	61.17 %	5879
Drinking Habit			
Never	(reference category)	48.97 %	4893
About once weekly		27.58 %	2521
More than once weekly		23.45 %	2042

Biological factors

Mother's Longevity

Not survived average LE	(reference category)	38.19 %	3711
Survived average LE	average life expectancy at 2010 (78 years)	61.81 %	5767

Father's Longevity

Not survived average LE	(reference category)	56.90 %	5437
Survived average LE	average life expectancy at 2010 (78 years)	43.10 %	4041

Socio-demographics

Age Cohort

65 - 75	(reference category)	52.13 %	4777
75 - 85		35.00 %	3518
85+		12.87 %	1183

Gender

Male	(reference category)	42.61 %	3930
Female		57.39 %	5548

Marital Status

Married /partnered	(reference category)	56.35 %	5463
Separated / Divorced		12.28 %	1074
Widowed		26.83 %	2678
Never Married		4.541 %	261

Race /ethnicity

White	(reference category)	83.11 %	7234
Black		8.28 %	1284
Hispanic		6.61 %	776
Other		2.00 %	183

Census Region

Northeast		17.33 %	1453
Midwest		25.42 %	2390
South	(reference category)	37.01 %	3909
West		20.06 %	1698
Other		0.1696 %	23

Insurance

Government Only	(reference category)	49.42 %	4875
Government & Private		47.65 %	4289

Private Only	2.39 %	201
No Insurance	0.55 %	61

Data are from 2010 Health and Retirement Study (HRS).

Appendix A2. Estimated Production Function for Healthy Aging and Estimated Models for Educational Attainments, Income and Wealth among Adults Ages 65+ (N=9,180).

Inputs	Education	Income	Wealth	Healthy Aging
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Biological Factors^a				
Mother survived average LE				0.031*** (0.011)
Father survived average LE				0.023** (0.011)
Childhood circumstances				
Childhood SES ^b				
Well off	0.944*** (0.123)	0.044 (0.049)	0.067 (0.113)	-0.031 (0.024)
Poor	-0.485*** (0.06)	0.034* (0.02)	-0.029 (0.054)	-0.06*** (0.017)
Self-rated health as a child ^c				
Excellent	0.84*** (0.091)	0.054** (0.026)	0.245*** (0.079)	0.107*** (0.02)
Very Good	0.45*** (0.086)	0.01 (0.023)	0.23*** (0.072)	0.044* (0.025)
Fair	0.149 (0.183)	-0.007 (0.052)	-0.003 (0.138)	-0.025 (0.035)
Poor	0.073 (0.249)	-0.198*** (0.075)	-0.519** (0.218)	-0.107* (0.061)
Father's Education Level ^d				
Not reported	-1.492*** (0.111)	-0.16*** (0.032)	-0.389*** (0.12)	-0.026 (0.021)
Less than high school	-0.868*** (0.081)	-0.103*** (0.027)	-0.096* (0.056)	-0.008 (0.016)
Mother's Education Level ^d				
Not reported	-1.777*** (0.144)	-0.063 (0.051)	-0.369*** (0.122)	-0.005 (0.027)

Less than high school	-0.986*** (0.078)	-0.088*** (0.03)	-0.042 (0.052)	-0.012 (0.014)
<u>Mid and later life circumstances</u>				
Education		0.089*** (0.006)	0.219*** (0.009)	0.029*** (0.003)
Ln(income)				0.044*** (0.009)
Ln(wealth)				0.038*** (0.004)
<u>Current Health Habits</u>				
Smoking Habit ^f				
Former smoker				-0.082*** (0.015)
Current smoker				-0.073*** (0.027)
Body Mass Index ^g				
Underweight				-0.058 (0.061)
Overweight				-0.047*** (0.01)
Obese				-0.191*** (0.016)
Level of Exercise ^f				
every day				0.309*** (0.033)
More than once a week				0.252*** (0.013)
Once a week				0.247*** (0.016)
1-3 times a month				0.252*** (0.017)
Drinking Habit ^f				

About once weekly				0.115*** (0.015)
More than once weekly				0.144*** (0.011)
<u>Socio-demographics</u>				
Age Cohort ^g				
75 - 84	-0.182** (0.074)	-0.198*** (0.024)	0.117* (0.067)	-0.193*** (0.016)
85+	-0.162 (0.108)	-0.209*** (0.034)	0.079 (0.112)	-0.451*** (0.03)
Gender				
Female	-0.26*** (0.062)	-0.103*** (0.015)	-0.116*** (0.044)	-0.002 (0.012)
Marital Status ^h				
Separated or divorced		-0.742*** (0.04)	-1.773*** (0.100)	0.002 (0.02)
Widowed		-0.623*** (0.028)	-0.979*** (0.072)	-0.002 (0.014)
Never Married		-0.765*** (0.079)	-1.541*** (0.204)	0.056 (0.041)
Race / Ethnicity ^k				
African American	-0.845*** (0.138)	-0.32*** (0.032)	-1.472*** (0.097)	-0.087*** (0.021)
Hispanic	-3.550*** (0.349)	-0.385*** (0.064)	-1.241*** (0.212)	-0.023 (0.027)
Other	-0.201 (0.482)	-0.166 (0.107)	-0.831*** (0.214)	-0.009 (0.048)
Census Region ^m				
Midwest				-0.010 (0.015)
South				-0.041** (0.018)
West				-0.022

Insurance ^q				(0.016)
Government only insurance				-0.046*** (0.012)
Intercept Term	14.077*** (0.103)	9.919*** (0.089)	9.690*** (0.190)	-1.113*** (0.095)

Reference Groups: ^aParent did not survive beyond average life expectancy, ^b about average, ^c good, ^d less than high school, ^f never, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^qgovernment plus private. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

APPENDIX B- WOMEN VS. MEN

Appendix B1: Variable Definitions and Descriptive Statistics for the Sample of Females Ages 65+ (N=5,822).

