6-25-2015

ETHNO-RACIAL DISPARITIES IN HEALTH OUTCOMES: EVIDENCE FROM THE AGING POPULATION

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by

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DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
Economics

The University of New Mexico
Albuquerque, New Mexico

May, 2015

Dedication

To God -
for the grace and strength to complete this journey

To my husband, Olatokunbo and amazing daughter, Ifeoluwapo -

My love for you is immeasurable!

Acknowledgements

I am deeply thankful for the support of my committee. To Robert Valdez, my dissertation chair, thank you for your invaluable feedback on my research, encouragement and professional support. Thank you for your solid confidence in my abilities! To Melissa Binder, my dissertation co-chair, your encouragement and guidance all through my doctoral studies are invaluable. Thank you for being a constant source of motivation and support. To Robert Berrens, thank you for imbibing in me the importance of detailed research through our work together, and for all your suggestions and advice. Thank you to Marcia Ory of the Texas A&M School of Rural Public Health for agreeing to work with me despite your busy schedule and for your professional advice.

To other faculty, Janie Chermak and Kate Krause, thank you for your kind words and support. I would also like to thank the Department of Economics at UNM for awarding me with the Gerald Boyle Memorial Student Award and the Alfred L. Parker Scholarship.

My utmost appreciation to my parents, Abayomi and Funmi Odufuwa for their love, constant prayers and for giving up so much to make sure I had the best foundation for graduate school. Dad, thank you for teaching me to work hard and to always be the best in everything I do. Mum, your constant messages and prayers kept me going. I am incredibly blessed to have such amazing parents as you both. Thank you to my siblings, Leke, Dotun and Seyi for your love and unconditional support all through this journey.

Most of all, I thank my husband and best friend, Olatokunbo. You encouraged me to start this journey. Thank you for believing in me, for being the best support system and for being my listening ear! To my daughter, Ifeoluwapo, you were the awesome blessing I received during this journey. You both mean the world to me!

Ethno-Racial Disparities in Health Outcomes: Evidence from the Aging Population

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ABSTRACT

This dissertation assesses racial and ethnic disparities in health outcomes of the aging population, with focus on improving functional health, health status and quality of life at both individual and community levels.

Chapter 2 examines racial and ethnic disparities in willingness to pay (WTP) for improved health among an aging population sample while also examining the impact of health status and risky health behaviors. Using contingent valuation survey data from the Health and Retirement Study (HRS), model results indicate that racial and ethnic minorities are more likely to have a positive WTP for improved health than non-Hispanic Whites. However, WTP for minorities is found to be significantly lower than for non-Hispanic Whites. However, when compared with non-Hispanic Whites, WTP for minorities

constitute a higher percentage of household income. Further analyses also examine the impact of health status and risky health behaviors on WTP for improved health.

The third chapter examines racial and ethnic disparities in the trajectories of functional health limitations among older adults. Analyses stratified by race indicate that Blacks and Hispanics are more likely to have functional limitations at the initial time period than non-Hispanic whites. However net of educational attainment and wealth, a "racial crossover" is observed in the baseline odds of functional limitations where Whites are found to have a higher level of functional limitations compared to both minority groups. In addition, non-Hispanic Whites tend to have faster increases in the rate of change in functional limitations over time. This chapter also analyses how health status and health-related behaviors contribute to the baseline level and rate of change in functional limitations over time.

Chapter 4 provides a cost effectiveness analysis of a physical activity and nutrition program, the *Texercise Select* program implemented in some Texas counties to improve functional health, nutritional habits and quality of life among the older population. Program effectiveness is measured using Quality adjusted life year (QALY) gain as well as health outcomes such as healthy days, weekly physical activity days and Timed Up-and-Go (TUG) test scores. Results indicate that the program is a cost-effective strategy for increasing physical activity and improving healthy nutrition practices among the older population as compared to other similar health promotion interventions and also in comparison to the common cost-effectiveness threshold of $50, 000 for a gained QALY.

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Chapter 1: Introduction

Longer life spans than in previous decades and aging baby boomers has resulted in a rapid growth in the number of older adults in the country. Continually seeking to improve or maintain the wellness of the older population has become an unavoidable necessity in order to ensure that baby boomers "age successfully" and look forward to their older years. More so when over 66% of the country's health care budget is incurred by this age group (CDC 2013). As a result, analyzing and understanding health problems that prevent successful aging is needed before effective efforts or measures can be put in place to alleviate them.

As the proportion of older adults is projected to increase rapidly, so also is racial and ethnic diversity. The CDC projects that the proportion of Hispanics and Blacks will increase to 20% and 11% of the total country's population by 2050 respectively. This is a rapid increase from 2010 data trends of 7% for Hispanics and 8.3% for Blacks (Census Bureau 2014). The existence of racial and ethnic disparities in health outcomes among older adults in the United States has also been documented. For example, compared with non-Hispanic Whites, racial and ethnic minorities have higher disability levels and shorter life expectancies (Hayward et al. 2000; Warner and Brown 2011). Thus, understanding and eliminating ethno-racial disparities in health outcomes is a major goal of health policy makers. In addition to eliminating disparities, a major goal in *Healthy People 2020*, a 10-year health objectives agenda developed by the US Department of Health and Human Services (DHHS), is to improve overall health, functioning, and quality of life of the aging US population on the premise that an individual's health and the health of the community are intertwined (DHHS 2012).

Health changes and problems due to aging may be accompanied or reflected by declines in functional changes. Prevention of these declines among the aging population is an area of national health priority as most older adults want to maintain independence so as to remain in their communities as long as possible. Functional limitations reflect both an individual's physical ability and characteristics of physical environment which may influence functioning. The disability framework for this dissertation is the International Classification of Functioning, Disability and Health model, by the World Health Organization. The model is used to measure health and functioning at both individual and population levels. As shown in Figure 1.1, the model suggests that disability and functioning are outcomes of interaction between health conditions and contextual factors. According to the model, the two categories of contextual factors which could influence an individual's health and functioning are environmental and personal factors (World Health Organization 2002). While the environmental factors include external factors such as climate and terrain, the personal factors on the other hand include gender and behavioral factors. This dissertation focuses on the economic analysis of health conditions and behavioral factors, two of the factors proposed as determinants of health, functioning and disability.

Specifically, this dissertation assesses health outcomes of the older population with focus on improving functional health, health status and quality of life at both individual and community levels. The second chapter "Racial and Ethnic Disparities in Willingness to Pay (WTP) for Improved Health: Evidence from the Aging Population" explores racial and ethnic disparities in willingness to pay (WTP) for improved health among an aging population sample. WTP is an economic valuation framework that attempts to reveal the

individual's preferences. The estimates reflect the value of current consumption of goods and services an individual will be willing to sacrifice for an improvement in health status or for morbidity reduction. Understanding individuals' willingness to sacrifice current consumption of goods and services for a change in health is important information for policy makers as such WTP estimates are used to estimate the optimal scale of proposed health policy interventions relative to a fixed budget (Dickie and List 2006). Sources of disparities or variation in WTP include age, gender, income and racial/ethnic group. While income, age and health status have been the most widely researched sources of disparities in WTP (Alberini et al. 2004; Krupnick and et al. 2002; Milligan, Bohara, and Pagan 2010), more research is required to determine if valuation of health among older adults differ by racial and ethnic groupings. Given the increasing racial and ethnic diversity, policymakers not only seek to estimate the aging population's willingness to pay for these interventions but also how results may vary across diverse racial and ethnic groups among this population. This chapter also examines the impact of health status and health-related behavioral factors on an older adult's health valuation.

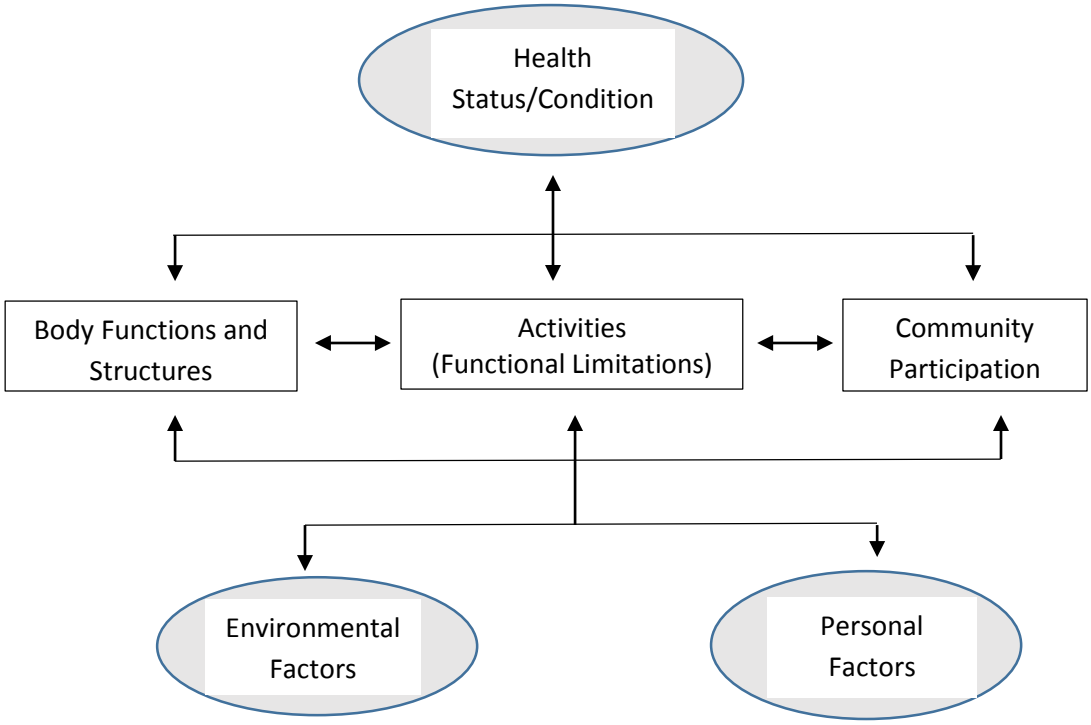
The third chapter takes a similar approach by examining racial and ethnic disparities in the trajectories of functional health limitations among older adults and also analyze the impact of health status and health-related behaviors on the baseline level and rate of change in functional limitations over time among older adults. Better understanding of the relationship between these two factors and functional limitations among older individuals is important for delaying the onset, minimizing or preventing such limitations. Recent data trends show that 30.8 percent of older adults had moderate to severe functional limitations in 2010 (DHHS 2012). This has necessitated more public health programs to

improve the functional status and overall health of the aging population. An example of such an initiative implemented at the local level to promote functional health and overall quality of life among older adults in the community is the *Texercise Select* program implemented in eight counties in Texas.

Chapter 4 therefore takes a practical approach by conducting the cost effectiveness analysis of the *Texercise Select* program. The program was implemented with the goal of improving functional health, nutritional habits and quality of the life among the older population. The specific objectives of the program were to improve participants' knowledge about the value of physical activity and good nutrition, increase participants' confidence in their ability to make healthier choices related to physical activity and nutrition, improve participants' mobility and increase the ease of sitting, standing and walking; and provide participants with effective strategies to prevent falling. Cost effectiveness analyses are important because they are a major criteria when deciding whether resources should be allocated to particular health interventions. In addition, cost effectiveness analyses also help inform policy makers or decision makers about the value of such particular health interventions or programs by analyzing the health outcomes subject to the costs of the program or comparing alternative programs.

This dissertation as a whole therefore addresses critical issues of importance to health economists especially as it relates to aging health and policy.

Figure 1.1 The ICF Model



Source: World Health Organization 2002

Chapter 2: Racial and Ethnic Disparities in Willingness to Pay for Improved Health: Evidence from the Aging Population

2.1 Introduction

Considerable research effort has been focused on estimating individual willingness to pay (WTP) for mortality risk reductions in the economics literature (Alberini et al. 2006, 2004; Krupnick and et al. 2002; Milligan, Bohara, and Pagan 2010). Relatedly, WTP for reduced morbidity or improved health is another important area of inquiry because of the large proportion of individuals affected and its possibility of progressing towards mortality. Morbidity is a case of being in less than 'perfect' or 'good' health and can either be chronic or acute (Freeman 2003). While acute morbidity only lasts for a couple of days, chronic morbidity is of a longer term or indefinite time period. Changes in actual or expected morbidity may affect an individual's risk-mitigation behavior. This may in turn bias estimates of the benefits for life-saving policies, such as estimates for the Value of a Statistical Life (VSL). The VSL is an aggregation of individuals' WTP for given changes in risk reduction. An economic valuation framework attempts to represent the preferences of individuals, as measured using either revealed preference approaches such as wage-risk observations or stated preference approaches such as contingent valuation and choice experiments. Contingent valuation (CV) is the most commonly used stated preference method for valuing changes in morbidity status, where WTP responses for a proposed scenario are elicited from individuals in a survey sample (Freeman 2003; Van Houtven et al. 2003).

WTP estimates for improved health are based on consumer preferences consistent with utility measure and are relevant for policy interventions regarding the reduction in non-fatal hazards. The WTP estimates, whether for mortality risk reduction or morbidity reduction, can be used to estimate the optimal scale of proposed health policy interventions relative to a fixed budget (Dickie and List 2006). In general, focusing on WTP estimates for different groups and settings requires taking into account the nature of the risk involved and other individual characteristics. The expected influence of such sources of disparities has also been proposed in some valuation studies (Sunstein 2004; EPA 2000; Viscusi 2010; EPA 2010). Income, age and health status have been the most widely researched sources of disparities (Milligan, Bohara, and Pagan 2010; Krupnick and et al. 2002; Alberini et al. 2004). Race and ethnicity are other possible sources of disparities in WTP estimates. Fully exploring how WTP estimates vary with race and ethnicity would require taking into account all possible economic and social mechanisms contributing to such disparities (Viscusi 2010). All these sources of disparities may also influence WTP for improved health.

The objective of this research is to examine racial and ethnic disparities in WTP valuations for improved health or reduced morbidity among a sample of the aging population. According to the U.S. Census Bureau, the U.S. population is aging rapidly. The population of older adults is also expected to more than double by 2050, with increasing racial and ethnic diversity (Vincent and Velkoff 2010). The Hispanic population which is the largest minority group has been projected to more than double the share of their population to 29% by 2050. The older population also has unique medical needs relative to younger adults, and is more likely to suffer from chronic illnesses (Prevention

2007). More importantly, minority population among the aging are known to suffer more chronic illnesses than non-Hispanic Whites in part due to lifestyle factors and less access to medical services. As a result, one of the priorities of the CDC is addressing the health needs of the country's older and minority population. This analysis explores how this group values improved health. The impact of an individual's health status and risky health behaviors on WTP is also examined. Not considering prior morbidity or illnesses may lead to models of health-seeking behavior poorly predicting individuals' investment in their health (DeShazo and Cameron 2005).

The major contribution of this paper is to demonstrate that willingness to pay for morbidity varies significantly by race, type of disease diagnosis and health – related lifestyles. There are very few WTP for morbidity studies and there has been no research jointly analyzing WTP for morbidity valuations of racial minorities compared to non-Hispanic Whites, while also controlling for the impact of risky health behaviors. To address this gap, the econometric analysis uses data from a valuation module of the Health and Retirement Study (HRS) data, which focuses on America's expanding aging population. The valuation module uses a non-standard CV format, which includes an initial selection question (for the absence or presence of positive WTP) and a structured sequence involving two different WTP response formats. Handling these two formats requires a pragmatic approach, retaining as many responses as possible (making full use of the sample) and accounting for possible selection bias using the Heckman two-step modeling technique.

Evidence across all estimated econometric models indicate possible racial and ethnic disparities in a minority grouping in relative WTP for improved health compared to non-Hispanic Whites. Hispanics, Blacks, American Indian and Asians groups, collectively,

are more likely to have a positive WTP for improved health than White-non Hispanics but their specific WTP amounts is significantly lower than for non-Hispanic Whites. Specifically, we find that minorities are 26-30% more likely to want to pay a positive amount for improved health but average WTP for minorities is 70% - 97% lower than for non-Hispanic Whites. However, when compared with non-Hispanic Whites, annual average WTP for minorities constitute a higher percentage of household income (23%) compared to Whites (14%). This result, however, possibly only holds for the lower income groups with household income less than $25,000. For the middle and high income categories, median WTP for minorities in both absolute and relative terms is lower that of Whites in the same categories. In addition, current morbidity does influence WTP for improved health as older adults with a previous diagnosis of cancer and lung diseases are more likely to have a positive WTP for improved health compared to healthy older adults. This indicates that perhaps cancer and lung disease health interventions could be the most valued among older adults. While results demonstrate that willingness to pay for improved health varies systematically and significantly by disease type, the same cannot be said for racial and ethnic groups as effects could be dependent on income categories and possibly the choice of either relative or absolute effects. However, risky health behaviors have no observable impact on WTP valuations.

2.2 Theoretical Framework of Utility for Health

WTP measures an individual's willingness to sacrifice a desired attribute (wealth) for future consumption in order to obtain another desired attribute - improved survival

(Shepard and Zeckhauser 1984). This improved survival is synonymous with improved health or a reduction in morbidity. In a simple conceptual framework, each individual is assumed to have preferences described as follows:

$$U = U\,[H, X(H)] \tag{1}$$

The individual's utility is a function of their own health capital, H and a vector of all other goods, X that contribute to utility. Here, health H is treated as an exogenous variable. As shown in *(1)*, it is assumed that the utility derived from all other goods is dependent on the individual's health status. Individuals are assumed to maximize *(1)* subject to a budget constraint:

$$Y = PX \tag{2}$$

where Y is an income level determined exogenously and P is a vector of prices. The indirect utility function corresponding to this utility maximization process can be written as follows:

$$V = V(Y, P, H) \tag{3}$$

The compensating variation expression for marginal willingness to pay for reduced morbidity can be expressed as follows:

$$V(Y, P, H) = V(Y - WTP, P, H^*) \quad (4)$$

This reflects the maximum amount the individual would be willing to give up for improved health.

In *(4)*, the WTP for improved health is a Hicksian compensating welfare measure (Freeman 2003). It indicates the change in current income (from Y to $[Y - WTP]$) the individual is willing to let go of for an improved health from his current health status (from H to H^*). WTP can also be defined explicitly as the difference between the individual's expenditures in the two health states.

$$WTP_c^+ = |e(\bar{P}, V, H) - e(\bar{P}, V, H^*)| \quad (5)$$

where $\bar{P}$ is a vector of prices; with $H^* > H$ indicating that H^* is an improved health status.

The WTP framework in *(5)* above implicitly indicates that WTP for a health improvement should increase the more severe the current condition is. In addition to current health status, other behavioral factors such as risky health behaviors and socioeconomic factors are likely to influence WTP for health improvements. These will be included in the econometric estimations of *(5)*. Large improvements in health could affect an individual's income level and their marginal utility of income (Reed Johnson, Fries, and Spencer Banzhaf 1997). However, for modeling and estimation ease, it is assumed that the individual's marginal utility of income is constant. It is also expected that an individual's WTP for health improvement should increase at a decreasing rate as current health conditions move towards perfect health.

2.3 Hypotheses

This chapter investigates racial and ethnic disparities in WTP for improved health and also analyses the impact of health status and health-related variables on WTP. Considerable prior research has revealed significant health disparities for minorities, as compared to the US population as a whole or with non-Hispanic whites. Such health disparities have been attributed to differences in social and economic determinants such as low socioeconomic status and lack of access to care (Koh, Graham, and Glied 2011). Various national initiatives aimed at reducing racial and ethnic health disparities underscore the importance of analyzing WTP valuations for health improvements among minorities.

In addition, this analysis jointly tests for the impact of the individual's health status and risky health behaviors on WTP, expressed in the following natural log WTP function:

$$\ln WTP = f(\beta^{H^j} X^{H^j}, \beta^{H^k} X^{H^k}, \beta^{SE} X^{SE}) \quad (6)$$

with $j = \{high\ blood\ pressure, diabetes, cancer, lung\ disease, heart\ conditions, stroke\}$

$k = \{tobacco\ use, alcohol\ use\}$

In *(6)*, X^{H^j} is a vector of the presence of chosen chronic illnesses in category *j* representing the individual's health status, X^{H^k} is a vector of chosen risky health behaviors in category k, X^{SE} is a vector of demographic and socioeconomic variables, including minority status, and the β's are conformable vectors of estimable coefficients.