	<u>Definition</u>	<u>Mean/</u> <u>%</u>	<u>SE /</u> <u>N</u>
<u>Dependent variables</u>			
Education	years of education (1-17+)	12.55	0.072
Income	annual household income	29944.77	0.023
Wealth	Wealth	95910.43	0.062
Healthy Aging		0.02	0.013
major disease	high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, arthritis, and depression	2.68	0.027
disabilities	Activities of daily living, difficulty: walking across a room, dressing, bathing/ showering, eating, and getting in/out bed /Instrumental activities of daily living ,	0.73	0.031
ADL/IADL	difficulty: using the phone, taking medication, managing money, shopping for grocery, preparing meals		
physical functioning	walking one block, walking several blocks, climbing one flight of stairs, climbing several flights of stairs, lifting or carrying items weighing more than 10 lbs., stooping, kneeling or crouching, and pulling or pushing large objects	2.67	0.044
cognitive functioning	Telephone Interview of Cognitive Status (TICS)	21.63	0.116
<u>Childhood circumstances</u>			
Father's Education Level			
At least high school	(reference category)	25.98%	1513
Less than high school		59.01%	3436
Not reported		15.02%	874
Mother's Education Level			
At least high school	(reference category)	29.94%	1743
Less than high school		60.60%	3528

Not reported		9.46%	551
self-rated health as a child			
Excellent		50.78%	2956
Very good		25.01%	1456
Good	(reference category)	17.91%	1043
Fair		4.71%	274
Poor		1.57%	92
Self-rated SES as a child			
Above average		6.73%	392
Average or varying	(reference category)	63.99%	3725
Below average		29.29%	1705
<u>Health Habits</u>			
Smoking Habit			
Never smoker	(reference category)	51.75%	3013
Former smoker		39.80%	2317
Current smoker		8.45%	492
Body Mass Index			
Normal / Underweight	BMI < 25 (reference category)	38.67%	2251
Overweight	25 < BMI < 30	32.92%	1917
Obese	BMI > 30	28.42%	1655
Level of weekly exercise			
Every day		69.22%	4030
More than once weekly		5.90%	344
Once a week		6.66%	388
1-3 times a month		16.44%	957
Never	(reference category)	1.78%	104
Drinking Habit			
High-Risk	(reference category)	4.39%	255
Low-Rsik		21.22%	1235
Not at risk / Non drinker		74.39%	4331
<u>Biological factors</u>			
Mother's age		77.37	0.306
Father's age		72.21	0.230

Socio-demographics

Age Cohort

65 - 75	(reference category)	49.69%	2893
75 - 85		33.94%	1976
85+		16.37%	953

Marital Status

Married /partnered	(reference category)	43.83%	2552
Separated / Divorced		14.16%	824
Widowed		38.95%	2268
Never Married		3.06%	178

Race /ethnicity

White	(reference category)	81.21%	4728
Black		9.62%	560
Hispanic		6.98%	406
Other		2.19%	127

Census Region

Northeast	(reference category)	17.86%	1040
Midwest		26.00%	1514
South		36.42%	2120
West		19.61%	1142
Other		0.11%	6

Insurance

Medicare	(reference category)	60.20%	3505
Medicare plus Medicaid		9.28%	540
Medicare plus private		26.80%	1560
Other insurance / not insured		3.71%	216

Data are from 2010 Health and Retirement Study (HRS).

Appendix B2: Variable Definitions and Descriptive Statistics for the Sample of Males Ages 65+ (N=4,138).

	<u>Definition</u>	Mean/ %	SE / N
<u>Dependent variables</u>			
Education	years of education (1-17+)	13.01	0.087
Income	annual household income	41984.68	0.026
Wealth	Wealth	170327.78	0.058
Healthy Aging		0.13	0.012
major disease	high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, arthritis, and depression	2.55	0.029
disabilities	Activities of daily living, difficulty: walking across a room, dressing, bathing/ showering, eating, and getting in/out bed /Instrumental activities of daily living , difficulty: using the phone, taking medication, managing money, shopping for grocery, preparing meals	0.54	0.029
ADL/IADL			
physical functioning	walking one block, walking several blocks, climbing one flight of stairs, climbing several flights of stairs, lifting or carrying items weighing more than 10 lbs., stooping, kneeling or crouching, and pulling or pushing large objects	1.82	0.037
cognitive functioning	Telephone Interview of Cognitive Status (TICS)	21.37	0.116
<u>Childhood circumstances</u>			
Father's Education Level			
At least high school	(reference category)	31.15%	1289
Less than high school		54.17%	2242
Not reported		14.68%	607
Mother's Education Level			
At least high school	(reference category)	38.54%	1595
Less than high school		50.89%	2106
Not reported		10.57%	437

self-rated health as a child

Excellent			
Very good		24.99%	1034
Good	(reference category)	16.79%	695
Fair		4.08%	169
Poor		1.18%	49

Self-rated SES as a child

Above average			
Average or varying	(reference category)	60.11%	2487
Below average		33.04%	1367

Health Habits

Smoking Habit

Never smoker	(reference category)	30.94%	1280
Former smoker		59.42%	2459
Current smoker		9.64%	399

Body Mass Index

Normal / Underweight	BMI < 25 (reference category)	26.64%	1102
Overweight	25 < BMI < 30	45.02%	1863
Obese	BMI > 30	28.35%	1173

Level of weekly exercise

Every day		0.00%	
More than once weekly		2.86%	118
Once a week		22.84%	945
1-3 times a month		9.64%	399
Never	(reference category)	10.52%	435
		54.13%	2240

Drinking Habit

High-Risk	(reference category)	6.40%	265
Low-Rsik		35.31%	1461
Not at risk / Non drinker		58.29%	2412

Biological factors

Mother's age		78.03	0.299
Father's age		71.90	0.283

Socio-demographics

Age Cohort			
65 - 75	(reference category)	56.65%	2344
75 - 85		32.31%	1337
85+		11.04%	457
Marital Status			
Married /partnered	(reference category)	73.34%	3035
Separated / Divorced		11.41%	472
Widowed		11.89%	492
Never Married		3.37%	140
Race /ethnicity			
White	(reference category)	81.78%	3384
Black		8.42%	348
Hispanic		7.15%	296
Other		2.65%	109
Census Region			
Northeast	(reference category)	16.35%	677
Midwest		25.28%	1046
South		37.69%	1560
West		20.51%	849
Other		0.15%	6
Insurance			
Medicare	(reference category)	60.12%	2488
Medicare plus Medicaid		5.54%	229
Medicare plus private		29.88%	1236
Other insurance / not insured		4.47%	185

Data are from 2010 Health and Retirement Study (HRS).

Appendix B3. Estimated Production Function for Healthy Aging and Estimated Models for Educational Attainments, Income and Wealth among Women Ages 65+ (N=5,822).

Inputs	Education	Income	Wealth	Healthy Aging
<u>Biological Factors</u> ^a				
Mother				0.001** (0.000)
Father				0.000 (0.001)
<u>Childhood circumstances</u>				
Childhood SES ^b				
Above Average	0.912*** (0.151)	0.030 (0.061)	0.170 (0.124)	-0.050 (0.031)
Below Average	-0.48*** (0.078)	0.041* (0.024)	-0.045 (0.072)	-0.074*** (0.021)
Self-rated health as a child ^c				
Excellent	0.73*** (0.104)	0.08** (0.037)	0.363*** (0.101)	0.138*** (0.020)
Very Good	0.449*** (0.104)	0.022 (0.033)	0.303*** (0.100)	0.059** (0.027)
Fair	0.165 (0.277)	0.015 (0.054)	0.092 (0.184)	-0.048 (0.046)
Poor	-0.007 (0.357)	-0.219** (0.086)	-0.579* (0.313)	-0.063 (0.077)
Father's Education Level ^d				
Not reported	-0.494*** (0.154)	-0.014 (0.043)	-0.154 (0.150)	-0.041 (0.027)
More than high school	0.828*** (0.104)	0.094** (0.040)	0.183** (0.076)	0.010 (0.019)
Mother's Education Level ^d				
Not reported	-0.527*** (0.188)	-0.012 (0.063)	-0.397** (0.177)	0.044 (0.040)
More than high school	1.001*** (0.096)	0.089** (0.036)	-0.006 (0.085)	0.022 (0.020)

Mid and later life circumstances

Education	0.096*** (0.006)	0.269*** (0.015)	0.022*** (0.004)
Ln(income)			0.045*** (0.011)
Ln(wealth)			0.031*** (0.004)

Current Health HabitsSmoking Habit ^f

Former smoker

0.035
(0.032)

Current smoker

0.127***
(0.028)Body Mass Index ^g

Overweight

0.147***
(0.020)

Normal/underweight

0.196***
(0.019)Level of Exercise ^f

1-3 times a month

0.263***
(0.024)

Once a week

0.248***
(0.021)

More than once a week

0.242***
(0.019)

every day

0.32***
(0.046)Drinking Habit ^f

Low risk alcohol drinker

0.069**
(0.033)

Not at risk/non drinker

-0.048
(0.036)

Socio-demographicsAge Cohort ^g

75 - 84	-0.082 (0.088)	-0.209*** (0.024)	0.083 (0.080)	-0.165*** (0.020)
85 ⁺	-0.056 (0.144)	-0.184*** (0.035)	-0.004 (0.130)	-0.444*** (0.034)

Marital Status ^h

Separated or divorced		-0.837*** (0.046)	-2.044*** (0.105)	0.027 (0.025)
Widowed		-0.701*** (0.033)	-1.049*** (0.076)	-0.001 (0.014)
Never Married		-0.846*** (0.102)	-1.889*** (0.253)	0.031 (0.047)

Race / Ethnicity ^k

African American	-0.386** (0.157)	-0.388*** (0.048)	-1.514*** (0.119)	-0.079*** (0.028)
Hispanic	-3.636*** (0.324)	-0.313*** (0.075)	-1.076*** (0.261)	-0.063 (0.040)
Other	-0.267 (0.535)	-0.044 (0.135)	-0.716** (0.323)	-0.044 (0.056)

Census Region ^m

Midwest				-0.006 (0.021)
South				-0.042** (0.023)
West				-0.045** (0.023)

Insurance ^q

Medicare & Medicaid				-0.224*** (0.040)
Medicare & Private				0.014 (0.018)
Other or No Insurance				-0.013

				(0.045)
Intercept Term	11.948*** (0.099)	9.558*** (0.096)	8.815*** (0.234)	-1.334*** (0.127)

^a Parent's current age or age at death

Reference Groups: ^b about average, ^c good, ^d more than high school, ^f current, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q Medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

† Combined Indirect effects is the sum of the three indirect effects (education, income and wealth).

Appendix B4. Estimated Production Function for Healthy Aging and Estimated Models for Educational Attainments, Income and Wealth among Men Ages 65+ (N=4,138).

Inputs	Education		Income		Wealth		Healthy Aging	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
<u>Biological Factors</u> ^a								
Mother							0.000	0.001
Father							0.001**	0.001
<u>Childhood circumstances</u>								
Childhood SES ^b								
Above Average	1.068***	0.198	0.069	0.075	-0.108	0.233	-0.005	0.033
Below Average	-0.439***	0.114	0.043	0.029	0.009	0.062	-0.021	0.022
Self-rated health as a child ^c								
Excellent	1.000***	0.155	0.017	0.047	0.136	0.139	0.044	0.027
Very Good	0.405***	0.154	-0.007	0.050	0.157	0.142	0.024	0.026
Fair	0.098	0.328	-0.048	0.082	-0.188	0.241	0.024	0.053
Poor	0.113	0.505	-0.157	0.151	-0.307	0.453	-0.102	0.071
Father's Education Level ^d								
Not reported	-0.622***	0.179	-0.038	0.064	-0.309**	0.142	0.033	0.033
More than high school	0.926***	0.121	0.098**	0.041	0.007	0.102	0.018	0.022
Mother's Education Level ^d								
Not reported	-0.998***	0.213	-0.054	0.044	-0.604***	0.172	-0.026	0.034
More than high school	0.984***	0.133	0.122***	0.041	0.111	0.098	0.011	0.022
<u>Mid and later life circumstances</u>								
Education			0.084***	0.009	0.184***	0.015	0.03***	0.004
Ln(income)							0.034***	0.012
Ln(wealth)							0.032***	0.006

Current Health HabitsSmoking Habit ^f

Former smoker -0.041 0.034

Current smoker -0.004 0.037

Body Mass Index ^g

Overweight 0.123*** 0.023

Normal/underweight 0.145*** 0.027

Level of Exercise ^f

1-3 times a month 0.191*** 0.027

Once a week 0.211*** 0.023

More than once a week 0.211*** 0.020

every day 0.256*** 0.040

Drinking Habit ^f

Low risk alcohol drinker -0.015 0.036

Not at risk/non drinker - 0.134*** 0.034

Socio-demographicsAge Cohort ^g

75 - 84 -0.179* 0.096 - 0.174*** 0.036 0.179* 0.096 - 0.202*** 0.018

85+ 0.086 0.198 - 0.248*** 0.047 0.322** 0.140 - 0.383*** 0.033

Marital Status ^h

Separated or divorced - 0.615*** 0.062 - 1.427*** 0.153 0.013 0.033

Widowed - 0.437*** 0.047 - 0.863*** 0.133 -0.016 0.032

Never Married - 0.668*** 0.104 - 1.032*** 0.265 0.101 0.062

Race / Ethnicity ^k

African American - 1.188*** 0.213 - 0.194*** 0.070 - 1.246*** 0.179 -0.043 0.032

Hispanic - 2.857*** 0.381 - 0.487*** 0.098 - 1.455*** 0.211 0.057 0.039

Other 0.176 0.405 -0.272** 0.120 - 0.289 0.031 0.073

Census Region ^m							0.919***	
Midwest							-0.022	0.020
South							-	0.017
West							0.047***	
Insurance ^q							-0.004	0.019
Medicare & Medicaid							-	0.051
Medicare & Private							0.177***	
Other or No Insurance							0.016	0.019
Intercept Term	12.103**						-	
	*	0.169	9.748***	0.121	9.978***	0.242	1.082***	0.130

^a Parent's current age or age at death

Reference Groups: ^b about average, ^c good, ^d more than high school, ^f current, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q Medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

†Combined Indirect effects is the sum of the three indirect effects (education, income and wealth).