2.3.1 Health Status and WTP

As noted, most previous health and WTP analyses have focused directly on mortality risk reductions, and not on health improvement or morbidity reductions. For instance, using a CV survey from Canada, Krupnick et al. found that with the exception of cancer, WTP is not affected by health status (Krupnick and et al. 2002). Alberini et al. also found that individuals diagnosed with cancer, chronic heart and lung conditions have higher WTP to reduce mortality risk (Alberini et al. 2004). Rather, this analysis focuses on WTP for health improvement and expands the list of chronic health illnesses to include not only cancer, lung and heart diseases but also diabetes, high blood pressure and stroke. Diabetes and high blood pressure can lead to heart problems and other chronic health problems. The chance of stroke and other medical conditions is also higher in individuals involved in risky health behaviors, such as smoking and heavy drinking (Markus 2012).

As implied from *(5)*, an individual's WTP for a health improvement could depend on current health status. Health status refers to the range of manifestation of any disease in an individual, including symptoms and its functional limitation (Rumsfeld 2002). Health status may often be measured by the diagnosis of various chronic illnesses such as cancer, diabetics, heart conditions, lung diseases, respiratory disease, and stroke. An individual's current morbidity and knowledge of it could determine whether or not he will be willing to pay more for improved health. In other words, morbidity may have a large impact on an individual's demand for health risk mitigation. Individuals with poor health may face further worsening of their health either due to current or other illnesses. Therefore, having an illness may increase the individual's demand for interventions that may mitigate the health condition or reduce the risk of occurrence. The difference between the two

expenditure functions in *(5)* may be greater for an individual diagnosed with any form of chronic illness. Therefore, WTP for improved health is expected to be positive and higher than for healthy individuals. Against the null of no effect on the level of WTP, a set of testable hypotheses across various health statuses is presented in the top half of Table 2.1.

2.3.2 Risky Health Behaviors and WTP

The relationship between risky health behaviors and WTP is also analyzed. Risky health behaviors such as tobacco use, alcohol consumption and sedentary lifestyles are major causes of death. The CDC reports that adverse health effects from cigarette smoking accounts for nearly one of every five deaths each year (CDC 2004). In their research identifying the leading cause of mortality in the US, Mokdad et al. found that 18.1% of total deaths were caused by tobacco consumption, 3.5% from alcohol use and 15.2% from poor diet and sedentary lifestyles (Mokdad et al. 2004). Khwaja et al. also analyzed whether health valuations varied between current smokers and former smokers (Khwaja, Sloan, and Salm 2006). However, their findings did not show any significant difference in WTP values between the two groups of individuals.

Based on these health reports, an individual's probability of dying is assumed to be higher if they engage in risky health behaviors. As a result, the difference between the two expenditure functions in *(5)* may be greater for an individual that engages in risky health behaviors. Against the null hypothesis of no effect on WTP values for a health improvement, a second set of testable hypotheses across both risky health behaviors is presented in the bottom half of Table 2.1. The HRS wave used for this analysis includes a

question on vigorous physical activity, such as sports, heavy housework or a job that involves physical labor (HRS 2002). It is assumed that the aging population is more likely to be involved in light physical activity such as walking, gardening or golfing. Such light physical activities are not included in the HRS wave 5 data, or in this analysis.

2.4 Data and Variable Description

2.4.1 Data

This paper uses the RAND HRS data. The HRS is a national longitudinal study funded by the National Institute on Aging (NIA) and conducted by the University of Michigan's Institute for Social Research (ISR). The HRS study follows age eligible individuals and their spouses every 2 years since initial survey administration (HRS 2002). To make the data more accessible to researchers, the RAND Center for the Study of Aging created the RAND HRS data files containing cleaned and processed variables, with consistent and intuitive naming conventions (Patricia St.Clair 2011).

The HRS began as two distinct but closely related surveys. The first survey, the original HRS, was initially administered in 1992 to a nationally representative sample of Americans born in the years 1931 through 1941 (ages 51 through 61). The second survey, the study of Assets and Health Dynamics among the Oldest Old (AHEAD), was initially administered in 1993 to a nationally representative sample of Americans born in 1923 or earlier (ages 70 and older). Both surveys were consolidated in 1998 and became the HRS(HRS 2002). In the same year, two new cohorts of participants were also added to the survey – War Babies cohort and Children of the Depression (CODA) cohort (Patricia

St.Clair 2011). The War Babies cohort consists of people who were born 1942 through 1947. They were added to replenish the original HRS cohorts who were aging and dying. CODA, on the other hand, consists of people who were born 1924 through 1930 – the age groups between the original HRS and AHEAD samples.

The HRS survey includes information on demographics, employment, assets and income, employment history, health insurance, family structure, health status and health-relevant behaviors of the older population. The RAND HRS Wave 5 data is used, which is synonymous with the HRS 2000 data, because it includes a health valuation module. In the module, respondents were asked to compare their current state of health to 'perfect' health in a series of CV WTP questions. The data collection period for the 2000 interview was February 2000 through January 2001. Individual respondent-level survey results are used for this analysis.

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2.4.2 WTP for improved health

The HRS 2000 survey includes a set of modules applied to a subset of respondents. At the end of the main survey, respondents were randomly assigned a number to determine if the respondent would proceed to the health valuation module. Based on this randomization procedure, 914 respondents were asked CV questions related to their WTP for perfect health given their current health. A brief introduction explained that the financial resources government and universities allocate to medical research requires knowledge about how people with different health conditions feel about their health problems. Responses help identify the most important health problems for medical research (HRS 2002). Then,

respondents were asked an initial 'yes' or 'no' health valuation selection question as follows:

> *"Imagine that you will live for 10 more years in your current state of health. Assuming that your current medical expenses and insurance premiums stay the same as they are now, would you be willing to pay more every month for additional medical treatment if it allowed you to live those ten years in perfect health?"*

The willingness to pay for health improvement via the additional medical treatments reflects each individual's preferences. Of the 914 survey respondents, 547 answered yes, 332 answered no, and 35 declined. The 547 respondents that expressed positive WTP ($WTP_{4HEALTH}>0$) continued with the CV questions. However as presented in Figure 1.1, the HRS valuation module uses a very non-standard format which consists of the initial selection question and a structured series or sequence involving two different WTP response formats. These are open ended (OE) and double-bounded dichotomous-choice (DB-DC) formats. Analyzing this requires a pragmatic approach for handling the two formats, retaining as many valuation responses as possible and accounting for possible selection bias in the initial screening question for positive WTP.

Open-ended (OE) questions:

As shown in Figure 1.1, the OE question asked:

"What is the greatest amount you would be willing to pay each month to live in perfect health?"

This provides continuous positive WTP data. Responses represent the individual's maximum WTP monthly for improved health, which is synonymous with the Hicksian compensating welfare measure in *(5)*. A total of 280 gave actual values of WTP. The other 267 either refused to answer or could not ascertain their maximum WTP. OE questions are relatively straightforward and perhaps the simplest to interpret (Freeman 2003). Compared to other elicitation formats, they do not have any starting point bias problems, where the suggestions of an initial starting point can influence final WTP. In addition, standard statistical techniques can be used to analyze continuous positive responses (Pearce, Atkinson, and Mourato 2006). However, they tend to yield protest zeroes, invalid large responses and sometimes unreliable responses (Freeman 2003; Mitchell and Carson 1989; Carson, Flores, and Meade 2001; Boyle 2003).

Of concern, mean OE WTP values are usually sensitive to the presence of large individual bids. Respondents can influence the outcome of a proposed change by stating a value that exceeds their true WTP (Boyle 2003). This problem of unreliable large responses can be potentially addressed by either using a rule of thumb about the relationship between the stated WTP value and the respondent's income, or using robust statistical estimators such as an α-trimmed mean where α is determined by the analyst (Mitchell and Carson 1989; Freeman 2003). In this sample, a small number of respondents reported extremely high OE WTP values. Carson suggests that WTP values should not exceed five percent of household income (Alberini and Cooper 2000). While this suggestion was made for

environmental goods, this chapter follows this rule of thumb in select models. Responses above five percent of income are not dropped but trimmed to the upper limit.

***Double-bounded dichotomous choice (DB-DC) questions**:*

Following Figure 1.1, the interviewer's instruction was to continue with DB-DC questions with respondents who could not provide OE responses. Thus, 267 respondents continued with the survey. Various types of discrete choice formats are commonly used for eliciting WTP responses. The DB-DC format does not elicit WTP values directly, but provides a bounded interval within which the respondent's WTP value lies. Respondents were asked their willingness to pay a specific dollar price, or payment amount, for a given change. Follow-up questions were asked, in which the amounts presented depends on the response to the previous question. If the response is positive, the respondent is asked a second discrete choice question of a specific higher amount but if the response is negative, a second question of a specific lower amount is asked. The upper and lower bounds are found when respondents provide a positive response to one of the questions and a negative response to the other (Hanemann and Kanninen 2001).

The initial dichotomous question (DC) asked

"Would you be willing to pay $1000 per month to live ten years in perfect health?"

Based on the response, follow up questions were asked with higher or lower payment amounts, which allow WTP classification into seven categories: less than $50, between

$50 and $200, $200 and $500, $500 and $1000, $1000 and $2000, $2000 and $5000, and over $5000.

To begin, DC questions could minimize non-response and protest zero situations because the format mimics a familiar market context for the respondent of simply accepting or rejecting a good with a posted payment amount. However, there has been mixed performance of the DB-DC elicitation format with some response anomalies, which appear to be due to possible strategic changes in a respondent's answers on the follow-up questions, especially after the first DC question is asked. There is a tendency for respondents who answered 'yes' to one of the follow-up questions to answer 'no' to the next follow up question. Possible explanations include the possibility that respondents may assume a lower follow-up amount corresponds to a lower quality of the good or that a higher follow-up amount is a form of exploitation (Haab and McConnell 2002). As a result, mean WTP may be biased depending on the presence of such strategic behaviors. Another important factor to be taken into consideration with DB-DC questions is the selection of the payment amounts. With a lower range of payment amounts, the estimated mean WTP could be biased downwards (Freeman 2003). In addition, DB-DC data require more complex statistical techniques, with results very sensitive to statistical assumptions made (Pearce, Atkinson, and Mourato 2006).

This chapter takes into account possible selection effects from the initial question, and further avoids having to ignore large subsamples by having multiple types of WTP data (both continuous OE and bounded categorical DB-DC). For example, studies using the HRS valuation module may ignore possible selection effects and available OE data, to simply estimate double-bounded maximum likelihood models on the DB-DC data. This

throws away the majority of the sample and would greatly limit the ability to explore sub-sample effects (e.g., minority status). Alternatively, this analysis converts all respondents in the DB-DC subsample to a single OE value. The highest payment amount with a 'yes' response is conservatively assumed as their maximum WTP. Thus, responses are coded such that respondents no longer have double-bounded WTP but only one maximum WTP. This provides a conservative estimator and allows us to combine all WTP responses in the data, and retain the maximum possible sample.

Further, Heckman selection models are used, where the selection equation uses the data from the initial binary question on positive WTP, and then the continuous WTP data is used for the outcome equation. To control for possible large individual bids in these calculated open-ended WTP data, values in select models are also trimmed to an upper limit of five-percent of reported annual household income. All estimations are done with and without this upper-limit trimming.

2.4.3 Explanatory variables

Ethnic minorities have higher rates of chronic illnesses, such as cancer and obesity, and higher incidence of risky health behaviors (Holly Mead 2008). Here, race and ethnicity (MINRACE) is coded in terms of racial minority (1 if respondent is Hispanic, Black, American Indian and Asian; 0 otherwise). Health status is measured by the diagnosis of chronic health conditions. Six chronic health problems are analyzed. These are high blood pressure (HBP), diabetes (DIAB), cancer (CANCER), lung disease (LUNG), heart problem (HEART), and stroke (STROKE). The specific health questions asked are:

"Has a doctor ever told you that you have high blood pressure or hypertension?", "Has a doctor ever told you that you have diabetes or high blood sugar?", "Has a doctor ever told you that you have cancer or a malignant tumor, excluding minor skin cancers?", "Has a doctor ever told you that you have chronic lung disease such as chronic bronchitis or emphysema?", "Has a doctor ever told you that you had a heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems?" and "Has a doctor ever told you that you had a stroke?"[1]

In addition to these health variables, respondents were also asked to rank their health on a 1 – 5 scale (SRHEALTH), with 1 representing excellent health and 5 poor health. Respondent's current smoking (TOBAC) and alcohol consumption status (ALCH) are the two risky health behaviors analyzed.

"Do you smoke cigarettes now?"; and "Do you ever drink any alcoholic beverages such as beer, wine or liquor?"

Following similar prior CV studies, other socioeconomic covariates are included such as age (AGE), marital status (MARITAL), gender (FEMALE), total annual household income

[1] The lifetime diagnosis question of *"have you ever…?"* of these chronic illnesses is used. While not available in the HRS data, the current diagnosis *"do you currently…"*of the chronic illnesses would be preferable given that health status of some respondents previously diagnosed with illnesses may have improved with consistent usage of prescribed treatments and drugs.

(INCM)[2] and highest education degree attained (EDUC). Age is centered at the lowest observed age (i.e, at 55, age = 0) therefore the effect of a 1-unit change in age on WTP can be analyzed. Educational attainment is measured in years, ranging from 0 to 17. To aid interpretation, educational attainment is also centered at the mean. According to economic theory, it is expected that willingness to pay will increase with higher income and higher educational attainment. .

2.5 Descriptive Statistics and Models

2.5.1 Descriptive Statistics

Four different individual monthly WTP measures are provided. The first two corresponds to the actual OE WTP responses while the last two corresponds to the calculation WTP derived from a combination of both OE and DB-DC responses. The four models are untrimmed WTP from open-ended questions (WTP_{OE}), trimmed WTP from OE questions ($WTP_{TRIM-OE}$), calculated WTP from both OE and DB-DC responses (WTP_{DCOE}), and trimmed calculated WTP from both OE and DB-DC responses ($WTP_{TRIM-DCOE}$).

Tables 2.2 and 2.3 present descriptive statistics for the total sample, minorities and non-Hispanic Whites. Both tables present conventional statistics based on a normal distribution. The number of observations, conventional mean responses and standard deviations are reported. Comparing minorities to their non-Hispanic White counterparts, mean WTP_{OE} is $15,093 and $5,340 for minorities and non-Hispanic Whites respectively. However, after

[2] Income includes before-tax income from earnings, unemployment, Social Security and public benefits, retirement income, interests and dividends, child support and income from other sources, with exception of non-cash benefits (e.g., food stamps).

trimming WTP_{OE} to an upper limit of five percent of annual household income, mean $WTP_{TRIM-OE}$ is $132 for minorities and $517 for non-Hispanic Whites. On the other hand, mean WTP_{DCOE} is $9,366 and $3,407 for minorities and non-Hispanic Whites, respectively but $340 and $608 for $WTP_{TRIM-DCOE}$. The large differences between the trimmed and untrimmed responses for minorities compared to the differences for the Whites indicates that the large individual bids or outliers are more likely to be from the minorities in the sample.

Table 2.3 shows that self-rated health rank, income and educational attainment for minorities are significantly lower than their White counterparts. With the exception of high blood pressure and diabetes, a higher percentage of the non-Hispanic White sample have been diagnosed with cancer, lung disease, heart disease and stroke compared to the minority grouping. Fifty four percent of the non-Hispanic sample reported current alcohol consumption compared to 36% of minorities. Average income for minorities is $38,760 while average income for Whites is $68,489. Whites reported higher self-rated health status, 3.43 compared to 2.80 for minorities. Further test of means reveal significant racial and ethnic differences in self-rated health status and income between minorities and Whites. These observed and significant differences in both health and behavioral variables between the two groups may influence each group's demand for health risk mitigation.

2.5.2 Econometric Models

An initial virtual inspection of maximum WTP values revealed highly skewed WTP responses. Since highly skewed values tend to produce heteroskedastic effects, natural log

of WTP is used to achieve a more uniform spread. The Breusch-Pagan test was used to test for additional heteroskedaticity effects. Comparing against the critical χ-squared value showed that taking the natural log of WTP did not completely eliminate the heteroskedastic effect. The natural log of WTP and heteroskedastic-consistent robust standard errors were therefore used for all estimations.

WTP values are only observed if the respondent provided a positive response to the initial selection question. As a result, unobserved characteristics or qualities may exist and cause individuals to self-select into either the positive or zero WTP groups. With this, possible sample selection bias may arise (Heckman 1979). When this happens, statistical analysis based on this non-randomly selected sample may lead to wrong conclusions. The Heckman technique therefore helps to correct for possible non-randomization in the sampling process. The Heckman two-step estimation consists of a selection (or participation equation) and an outcome equation. The selection equation uses the WTP data from the initial binary selection question while the continuous WTP data is used for the outcome equation.

$$\textbf{\textit{Selection equation:}} \quad y_t{}^* = f(\propto^{H^j} X^{H^j}, \propto^{H^k} X^{H^k}, \propto^{SE} X^{SE}) + \epsilon_t \qquad 7.$$

$$y_t = 1 \; if y_t{}^* > 0; \; y_t = 0 \; if y_t{}^* \leq 0$$

$$\textbf{\textit{Outcome equation:}} \quad \ln WTP = f(\beta^{H^j} X^{H^j}, \beta^{H^k} X^{H^k}, \beta^{SE} X^{SE}) + u_t \qquad 8.$$

y_t^* in *(7)* represents whether or not the respondent provided a positive response to the first WTP question. $y_t = 1$ with positive WTP; and 0 otherwise. For values of $y_t = 1$, estimating *(7)* gives a set of $\propto$ coefficents. ϵ_t is assumed to be normally distributed with mean 0 and standard deviation σ. The outcome equation estimates the WTP equation, conditional on being observed. WTP is a continuous variable in the outcome equation. Estimating *(8)* gives a set of β coefficients, corresponding to health status, risky health behaviors and other socioeconomic variables. u_t is assumed to be normally distributed with mean 0 and standard deviation σ. The error terms, ϵ_t and u_i are assumed to have a correlation of ρ. The selection bias results if $\rho \neq 0$, implying that applying standard regression techniques to the outcome equation would yield biased results.

2.6 Results

2.6.1 Race/Ethnicity and WTP

χ-squared values for Wald test results on the data in Table 2.4 provide evidence of selection bias due to sample selection on the initial selection question (i.e., whether $WTP_{4HEALTH}>0$). This implies that applying standard regression techniques would not be appropriate. Thus, four specifications of the Heckman two-step model (each with both selection and outcome equation results) are presented in Table 2.4 (Models 1-4). All four specifications have the same selection equation but differ in outcome equations, in terms of the WTP dependent variable used. In addition to the independent variables in the outcome equation, a well-identified Heckman selection model should contain at least one independent variable not in the outcome equation (StataCorp 2009). This identifying

variable usually significantly affects selection but not the outcome (Heckman 1979). In a variety of separate preliminary models, the estimated coefficient on the respondent's self-rated health rank (SRHEALTH) was significant on selection (i.e,$WTP_{4HEALTH}>0$), but never significant in the outcome models. This variable is used as the identifying variable in the Heckman selection models, and its estimated coefficient is shown to be positive and significant across all models. In the selection equations, the probability of having a positive WTP amount is expressed as a function of self-rated health rank, racial and ethnic grouping, health status, risky health behavioral status and other socioeconomic covariates. The outcome equation in Model 1 examines the effect of health status and risky health behaviors on WTP_{OE}. Model 2 includes all the same explanatory terms used in Model 1 but with $WTP_{TRIM-OE}$ as the dependent variable. WTP_{DCOE} and $WTP_{TRIM-DCOE}$ are used in Models 3 and 4 respectively.

Across all specifications of the Heckman model, evidence reveals that Hispanics, Blacks, American Indian and Asian groups, collectively, are more likely to have a positive WTP than their non-Hispanic White counterparts. Specifically, minorities are 26% - 30% more likely to have a positive WTP for improved health, compared to non-Hispanic Whites. However, results from the outcome equations indicate that WTP responses for minorities are significantly lower when compared to WTP for Whites. In Model 1, WTP_{OE} for the specified minority groups, collectively, is 77% lower than that of their non-Hispanic White counterparts, 97% lower using $WTP_{TRIM-OE}$ in Model 2, 70% lower using WTP_{DCOE} in Model 3, and 89% lower using $WTP_{TRIM-DCOE}$ in Model 4.