APPENDIX C- DISCRETE OUTCOME MODEL

Appendix C1: Sample Characteristics in Discrete outcome model, US Adults Aged 65+ from 2010 Health and Retirement Study Data (HRS).

Characteristics	Aging Healthy		Total (n=8,212)	P-Value / [range]
	M (SD) / %			
	No (n=7,181)	Yes (n=1,031)		
Dependent Variables				
Years of education	12.49 (0.077)	14.09 (0.108)	12.69 (0.079)	[0-17]
log(annual household income)	10.39 (0.020)	10.95 (0.041)	10.46 (0.022)	[4.61-17-91]
log(wealth)	11.53 (0.063)	12.88 (0.057)	11.70 (0.061)	[4.61-18.22]
Healthy Aging	-	-	0.126 (0.005)	[0,1]
Childhood characteristics				
Father's Education Level				
At least high school	28.51%	50.07%	31.21%	<0.001
Less than high school	57.38%	43.75%	55.67%	
Not reported	14.11%	6.17%	13.12%	
Mother's Education Level				
At least high school	34.26%	56.41%	37.04%	<0.001
Less than high school	56.58%	41.01%	54.62%	
Not reported	9.16%	2.58%	8.34%	
Self-rated SES as a child				
Above-average	6.12%	8.37%	6.40%	<0.001
Average or varying	62.20%	70.58%	63.25%	
Below-average	31.68%	21.05%	30.35%	
Self-rated health as a child				
Excellent/very good	76.00%	87.34%	77.43%	<0.001
Good	17.72%	9.72%	16.72%	
Fair/Poor	6.28%	2.94%	5.86%	
Demographics				
Age				
65-75	50.38%	77.29%	53.76%	<0.001
75-85	36.89%	20.95%	34.89%	

85+	12.73%	1.76%	11.35%	
Sex				
Male	42.21%	40.20%	41.96%	0.333
Female	57.79%	59.80%	58.04%	
Race/ethnicity				
White	83.40%	92.46%	84.54%	<0.001
Black	9.20%	3.20%	8.44%	
Hispanic	5.49%	2.16%	5.07%	
Other	1.91%	2.19%	1.95%	
Marital Status				
Married	53.34%	64.85%	54.78%	<0.001
Separated / divorced	14.16%	12.71%	13.98%	
Widowed	28.90%	18.60%	27.60%	
Never married	3.60%	3.84%	3.63%	
Insurance				
Government only	32.88%	12.30%	30.33%	<0.001
Government and private	67.12%	87.70%	69.67%	
Region				
Northeast	17.41%	19.29%	17.64%	0.156
Midwest	27.11%	27.45%	27.15%	
South	38.95%	34.24%	38.36%	
West	16.53%	19.03%	16.85%	
Self-rated current health status				
Excellent	5.97%	26.43%	8.53%	<0.001
Very Good	28.47%	54.41%	31.73%	
Good	36.77%	17.69%	34.37%	
Fair/Poor	28.79%	1.47%	25.36%	
Health Habits				
Smoking status				
Never	41.72%	47.00%	42.38%	<0.001
Former smoker	48.56%	46.36%	48.28%	
Current smoker	9.73%	6.63%	9.34%	

Body mass index				
Not overweight	31.06%	37.68%	31.89%	<0.001
Overweight	38.42%	42.65%	38.95%	
Obese	30.52%	19.67%	29.16%	
Level of weekly exercise				
Never	9.38%	0.72%	8.29%	<0.001
Moderate	61.01%	50.69%	59.71%	
Vigorous	29.61%	48.60%	32.00%	
Drinking habits				
Never	51.99%	31.35%	49.39%	<0.001
About once weekly	26.78%	29.91%	27.18%	
More than once weekly	21.23%	38.74%	23.43%	

APPENDIX D- FOUR INDIRECT PATHWAY MODEL

Appendix D1: Specific Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among Adults Ages 65+, Based on the Four Indirect Model, Year 2010, (N=9,180).

Childhood Factors (C_j)	Indirect through				+ Direct	=	Total
	Educatio n (E)	+ Income (I)	+ Wealth (W)	+ Health Behavior s (HB)			
<u>Childhood Socioeconomic Status</u> ^a							
Above average	0.045*** (0.006)	0.002 (0.002)	0.004 (0.005)	0.008 (0.007)	-0.025 (0.022)	0.034 (0.026)	
Below average	-0.022*** (0.003)	0.001 (0.001)	-0.001 (0.002)	-0.001 (0.003)	-0.056*** (0.015)	-0.079*** (0.016)	
<u>Childhood Health</u> ^b							
Excellent	0.039*** (0.005)	0.003* (0.001)	0.012*** (0.004)	0.000 (0.005)	0.108*** (0.018)	0.162*** (0.018)	
Very Good	0.020*** (0.004)	0.001 (0.001)	0.011*** (0.004)	0.000 (0.005)	0.041* (0.022)	0.073*** (0.021)	
Fair	0.005 (0.009)	0.000 (0.002)	-0.003 (0.007)	-0.002 (0.007)	-0.029 (0.037)	-0.029 (0.041)	
Poor	0.000 (0.013)	-0.008** (0.004)	-0.025** (0.010)	-0.007 (0.010)	-0.092 (0.061)	-0.133** (0.064)	
<u>Parental Education</u> ^c							
Father More than high school	0.040*** (0.004)	0.004*** (0.002)	0.004* (0.003)	0.002 (0.004)	0.015 (0.014)	0.066*** (0.016)	
Mother More than high school	0.046*** (0.004)	0.004*** (0.001)	0.003 (0.002)	0.000 (0.003)	0.026** (0.013)	0.079*** (0.014)	

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Appendix D2: Specific Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among Adults Ages 65+, Based on the Four Indirect Model, Year 2012, (N=9,180).