In Table 2.5, we present mean and median WTP for both minorities and Whites. It should be noted that that conventional mean WTP observations and calculations reported

in Table 2.2 could be biased because they are based on a normal distribution assumption. Separate analysis of the initial WTP responses from the sample respondents reveal a log-normal distribution hence the mean, median and confidence intervals should not be calculated conventionally. Mean and median estimates of WTP for the overall sample are therefore calculated using the maximum likelihood method

$$Mean = \exp(\mu + \sigma^2/2) \quad (9)$$

$$Median = \exp(\mu) \quad (10)$$

where μ and σ^2 are the mean and variance of the distribution of logarithms of the lognormal WTP distribution respectively (Land 1972). As shown in Table 2.5, average monthly WTP for minorities is significantly lower than for non-Hispanic Whites with both the trimmed open-ended WTP and trimmed calculated WTP. The trimmed models are preferred to the untrimmed models because they not only control for WTP outliers not consistent with income levels but also have reasonable confidence intervals for the estimated WTPs. From the trimmed open-ended WTP, the average monthly WTP for minorities and whites is $259 and $476 respectively. Similarly, from the trimmed calculated WTP, average monthly WTP for minorities and Whites is $742 and $772, respectively. These WTP estimates reflects the average monthly amount each group is willing to pay for improved health, with reasonable confidence interval ranges. While clearly lower in absolute terms, we caution that this may not signify minorities' lower valuation of improved health as estimated annual WTP for minorities constitutes a higher percentage of annual household income, compared

to Whites. In terms of relative WTP, the average annual WTP from the trimmed calculated WTP for minorities constitutes 23% of their annual household income as compared to 14% for non-Hispanic Whites. Median WTPs are also reported in Table 2.5. Significant difference in WTP are also observed with the monthly median WTP. Monthly median WTP for minorities is $55 and $79 for both trimmed WTPs while monthly median WTP for Whites is $158 and $200 respectively.

Ninety-five percent confidence intervals for the respective monthly mean WTP estimates are reported in Table 2.5. Confidence intervals for mean WTP estimates should also not be calculated using standard estimation techniques due to its log-normality. Thus, the widely used Cox method for estimating confidence intervals for log-normal means is used (Parkin, Chester, and Robinson 1990; Land 1972). The Cox method is based on estimating a confidence interval about the mean of the log-normal distribution using the first two moments of the sample mean and variance of the log transformed WTP distribution and then exponentiating the results (Land 1972).

2.6.2 Health, Health-related behavior and WTP

The results from Models 1-4 in Table 2.4 also allow evaluation of the hypotheses of the influence of health status and risky health behaviors on WTP, as presented in Table 2.1. Starting with the set of hypotheses on *j* health status categories as stated in Table 2.1, evidence across all four outcome indicates no effect of health status on WTP outcomes. In particular, a diagnosis of any of the chronic health illnesses does not significantly affect the amount of dollars the aging population is willing to pay for improved health. However, evidence does not support the null hypothesis as health status is found to be a significant

predictor on WTP across all selection equations. Individuals diagnosed with cancer are 35% more likely to have a positive WTP in the selection equations in Models 1- 3, and 37% more likely in Model 4. These estimated coefficients are highly significant at the five percent level. Similarly, individuals diagnosed with lung diseases are 66% more likely to have a positive WTP in the selection equation in Model 1, 58% more likely in the selection equation in Model 2, 73% more likely in the selection equation in Model 3 and 56% more likely in the selection equation in Model 4.

Turning to the set of hypotheses on risky health behaviors as stated in Table 2.4, evidence across all outcome equations also support the null hypotheses of no effect of risky health behaviors on WTP outcomes. Both risky health behaviors assessed had no significant effect on WTP across all selection and outcome equations. In other words, tobacco use or alcohol consumption does not affect whether an older adult would have a positive WTP (from the selection equations), neither does it affect the amount of dollars they are willing to pay (from the outcome equations) for improved health.

Self-rated health status is however found to be significantly related to whether or not the individual will have a positive valuation for improved health. Lower self-rated health status increases the probability of the individual having a positive WTP. In addition, the higher the level of education attained, the higher the amount of money the aging would be willing to pay for improved health, as reflected in the outcome models. Specifically, an extra year of education is attributed to a 23% - 36% increase in WTP.

This result suggests that perhaps older adults value health interventions focused on reducing morbidity and attendant mortality from cancer and lung disease, than the other diagnosed chronic illnesses. A possible reason for this could be the perceived

controllability and degree of dread associated with cancer and lung diseases. While chronic illnesses such as high blood pressure can be maintained by regular visits to the physician, regular usage of prescribed medications and increased rest; the same cannot be said for a diagnosis of cancer. The lower the perceived controllability an individual has over a specific illness, the more willing he will be to pay a positive amount for interventions related to such illness.

2.6.3 WTP and Income

As expected, the estimated coefficients of annual household income exhibit a positive and significant relationship with WTP for improved health. This positive relationship holds in both selection and outcome equations across all models. For further analyses, we examine if the observed results are similar across all income levels. However, because of the highly skewed WTP responses, median WTP across income levels are estimated rather than average WTP. The reported household income are categorized as low income (< $25,000), middle income ($25,000 - $65,000) and high income (> $65,000). Median absolute and relative WTP are then calculated for both minorities and Whites in each income category, using the trimmed calculated open-ended WTP. Results are presented in Table 2.6.

Results suggest the existence of racial and ethnic disparities in willingness to pay for improved health. Specifically, results indicate that monthly median WTP for minorities across all income categories is significantly lower that for non-Hispanic Whites. Monthly median WTP for minorities in the low income range is $74 compared to $112 for Whites in the same category. As earlier observed, this WTP though lower in absolute terms, when

converted to annual values, constitute a higher percentage of annual household income for minorities (10.2% and 8.8% of annual household income for minorities and Whites respectively).

Similar results in absolute median WTP are found with the middle and high income categories. For both categories, monthly median WTP for minorities is lower than for non-Hispanic Whites. However, when converted to annual values, they constitute a lower percentage of annual household income for minorities compared to non-Hispanic Whites. For the middle income category, monthly median WTP is $65 (1.9% of income with estimated annual values) for minorities and $194 (5.5% of income with estimated annual values) for Whites. Similarly, for the high income category, monthly median WTP for minorities and Whites is $222 (1.96% of income with estimated annual values) and $350 (2.7% of income with estimated annual values) respectively.

2.6.4 Sensitivity Analysis

Individual model specifications for separate sub-samples of minorities and non-Hispanic whites were also explored. However the Heckman specification did not converge for the minorities' sub-sample. This could likely be due to the relatively small sub-sample of minorities compared to non-Hispanics whites. Minorities make up 22 percent of the sample. Further, to test robustness of the results in Table 2.5, both trimmed model specifications are re-estimated with monthly WTP responses trimmed to two-percent of reported annual household income. From these additional estimations, previous magnitude and significance for estimates remain largely unchanged.

2.7 Conclusion

This chapter uses contingent valuation data from the RAND HRS, a survey focused on older Americans, to analyze racial and ethnic disparities in WTP responses for improved health. Specifically, we examine how the individual's' demand for morbidity reduction varies with the individual's racial/ethnic group, health status and risky health behaviors. Responses to an initial question in the valuation module of the survey show the presence of selection bias, therefore the Heckman econometric estimation approach is used to control for selection bias. Researchers using the HRS survey may ignore possible selection effects and estimate DB-DC models on only the much smaller DB-DC portion of the data. However given the unique layered elicitation format design in the HRS survey, such an approach leaves out much of the available data, ignores selection bias and runs into possible concerns or limitations of the DB-DC approach. This chapter contributes a pragmatic alternative approach to account for the selection bias and more fully utilize available HRS data. Within that approach, evidence from comparing the mean and median WTP estimates from trimmed and untrimmed models also confirms that OE WTP responses are influenced by large individual bids. Therefore trimming WTP to a maximum of five percent of household income in select models helped control for such effects.

Results suggest that the assumption of a single VSL for everyone may be inaccurate. Even though the use of single VSL for everyone may be guided by political concerns, economically, this chapter reveals heterogeneity in WTP. Evidence across all Heckman specifications indicates that although minorities are more likely to have a positive WTP than non-Hispanic Whites, the amount of dollars they are willing to pay in absolute terms for improved health is lower. However in relative terms, mean WTP for

minorities is a higher percentage of their annual household income compared to non-Hispanic Whites. Further analyses however reveal that this only holds for the lower income group as median WTP for minorities in middle and high-income categories is lower that of Whites in the same categories, both in absolute and relative terms. In addition, we find that WTP for an older individual is not influenced by the health-related behaviors assessed. Specifically, alcohol and tobacco consumption do not affect the probability of the individual having a positive WTP or the specific WTP valuation. . Health status (a previous or current diagnosis of cancer and lung diseases) does affect whether or not an individual will have a positive WTP but not the specific dollar amount. This suggests that perhaps although older adults place a higher value on cancer and lung diseases than other chronic health conditions due to their higher degree of dread and lower perceived controllability. Health interventions or medical treatment to reduce morbidity and mortality from these chronic health illnesses are therefore the most valued.

Finally, while advocating for exploring the heterogeneity in WTP, Viscusi correctly notes that there is substantial reluctance in analyzing the existence of racial and ethnic disparities in WTP valuations as it would also require fully exploring possible economic and social mechanisms contributing to such disparities, if any (Viscusi 2010). For example, if historical or current discrimination has contributed (with possible intra-generational transmission effects) to lower education and income then one might expect lower absolute WTP. As evident in this analysis, the lower observed WTP estimates for minorities compared to non-Hispanic whites should not portray that minorities value improved health less than their non-Hispanic Whites counterparts do. While results demonstrate that willingness to pay for improved health varies systematically and significantly by disease

type, the same cannot be said for racial and ethnic groups as effects could depend on income categories and possibly the choice of either relative or absolute effects.

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Table 2.1 Hypotheses

Category j hypotheses – Health Status		
Category j	Null hypothesis (H_o)	Alternative hypothesis (H_1)
High blood pressure	$\beta^{HBP} = 0$	$\beta^{HBP} > 0$
Diabetes	$\beta^{DIAB} = 0$	$\beta^{DIAB} > 0$
Cancer	$\beta^{CANCER} = 0$	$\beta^{CANCER} > 0$
Lung disease	$\beta^{LUNG} = 0$	$\beta^{LUNG} > 0$
Heart conditions	$\beta^{HEART} = 0$	$\beta^{HEART} > 0$
Stroke	$\beta^{STROKE} = 0$	$\beta^{STROKE} > 0$
Category k hypotheses – Risky health behaviors		
Category k	Null hypothesis (H_o)	Alternative hypothesis (H_1)
Tobacco	$\beta^{TOBAC} = 0$	$\beta^{TOBC} > 0$
Alcohol	$\beta^{ALCH} = 0$	$\beta^{ALCH} > 0$

Table 2.2 Summary Statistics - Dependent Variables (Absolute WTP)

Variable	Description	Total Sample Mean (St. dev)	Minorities Mean (St. dev)	Whites Mean (St. dev)
$WTP_{4HEALTH}>0$	Whether or not a respondent's WTP is positive (Selection question: 1=Yes, 0 otherwise)	0.62 (0.49) [n=877]	0.67 (0.47) [n=189]	0.61 (0.49) [n=688]
WTP_{OE}	Non-trimmed open-ended (OE) monthly WTP values ($)	7673.74 (84334.16) [n = 280]	15093.40 (122149.20) [n = 67]	5339.86 (68498.75) [n = 213]
$WTP_{TRIM-OE}$	Trimmed monthly OE WTP values ($)	424.51 (1170.46) [n = 280]	131.90 (170.74) [n = 67]	516.56 (1326.01) [n = 213]
WTP_{DCOE}	Calculated monthly WTP from both OE and dichotomous choice responses ($)	4772.93 (62778.69) [n = 506]	9366.47 (92790.99) [n = 116]	3406.65 (50624.46) [n = 390]
$WTP_{TRIM-DCOE}$	Trimmed calculated WTP from both OE and dichotomous choice responses ($)	546.94 (1137.97) [n = 506]	340.27 (761.37) [n = 116]	608.41 (1221.98) [n = 390]

Source: RAND HRS data (Wave 5). n = sample size

Table 2.3 Summary Statistics - Explanatory Variables

Variable	Description	Total Sample Mean (St.dev)	Minorities Mean (St.dev)	Whites Mean (St.dev)
Health Status (1 = Yes; 0 otherwise)				
HBP	Whether the respondent was ever diagnosed with high blood pressure	0.45 (0.50)	0.54 (0.50)	0.43* (0.50)
DIAB	Whether the respondent was ever diagnosed with diabetes	0.13 (0.33)	0.23 (0.42)	0.10* (0.30)
CANCER	Whether the respondent was ever diagnosed with cancer	0.12 (0.32)	0.10 (0.29)	0.12 (0.33)
LUNG	Whether the respondent was ever diagnosed with lung diseases	0.07 (0.25)	0.04 (0.20)	0.08* (0.27)
HEART	Whether the respondent was ever diagnosed with any heart condition	0.19 (0.39)	0.17 (0.38)	0.19 (0.40)
STROKE	Whether the respondent was ever diagnosed with stroke	0.04 (0.21)	0.03 (0.18)	0.05 (0.21)
Risky health behaviors(1 = Yes; 0 otherwise)				
ALCH	Whether the respondent ever drinks any alcohol	0.50 (0.50)	0.36 (0.48)	0.54* (0.50)
TOBAC	Whether the respondent smokes now	0.15 (0.36)	0.20 (0.40)	0.14 (0.35)
Other covariates				
MINRACE	Proportion of minority races (Hispanics, African-Americans, American Indian, Asian; %)	0.22 (0.41)	- -	- -
SRHEALTH	Respondent's self-rated health rank(1=poor,…, 5=excellent)	2.70 (1.10)	2.80 (1.10)	3.43* (1.06)
INCM	Annual household income (/$1,000)	62.08 (194.42)	38.76 (50.36)	68.49* (217.52)
EDUC	Respondent's highest education degree level attained 1=no degree, 2= GED and high school, and	2.47 (1.88)	1.70 (1.84)	2.68* (1.84)

AGE	Respondent's age (in years)	65.55 (10.61)	64.05 (10.32)	65.96* (10.66)
FEMALE	Proportion of females (%)	0.64 (0.48)	0.61 (0.49)	0.65 (0.48)
MARITAL	Proportion of married respondents (%)	0.69 (0.46)	0.60 (0.49)	0.71 (0.45)

N = 877: Minorities n = 189, Non-Hispanic Whites n = 688. T-test for Minorities vs. Whites Means conducted where * represents significance at 10 percent level. Two observations dropped due to missing variables. Source: RAND HRS data.

Table 2.4 Heckman Selection and WTP Estimations

	(1)		(2)		(3)		(4)	
OUTCOME EQUATION	WTP_{OE}	SE	$WTP_{TRIM-OE}$	SE	WTP_{DCOE}	SE	$WTP_{TRIM-DCOE}$	SE
MINRACE	-0.772**	0.323	-0.967***	0.289	-0.703**	0.292	-0.885***	0.262
HBP	0.033	0.229	-0.031	0.221	0.307	0.204	0.234	0.191
DIAB	-0.174	0.312	-0.023	0.292	-0.117	0.291	-0.021	0.274
CANCER	-0.063	0.331	-0.136	0.312	-0.107	0.301	-0.087	0.283
LUNG	1.073	0.660	-0.023	0.445	0.030	0.469	-0.634*	0.351
HEART	0.170	0.282	-0.132	0.268	0.303	0.255	0.154	0.231
STROKE	-0.613	0.435	-0.932*	0.561	-0.500	0.517	-0.734	0.486
TOBAC	-0.259	0.293	-0.064	0.291	-0.067	0.278	-0.022	0.263
ALCH	0.326	0.218	0.327	0.214	0.089	0.199	0.152	0.190
INCM	0.001***	0.000	0.001**	0.000	0.001**	0.000	0.001**	0.000
EDUC	0.284*	0.170	0.229	0.163	0.364**	0.150	0.356**	0.143
SELECTION EQUATION								
MINORITY	0.278*	0.146	0.297**	0.139	0.255**	0.122	0.284**	0.117
SRHEALTH	-0.137**	0.055	-0.108**	0.050	-0.090**	0.041	-0.052**	0.034
HBP	-0.138	0.110	-0.123	0.108	-0.029	0.091	-0.025	0.088
DIABETES	-0.069	0.156	-0.080	0.151	-0.172	0.136	-0.154	0.130
CANCER	0.350**	0.169	0.347**	0.164	0.349**	0.143	0.369***	0.140
LUNG	0.662**	0.330	0.584**	0.247	0.727***	0.255	0.559***	0.180
HEART	0.035	0.144	0.026	0.137	0.006	0.122	-0.011	0.113
STROKE	0.085	0.267	0.166	0.271	0.324	0.240	0.348	0.225
TOBAC	0.076	0.157	0.080	0.155	0.174	0.132	0.185	0.128
ALCH	0.032	0.110	0.021	0.108	-0.037	0.092	-0.051	0.090
INCM	0.001	0.001	0.002**	0.001	0.001	0.001	0.001**	0.001
EDUC	0.066	0.086	0.057	0.084	0.026	0.071	0.021	0.068
Wald test($\rho = 0$)	18.37		71.70		79.76		109.75	
Mean WTP	$679.97		$455.87		$1394.16		$812.41	

95%CI for Mean WTP	$485.03-$953.26	$341.71-$608.17	$1033.41-$1880.84	$630.20-$1047.29
Median WTP	$137.00	$122.73	$192.48	$160.77
N	612	612	838	838

AGE, MARITAL, FEMALE are included in the Heckman estimations for all models but not reported in this table.
Source: RAND HRS data . Significance level: * p< 0.10, ** p< 0.05, *** p< .01.

Table 2.5 Estimated Average WTP

WTP	Description	Minority	White
WTP_{OE}	Open-ended WTP		
	Mean	$662.72 (20.5%)	628.56 (11.0%)
	95% Confidence Intervals	$260.69 - $1684.75	$454.29 - $869.69
	Median	$65.50	$174.17
$WTP_{TRIM-OE}$	Trimmed Open-ended WTP		
	Mean	$258.88 (1.2%)	$475.77 (1.1%)
	95% Confidence Intervals	$131.53 - $501.71	$356.28 – 635.34
	Median	$54.65	$157.64
WTP_{DCOE}	Calculated WTP		
	Mean	$2601.92 (80.6%)	$1121.89 (19.7%)
	95% Confidence Intervals	$1022.92 - $6622.40	$844.98 - $1489.55
	Median	$108.64	$230.61
$WTP_{TRIM-DCOE}$	Trimmed Calculated WTP		
	Mean	$742.09 (23.0%)	$771.00 (13.5%)
	95% Confidence Intervals	$372.19 - $1479.61	$600.69 - $989.60
	Median	$79.37	$200.16

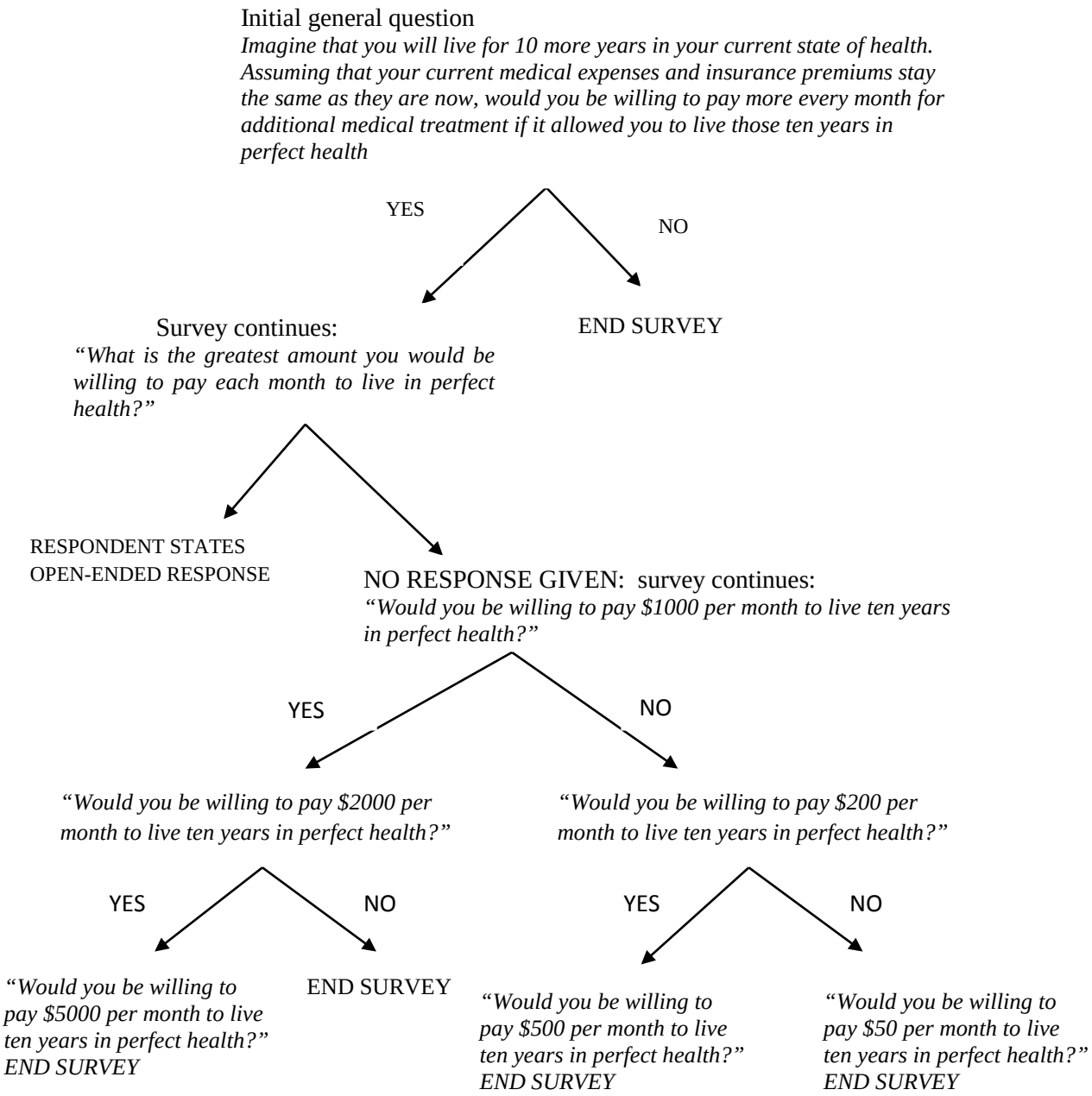
Note: Average WTP are calculated using the maximum likelihood method. Average WTP in annual terms estimated as a proportion of household income are reported in parenthesis. Source: RAND HRS data

Table 2.6 Median WTP by Income categories

WTP	Minority	White
Low income (< $25,000)	$73.73	$111.93
	(10.22%)	(8.80%)
Middle income ($25,000 - $65,000)	$65.16	$194.27
	(1.90%)	(5.49%)
High income (>$65,000)	$222.41	$350.46
	(1.96%)	(2.65%)

Note: Estimates are from the trimmed calculated WTP ($WTP_{TRIM\text{-}DCOE}$). Median WTP are calculated using the maximum likelihood method. Median WTP in annual terms estimated as a proportion of household income are reported in parenthesis. Source: RAND HRS data

Figure 2. 1 WTP Valuation Format



Chapter 3: Ethno-Racial Disparities in Functional Health Trajectories among Older Adults: The Influence of Health and Health-related Behaviors

3.1 Introduction

As the US population ages rapidly, improving the health of the older population becomes an unavoidable necessity especially when most morbidity and associated medical costs are incurred in the older years (Fries 1980). Understanding disparities in the health of the older population is crucial in finding efficient measures to reduce morbidity. Considerable evidence demonstrates the existence of health disparities among older adults in the United States (CDC 2013; Williams and Sternthal 2010). These health disparities also persist through the entire life cycle.

Health changes due to aging and morbidity may be accompanied or reflected by declines in functional health status. Data trends estimate that 47.5 million elderly over 65 years of age reported having disabilities in 2005, an increase from 34.1 million in 1996, (DHHS 2000). Functional limitations and disability also create individual, family and societal burden due to reduced independence, decreased quality of life, reduced market productivity, increased demand for public assistance and increased health care costs (CDC 2013; Ostermann and Sloan 2001). This increase in disabilities among older adults has necessitated more health-promoting programs and interventions. One of the goals of the U.S. Department of Health and Human Services (DHHS) is to promote the health of people with disabilities through both accessible health and wellness programs and with assistive devices and technology (DHHS 2000). Such initiatives are usually implemented at the local

level. For example, *Texercise* is an example of a program implemented by the Texas Department of Aging and Disability Services (DADS) to educate and encourage older Texans on healthy lifestyle habits, such as proper nutrition and regular physical activity. Such programs are expected to support and promote functional health and improve overall well-being of older adults.

Functional health among older adults has been measured in various ways over the years. The most popular measures are the Katz activities of daily living (ADL) and Lawton's Instrumental ADL (IADL) (Katz et al. 1963; Lawton and Brody 1969). ADLs are basic everyday tasks that are required for independent living and self-care. They include daily activities such as bathing or showering, eating, dressing and undressing, toileting, getting in and out of bed or chairs and getting around inside the house. The original purpose of selecting these activities as measures of functional ability was to differentiate physical functioning abilities among recuperating and rehabilitation patients (Wiener et al. 1990). In addition, ADLs are increasingly being used in various fields to measure disability because they are very specific and reliably measure individual behaviors. Problems performing ADLs are more prevalent and increase among older adults over time. They reduce an individual's capacity for living independently and as a result, assistance is usually required either from other human beings and/or mechanical devices. Private and public long-term care insurance programs often use ADL measures to determine an individual's eligibility for benefits (Wiener et al. 1990). Inability to perform ADLs also influence nursing home admission decisions (Gaugler et al. 2007).

Another useful and extended measure of functional limitations are the IADLs. These measures were developed to supplement in-home activities with assessment of

useful activities required for independent living out in the community, such as doing light housework, going outside the home, shopping for groceries or clothes, preparing meals, using the telephone, managing money and taking medications (Brault 2010). IADLs help older adults to continue dwelling in a community setting (Verbrugge and Jette 1994). Difficulties in both ADLs and IADLs can either be measured by accessing level of difficulty in performing each activity, duration of the disability or type of helpful human or mechanical assistance used to alleviate performance problems.

This paper seeks to contribute to research on health of the older population by analyzing racial and ethnic disparities in functional health trajectories using a latent growth model. Better understanding of the factors contributing to functional limitations among older individuals is important for delaying the onset, minimizing or preventing such limitations. Using longitudinal data from the Health and Retirement Study (HRS), this chapter presents quantitative evidence and insights about the trend in functional status among America's increasing population of older adults. The best measures of functional ability should reflect functional difficulties while minimizing the influence of social and environmental factors (Haas 2008). However, most current measures of functional difficulties may not be completely independent of the influence of the environment or the use of assistive technology. Rather than the frequently used ADLs and IADLs adopted in previous studies on functional status, this chapter uses a count of self-reported mobility functional limitations that assess upper and lower body mobility and strength. Second, racial and ethnic disparities in the onset and rate of change in functional limitations are explored. In addition, this chapter also examines whether any observable disparities are

attributable to racial or ethnic differences in health and health-related risk factors. The specific research questions this chapter seeks to answer are:

- Do Blacks and/or Hispanics experience more functional limitations both at onset and over time, compared to non-Hispanic Whites?
- If disparities in trajectories are observed, do these disparities result from differences in risk factors such as health status and health-related behaviors?

3.2 Aging and Health Trends

3.2.1 Aging Trend

In the United States, longer life spans than in previous decades and aging baby boomers has resulted in a rapid growth in the number of older adults. The CDC predicts that the number of older adults above 65 years will increase from 40.3 million to 89 million by 2050 (CDC 2013). Life expectancy has also increased significantly. According to the US Census Bureau, a child born today can expect to live 79 years and life expectancy by 2060 is projected to be 85 years (Census Bureau 2014). This shift towards an older population has increased the need for maintaining the independence and successful aging of the older population. This concern has also become a national public health priority as over 66% of the country's health care budget is incurred by this age group (CDC 2013).

As the proportion of the older adults is projected to increase rapidly, so is racial and ethnic diversity. The CDC projects the proportion of Hispanics and Blacks will increase to 20% and 11% of the total country's population by 2050 respectively. This is a rapid increase from 2010 data trends of 7% for Hispanics and 8.3% for Blacks. Similarly the

proportion of non-Hispanic Whites is expected to fall by more than 20%. Racial and ethnic groups also continue to differ in age-related metrics such as life expectancy and disease prevalence. Life expectancy for Whites today is 79 years compared to 76 years for Blacks and 81 years for Hispanics. Life expectancy projections for 2060 is 85 years for Whites, 83 years for Blacks and 86 years for Hispanics (Census Bureau 2014). Thus, understanding ethno-racial differences in demographic and health trend is needed before effective and necessary aging health-related policies can be developed.

3.2.2 Health and Functional Health Trend

Health changes and well-being issues due to the aging process, such as memory loss, visual changes, hearing impairment and chronic illnesses, may be accompanied or reflected by declines in functional status. As of 2010, approximately 16% of non-institutionalized elders needed assistance from another person to perform one or more ADLs or IADLs (Brault 2010). Prior research has also documented racial and ethnic disparities in other health outcomes and mortality rates especially among older adults (CDC 2013; Williams and Sternthal 2010). Compared with non-Hispanic Whites, Blacks and Hispanics have higher incidence of chronic health conditions, higher mortality rates and a lower self-assessment of health status (Williams 2005). Significant racial and ethnic differences in the various measures of functional health status have also been documented (Kington and Smith 1997; Cho et al. 2004; Himes 2000). For example, using the Health and Retirement Study, Kingston and Smith (1997) found that Blacks and Hispanics reported higher incidence of functional health problems than non-Hispanic Whites. Thus, indicating that longer life expectancy does not necessarily indicate better quality of life, especially for

Hispanics. Both minority groups are also more likely to report disabilities and have higher disabilities prevalence rates (Dunlop et al. 2007). In particular, preventing or postponing the onset of functional limitations is crucial as older adults want to maintain independence and stay in their community as long as possible. This is also synonymous with the "successful aging" concept by the MacArthur Foundation Research Network. Successful aging goes beyond increased longevity, it also involves increasing the number of healthy and active life without disabilities (Rowe and Kahn 1997).

Health trajectories over an individual's lifespan are based on an integrated continuum of exposures, experiences and interactions (Fine and Kotelchuck 2010). Differentials in functional health have historically been explained theoretically using early life programming theory, critical period theory and the cumulative impact theory (Fine and Kotelchuck 2010; Haas 2008). The early life programming model posits that health problems or vulnerability to health conditions in later life can be attributed to early life experiences, such as exposure in utero and mother's health prior to conception. Detrimental early experiences however may not manifest in disease pathologies until later in life (Haas 2008). Barker (2004) proposed the 'fatal origin hypothesis' version of the early life model proposing that adult health problems and chronic diseases could also be attributed to under-nutrition during prenatal days and infancy. On the other hand, the cumulative impact model suggests that the lifetime accumulation of deleterious experiences overtime significantly impact an individual's health and increases risk of health problems. Understanding trends and possible risk factors in trajectory of functional limitations may offer insight and help plan for effective health interventions to ensure successful aging.

Common explanations for ethno-racial health disparities have often included genetic, socioeconomic and behavioral factors (Nazroo 1998). Recent research however reveals the flaws with the genetic arguments as evidence has demonstrated that genetic variation is greater within racial groupings than between racial/ethnic groupings (Williams 1999; Bradby 1995). Other dominant pre-disposing risk factors are demographic, socioeconomic, behavioral, psychological and environmental (Brown, O'Rand, and Adkins 2012; Verbrugge and Jette 1994). Better knowledge of health determinants will help achieve substantial improvement in health of the older population. Williams (2005) also suggested that further research on racial differences in health should focus on factors characteristic of each racial group.

In this chapter, racial and ethnic differences in the development of functional limitations, and in its rate of change over time are examined. In addition, this chapter also analyzes whether observable disparities in functional status can be attributed to health status and health-related lifestyle factors characteristic of each racial and ethnic group. The compression of mobility hypothesis predicts that health-promoting lifestyles may reduce cumulative lifetime disability by postponing the onset of functional limitations and mortality until near the end of life (Fries 2000). The linkage between health-related behavioral factors and functional status among older adults is subtle. Regular physical activity (irrespective of the level), even when begun later in life, has been found to be beneficial in delaying the onset of functional problems, prolongation of a disability-free life and reducing the risk of decline in physical functioning (Berk, Hubert, and Fries 2006; He and Baker 2004; Wang et al. 2002; Clark 1996). However, differing opinions exist regarding the linkage between smoking, alcohol consumption and functional limitations.

While some studies show that smoking increases the odds of having functional limitations and predicts the onset of disability (LaCroix et al. 1993; Ostermann and Sloan 2001), others find that current smoking predicts lower levels of disability (Kelley-Moore and Ferraro 2004). Heavy drinking has also been associated with a greater prevalence of disability (Ostermann and Sloan 2001) while non-drinkers and excessive drinkers have been found to have a high risk of developing functional limitations, compared to moderate drinkers (LaCroix et al. 1993). This chapter also examines the effects of health-related risk factors on ethno-racial disparities in functional health trajectories.

3.3 Theoretical Framework

This chapter applies a standard health economics model developed by Grossman (1972) using a functional limitations framework. The Grossman health production function assumes health outcomes or outputs in period t, H_t is dependent on stock of health in the previous period, H_{t-1}, genetic endowment (G_o), health-related behaviors (HB), market health inputs such as medical services and medications (M), and socio-demographic factors such as the individual's educational level (S).

$$H_t = f(H_{t-1}, G_o, M, HB, S) \quad (1)$$

Individuals are endowed with an initial stock of health capital which depreciates over time, with varying depreciation rates for each individual in various age groups. The model assumes that the health of the aging population will depreciate rapidly at an increasing rate

and as a result, older adults will have a higher demand for healthcare as compared to the younger population. It can however be replenished, maintained or improved by health investments such as health care and good behavioral habits (Grossman 1972; Kington and Smith 1997). M includes the demand for medical services and/or the use of medical technology and facilities. HB on the other hand involves practicing health promoting behaviors such as regular participation in physical activity, good nutritional habits and cessation of risky health behaviors (such as smoking and heavy alcohol consumption). Socio-demographic indicators include race/ethnicity, educational level and per capita income.

In a disability or functional status framework, H_t could be measured by the number of functional limitations (FL) reported in any given time period (in a one-period functional status model) and over time (in a trajectory modeling framework).

$$FL = f(H_{t-1,}, G_o, M, HB, S) \tag{2}$$

Unlike a usual health production function where outputs increase as more inputs are added, FL in (2) decreases or remains constant as the quantities of inputs added increases. The increasing rate of health depreciation among the older population reflects the importance of HB in (2). Health promoting behaviors typically move individuals towards functional independence and increase optimal health. Risky health behaviors, on the other hand, are significant predictors of disability and mortality rates especially in the older years (Breslow 1999; Grzywacz and Keyes 2004). The stock of health in a previous time period is also important in the older population's health production framework. For example, previously

diagnosed chronic health conditions are often found to be associated with functional status and health-promoting behaviors (Rasinaho et al. 2007). For the aging, it is assumed that health investments to the current stock of functional health may not have an immediate and quantitatively large impact on the stock of health. Rather, it is more likely to be a gradual process as the current stock is determined by health investments and other inputs in a previous time period, as suggested by the cumulative impact theory.

3.4 Data and Measures

This chapter uses the RAND HRS data, a subset of the HRS created by the RAND Center for the Study of Aging (RAND 2011). The HRS survey is a nationally representative study that surveys a representative sample of Americans over the age of 50 every 2 years. The HRS began as two distinct surveys. The first survey, the original HRS, was initially administered in 1992 to a nationally representative sample of Americans born in the years 1931 through 1941 (ages 51 through 61). The second survey, the study of Assets and Health Dynamics among the Oldest Old (AHEAD), was initially administered in 1993 to a nationally representative sample of Americans born in 1923 or earlier (ages 70 and older). Both surveys were consolidated in 1998 and became the HRS (HRS 2002). It is a good dataset for analyzing health challenges of the aging and for exploring other aging-related concerns. To allow for independent analysis of racial and ethnic groups, Blacks and Hispanics were over-sampled in the survey (RAND 2011). Respondents were interviewed face to face at baseline and over the telephone in follow-up surveys (Newsom, Jones, and Hofer 2012).

This chapter uses data from wave 2 through 10 of the RAND HRS. Respondents from Wave 1 are excluded due to the different functional limitations assessment, compared to subsequent waves. The sample is restricted to respondents who are age 55 and above at baseline. Spouses are excluded. Respondents in longitudinal surveys may be missing from follow-up years due to death or unavailability. For each follow-up year, respondents with proxy reporting on their behalf were dropped from the respective waves. Proxy responses have been historically associated with possible inaccuracy and low quality of proxy responses in health surveys (Elliott et al. 2008; Andresen et al. 2000). The percentage of the initial baseline sample that became out of scope was 9.6% by the end of the final follow-up year. The number of respondents with complete data across all waves was 84.8%. With these exclusion criteria, the final sample at baseline includes 5,163 respondents. Non-Hispanic whites, Blacks and Hispanics constituted 79%, 13% and 8% of the final sample respectively. The residual group which constitute American Indians and Asians are excluded due to their small proportion relative to the whole sample (< 1%).

All analyses are adjusted for differences in attrition by including a count variable indicating the number of waves a respondent was interviewed. Another approach to controlling for non-random attrition is to use the Heckman two-step procedure (Miller and Hollist 2007). In the first step, a logit regression of whether or not each participant participated in the final wave is estimated based on predictors associated with attrition, such as age, gender, race and health status (Van Beijsterveldt et al. 2002; Mein et al. 2012). Results (not reported) suggested that attrition may not be random as individuals with higher self-rated health status and females were more likely to drop out of the study. In addition, compared to non-Hispanic Whites, Hispanics were less likely to drop out. A non-random

attrition indicator (known as λ) explaining the causation of attrition in the sample is then computed for all the individuals and included as a covariate in subsequent analyses. Higher values of λ indicates a higher likelihood of dropping out of the study[3].

3.4.1 Functional Limitations

This chapter uses a count of self-reported functional limitations which assess mobility and strength of the upper and lower body. The HRS survey asked respondents if any difficulties were experienced in performing each of the mobility functional limitations. These mobility functional limitations include - walking several blocks, walking one block, jogging one mile, walking across the room, climbing several flight of stairs, sitting for two hours, getting up from seated position, stooping, kneeling or crouching, pushing or pulling objects, lifting ten pounds, picking a dime off the table and raising arms above the shoulder level (raise or extend arms up). These measures assess general physical ability. Respondents provided dichotomous responses for each measure. A score of 1 indicated that at least some difficulty in task was experienced and a 0 otherwise. A summary index is used in this analysis with values ranging from 0 to 12. A higher score corresponds to more mobility functional limitations. To measure the consistency and reliability of the functional limitation scale, the Cronbach's alpha coefficient of reliability is computed. For all waves, the alpha coefficient varied from 0.72 - 0.84[4]. This result is consistent with other

[3] The Heckman two-step procedure to correct for differences in attrition was tested in select models however some models had convergence problems with the inclusion of the non-random attrition indicator so the first approach is used across all models. Both approaches have been found to yield similar results (Warner and Brown 2011).

[4] The Cronbach's alpha statistic is the most widely used reliability coefficient. It measures the internal consistency of a multi-item scale by indicating the extent to which the combination of

studies analyzing functional limitations with the HRS data (Brown, O'Rand, and Adkins 2012). Basically, a value of 0.70 and above is generally acceptable and an alpha of .8 is a reasonable goal for Likert-type scales (Pevalin and Robson 2009; Gliem and Gliem 2003).

Table 3.1 presents the average number of functional limitations for all three racial and ethnic groups - non-Hispanic Whites, Blacks and Hispanics. For all groups, a general upward trend in average functional limitations is observed but Hispanics showed a decline in functional limitations in the first wave of the study period. Blacks had the highest level of functional limitations than Hispanics and non-Hispanic Whites across all nine waves (with the exception of the baseline wave). Non-Hispanic Whites reported the least level of functional limitations. Average functional limitations index at baseline was 1.89, 2.65 and 2.74 for non-Hispanic Whites, Blacks and Hispanics respectively. By the 2010 wave, this index had increased to 3.71, 4.37 and 4.05 for the three groups. Using the one-way analysis of variance (ANOVA) for each wave, these differences were found to be statistically significant. Additionally, a Bonferroni multiple-comparison test estimated to identify which specific group differed also indicated that each racial and ethnic group's average functional limitations was significantly different from the other[5]. Based on these racial and

selected items measure the conceptual variable (Peterson 1994). Values range from 0 to 1. Values closer to 1 indicates a more consistent scale.