Childhood Factors (C_j)	Indirect through				+ Direct	= Total
	Education (E)	+ Income (I)	+ Wealth (W)	+ Health Behavior s (HB)		
<u>Childhood Socioeconomic Status</u> ^a						
Above average	0.044*** (0.006)	0.003 (0.003)	0.004 (0.005)	0.008 (0.007)	-0.031 (0.033)	0.028 (0.036)
Below average	-0.021*** (0.003)	0.002 (0.001)	-0.001 (0.002)	-0.001 (0.003)	-0.047*** (0.017)	-0.068*** (0.017)
<u>Childhood Health</u> ^b						
Excellent	0.038*** (0.005)	0.004* (0.002)	0.011*** (0.004)	0.000 (0.005)	0.112*** (0.020)	0.165*** (0.019)
Very Good	0.020*** (0.004)	0.001 (0.002)	0.010*** (0.004)	0.000 (0.005)	0.022 (0.024)	0.053*** (0.021)
Fair	0.005 (0.009)	0.000 (0.003)	-0.003 (0.006)	-0.002 (0.007)	-0.008 (0.038)	-0.008 (0.040)
Poor	0.000 (0.012)	-0.011** (0.006)	-0.024** (0.010)	-0.008 (0.010)	-0.113* (0.059)	-0.156** (0.062)
<u>Parental Education</u> ^c						
Father-More than high school	0.039*** (0.004)	0.006*** (0.002)	0.004* (0.003)	0.002 (0.004)	0.020 (0.016)	0.070*** (0.018)
Mother-More than high school	0.045*** (0.005)	0.006*** (0.002)	0.003 (0.002)	0.000 (0.003)	0.039** (0.016)	0.092*** (0.015)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Appendix D3: Combined Indirect, direct and Total Effects of all Inputs on Healthy Aging Scores among Adults Ages 65+, Evaluated at the Sample Mean, Based on the Four Indirect Model, (N=9,180).

Inputs	2010			2012		
	Combined Indirect†	Direct	Total	Combined Indirect†	Direct	Total
<u>Biological Factors</u> ^a						
Mother			0.0008** (0.0004)			0.0009* (0.0005)
Father			0.0004 (0.0004)			0.0011** (0.0005)
<u>Childhood circumstances</u>						
Childhood SES ^b						
Above Average	0.059*** (0.010)	-0.025 (0.022)	0.034 (0.026)	0.059*** (0.011)	-0.031 (0.033)	0.028 (0.036)
Below Average	-0.023*** (0.006)	-0.056*** (0.015)	-0.079*** (0.016)	-0.022*** (0.006)	-0.047*** (0.017)	-0.068*** (0.017)
Self-rated health as a child ^c						
Excellent	0.054*** (0.008)	0.108*** (0.018)	0.162*** (0.018)	0.053*** (0.009)	0.112*** (0.020)	0.165*** (0.019)
Very Good	0.032*** (0.008)	0.041* (0.022)	0.073*** (0.021)	0.031*** (0.009)	0.022 (0.024)	0.053*** (0.021)
Fair	0.001 (0.014)	-0.029 (0.037)	-0.029 (0.041)	0.000 (0.015)	-0.008 (0.038)	-0.008 (0.040)
Poor	-0.041** (0.021)	-0.092 (0.061)	-0.133** (0.064)	-0.043** (0.021)	-0.113* (0.059)	-0.156** (0.062)
Father's Education Level ^d						
Not reported	-0.039*** (0.010)	-0.018 (0.018)	-0.057*** (0.019)	-0.039*** (0.010)	-0.010 (0.019)	-0.049** (0.020)
More than high school	0.050*** (0.006)	0.015 (0.014)	0.066*** (0.016)	0.051*** (0.007)	0.020 (0.016)	0.070*** (0.018)
Mother's Education Level ^d						
Not reported	-0.048*** (0.009)	0.019 (0.024)	-0.028 (0.025)	-0.046*** (0.009)	0.031 (0.026)	-0.015 (0.027)
More than high school	0.053*** (0.006)	0.026** (0.013)	0.079*** (0.014)	0.053*** (0.006)	0.039** (0.016)	0.092*** (0.015)
<u>Mid and later life circumstances</u>						
Education	0.016***	0.029***	0.046***	0.017***	0.027***	0.044***

	(0.001)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)
Ln(income)	0.001	0.044***	0.045***	0.001	0.06***	0.061***
	(0.002)	(0.008)	(0.008)	(0.002)	(0.012)	(0.012)
Ln(wealth)	0.007***	0.038***	0.045***	0.007***	0.035***	0.043***
	(0.001)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)
Health Behaviors			0.063***			0.068***
			(0.003)			(0.004)
<u>Socio-demographics</u>						
Age Cohort ^g						
75 - 84	0.002	-0.196***	-0.193***	0.000	-0.233***	-0.233***
	(0.006)	(0.016)	(0.016)	(0.007)	(0.018)	(0.017)
85 ⁺	0.018**	-0.445***	-0.427***	0.016*	-0.555***	-0.539***
	(0.009)	(0.027)	(0.026)	(0.010)	(0.028)	(0.028)
Gender						
Female	-0.005	-0.034***	-0.039***	-0.005	-0.023*	-0.028**
	(0.005)	(0.012)	(0.013)	(0.006)	(0.013)	(0.014)
Marital Status ^h						
Separated or divorced	-0.121***	0.026	-0.095***	-0.130***	0.006	-0.125***
	(0.010)	(0.020)	(0.022)	(0.012)	(0.027)	(0.029)
Widowed	-0.075***	-0.009	-0.084***	-0.083***	-0.024	-0.108***
	(0.007)	(0.014)	(0.017)	(0.008)	(0.015)	(0.016)
Never Married	-0.091***	0.058	-0.033	-0.100***	0.099**	-0.001
	(0.016)	(0.040)	(0.044)	(0.016)	(0.044)	(0.046)
Race / Ethnicity ^k						
African American	-0.098***	-0.089***	-0.188***	-0.099***	-0.080***	-0.180***
	(0.009)	(0.022)	(0.023)	(0.011)	(0.022)	(0.023)
Hispanic	-0.210***	0.008	-0.202***	-0.209***	0.003	-0.206***
	(0.022)	(0.029)	(0.036)	(0.022)	(0.036)	(0.039)
Other	-0.015	-0.010	-0.025	-0.014	0.015	0.001
	(0.027)	(0.044)	(0.060)	(0.027)	(0.049)	(0.058)
Census Region ^m						
Midwest			-0.025			-0.025
			(0.018)			(0.025)
South			-0.05***			-0.061**
			(0.018)			(0.024)
West			-0.026			-0.014
			(0.018)			(0.028)

Insurance ^q			
Medicare	&	-0.199***	-0.202***
Medicaid		(0.030)	(0.037)
Medicare	&	0.015	0.035***
Private		(0.013)	(0.012)
Other or No		0.012	0.039
Insurance		(0.033)	(0.037)

^a Parent's current age or age at death

Reference Groups:^b about average, ^c good, ^d more than high school, ^f never, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q Medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

†Combined Indirect effects is the sum of the four indirect effects (education, income, health habits and wealth).