[5] The one-way analysis of variance (ANOVA) is used to determine whether the differences in average functional limitations index between the three racial and ethnic groups are significant. Results revealed a statistically significant difference between non-Hispanic Whites, Blacks and Hispanics($F = 29.92, p < 0.01$). The Welsh adjusted F statistic used under conditions of unequal variances is also found to be significant and hence results from the post-hoc Bonferroni multiple-comparison test are considered valid.

ethnic differences in average functional limitations index, trajectory models are estimated for each group separately.

3.4.2 Predictor Variables

The primary predictor of interest measures the respondent's self-reported race and ethnicity. The functional limitations trajectories of Blacks and Hispanics are contrasted with the functional limitations trajectories of non-Hispanic Whites (the reference category). Respondents are coded as Whites or Blacks if they reported themselves as such and did not report any Hispanic ethnicity. Minorities have been reported in the literature to have more limitations (Liang et al. 2008). Other predictors selected for this analysis were selected based on theoretical considerations (Al Snih et al. 2007; Murray et al. 2006; Liang et al. 2008).

Health status is a risk factor for functional status. The first stage of the disablement process suggests that chronic diseases may lead to an impairment that may in turn result in a functional limitation (Verbrugge and Jette 1994). Two measures of adult health status are analyzed, morbidity and self-rated health status. In addition to physical functionality, these measures are two of the three most commonly used assessments of health status among older adults, (Ferraro, Farmer, and Wybraniec 1997; Johnson and Wolinsky 1993). The HRS survey asked respondents if they had ever been diagnosed with some serious health conditions[6]. The specific question asked:

[6] The lifetime diagnosis question of *"have you ever…?"* of these chronic illnesses is used. While not available in the HRS data, the current diagnosis *"do you currently…"*of the chronic illnesses would be preferable given that health status of some respondents previously diagnosed with illnesses may have improved with consistent usage of prescribed treatments and drugs.

"Has a doctor ever told you that you have… [put in health condition]?".

These conditions include cancer, high blood pressure, lung disease, stroke, diabetes, heart disease, arthritis and hypertension. Lung disease includes chronic lung disease such as bronchitis and emphysema. Heart problems include heart attack, angina, coronary heart disease, congestive heart failure or any other heart problems (Chien et al. 2013). A count index of the total number of health conditions reported is used to measure morbidity. This morbidity index ranged from 0 - 8 where a higher count signifies more conditions reported. This count procedure is a conventional practice in previous literature because it helps to analyze broad health dimensions rather than utilizing a single health condition (Ferraro, Farmer, and Wybraniec 1997; Brown, O'Rand, and Adkins 2012; Haas 2008; Haas and Rohlfsen 2010). Respondent's self-rated health measure is also included. Respondents were asked to rate their present health on a scale of 1- 5 where a higher number indicates poor health. These responses are recoded such that higher values represent better health status (1 = poor, 2 = fair, 3 – good, 4 = very good and 5 = excellent).

Body weight is a risk factor for disability and disease. Al Snih et al. (2007) found that the risk of disability was higher in both underweight and overweight aging population. Thus, the respondent's body mass index (BMI) is another health risk measure used in this analysis. BMI is calculated by dividing weight (kilograms) by height (meters) squared, both self-reported values. An individual's body size limits mobility especially in activities requiring lower-body strength because it reduces flexibility of the joints and reduced muscle strength (Himes 2000). For example, excess weight has been linked to functional limitations in ADLs (Alley and Chang 2007). Baseline BMI is included in this analysis and

is categorized according to the World Health Organization (WHO) International Classification - *Underweight = BMI < 18.5 kg/m^2, Normal = 18.5 < BMI ≤ 24.99 kg/m^2, Overweight = 25 ≤ BMI ≤ 29.99 kg/m^2 and Obese ≥ 30 kg/m^2*. Each category is coded as a dummy variable, with normal weight as the reference group.

Respondents' health-related behaviors from baseline are also included, tobacco and alcohol consumption. In order to assess the impact of various smoking categories on the trajectory of functional limitations, a binary variable of smoking behavior is used for each of the following categories: never smoked (reference category), former smoker and current smoker. A similar classification is also created for alcohol consumption with the following categories: nondrinkers, light drinkers (one to two drinks per day) and heavy drinkers (three drinks or more per day).

Socioeconomic status is measured by educational attainment and household wealth. Household wealth is used rather than household income because given the age group included in this analysis, a large percentage of the sample may be out of the working force. In addition, functional limitations may affect earning potential. For a more standardized distribution, household wealth is transformed by taking the natural log[7]. Educational attainment is measured in years and centered at the mean. All analyses also control for the following demographic characteristics - respondent's age, marital status (1 = married or partnered even if spouse was absent, 0 otherwise), gender (1 = female, 0 = male) and region of residence (coded as a dummy variable for each category – South, West, Northeast and

[7] Household wealth reflects the total household assets net of all debts, excluding IRAs. Negative wealth is transformed by obtaining the natural log of their absolute values and reassigning them as negative values. For individuals with 0 wealth, log (x) is replaced with 0.

Midwest). For ease of interpretation, age is centered at the lowest observed age (i.e, at 55, age = 0) therefore the effect of a 1-unit change in age on functional limitations over time can be analyzed. A quadratic age parameter (age^2) is also added as research has found changes in disability due to age to be non-linear (Kim and Miech 2009). Living in the South has also been found to be a risk factor for the onset and growth of functional limitations (Murray et al. 2006).

A measure of the respondent's cognitive functional abilities is included in the analysis. This index is the sum of self-reported correct answers to some explicit numeracy questions asked in the survey. The cognitive functioning measures include recalls of ten short, high-frequency nouns (both immediately and five minutes later), counting backwards from 20/10 for 10 continuous numbers, naming tasks (e.g. naming the day of the week, date and the President), and vocabulary questions (definition of five given words). These measures are useful in assessing memory, language, knowledge and orientation (Ofstedal, Fisher, and Herzog 2005). Values ranged from 0 – 35 and are coded as a continuous variable. For respondents with missing cognitive scores, the mean cognitive score correlating to their gender and racial/ethnic category is estimated and assigned. A dummy variable is also included to control for the missing cognitive scores.

Baseline descriptive statistics of predictors for non-Hispanic Whites, Blacks and Hispanics are presented in Table 3.2. Fifty-seven percent of the non-Hispanic White sample were female and 79% were married. For Blacks, 66% were female and 52% were married. Fifty-nine percent of the Hispanic population were females and 69% were married. As shown in Table 3.2, the majority of non-Hispanic Whites and Black respondents resided in the South region while the majority of Hispanics resided in the West.

The 2010 Census also reported similar statistics with White and Blacks concentrations in the South. Blacks had the highest reported number of chronic conditions while non-Hispanics Whites had the higher self-rated health index. Morbidity index for Blacks in the reference period was 1.3 compared to 1.0 for non-Hispanic Whites and Hispanics while self-rated health index for non-Hispanic Whites was 3.7 as compared to 3.0 and 2.8 for Blacks and Hispanics respectively. Across the three racial and ethnic groups, the majority body mass index category was the overweight category. Forty percent, 45% and 43% of non-Hispanic Whites, Blacks and Hispanics respectively were overweight. Current smokers constituted the smallest smoking category. The largest proportion of each racial and ethnic group have never smoked. Compared to Blacks and Hispanics, non-Hispanics Whites had the highest concentration of light drinkers while Blacks had the highest concentration of respondents reporting 0 drinks per day in the reference period. Whites also had better cognitive performance than Blacks and Hispanics.

3.5 Model and Statistical Methods

Previous studies have analyzed functional limitations trajectories using a multi-level hierarchical model where repeated data measures are clustered within each respondent (Brown, O'Rand, and Adkins 2012). This chapter uses a latent growth model (LGM) to analyze the trajectories of functional limitations index. LGMs can be regarded as an application of multilevel modeling in the framework of a structural equation model (Wang and Wang 2012). LGMs are preferable because they make no assumption about the linearity of the functional limitations trajectories, allows for analyses of time-varying predictors and they enable analyses of data from all waves simultaneously in the same

model (Kelley-Moore and Ferraro 2004). More importantly, LGMs analyses growth trajectories at both the group and individual levels, unlike other traditional repeated measures techniques.

In a LGM, two parameters are treated as latent variables – the intercept factor and the slope factor. The intercept factor measures the initial status (or baseline) of the outcome variable for each person and the slope factor measures the individual change in the outcome variable over time. In addition, the LGM technique estimates each population's mean functional limitations trajectory, how individual values vary about the population mean and identifies significant predictors of this variation (Duncan, Duncan, and Strycker 2013). Both linear and non-linear growth models can be analyzed in latent growth modeling. Individual trajectories of functional limitations are aggregated to estimate the average initial status of the growth curve and the rate of change across the time points for the entire sample, with resulting variances.

The LGM is conducted in two steps. The first step estimates the growth model without the covariates (unconditional model). Unconditional models without predictors are fitted to describe the growth trajectories of functional limitations during the reference period. This helps to estimate the mean initial level and slope in functional limitations and to determine the best model fit in terms of Bayesian information criteria. The second step incorporates predictors into the model to examine their influence on the initial level and on the rate of change in functional limitations (conditional model). The intercept coefficients of the covariates will indicate its effect on the initial level or baseline wave of functional limitations. On the other hand, the slope coefficients will indicate the effect of the predictors on the rate of change in functional status. In select models, covariates are added

as either time-invariant or time-varying covariates. Models are estimated with Mplus software *(version 7.0)* using a full information maximum likelihood estimator. Rather than the traditional method of using listwise deletion of cases with missing data, the full information maximum likelihood estimator uses all available data and has been shown to be more efficient as it produces unbiased parameter estimates and standard errors (Little, Schnabel, and Baumert 2000; Schafer and Graham 2002).

3.5.1 Unconditional Model Specification

The observed repeated measures in Table 3.1 are the functional limitations index from wave 2 to wave 10 of the HRS at an interval of two years over a 17-year period. The simple unconditional linear LGM can be expressed with the equations below where individual change in functional limitations is modeled as a function of time and then used to estimate change in functional limitations for the whole sample (Bollen and Curran 2006).

$$Y_{it} = \alpha_i + \beta_i X_t + \varepsilon_{it} \quad (3)$$

$$\alpha_i = \mu_\alpha + \varsigma_{\alpha i} \quad (4)$$

$$\beta_i = \mu_\beta + \varsigma_{\beta i} \quad (5)$$

Eqn. (3) indicates the expected trajectory of the variable of interest for each individual in the sample during the reference period. In this chapter, the outcome Y_{it} represents the

functional limitations index for each individual i at time t. X_t is the variable of time (corresponding to the interview year or wave in this analysis). α_i and β_i are the respective random intercept and random slope for each individual while ε_{it} is the error term at each time point for each individual. In a LGM, each case is allowed to have a distinct intercept and slope. Intercepts are constant for each individual across time hence they are coded with a fixed value of 1 on the repeated measures. The time at the first wave of the survey is typically coded as zero ($X_1 = 0$) to help estimate the mean value of functional limitations at the first time period. The value of the slope factor, β_i , depends on time passed between the follow-up waves. For instance, with a one-year interval where $X_1 = 0$ and $X_2 = 1$, β_i will indicate the change in the variable of interest between the time periods.

By specifying (4), the individual intercept α_i is stated as a function of the mean intercept or initial level of functional limitations for all individuals in the sample and a disturbance term, $\varsigma_{\alpha i}$. Similarly, (5) indicates that the individual rate of change in functional limitations is a function of the mean rate of change for all individuals and a disturbance term, $\varsigma_{\beta i}$. In both cases, the disturbance terms signifies the individual variability in both the initial level and rate of change in functional limitations.

3.5.2 Conditional Model Specification

In line with the functional status framework in (2) above, conditional LGMs are specified in subsequent models. Here, predictors are incorporated into the model to explain individual variability in the initial level and rate of change in the trajectory of functional

limitations over time. In other words, the selected predictors are incorporated into the intercept and slope equations in (4) and (5) as shown below:

$$\alpha_i = \mu_\alpha + \gamma_{\alpha C_i} C_i + \varsigma_{\alpha i} \quad (6)$$

$$\beta_i = \mu_\beta + \gamma_{\beta C i} C_i + \varsigma_{\beta i} \quad (7)$$

where C_i denotes the health, health-related behaviors and control variables. $\gamma_{\alpha C_i}$ and $\gamma_{\beta C i}$ are regression coefficients showing the impact of a change in the predictor on the random intercept and slope. The predictors are assumed to be uncorrelated with the disturbances.

3.6 Results

3.6.1 Unconditional Model

A multi-group specification is useful in estimating the moderating effects of membership in specific groups, such as racial and ethnic groups (Bollen and Curran 2006). In this chapter, a multi-group approach is used to compare non-Hispanic Whites, Blacks and Hispanic groups. Here, the growth model is estimated simultaneously and separately for each racial and ethnic group with no constraint on the parameters. This approach takes into consideration the differences in variances and functional forms between the groups.

To determine the growth model with the best fit, an unconditional LGM was estimated with linear, quadratic and free time scores for each racial and ethnic group (Whites, Blacks and Hispanics). For the linear specification, the factor loadings of the slope factors are

constrained with intervals of one-tenth ($X_1 = 0,\ X_2 = 0.1, X_3 = 0.3, \ldots$) to represent equidistant time points (Duncan, Duncan, and Strycker 2013)[8]. To choose the best fitting model in an LGM, overall goodness of fit of a growth curve model is measured using (either) the χ^2 – test, comparative fit index (CFI), root mean square error of approximation (RMSEA), Aikake's information criterion (AIC), Bayes information criterion (BIC) and Tucker-Lewis index (TLI) (Schwarz 1978; Akaike 1998; Bollen and Curran 2006; Duncan, Duncan, and Strycker 2013). The χ^2 – test is the most widely used but it is usually sensitive to the sample size of the study population. The AIC, CFI, TLI and RMSEA fit indices are reported for all models[9].

Resulting fit indices for the linear growth was $\chi 2\ (120) = 1503.3,\ CFI = 0.96, TLI = 0.96, RMSEA = 0.08$ while fit indices for the quadratic growth was $\chi 2\ (108) = 638.2,\ CFI = 0.98, TLI = 0.98, RMSEA = 0.05$. The quadratic growth model provided a much better fit compared to the linear and free time specifications thus indicating a quadratic trajectory of functional limitation where the time factor is raised to the second power as shown below:

$$Y_{it} = \alpha_i + \beta_{1i} X_{it} + \beta_{2i} X_{it}^2 + \varepsilon_{it} \qquad (8)$$

With the addition of the third growth factor, β_{2i}, the linear factor loadings are transformed into their squared values. The quadratic slope measures the curvature of the individual

[8] Intervals of one-tenth is used rather than intervals of two units to aid model convergence for the full conditional growth models.

[9] CFI and TLI range from 0 to 1. Models with good fit will usually have TLI and CFI greater than 0.90, RMSEA value less than 0.05 and smaller AIC and BIC when compared to other models.

trajectories. Both linear and quadratic path diagrams are presented in Figures 2.1 and 2.2. Goodness of fit results and parameter estimates for the intercept and slope means for the unconditional growth model with quadratic trend analysis are presented in Table 3.3.

Results from the multiple group unconditional LGM in Table 3.3 indicate that Blacks and Hispanics had a significantly higher initial level of functional limitations compared to Whites. Specifically, Blacks and Hispanics had an average initial starting point of the functional limitations trajectory index of 2.70 ($p < .01$) and 2.57 ($p < .01$) respectively as compared to 1.92 ($p < .01$) for Whites. The positive and significant slope factor for Whites (0.40, $p < .01$) and Blacks (0.21) indicate an upward trend in functional limitation between each wave (also shown with the mean plot of functional limitations presented in Figures 2.3 and 2.4). The significant slope factor for non-Hispanic Whites also indicates a faster average change in functional limitation for each wave, compared to Blacks and Hispanics.

In addition, as shown in Table 3.3, a significant variance of the intercept and slope factors is observed for Whites, Blacks and Hispanics. This indicates meaningful individual variability around the average intercept and slope of functional limitations (that is, inter-individual differences in functional limitations trajectories), therefore justifying the addition of predictors to explain the variation in the individual trajectories (Intercept variance – Whites 3.7, Blacks 6.6, Hispanics 5.9; Slope variance – Whites 27.2, Blacks 43.2, Hispanics 43.8). Additionally, for all racial/ethnic groups, a statistically significant negative covariance (Whites: -1.43, $p < .01$; Blacks: -4.50, $p < .01$; Hispanic: -3.81, $p < .01$) between the intercept and slope is also observed which indicates that older adults with lower levels of functional limitations index at baseline had a higher rate of growth initially

and vice versa. Thus, predicting that baseline individual difference in the levels of functional limitations may eventually diminish in future years.

3.6.2 Conditional models

A series of conditional quadratic LGMs are fitted by sequentially adding time-invariant and time-varying covariates to explain inter-individual differences in functional limitations trajectories. The conditional LGM examines the association of the specified health and health-related behavioral factors on functional limitations trajectories by race, while controlling for the socio-demographic factors (age, gender, years of education, region of residence, marital status and household wealth).

Table 3.4 (model II) analyzes the relationship between time-invariant socio-demographic factors and functional limitations. Findings reveal that gender and age significantly predicts the initial levels of functional limitation across all three racial/ethnic groups. Gender effects on the initial level of functional limitations were more pronounced for Blacks. Women had significantly more functional limitations at baseline compared to men with a statistically significant estimate of 0.56, 1.25 and 0.57 for Whites, Blacks and Hispanics respectively. This finding is consistent with Liang et al. (2008) who also found that females are associated with more limitations. Results also show that an increase in age corresponds to faster rate of growth in limitations for all groups, with results more pronounced for Blacks. Blacks had the highest rate of change in functional limitations as they age as a one-unit change in age is associated with a .40 increase in the rate of change in functional limitations for Blacks compared to .35 increase for Whites and .25 increase for Hispanics. Additionally, higher years of education corresponds with lower functional

limitations at the initial period for all three racial and ethnic groups. Specifically, an extra year of education corresponds to a .13 lower level of functional limitations among non-Hispanic Whites, .12 among Blacks and .08 among Hispanics. Also, higher wealth is associated with lower baseline level of functional limitations.

Parameter estimates for the intercept and slope means in Table 3.4 (model II) shows that adjusting for socioeconomic factors reduced the initial observed baseline level of functional limitations (intercept) for both Blacks and Hispanics. Specifically, a "racial crossover" is observed in the baseline odds of functional limitations from higher odds for Blacks and Hispanics to higher odds for Whites. Blacks and Hispanics are shown to have an average initial starting point of the functional limitations trajectory index of 2.0 ($p < .05$) and 2.5 ($p < .05$) respectively as compared to 3.4 ($p < .01$) for Whites. This finding indicates that socio-economic characteristics account for a significant part in racial and ethnic disparities in functional status among the aging population. In addition, compared to Table 3.3, the variances in Table 3.4 still indicate significant but lower inter-individual differences in the trajectories of functional limitations. Specifically, the socioeconomic predictors accounted for 14% of the variance in baseline limitations for each racial/ethnic group while they accounted for 10%, 13% and 7% of the individual variability in the latent slope for Whites, Blacks and Hispanics respectively. (Intercept variance – Whites 3.2, Blacks 5.7, Hispanics 5.2; Slope variance – Whites 24.5, Blacks 37.5, Hispanics 40.8).

Table 3.5 (model III) is the full model adjusting for health status and health-related behavioral factors. As expected, health status is found to have a highly significant effect on functional limitations. Higher morbidity index corresponds to higher initial functional limitation level across all three groups, with more pronounced effects for Hispanics and

Blacks. Higher self-rated health values are associated with a lower functional limitations at baseline but a higher rate of change over time, indicating that individuals may be reporting a true and accurate self-rating of health status at baseline. Body mass index is also found to significantly influence functional status, especially for Whites and Blacks. Overweight and obese White and Black older adults were more likely to have more functional limitations index at the initial level. Compared to non- smokers, among White and Black older adults, current and former smokers had significantly higher functional limitations at baseline. Light drinking was also associated with lower limitations at baseline for non-Hispanic Whites.

For Blacks and Hispanics, previous socio-economic differences observed in Table 3.4 (model II) are attenuated by the addition of the health and behavioral predictors in Table 3.5 (model III). Educational attainment and wealth were no longer significant predictors of the initial level of functional limitations net of the health and health-related behavioral predictors. Thus, the observed large impact of socio-economic factors on functional limitations for minorities may be attributed to possible racial and ethnic differences in health and behavioral factors. Fit statistics in Table 3.5 also indicate that model III was a better model compared to the previous models. Variances in intercepts and slopes were significantly reduced, indicating that the additional covariates included in the model helped explain more individual variability in the initial level and rate of change in functional limitations. Black and Hispanic minorities still had lower initial levels of functional limitations compared to non-Hispanic Whites, net of health and health-related behavioral predictors in model III (Intercept – Whites 4.3, Blacks 3.5, and Hispanics 4.1).

In Table 3.6 (Model IV), both time-invariant and time-varying predictors are included. Time varying variables change over time while time invariant variables rarely change or change without individual differences over time. Time-varying covariates are specified because some predictors could change over an extended time period of time (Liang et al. 2008). Predictors assumed to be time-invariant (for the purpose of this analysis) and measured only at baseline are race/ethnicity, age, gender, years of education, marital status, region of residence, self-rated health index, alcohol and smoking status categories. In order to measure the effect of health changes on functional status over time, morbidity index is assumed to be time-varying and measured at each time period of analysis. Body mass index, wealth and age are also varied with time. Results show that morbidity index is positively related to functional limitations index across all waves, indicating that older adults with more chronic illnesses generally tend to have increased limitations over a period of time. Results also indicate that the time-varying negative effect of an excess body weight on functional limitations generally may be higher for non-Hispanic Whites than minorities, as overweight and obese Whites in every time period had significantly more functional limitations.

3.7 Discussion and Conclusion

This chapter contributes to previous findings on functional limitations trajectory by using a longer time period of longitudinal data from the HRS to examine racial and ethnic disparities in trajectories of functional limitations both at onset and over time (nine repeated measures of functional limitations equivalent to 17 years). In addition, this chapter examines whether any observed racial and ethnic differences in trajectories of functional

limitations were accounted for by differences in health status and health-related behavioral factors. Another significant contribution of this analysis is the inclusion of both time-invariant and time varying predictors, rather than analyzing only baseline predictors. This allows for exploring the impact of changes in selected predictors over the time period of analysis on changes in functional limitations.

Socio-economic factors, such as level of educational attainment and wealth, are found to be important determinants and accounted for the observed racial and ethnic disparities in functional limitations at the initial level. Higher level of educational attainment was associated with lower functional limitations at the initial period for all three racial and ethnic groups. Thus, more educated older adults may be more knowledgeable about and therefore engage in healthy lifestyle behaviors or nutritional habits that postpone the onset of functional limitations as they age. Schoeni, Freedman and Martin (2008) also find greater educational attainment to be associated with declining disability among the older population.

Findings reveal racial and ethnic differences in functional health trajectories. Compared to non-Hispanic Whites, Blacks and Hispanics initially had higher risks of functional limitations however adjusting for socio-economic factors reduced the initial observed baseline level of functional limitations for both Blacks and Hispanics. In particular, a "racial crossover" is observed in the baseline level of functional limitations from higher odds for Blacks to higher odds for Whites net of education and wealth. In other words, Whites are found to have a higher level of functional limitations compared to both minority groups, net of socio-economic factors. Similar results were found by Clark et al. (1993) suggesting that racial and ethnic differences in functional status among older adults

may be age or time-dependent. Specifically, they found that Blacks were initially more likely to experience functional decline. However, after age 85, Blacks were less likely to experience decline in functional status.

Importantly, results also demonstrate that health status and health-related behavioral habits are significant contributors to racial and ethnic disparities. The effect of socio-economic factors was attenuated with the inclusion of the health and health-related behavioral factors (morbidity index, self-rated health, body mass index, smoking categories and alcohol categories). Thus, suggesting that lower socio-economic factors among Blacks and Hispanics negatively impacts their trajectories of functional limitations in part through racial and ethnic differences in health status and differences in behavioral factors.

Higher morbidity index, being underweight/overweight and current smoking significantly influenced the onset of functional limitations for Whites and Blacks as found in previous studies (Ostermann and Sloan 2001; LaCroix et al. 1993). These effects were again more pronounced for Blacks compared to Whites. This is consistent with Mead and Fund (2008) who find that Blacks are much more likely than Whites to be overweight or obese, which explains some of the health disparities. Other studies found that smoking is associated with lower levels of disability (Kelley-Moore and Ferraro 2004). Light drinking was not found to be hazardous to functional health. Instead, light drinking significantly reduced the risk of functional limitations for Whites, with 18% less limitations at baseline. Chen and Hardy (2009) also find similar results, where light drinkers had reduced risk of functional health decline. In addition, females were also more likely to develop functional limitations and also exhibited a faster rate of growth in functional limitations over time

especially for Black females. Black females had significantly more functional limitations in the initial time period compared to White females and Hispanic females.

While similar studies have treated covariates as temporally fixed effects (that is, treating all covariates as time-invariant), this chapter also explored the effect of some selected time-varying covariates on the trajectory of functional limitations. Changes in covariates could affect the shape of the trajectory over time (Haas 2008). Increases in the number of chronic conditions reported over time continues to contribute to decline in functional status over time across both groups. Future research may examine the association between each chronic illness with the level and trend of functional limitations, where functional limitations at each wave will be regressed on wave-specific incident chronic condition, rather than on the cumulative chronic count. This will help provide more information about which specific chronic condition has the highest impact on functional limitations.

A possible limitation to note is the non-inclusion of childhood health factors. While this study recognizes that previous research has found childhood health and childhood socioeconomic status to be predictive of the trajectory of functional limitations (Kuh and Ben-Shlomo 2004; Freedman et al. 2008; Blackwell, Hayward, and Crimmins 2001; Haas 2008), these factors are not included in this analysis. The HRS included an experimental module on retrospective measure of childhood factors. However, care should be taken in using retrospective measures given the older age group in this study population. Haas (2008) also postulated that further research is needed to establish a better understanding of the retrospective childhood health factors.

In conclusion, findings from this chapter indicate that addressing racial and ethnic disparities in health and health-related risk factors, such as tobacco consumption and weight gain, is a necessary foundation for minimizing or eliminating racial and ethnic disparities in functional health status and for improving functional health among older adults. This will help postpone the onset of, reduce the severity of or improve overall functional health and attendant quality of life for older adults. Thus, ensuring that baby boomers "age successfully" and look forward to their older years (CDC 2013). In other words, the combined impact of reducing health disparities and encouraging healthy behavioral habits is crucial in achieving fully-functional older years.

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Table 3.1 Functional limitations

Functional Limitations	Non-Hispanic Whites (S.E)	Blacks (S.E)	Hispanics (S.E)
Wave 2	1.89 (2.26)	2.65 (2.98)	2.74 (2.93)
Wave 3	2.05 (2.36)	2.85 (2.99)	2.50 (2.87)
Wave 4	2.10 (2.36)	2.83 (2.95)	2.60 (2.81)
Wave 5	2.15 (2.35)	2.91 (2.97)	2.68 (2.95)
Wave 6	2.50 (2.43)	3.30 (2.97)	3.07 (2.91)
Wave 7	2.70 (2.47)	3.35 (3.00)	3.15 (2.90)
Wave 8	3.04 (2.59)	3.67 (3.08)	3.51 (2.99)
Wave 9	3.19 (2.67)	3.88 (3.13)	3.64 (2.99)
Wave 10	3.71 (2.78)	4.37 (3.24)	4.05 (3.13)

Note: One-way analysis of variance (ANOVA) and Bonferroni multiple-comparison tests are used to test differences. Source: RAND HRS 1994 -2010 data.

Table 3.2 Baseline sample description

Predictors	Non-Hispanic Whites (S.E)	Blacks (S.E)	Hispanics (S.E)	p-value
Socio-demographic factors				
Age	62.4 (6.4)	61.7 (6.3)	61.4 (6.3)	<0.1*
Female (%)	56.7	66.0	59.4	<0.1*
Married (%)	78.6	51.9	68.9	<0.1*
Region of residence				
Northeast (%)	17.0	16.5	10.5	<0.1*
Midwest (%)	29.8	22.7	3.1	<0.1*
South (%)	34.5	52.9	38.5	<0.1*
West (%)	16.6	5.8	41.3	<0.1*
Years of education	12.8 (2.6)	10.9 (3.4)	8.0 (4.6)	<0.1*
Ln(Wealth)	11.6 (2.2)	8.9 (4.1)	9.2 (3.9)	<0.1*
Health Factors				
Morbidity index	1.0 (1.0)	1.3 (1.1)	1.0 (1.0)	<0.1*
Self-rated health	3.7 (1.0)	3.0 (1.1)	2.8 (1.1)	<0.1*
Body mass index				
Underweight (%)	0.8	0.6	0.5	<0.1*
Normal (%)	37.0	18.9	24.9	0.7
Overweight (%)	40.0	44.9	42.8	<0.1*
Obese (%)	22.1	35.7	31.8	<0.1*
Health-related behaviors				
Smoking status				
Never smoker (%)	43.1	43.5	44.9	<0.1*
Former smoker (%)	41.0	36.1	34.2	<0.1*
Current smoker (%)	13.8	18.3	14.3	<0.1*
Alcohol consumption				
0 drinks per day (%)	37.9	58.5	57.7	<0.1*
Light drinker (%)	56.4	37.0	32.3	<0.1*
Heavy drinker (%)	5.7	4.5	10.0	0.7
Cognitive Status	23.5	18.0	18.8	<0.1*

Non-Hispanic N= 4069, Blacks N = 673, Hispanics N = 421

Note: Years of education was centered at the mean of 12 years for the growth model analysis. One-way analysis of variance at baseline used to test differences in means between the three groups. * signifies statistically significant difference at the 5% level. Source: RAND HRS 1994-2010 data.

Table 3.3 Unconditional Quadratic LGM

	Whites (S.E)	**Blacks** (S.E)	**Hispanics** (S.E)
Means			
Intercept	1.92***	2.70***	2.57***
	(0.03)	(0.11)	(0.14)
Linear slope	0.40***	0.21	-0.46
	(0.13)	(0.40)	(0.52)
Quadratic slope	2.30***	2.31***	3.03***
	(0.15)	(0.46)	(0.62)
Variances			
Intercept	3.67***	6.61***	5.87***
	(0.11)	(0.47)	(0.57)
Slope	27.15***	43.22***	43.83***
	(1.69)	(6.34)	(8.60)
Fit statistics			
AIC		176034.1	
CFI		0.98	
TLI		0.98	
RMSEA		0.05	

Note: AIC = Akaike Information Criterion; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation. Standard errors in parentheses. *** p<.01; **p<.05; *p<.10 . Source: RAND HRS 1994-2010 data.

Table 3.4 Conditional Quadratic LGM – Model II

	White S.E)	Black (S.E)	Hispanic (S.E)
Means			
Intercept	3.37***	2.00**	2.49**
	(0.38)	(0.81)	(1.18)
Linear Slope	4.86***	3.02	-0.079
	(1.50)	(3.09)	(4.64)
Quadratic Slope	-3.68**	-2.68	4.86
	(1.87)	(3.62)	(5.75)
Variances			
Var. Intercept	3.19***	5.74***	5.17***
	(0.10)	(0.42)	(0.52)
Var. Slope	24.46***	37.48***	40.81***
	(1.58)	(5.86)	(8.42)

Time-invariant predictors	Intercept on	Slope on	Intercept on	Slope on	Intercept on	Slope on
Age	-0.08***	0.35***	-0.08***	0.40***	-0.07***	0.25***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.09)
Female	0.56***	1.19***	1.25***	0.59	0.57**	-0.02
	(0.07)	(0.26)	(0.27)	(1.00)	(0.29)	(1.11)
Married	-0.11	0.04	0.05	0.19	-0.76**	2.36*
	(0.09)	(0.33)	(0.24)	(0.87)	(0.32)	(1.23)
Northeast	-0.19**	0.34	-0.23	0.37	0.53	-3.16*
	(0.10)	(0.37)	(0.31)	(1.10)	(0.47)	(1.80)
West	-0.13	0.39	0.27	-3.29**	-0.25	1.24
	(0.10)	(0.37)	(0.47)	(1.70)	(0.30)	(0.27)
Midwest	-0.01	-0.42	-0.20	-2.32**	0.31	-1.32
	(0.01)	(0.31)	(0.27)	(0.98)	(0.80)	(0.67)
Education	-0.13***	-0.02	-0.12***	0.24*	-0.08**	0.01
	(0.01)	(0.05)	(0.04)	(0.13)	(0.03)	(0.13)
Wealth	-0.09***	0.05	-0.07***	0.03	-0.10***	0.08
	(0.01)	(0.05)	(0.02)	(0.08)	(0.03)	(0.11)

Fit Statistics	
AIC	170690.2
CFI	0.97
TLI	0.97
RMSEA	0.04

Note: Cognitive index was included in all estimations. AIC = Akaike Information Criterion; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation. Standard errors in parentheses. *** p<.01; **p<.02; *p<.10. Source: RAND HRS 1994-2010 data.

Table 3.5 Conditional Quadratic LGM – Model III

	White (S.E)	Black (S.E)	Hispanic (S.E)
Means			
Intercept	4.30***	3.51***	4.10***
	(0.35)	(0.80)	(1.08)
Linear Slope	2.73*	0.45	-7.82
	(1.60)	(3.51)	(5.09)
Quadratic Slope	-2.81***	-2.45	10.87*
	(1.99)	(4.13)	(6.37)
Variances			
Var. Intercept	2.00***	3.65***	2.88***
	(0.07)	(0.30)	(0.36)
Var. Slope	24.68***	35.88***	39.28***
	(2.29)	(5.72)	(8.16)

Time-invariant predictors	Intercept on	Slope on	Intercept on	Slope on	Intercept on	Slope on
Age	-0.07***	0.36***	-0.07***	0.40***	-0.07***	0.25***
	(0.01)	(0.02)	(0.02)	(0.07)	(0.02)	(0.09)
Female	0.58***	1.32***	0.81***	0.89	0.40	0.69
	(0.06)	(0.28)	(0.25)	(1.05)	(0.27)	(1.24)
Married	-0.03	-0.01	-0.10	0.14	-0.88***	2.94**
	(0.07)	(0.33)	(0.21)	(0.86)	(0.27)	(1.23)
Northeast	-0.13*	0.27	0.13	-0.05	0.39	-3.18*
	(0.08)	(0.37)	(0.26)	(1.09)	(0.38)	(1.79)
West	-0.04	0.35	-0.05	-3.14*	-0.22	1.23
	(0.08)	(0.37)	(0.40)	(1.69)	(0.24)	(1.12)
Midwest	-0.02	-0.43	-0.13	-2.53***	0.24	-1.05
	(0.07)	(0.31)	(0.23)	(0.98)	(0.65)	(3.09)
Education	-0.03***	-0.06	-0.03	0.11	-0.02	-0.08
	(0.01)	(0.05)	(0.03)	(0.13)	(0.03)	(0.13)
Wealth	-0.03***	0.04	-0.03*	-0.01	-0.03	0.05
	(0.01)	(0.05)	(0.02)	(0.08)	(0.03)	(0.11)
Morbidity index	0.42***	0.13	0.59***	-0.19	0.65***	0.55
	(0.03)	(0.14)	(0.10)	(0.41)	(0.13)	(0.59)
Self-rated health	-0.79***	0.61***	-0.98***	1.05***	-1.08***	1.55***
	(0.03)	(0.14)	(0.10)	(0.41)	(0.11)	(0.52)
Underweight	-0.20	-0.06	-0.47	-1.38	0.12	5.96
	(0.31)	(1.42)	(1.21)	(5.52)	(1.53)	(6.98)
Overweight	0.22***	0.13	0.52**	-0.88	-0.09	2.14*
	(0.06)	(0.29)	(0.25)	(1.07)	(0.27)	(1.26)
Obese	0.65***	0.81**	0.99***	0.83	0.09	3.01**
	(0.08)	(0.36)	(0.27)	(1.16)	(0.32)	(1.47)
Current smoker	0.38***	-0.06	0.75***	-2.02*	0.13	0.29
	(0.09)	(0.40)	(0.27)	(1.14)	(0.34)	(1.56)
Former smoker	0.12**	0.26	0.46**	-0.56	0.19	0.17
	(0.06)	(0.28)	(0.21)	(0.88)	(0.27)	(1.27)
Light drinker	-0.18***	0.12	-0.01	1.16	-0.17	1.27
	(0.06)	(0.28)	(0.20)	(0.86)	(0.26)	(1.23)

Fit Statistics	
AIC	168667.7

CFI	0.98
TLI	0.97
RMSEA	0.04

Note: Cognitive index and heavy drinker were included in all estimations. AIC = Akaike Information Criterion; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation. Standard errors in parentheses. *** p<.01; **p<.02; *p<.10 . Source: RAND HRS 1994-2010 data.

Table 3.6 Conditional Quadratic LGM – Model IV

	White (S.E)	Black (S.E)	Hispanic (S.E)
Means			
Intercept	9.28***	9.19***	8.59***
	(0.51)	(1.47)	(1.81)
Linear Slope	-21.61***	-22.32***	-16.24**
	(2.28)	(6.17)	(8.54)
Quadratic Slope	10.95***	9.30	4.59
	(2.81)	(7.28)	(10.45)
Variances			
Var. Intercept	2.01***	4.03***	2.63***
	(0.08)	(0.36)	(0.37)
Var. Slope	22.90***	35.52***	33.41***
	(1.55)	(5.99)	(8.16)

Time-invariant predictors	Intercept on	Slope on	Intercept on	Slope on	Intercept on	Slope on
Female	0.57***	1.19***	0.81***	1.44	0.23	0.01
	(0.07)	(0.29)	(0.28)	(1.14)	(0.29)	(1.32)
Married	-0.03	-0.16	-0.07	0.08	-1.02***	1.52
	(0.07)	(0.34)	(0.22)	(0.90)	(0.28)	(1.29)
Northeast	-0.19**	0.62	0.22	0.32	0.89**	-4.80**
	(0.09)	(0.38)	(0.29)	(1.17)	(0.42)	(1.89)
West	-0.05	0.54	-0.08	-3.07*	-0.17	0.86
	(0.09)	(0.39)	(0.43)	(1.74)	(0.26)	(1.18)
Midwest	-0.01	-0.30	-0.14	-1.56	0.92	-1.15
	(0.07)	(0.32)	(0.27)	(1.07)	(0.73)	(3.31)
Education	-0.04***	-0.03	-0.04	0.04	-0.02	-0.21*
	(0.01)	(0.06)	(0.04)	(0.15)	(0.03)	(0.14)
Wealth	-0.04***	0.04	-0.04*	-0.01	-0.04*	-0.04
	(0.01)	(0.05)	(0.30)	(0.08)	(0.03)	(0.11)
Self-rated health	-0.82***	0.57***	-1.12***	1.26***	-0.99***	1.14**
	(0.03)	(0.15)	(0.11)	(0.45)	(0.13)	(0.56)
Current smoker	0.33*	-0.20	0.72**	-2.55*	0.27	-0.22
	(0.10)	(0.41)	(0.30)	(1.20)	(0.36)	(1.63)
Former smoker	0.11*	0.28	0.51**	-0.57	0.42	-0.42
	(0.07)	(0.29)	(0.24)	(0.95)	(0.30)	(1.34)
Light drinker	-0.15**	-0.05	-0.16	1.24	-0.43	2.20*
	(0.07)	(0.29)	(0.23)	(0.91)	(0.29)	(1.31)

Time-varying predictors	Functional Limitations on	Functional Limitations on	Functional Limitations on
Wave 2 Morbidity index	0.36*** (0.03)	0.53*** (0.10)	0.76*** (0.13)
Wave 3 Morbidity index	0.38*** (0.03)	0.43*** (0.08)	0.38***(0.11)
Wave 4 Morbidity index	0.35*** (0.02)	0.45*** (0.07)	0.52***(0.10)
Wave 5 Morbidity index	0.33*** (0.03)	0.51*** (0.07)	0.55***(0.09)
Wave 6 Morbidity index	0.36*** (0.02)	0.49*** (0.07)	0.52***(0.08)
Wave 7 Morbidity index	0.35*** (0.02)	0.51*** (0.06)	0.44***(0.08)
Wave 8 Morbidity index	0.40*** (0.02)	0.58*** (0.06)	0.39***(0.08)
Wave 9 Morbidity index	0.39*** (0.02)	0.48*** (0.07)	0.44***(0.08)
Wave 10 Morbidity index	0.46*** (0.03)	0.57*** (0.02)	0.60***(0.09)
Wave 2 overweight	0.23*** (0.060)	0.29 (0.24)	-0.18 (0.28)

Wave 3 overweight	0.09 (0.06)	0.44** (0.21)	-0.13 (0.28)
Wave 4 overweight	0.10* (0.06)	0.04 (0.20)	0.11 (0.26)
Wave 5 overweight	0.11* (0.06)	-0.07 (0.21)	0.23 (0.26)
Wave 6 overweight	0.30*** (0.06)	0.08 (0.21)	-0.11 (0.25)
Wave 7 overweight	0.28*** (0.06)	0.05 (0.20)	0.33 (0.27)
Wave 8 overweight	0.27*** (0.06)	0.07 (0.21)	0.36 (0.30)
Wave 9 overweight	0.18*** 0.07)	0.30 (0.23)	0.09 (0.30)
Wave 10 overweight	0.08 (0.08)	0.01 (0.23)	0.55* (0.33)

Fit Statistics	
AIC	148972.3
CFI	0.97
TLI	0.97
RMSEA	0.02

Note: Cognitive index, heavy drinker, time-varying age, time-varying obese BMI category and time-varying wealth were included in all estimations. AIC = Akaike Information Criterion; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation. Standard errors in parentheses. *** p<.01; **p<.02; *p<.10 . Source: RAND HRS 1994-2010 data.