Appendix D4. Estimated Production Function for Healthy Aging and Estimated Models for Educational Attainments, Income, Wealth and Health Behaviors among Adults Ages 65+, Based on the Four Indirect Model, (N=9,180).

Inputs	Education	Income	Wealth	Health Behaviors	Healthy Aging 2010	Healthy Aging 2012
<u>Biological Factors</u>						
Mother ^a					0.0008** (0.0004)	0.0009* (0.0005)
Father ^a					0.0004 (0.0004)	0.0011** (0.0005)
<u>Childhood circumstances</u>						
Childhood SES ^b						
Above Average	0.979*** (0.123)	0.051 (0.051)	0.088 (0.118)	0.123 (0.104)	-0.025 (0.022)	-0.031 (0.033)
Below Average	-0.48*** (0.060)	0.028 (0.019)	-0.026 (0.056)	-0.015 (0.048)	-0.056*** (0.015)	-0.047*** (0.017)
Self-rated health as a child ^c						
Excellent	0.862*** (0.097)	0.059** (0.028)	0.268*** (0.084)	0.000 (0.072)	0.108*** (0.018)	0.112*** (0.020)
Very Good	0.44*** (0.088)	0.015 (0.028)	0.242*** (0.081)	0.006 (0.077)	0.041* (0.022)	0.022 (0.024)
Fair	0.107 (0.199)	-0.003 (0.051)	-0.060 (0.150)	-0.024 (0.106)	-0.029 (0.037)	-0.008 (0.038)
Poor	0.007 (0.277)	-0.186** (0.078)	-0.57** (0.226)	-0.115 (0.155)	-0.092 (0.061)	-0.113* (0.059)
Father's Education Level ^d						
Not reported	-0.537*** (0.120)	-0.021 (0.034)	-0.237** (0.119)	-0.054 (0.075)	-0.018 (0.018)	-0.010 (0.019)
More than high school	0.869*** (0.084)	0.098*** (0.026)	0.098* (0.059)	0.028 (0.057)	0.015 (0.014)	0.020 (0.016)
Mother's Education Level ^d						
Not reported	-0.709*** (0.160)	-0.031 (0.039)	-0.427*** (0.126)	0.082 (0.065)	0.019 (0.024)	0.031 (0.026)
More than high school	1.002*** (0.077)	0.099*** (0.031)	0.073	-0.005 (0.047)	0.026** (0.013)	0.039** (0.016)
<u>Mid and later life circumstances</u>						
Education		0.089***	0.223***	0.036***	0.029***	0.027***

		(0.006)	(0.009)	(0.007)	(0.003)	(0.004)
Ln(income)				0.018	0.044***	0.060***
				(0.024)	(0.008)	(0.012)
Ln(wealth)				0.108***	0.038***	0.035***
				(0.010)	(0.003)	(0.004)
Health Behaviors					0.063***	0.068***
					(0.003)	(0.004)
<u>Socio-demographics</u>						
Age Cohort ^g						
75 - 84	-0.123*	-0.196***	0.124*	0.18***	-0.196***	-0.233***
	(0.070)	(0.023)	(0.068)	(0.044)	(0.016)	(0.018)
85+	-0.031	-0.215***	0.087	0.401***	-0.445***	-0.555***
	(0.101)	(0.030)	(0.114)	(0.062)	(0.027)	(0.028)
Gender						
Female	-0.269***	-0.096***	-0.092*	0.25***	-0.034***	-0.023*
	(0.058)	(0.015)	(0.049)	(0.043)	(0.012)	(0.013)
Marital Status ^h						
Separated or divorced		-0.742***	-1.79***	-0.127**	0.026	0.006
		(0.042)	(0.102)	(0.064)	(0.020)	(0.027)
Widowed		-0.619***	-0.962***	-0.063	-0.009	-0.024
		(0.029)	(0.066)	(0.051)	(0.014)	(0.015)
Never Married		-0.759***	-1.507***	0.163	0.058	0.099**
		(0.081)	(0.197)	(0.125)	(0.040)	(0.044)
Race / Ethnicity ^k						
African American	-0.724***	-0.324***	-1.407***	0.189***	-0.089***	-0.080***
	(0.149)	(0.039)	(0.149)	(0.063)	(0.022)	(0.022)
Hispanic	-3.429***	-0.414***	-1.305***	0.36***	0.008	0.003
	(0.335)	(0.064)	(0.203)	(0.092)	(0.029)	(0.036)
Other	-0.047	-0.158	-0.84***	0.5***	-0.010	0.015
	(0.418)	(0.111)	(0.206)	(0.155)	(0.044)	(0.049)
Census Region ^m						
Midwest					-0.025	-0.025
					(0.018)	(0.025)
South					-0.050***	-0.061**
					(0.018)	(0.024)
West					-0.026	-0.014
					(0.018)	(0.028)

Insurance ^a						
Medicare & Medicaid					-0.199***	-0.202***
					(0.030)	(0.037)
Medicare & Private					0.015	0.035***
					(0.013)	(0.012)
Other or No Insurance					0.012	0.039
					(0.033)	(0.037)
Intercept Term	12.159***	9.710***	9.461***	2.736***	-1.486***	-1.753***
	(0.104)	(0.094)	(0.167)	(0.285)	(0.090)	(0.128)

^a Parent's current age or age at death

Reference Groups:^b about average, ^c good, ^d more than high school, ^e never, ^f normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Appendix D5: Effects of Childhood Characteristics on Educational Attainment (E), Income (I), and Wealth (W) among Adults Ages 65+, Expressed as Partial Derivatives, Based on the Four Indirect Model.