Figure 3.1 Conceptual Linear Path Diagram over 9 waves

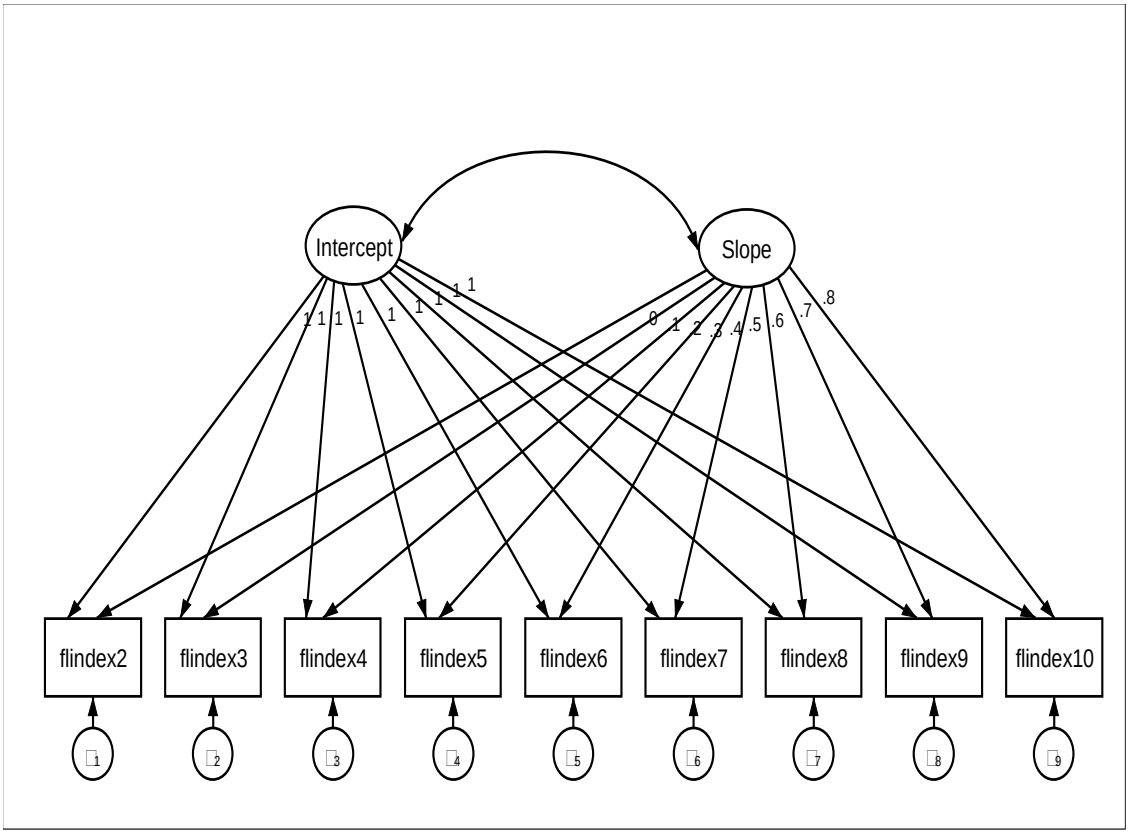


Figure 3.2 Conceptual Quadratic Path Diagram over 9 waves

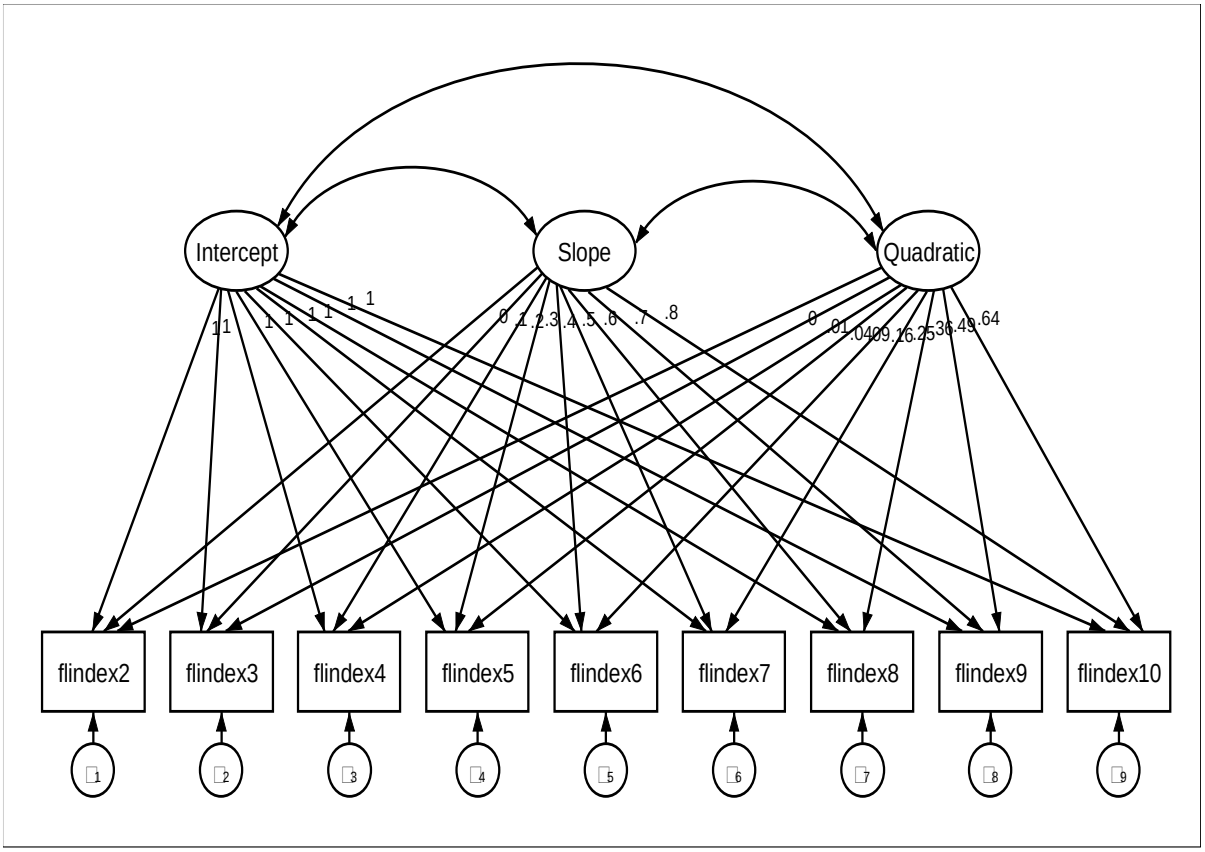
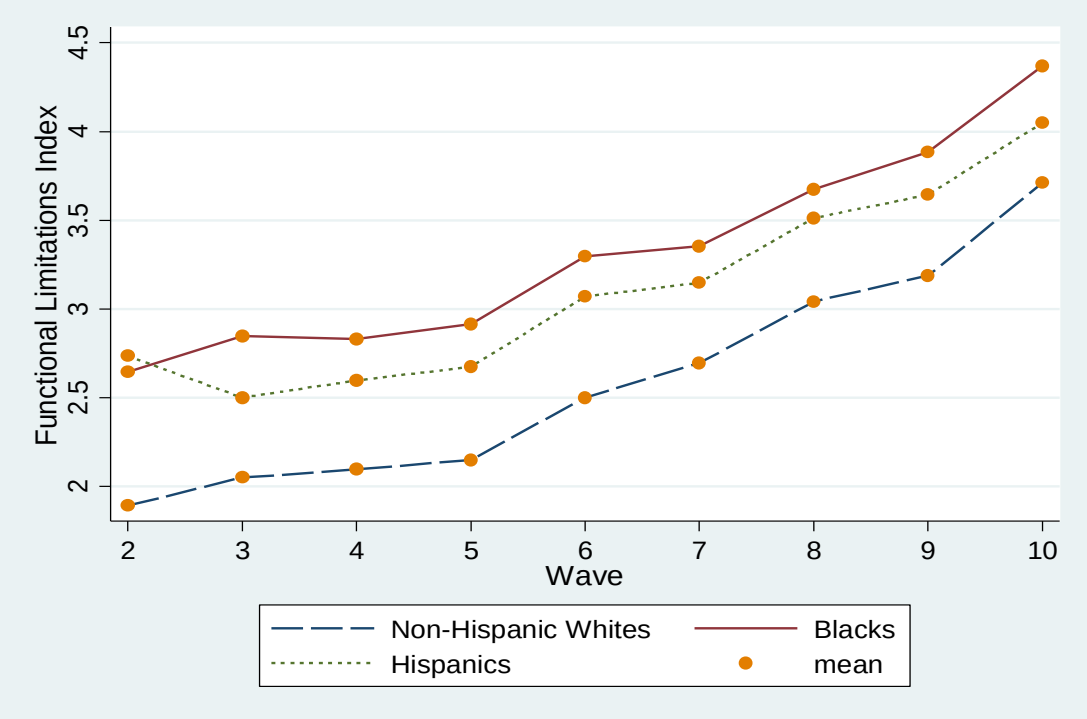
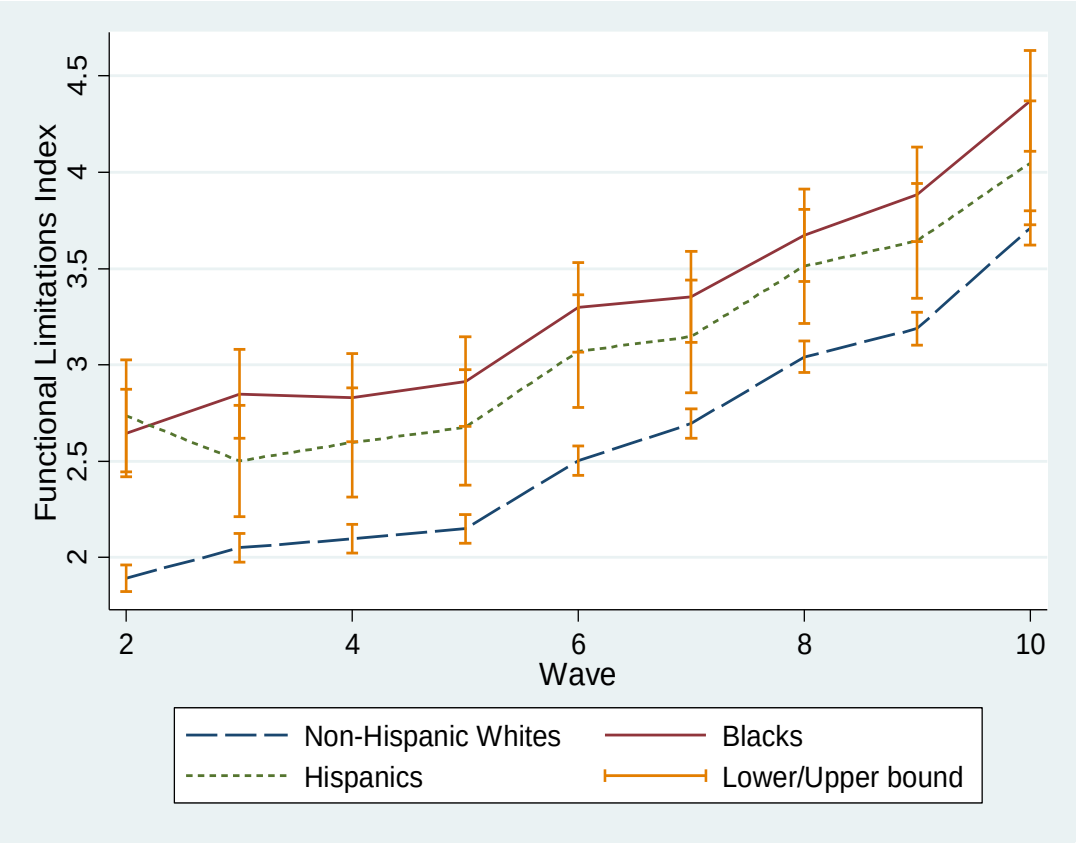


Figure 3.3 Trajectories of functional limitations for racial and ethnic groups.



Source: HRS 1994-2010.

Figure 3.4 Trajectories of functional limitations across racial and ethnic groups – with 95% confidence intervals



Source: HRS 1994-2010.

Chapter 4: Cost Effectiveness Analysis of a Community Exercise and Nutrition Program for Older Adults: *The Texercise Select*

4.1 Introduction

Physical activity and nutrition patterns are two important health concerns among the U.S. increasing older population, and are important factors to be considered when assessing health problems and health outcomes of older adults in the community. Among older adults, physical activity and good dietary practices have been associated with prevention or delayed onset of health conditions such as stroke, high blood pressure, coronary heart disease, type 2 diabetes, depression, some cancers, functional limitations, higher risk of falling, reduced cognitive function, reduced sleep quality and a reduced quality of life (Chernoff 2001; DHHS 2008b; Friedenreich and Cust 2008; Tardon et al. 2005).

Regular physical activity is associated with lower mortality risk for both older and younger adults, as it decreases the risk of cardiovascular disease and some cancers (Blair et al. 1989; DHHS 1996; Friedenreich and Cust 2008; Tardon et al. 2005). For older adults, regular physical activity helps build stronger muscles to reduce the risk of falling and for continued independent living in the community (DHHS 1996; Sherrington et al. 2008). Previous research has found a positive relationship between obesity/overweight from physical inactivity and functional limitations (Clark, Stump, and Wollnsky 1998; Houston et al. 2005). The economic burden or costs of physical inactivity has also been documented. Colditz (1999) reported that economic costs from physical inactivity were approximately

2.4% of the U.S health care expenditures in 1995 dollars. Chenoweth and Leutzinger (2006) also estimated economic cost of physical inactivity to be approximately $251 billion in 2003 dollars. Economic costs from a sedentary life are classified into three categories: direct costs from medical care use, indirect costs from productivity loss and workers' compensation; and forgone earnings from premature mortality attributed to physical inactivity (Colditz 1999; Pratt, Macera, and Wang 2000). In an older population setting, most economic costs would accrue from direct costs from medical care use because a large percentage of older adults may be inactive and retired, hence limited or no productivity loss and forgone earnings.

Community-based physical activity interventions have been shown to help foster better health status, improve physical function, improve cognitive function, reduce risk of falling, improve quality of life, reduce symptoms of various illnesses and reduce health care costs (Aoyagi and Shephard 2011; Fitzpatrick et al. 2008; Kolbe-Alexander, Lambert, and Charlton 2005; van der Bij, Laurant, and Wensing 2002; Yates and Dunnagan 2001). However, despite these health benefits of physical activity in reducing morbidity and mortality, and the cost savings from the reduced economic burden, the prevalence of leisure time physical activity among older adults is still lower compared with younger adults (DHHS 1996; Prohaska et al. 2006). Possible racial and ethnic differences also exist as physical inactivity is reported to be more prevalent among Blacks and Hispanics than non-Hispanic Whites (Saffer et al. 2013; Vasquez et al. 2013).

Research has established the relationship between good nutritional habits and improved health. Several studies have related healthy dietary patterns to attenuate decline in cognitive functioning that comes with the aging process (Kesse-Guyot et al. 2012;

Wengreen et al. 2009). For older adults, consuming a healthy variety of recommended foods is an important component of healthy nutrition and is a major recommendation of the 2010 dietary guidelines for Americans (USDA and USDHHS 2010). Racial and ethnic minorities have also been found to engage in less healthy dietary habits compared to Whites (August and Sorkin 2011; Kirkpatrick et al. 2012)

Several organizations in the country have proposed physical activity and dietary recommendations aimed at preventing or reducing mortality and improving overall quality of life. For older adults at risks of falling, evidence has suggested an exercise program which includes moderate intensity muscle-strengthening activities for 30 minutes per session, thrice a week and moderate-intensity walking activities for 30 minutes per session, twice a week will help reduce the risk of falling by about 30% (DHHS 2008b). For older adults with no limiting health condition, the Centers for Disease Control and Prevention (CDC) recommends moderate-intensity aerobic activity (such as brisk walking and pushing a lawn mower) for 150 minutes weekly and muscle strengthening activities (such as heavy gardening and yoga) for at least two days a week (DHHS 2008a). In addition to physical activity recommendations, the 2010 dietary guidelines for Americans also recommends controlling calorie intake to manage body weight, increasing fruit and vegetable intake and eating a variety of vegetables, milk products and protein foods, such as dark-green vegetables, beans, fortified soy beverages, milk, lean meat and eggs. Additional nutrition recommendations for the older population include consuming foods rich in Vitamin B12, such as fortified cereals (USDA and USDHHS 2010).

Major barriers to participation in physical activity and healthy eating for the older population include lack of access to low-cost community-based programs (Prohaska et al.

2006), limited nutritional knowledge (Baker and Wardle 2003; Wardle, Parmenter, and Waller 2000), low motivation (Hughes, Bennett, and Hetherington 2004), functional limitations and built-environmental limitations that could influence assess to healthy food (Kamphuis et al. 2006; French, Story, and Jeffery 2001; Moore, Roux, and Brines 2008). While a single strategy may not be able to reduce all afore-mentioned barriers, primary intervention strategies to improve both physical and nutrition lifestyles in the community include health education and health promotion programs , nutrition education campaigns and low-cost nutrition programs. One such program at the local level is the *Texercise Select.* The *Texercise Select* community-based program follows the physical activity and nutrition recommendations of the CDC and USDA by educating participants on healthy nutritional habits and introducing and encouraging physical activity among older adults.

The primary objective of this chapter is to conduct a cost effectiveness analysis of the *Texercise Select* program by assessing the cost and outcome measures from the program relative to no intervention. Possible racial and ethnic disparities in program effectiveness are also examined. This will be the first study to examine the economic cost – effectiveness analysis of the *Texercise Select* program. Specifically, the objectives of this chapter are to:

- Describe the *Texercise Select* program
- Identify and describe the outcome and cost measures associated with *Texercise Select*.
- Describe and conduct cost effectiveness analyses, and assess racial and ethnic disparities in program effectiveness, if any.

In addition, the conclusive summary makes recommendations on whether a program expansion is worth the investment based on results from the cost effectiveness analysis.

Recommendations will also include possible improvements to the program and assessment instrument.