Childhood Factors (C_j)	$\frac{\partial E}{\partial C_i}$	$\frac{\partial I}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$	$\frac{\partial W}{\partial C_i}$
Childhood Socioeconomic Status ^a				
Above Average	0.979*** (0.123)	0.051 (0.051)	0.088 (0.118)	0.123 (0.104)
Below Average	-0.48*** (0.06)	0.028 (0.019)	-0.026 (0.056)	-0.015 (0.048)
Childhood Health ^b				
Excellent	0.862*** (0.097)	0.059** (0.028)	0.268*** (0.084)	0.000 (0.072)
Very Good	0.44*** (0.088)	0.015 (0.028)	0.242*** (0.081)	0.006 (0.077)
Fair	0.107 (0.199)	-0.003 (0.051)	-0.06 (0.150)	-0.024 (0.106)
Poor	0.007 (0.277)	-0.186** (0.078)	-0.57** (0.226)	-0.115 (0.155)
Parental Education ^c				
Father-More than high school	0.869*** (0.084)	0.098*** (0.026)	0.098* (0.059)	0.028 (0.057)
Mother-More than high school	1.002*** (0.077)	0.099*** (0.031)	0.073 (0.055)	-0.005 (0.047)

Reference Groups: Reference Groups: a average, b good, c more than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

APPENDIX E- ALTERNATIVE DEFINITION OF HEALTHY AGING (NOT CONSIDERING COGNITION IN THE OUTCOME MEASURE)

Appendix E1. Specific Indirect, Direct, and Total Effects of Childhood Characteristics on Alternative Healthy Aging Scores (excluding cognition) among Men Ages 65+, Year 2010 (N=10,174)

Childhood Factors (C_j)	Indirect through			Health Behaviors (HB)	Direct	Total
	Education(E)	Income(I)	Wealth(W)			
Childhood Socioeconomic Status ^a						
Above average	0.029** (0.005)	0.002 (0.002)	0.004 (0.006)	0.011 (0.009)	-0.023 (0.026)	0.023 (0.030)
Below average	-0.014*** (0.003)	0.001 (0.001)	-0.001 (0.003)	-0.001 (0.004)	- 0.066*** (0.018)	- 0.082*** (0.019)
Childhood Health ^b						
Excellent	0.026*** (0.004)	0.002 (0.001)	0.013*** (0.004)	0.000 (0.006)	0.115*** (0.023)	0.156*** (0.023)
Very Good	0.013*** (0.003)	0.000 (0.001)	0.012*** (0.004)	0.001 (0.007)	0.019 (0.028)	0.046** (0.027)
Fair	0.003 (0.006)	0.000 (0.002)	-0.003 (0.007)	-0.002 (0.009)	-0.060 (0.045)	-0.062 (0.047)
Poor	0.000 (0.008)	-0.006* (0.003)	-0.028** (0.011)	-0.010 (0.013)	-0.118 (0.077)	-0.162** (0.080)
Parental Education ^c						
Father More than high school	0.026*** (0.003)	0.003** (0.001)	0.005 (0.003)	0.003 (0.005)	0.023 (0.018)	0.060*** (0.020)
Mother More than high school	0.030*** (0.004)	0.003*** (0.001)	0.004 (0.003)	-0.001 (0.004)	0.031* (0.016)	0.068*** (0.017)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement

Survey.

Appendix E2. Estimated Production Function for Healthy Aging and Estimated Models for Educational Attainments, Income, Wealth and Health Behaviors among Adults Ages 65+, Based on the Four Indirect Model, (N=10,174).

Inputs	Education	Income	Wealth	Health Behaviors	Healthy Aging 2010
<u>Biological Factors</u>					
Mother ^a					0.001** (0.0001)
Father ^a					0.001 (0.001)
<u>Childhood circumstances</u>					
Childhood SES ^b					
Above Average	0.979*** (0.123)	0.051 (0.051)	0.088 (0.118)	0.121 (0.104)	-0.023 (0.026)
Below Average	-0.48*** (0.060)	0.028 (0.019)	-0.026 (0.056)	-0.015 (0.049)	-0.066*** (0.018)
Self-rated health as a child ^c					
Excellent	0.862*** (0.097)	0.059** (0.028)	0.268*** (0.084)	0.003 (0.072)	0.115*** (0.023)
Very Good	0.44*** (0.088)	0.015 (0.028)	0.242*** (0.081)	0.010 (0.077)	0.019 (0.028)
Fair	0.107 (0.199)	-0.003 (0.051)	-0.060 (0.150)	-0.024 (0.106)	-0.06 (0.045)
Poor	0.007 (0.277)	-0.186** (0.078)	-0.570** (0.226)	-0.114 (0.155)	-0.118 (0.077)
Father's Education Level ^d					
Not reported	-0.537*** (0.120)	-0.021 (0.034)	-0.237** (0.119)	-0.052 (0.075)	-0.032 (0.027)
More than high school	0.869*** (0.084)	0.098*** (0.026)	0.098* (0.059)	0.030 (0.057)	0.023 (0.018)
Mother's Education Level ^d					
Not reported	-0.709*** (0.160)	-0.031 (0.039)	-0.427*** (0.126)	0.080 (0.065)	0.082*** (0.030)
More than high school	1.002***	0.099***	0.073	-0.006	0.031*

	(0.077)	(0.031)	(0.055)	(0.047)	(0.016)
<u>Mid and later life circumstances</u>					
Education	0.089***	0.223***	0.036***	0.013***	
	(0.006)	(0.009)	(0.007)	(0.004)	
Ln(income)			0.017	0.031***	
			(0.024)	(0.010)	
Ln(wealth)			0.108***	0.04***	
			(0.010)	(0.004)	
Health Behaviors				0.087***	
				(0.004)	
<u>Socio-demographics</u>					
Age Cohort ^g					
75 - 84	-0.123*	-0.196***	0.124*	0.182***	-0.170***
	(0.070)	(0.023)	(0.068)	(0.044)	(0.018)
85+	-0.031	-0.215***	0.087	0.403***	-0.389***
	(0.101)	(0.030)	(0.114)	(0.062)	(0.031)
Gender					
Female	-0.269***	-0.096***	-0.092*	0.251***	-0.107***
	(0.058)	(0.015)	(0.049)	(0.043)	(0.016)
Marital Status ^h					
Separated or divorced		-0.742***	-1.79***	-0.127**	0.012
		(0.042)	(0.102)	(0.064)	(0.024)
Widowed		-0.619***	-0.962***	-0.064	-0.038**
		(0.029)	(0.066)	(0.051)	(0.018)
Never Married		-0.759***	-1.507***	0.162	0.055
		(0.081)	(0.197)	(0.125)	(0.053)
Race / Ethnicity ^k					
African American	-0.724***	-0.324***	-1.407***	0.191***	0.015
	(0.149)	(0.039)	(0.098)	(0.063)	(0.027)
Hispanic	-3.429***	-0.414***	-1.305***	0.362***	0.049
	(0.335)	(0.064)	(0.203)	(0.091)	(0.037)
Other	-0.047	-0.158	-0.84***	0.499***	0.074*
	(0.418)	(0.111)	(0.206)	(0.155)	(0.044)

Census Region ^m					
Midwest					-0.011 (0.017)
South					0.027 (0.041)
West					-0.025 (0.024)
Insurance ^q					
Medicare & Medicaid					-0.222*** (0.039)
Medicare & Private					-0.011 (0.017)
Other or No Insurance					0.027 (0.041)
Intercept Term	12.159*** (0.104)	9.71*** (0.094)	9.461*** (0.167)	2.74*** (0.284)	-1.297*** (0.118)

^a Parent's current age or age at death

Reference Groups:^b about average, ^c good, ^d more than high school, ^f never, ^g normal, ^g aged 65-74, ^h married/partnered, ^k white, ^m northeast, ^q medicare. *p<0.1, **p<0.05, ***p<0.01. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

APPENDIX F- AGE-GROUP TABLES

Appendix F1. Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among the Young-old group, Adults Ages 60-69, (N=5,069)

Childhood Factors (C_j)	Indirect through			Direct	Total
	Education (E)	Income (I)	Wealth (W)		
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.029*** (0.007)	0.001 (0.002)	0.004 (0.006)	0.022 (0.048)	0.055 (0.050)
Below average	-0.017*** (0.005)	-0.001 (0.002)	-0.003 (0.004)	-0.057** (0.025)	-0.078*** (0.026)
<u>Childhood Health</u> ^b					
Excellent	0.025*** (0.006)	0.003 (0.003)	0.012* (0.006)	0.132*** (0.042)	0.172*** (0.042)
Very Good	0.016** (0.007)	0.003 (0.002)	0.000 (0.006)	0.026 (0.051)	0.044 (0.050)
Fair	0.012 (0.008)	0.001 (0.002)	-0.016** (0.008)	-0.028 (0.067)	-0.032 (0.067)
Poor	0.013 (0.014)	-0.008 (0.006)	-0.054*** (0.014)	-0.238** (0.121)	-0.287 (0.120)
<u>Parental Education</u> ^c					
Father More than high school	0.032*** (0.005)	0.002 (0.001)	0.006* (0.003)	0.033 (0.027)	0.073*** (0.027)
Mother More than high school	0.04*** (0.008)	0.002 (0.002)	0.003 (0.003)	0.001 (0.030)	0.045 (0.030)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Appendix F2. Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among the Old group, Adults Ages 70-79, (N=5,249)

Childhood Factors (C_j)	Indirect through			Direct	Total
	Education (E)	Income (I)	Wealth (W)		
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.036*** (0.007)	-0.004 (0.006)	-0.005 (0.007)	-0.034 (0.041)	-0.006 (0.044)
Below average	-0.025*** (0.005)	0.002 (0.002)	0.002 (0.003)	-0.055 (0.018)	-0.076*** (0.019)
<u>Childhood Health</u> ^b					
Excellent	0.036*** (0.007)	0.002 (0.003)	0.009*** (0.003)	0.078*** (0.025)	0.124*** (0.025)
Very Good	0.018*** (0.007)	-0.001 (0.002)	0.008** (0.004)	0.037 (0.029)	0.062** (0.030)
Fair	0.017** (0.009)	-0.003 (0.005)	-0.007 (0.006)	-0.042 (0.053)	-0.035 (0.055)
Poor	-0.001 (0.013)	-0.006 (0.007)	-0.012 (0.011)	-0.072 (0.065)	-0.092 (0.068)
<u>Parental Education</u> ^c					
Father More than high school	0.048*** (0.006)	0.005** (0.002)	0.003 (0.003)	0.009 (0.019)	0.065*** (0.019)
Mother More than high school	0.042*** (0.006)	0.009*** (0.003)	0.006 (0.004)	0.025 (0.016)	0.082*** (0.016)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

Appendix F3. Indirect, Direct, and Total Effects of Childhood Characteristics on Healthy Aging Scores among the Old-old group, Adults Ages 80+, (N=2,973)

Childhood Factors (C_j)	Indirect through			Direct	Total
	Education (E)	Income (I)	Wealth (W)		
<u>Childhood Socioeconomic Status</u> ^a					
Above average	0.037*** (0.009)	0.000 (0.002)	0.005 (0.007)	-0.068 (0.058)	-0.026 (0.06)
Below average	-0.02*** (0.005)	0.000 (0.001)	-0.005 (0.004)	-0.061 (0.035)	-0.085** (0.034)
<u>Childhood Health</u> ^b					
Excellent	0.03*** (0.008)	0.001 (0.002)	0.006 (0.005)	0.121*** (0.031)	0.157*** (0.035)
Very Good	0.01 (0.007)	0.000 (0.001)	0.013** (0.005)	0.039 (0.034)	0.062* (0.036)
Fair	-0.009 (0.013)	0.000 (0.003)	0.011 (0.010)	-0.051 (0.071)	-0.048 (0.076)
Poor	-0.01 (0.016)	-0.002 (0.005)	0.000 (0.014)	-0.03 (0.157)	-0.042 (0.157)
<u>Parental Education</u> ^c					
Father More than high school	0.028*** (0.007)	0.001 (0.003)	0.003 (0.005)	-0.031 (0.039)	0.002 (0.039)
Mother More than high school	0.026*** (0.007)	0.000 (0.002)	-0.001 (0.005)	0.065** (0.033)	0.09*** (0.033)

Reference Groups: ^aaverage, ^bgood, ^cless than high school. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The p-value corresponds to a test of difference from zero. Standard errors are reported in parentheses and were calculated using bootstrapping methods. All estimates are weighted to represent the non-institutionalized U.S. population, ages 65 and older, based on sampling weights of the 2010 Health and Retirement Survey.

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ABSTRACT**ESSAYS ON HEALTHY AGING FROM THE PERSPECTIVE OF A
HEALTH PRODUCTION FUNCTION**

by

NASIM BAGHBAN FERDOWS**December 2016****Advisor:** Dr. Gail Jensen Summers**Major:** Economics**Degree:** Doctor of Philosophy

This dissertation examines the determinants of healthy aging among older adults using Grossman's framework of a health production function. Healthy aging is produced using a variety of inputs, including some determined in early life, such as health and socioeconomic status as a child, others determined in young adulthood, such as education, others determined in mid-life, such as household wealth, and still others determined in later-life, such as current health habits. A production function for healthy aging is estimated using nationally representative data from the 2010 Health and Retirement Study on non-institutionalized seniors, and positing a simultaneous equations mediation model, recognizing that childhood outcomes influence adulthood outcomes, which in turn influence healthy aging. I quantify how childhood factors contribute to healthy aging, both directly and indirectly through these effects on mediating adult outcomes. The importance of current health habits to healthy aging are also examined. The results indicate that favorable childhood conditions significantly improve healthy aging scores, both directly and indirectly, mediated through education, income, and wealth. Moreover, good health habits have positive effects on healthy aging that are larger in magnitude than the effects

of childhood factors. The findings suggest that exercising, maintaining a proper weight, and not smoking can more than compensate for unfavorable conditions experienced as a child.

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