4.2 The *Texercise Select* Program

Texercise is a health promotion and wellness program developed by the Texas Department of Aging and Disability Services (DADS) for older adults in the state of Texas. The *Texercise Select* community program was an adaptation of the existing state's *Texercise* classic program. It was developed with the primary goal of evaluating and establishing the evidence-base for the on-going *Texercise* health promotion program in terms of reach and effectiveness. The program was administered at various locations in eight counties in Texas - Bell, Robertson, Madison, Brazos, Burleson, Grimes, Washington and Fort Bend[10]. The objectives of the program were to improve participants' knowledge about the value of physical activity and nutrition, increase participants' confidence in their ability to make healthier choices related to physical activity and nutrition, improve participants' mobility and increase the ease of sitting, standing and walking; and provide participants with effective strategies to prevent falling.

The *Texercise Select* was a 12-week program that included two weeks of program recruitment and 10 weeks of interactive classes. Twenty-nine facilitators were trained in four six-hour long one-day sessions. The cost of the program was minimized by holding the class sessions in local facilities such as multi-purpose community facilities, senior centers, faith-based organizations and senior housings. Recruitment was therefore

[10] The *Texercise Select* program was administered by the Healthy Aging Program at the Texas A&M School of Rural Public Health in partnership with Scott and White HealthCare.

influenced by attendance at these local facilities. These local facilities did not charge the program to use their facilities. The first two weeks of the program were used for program recruitment, program presentation to participants and registration of participants while the 10 weeks of classes included twenty 1.5-hours long workshops delivered in the various local facilities. Participants were recruited through a variety of communication channels such as community presentations, flyers and word of mouth. Participants signified their interest in participating in the program.

Each session was structured to provide a variety of activities that were expected to help participants develop healthy behavioral skills in both physical activity and nutrition. The program for physical activity in each session included a 30-45 minute exercise component that focused on building endurance, strength, balance and flexibility. The dietary program focused on teaching participants on healthy eating practices such as incorporation of fruits and vegetables, portion control and healthy cooking. Participants were encouraged to complete daily physical activity and nutrition logs for the first four weeks of the program and set weekly physical activity and nutrition action goals. Individual progress on these action goals were reported at the beginning of each week and possible barriers to making progress on the action goals are identified with helpful suggestions made by facilitators. Each session also included interactive group activities such as group discussions or brainstorming centered on a specific health topic. These activities are expected to help participants develop the knowledge, skills and confidence to resume or increase physical activities and improve nutritional habits crucial to a healthy lifestyle (*Texercise* Facilitator Manual).

4.3 Data and Methods

Program participants were surveyed using self-reported instruments distributed at each workshop location[11]. Identical instruments were distributed at baseline and at follow-up. A total of 220 participants were registered at baseline, with only 132 completing the follow-up assessment (60% completion rate)[12]. It should be noted that some participants treated the program as a "drop in program" at their convenience thereby contributing to the low completion rate because they either attended fewer than recommended classes or missed key baseline and follow-up data. Factors assessed include socio-demographic, health, physical activity and nutrition - related indicators. Socio-demographic characteristics assessed the participant's gender, age, race/ethnicity and level of educational attainment. Health indicators include the participant's body mass index (BMI), healthy days index based on health-related quality of life (HRQOL) measures and the Timed Up-and-Go (TUG) test.

The Centre for Disease Control (CDC) created four core measures to assess HRQOL. These standard HRQOL-4 measures have been included in various household and health surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) (CDC 2014a) and National Health and Nutrition Examination Survey (CDC 2014b). These measures have also been historically used to track the perceived physical and mental health needs of older adults over the years (Moriarty et al. 2005). The first question focuses on self-perceived health. The second and third questions measure physical and mental health

[11] Facilitators provided assistance to participants that needed help filling out the questionnaires.
[12] Of the 132 participants who completed the follow-up assessment, 1 participant was excluded from the economic analysis die to missing data on health outcomes.

and are assumed to be mutually exclusive while the last question incorporates both physical and mental health to assess functional activity limitation (Zullig 2010). The specific HRQOL question set are as follows:

> *Would you say that in general your health is excellent, very good, good, fair or poor?*
>
> *Thinking about your physical health, which includes physical illness and injury, how many days during the past 30 days was your physical health not good?*
>
> *Thinking about your mental health, which includes physical illness and injury, how many days during the past 30 days was your mental health not good?*
>
> *During the past month, how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work or recreation?*

The first question indicates the respondent's self-rating of health status on a scale of 1 to 5, with higher numbers representing worse health. These responses are recoded such that higher values represent better health status (1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent). With the exception of the first question, participant responses ranged from 0 to 30 days. The summary index of unhealthy days is calculated by estimating the total number of days during the past month when the participant reported his or her physical or mental health not good (that is, responses to the second and third questions above are summed, with a maximum cap of 30 days). The healthy days index is then derived by subtracting the number of unhealthy days from 30 days.

The TUG is a measure of the time it takes an individual to rise up from an arm chair, walk 3 meters, turn, walk back and sit down again (Podsiadlo and Richardson 1991). Participants are timed in seconds when performing the TUG activity. The original purpose of the TUG was to test basic mobility skills of older adults and it has been indicated to be a useful index to predict falls or onset of difficulties in activities of daily living (ADL) (Shumway-Cook, Brauer, and Woollacott 2000; Wennie Huang et al. 2010). For *Texercise Select*, the TUG test scores reflects the effectiveness of the program in improving participants' mobility and increasing the ease in mobility functional status of the upper and lower body. A faster time indicates better functional performance. Research has found that a TUG cut-off score of $\geq$ 13.5 seconds identifies older adults at increased risk of falls (Shumway-Cook, Brauer, and Woollacott 2000).

Participants reported the count of chronic health conditions they had ever been diagnosed. Chronic illnesses assessed include diabetes, asthma, chronic obstructive pulmonary disease, high blood pressure, heart disease, cancer, arthritis and other lung conditions. The respondent's level of physical activity and nutritional habits were also assessed. For physical activity, respondents were provided a standard set of description and examples of light (e.g. walking leisurely), moderate (e.g. brisk walking) and vigorous physical activity (e.g. jogging) after which they were assessed on their level of each type of physical activity based on the CDC's recommended physical activity (DHHS 2008b, 2008a). The specific physical activity question from program assessment utilized in this chapter was:

Over the past 7 days, how many days did you do moderate to vigorous physical activity?

For nutritional habits, participants were asked questions assessing their fast food consumption, fruit/vegetable consumption, soda/sweetened drinks consumption based on the CDC's recommendations for older adults. The specific questions were:

Over the past 7 days, how many servings of fruits/vegetables did you eat each day?

Over the past 7 days, how many times did you eat fast food meals or snacks?

Over the past 7 days, how many soda or sugar-sweetened drinks did you drink each day?

In the average day, how many cups of water did you drink each day?

Responses to the physical activity and nutrition-related questions included yes/no response, closed-response, Likert-type scales and open-ended formats.

4.3.1 Cost Measures

The measurement of costs used in this analysis are based on the actual direct costs of implementing the *Texercise Select* program. The total direct cost to deliver the 10-week physical activity and nutrition intervention was $50,474 and corresponded to an average cost of $229 per participant. Where applicable, costs are calculated based on an average of 19 participants per workshop class and per program with the total number of participants (n= 220). For sensitivity analysis, costs are calculated using the maximum and minimum workshop class size. Each cost category is described below:

Cost of program incentive: To encourage program participation, incentives were given to all participants during the program. These incentives include pedometers, handbooks, pledge sheets, resistance bands, t-shirts and certificates. The average price of all incentives was $6.91 per participant (equivalent to $131.29 per workshop class and a total program cost of $1,520.20)[13].

Cost of recruitment and outreach materials: During the program, all facilitators were given a kit containing recruitment materials at the beginning of the *Texercise Select* program. One kit was provided per class. The average cost of the kit was $8.19 per workshop class which is equivalent to a cost of 43 cents per participant (and a total program cost of $94.60).

Personnel cost: Facilitators' cost is calculated as hours worked multiplied by the cost per hour. Twenty-nine individuals were trained to facilitate the intervention program. The total estimated hours worked by each facilitator was 72 hours. This includes the time spent on program awareness, recruitment of participants, planning, preparing and conducting each class session. The first two weeks of the 12-week program was assigned to program recruitment, program presentation and registration of participants. A one-day 6-hour training was conducted for facilitators. Recruitment time was 3 hours per week (equivalent to a total of 6 hours for two weeks). Estimated time for preparing for each class was 1.5 hours per session (equivalent to a total of 30 hours for 20 class sessions). Class preparation time takes into account the time spent setting-up/tearing down workshop materials and time

[13] Here, total cost refers to the cost for all 220 participants in all eight counties.

spent on questions & answers after each session. Finally, during the 10 weeks, sessions were held twice a week for 90 minutes each (equivalent to 30 hours for 10 weeks).

However, since all facilitators were voluntary participants with no expected monetary earnings from participation, the value of volunteer time is therefore calculated using the independent sector value of volunteer time[14]. This value of volunteer time is the average wage of non-management, non-agricultural workers for Texas, extracted from the Bureau of Labor Statistics. It is updated annually to reflect current price indices. It should be noted that the value of volunteer time is based on the volunteer work and not on the volunteer's actual earning power or specialized skill. The independent sector's value of volunteer time in Texas in 2013 was $23.40. Total estimated cost for each facilitator was therefore $1684.80 and a total cost of $48, 859.20 for all 29 facilitators. This is equivalent to a per-participant personnel cost of $222.09. Sensitivity analysis is also conducted by using the average hourly wage rate of community and social service occupational group for the Bryan-College Station area to calculate the value of volunteer time, $20.01 in May 2013 (Bureau of Labor Statistics 2013).

Cost of participant time and travel cost of facilitators were excluded from cost analyses. The cost of participant time is usually measured by estimating the opportunity cost of participating in the program. Such costs can include forgone wages and value of leisure time. However, these are excluded because this analysis assumes the value of forgone wages will tend towards zero given the older age group of the participants. In other

[14] The independent sector value of volunteer time for 2013 was extracted from https://www.independentsector.org/volunteer_time (Last accessed 04/01/2014)

words, the participants may otherwise have been inactive and retired. The value of leisure time is also excluded given the difficulty in estimating such time for this age-group. This analysis also excludes the travel cost of facilitators as it was not available, and it also assumed to be minimal. In addition, this estimated cost also ignores economies of scale that could result from trained facilitators training other facilitators.

Costs are not discounted due to the short time horizon of the program. Costs are generally discounted in studies with a time horizon longer than one-year (Drummond and Jefferson 1996).

4.3.2 Outcome Measures

This chapter focuses on two categories of outcomes for cost effectiveness calculations - Quality adjusted life year (QALY) and selected physical activity and health related outcomes.

QALY outcome: The conventional and commonly used QALY in cost effectiveness analyses combines gains from reduced morbidity and mortality into a single measure ranging from 0 to 1, where a weight of 1 corresponds to perfect health and a weight of 0 corresponds to a state of health equivalent to death (Weinstein et al. 1996; Whitehead and Ali 2010). QALY is expressed in terms of "years lived in perfect health". In other words, it is assumed that a year of life lived in perfect health is worth 1 QALY and a year of life lived in a state of less than this perfect health is worth less than 1[15]. The number of QALY

[15] For example, 0.5 QALYs indicates half a year lived in perfect health.

gain from a program is estimated by multiplying the preference based or utility values induced by the program by the duration of the program. Unlike the non-preference based CDC healthy days measure included in the *Texercsie Select* assessment, QALYs can be calculated from preference based HRQOL measure, such as the EuroQol 5D (EQ-5D) scores (Jia et al. 2011).

The EQ-5D is a preference based measure of health status consisting of a descriptive system and visual analogue scale. Cost effectiveness analyses focuses on the descriptive system, which assesses health in five categories – mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each category is assessed with 3 levels – no problem, some problems and severe programs. The descriptive system health measures are converted to a single summary index by attaching weights to each level in each category and deducting the weights from 1, the value for full health (Cheung, Oemar, Oppe, & Rabin, 2009)

The non-preference based healthy days measures utilized in the program assessment are therefore converted to preference-based EQ-5D scores using a methodology proposed by Jia and Lubetkin (2008)[16]. Jia and Lubetkin (2008) estimated EQ-5D scores from healthy days by matching the cumulative distributions of the healthy days and the EQ-5D scores from the BRFSS and the Medical Expenditure Panel Survey (MEPS), with the assumption that both surveys are comparable and will therefore have similar average scores of HRQOL if the same HRQOL measure was used. In this chapter, EQ-5D utility

[16] Detailed description of the estimation method can be found in Jia and Lubetkin (2008).

scores corresponding to the number of healthy days and age category are derived for each participant using Jia and Lubetkin's (2008) estimates.

The resultant EQ-5D scores are further used to calculate QALYs using the area under the curve approach, where the total study period is divided into time intervals corresponding to the number of follow-up assessments and each interval is weighed by the individual's utility (EQ-5D) scores during that period of time (Manca, Hawkins, and Sculpher 2005). With the assumption that the individuals' utility are neither missing nor censored, QALYs can be calculated as shown below:

$$Incremental\ QALYs = \sum_{t=1}^{n} \frac{Q_t + Q_{t+1}}{t+1}.\ D_t \qquad (1)$$

Q_t in (1) represents the individuals' EQ-5D scores during period t (at baseline) and D_t is the time duration for period t (= 2.5 months in this analysis) usually expressed as a fraction of twelve months (Manca, Hawkins, and Sculpher 2005). n represents the number of time intervals or follow-ups (= 1 in this analysis). Average EQ-5D scores for all participants in this analysis are substituted for Q_t and Q_{t+1} respectively. For example, for a respondent with estimated EQ-5D score at baseline and post-intervention of 0.811 and 0.883 respectively:

$$Incremental\ QALY = \left[\frac{0.811 + 0.883}{2}.\frac{2.5}{12}\right] = 0.176 \qquad (2)$$

Physical activity and health-related outcomes: Program effectiveness is also measured with three physical activity and health-related outcomes. The first outcome is the number of users who reported an improvement in healthy days. The second is the number of users who reported an increase in the days engaged in moderate to vigorous physical activity for each week. This outcome indicates the effectiveness of the program in improving knowledge about and promoting physical activity. The third outcome is the number of participants who reported an improvement in TUG test scores. All three outcomes collectively access quality of life among participants from baseline to post-intervention.

4.3.3 Economic Analysis

Cost effectiveness analysis is a major criterion when deciding whether resources should be allocated to preventive health interventions. Such analyses help inform policy makers or decision makers about the value of a particular health intervention or program by comparing the outcomes and costs of alternative programs. Cost effectiveness analyses has been used in previous research on older adults to evaluate interventions such as fall prevention programs (Frick et al. 2010) and community-based exercise programs (Foley, Hillier, and Barnard 2011; Munro et al. 2004). Health outcomes in cost effectiveness analyses range from non-monetary but quantifiable intermediate outcomes, such as number of unhealthy days averted and number of individuals who reported a specific improvement in health, to more distal outcomes such as QALY (Weinstein et al. 1996). The QALY is however the most common and comprehensive effectiveness measure used in cost effectiveness analyses. Program costs are valued in monetary terms.

Cost effectiveness deals with comparing the difference in costs and outcomes between interventions through the calculation of an incremental cost effectiveness ratio (ICER). The ICER compares the difference in costs between two mutually exclusive interventions to the difference in effectiveness between the interventions as shown below:

$$ICER = \frac{C_i - C_0}{E_1 - E_0} \tag{3}$$

Here, C_i represents the cost of the program of study while C_0 is the cost of the default program. Similarly, E_1 and E_0 represents the effectiveness of the program of study and default program respectively. The default program is usually the next best alternative. The ICER can also be described as the ratio of incremental costs to incremental outcomes (say, QALY). The incremental cost is the difference between the average cost of the intervention and the average cost with no intervention. Similarly, incremental QALYs represents the difference between the gained QALY from the program and the gained QALY with no intervention (Roux et al. 2008; Cellini and Kee 2010). ICER is the most widely used technique for cost effectiveness analyses.

This cost effectiveness analysis is conducted from a societal perspective with all relevant costs and effects being measured. Program effectiveness is assessed using QALY, healthy days, days engaged in physical activity each week and TUG test scores. In this chapter, the default alternative is a do-nothing or no-intervention option hence there is zero average cost for the alternative option. In this default alternative, participants are assumed to go about their daily activities and nutrition routine like they were before the program

implementation. In other words, C_0 and E_0 are assumed to be zero indicating that the numerator represents the average cost for implementing the *Texercise Select* and the denominator represents the specific outcome measure.

Cost effectiveness analysis with QALY outcome: The cost effectiveness ratio with QALY outcome of the *Texercise Select*, relative to no intervention alternative, is calculated by dividing the average cost by the average QALYs gained as shown below. The ratio will indicate the cost per QALY gain.

$$ICER = \frac{Average\ cost\ per\ participant\ - \$0}{QALYs\ gained\ - 0} \quad (4)$$

Cost effectiveness analysis with selected health outcomes: Here, cost effectiveness ratios are calculated by dividing the average cost by each non-monetary unit of the three selected physical activity and health-related outcomes. For the healthy days outcome, the ratio will indicate the cost required for one individual who reported an improvement in healthy days. For the physical activity outcome, the ratio will indicate the cost required for an individual who reported an increase in the days engaged in physical activity each week. Finally, the cost effectiveness ratio with the TUG outcome will indicate the cost required for one individual who reported an improvement in TUG scores as a result of the program.

$$ICER = \frac{Average\ cost\ per\ participant\ - \$0}{Units\ of\ outcome\ - 0} \quad (5)$$

4.4 Results

Baseline and follow-up (where applicable) sample characteristics of the respondents are presented in Table 3.1. Analysis were based on matched baseline and follow-up assessments. The average age of respondents was 75 years. Females and non-Hispanic Whites constituted the largest percentage of the respondents, 84% females and 79% non-Hispanic Whites. Eight percent of the respondents were Hispanics and 13% were Blacks. Forty percent of the sample were married. The average number of chronic conditions and self-rated health reported at baseline was 2.40 and 3.02 respectively. Follow-up statistics are presented for select time-invariant variables. There was a significant increase in self-rated health from 3.02 to 3.28 at follow-up, indicating that respondents rated health higher at the completion of the program. A positive and significant change in TUG scores was also reported at follow-up. TUG scores decreased from 13.03 seconds to 11.53 seconds at follow-up indicating improved functional performance at program completion. There was also a significant and positive change in all physical activity and nutrition-related assessments. Physical activity days in a week increased from 2.8 to 4 days at follow-up. Fast food consumption days in a week declined from 2 days to 1.8 days, fruits/vegetable servings in a week increased from 3.3 days to 3.7 days while daily cups of water consumed increased from 5.5 cups to 6.03 cups.

Descriptive statistics of the HRQOL measures for the overall sample are presented in Table 4.2. Respondents reported approximately 20 healthy days at baseline and estimated average EQ-5D score was 0.75 at baseline. Follow-up statistics reveal a significant increase in both measures at program follow-up, 23 healthy days and 0.77 average EQ-5D scores. Higher EQ-5D values corresponds to a better health state thus

indicating the positive impact of the *Texercise Select* in improving health. Some participants treated the program as a "drop in program" and therefore missed key baseline or follow-up data. Further analysis of attrition revealed that respondents with lower healthy days were less likely to complete the program. No other significant differences existed between the program completers and non-completers.

Table 4.3 presents summary statistics for healthy days and corresponding EQ-5D scores by socio-demographic characteristics at baseline and follow-up. Significant differences also existed in EQ-5D scores by socio-demographic characteristics, both at baseline and follow-up. On average, females reported more healthy days and had higher EQ-5D scores compared to male, both at baseline and follow-up. For racial and ethnic categories, Blacks and non-Hispanic Whites had significant improvement in healthy days and EQ-5D scores from baseline to the follow-up period. The statistics however showed that Hispanics had a decline in healthy days at follow-up. This indicates that the *Texercise* exercise program improved overall health for Blacks and non-Hispanic Whites.

Table 4.4 details the cost analyses of the *Texercise Select* program. The average cost per participant was $229 while total program cost for all participants in all counties was $50,474.

Cost effectiveness ratios for the *Texercise Select* program are presented in Table 4.5. Cost effectiveness ratios are calculated for each measure of outcome for both the overall population and for each racial and ethnic group. The corresponding QALY gained are presented for each category. The average QALY gain of 0.159 for the overall population resulted in an incremental cost per QALY gain of $1,443. This ratio is lower when compared to the common cost-effectiveness threshold of $50, 000 for a gained

QALY and also in comparison to other health promotion interventions. Munro et al. (2004) reported an incremental cost per QALY of £17,174 (corresponding to $26,373) for a community-based exercise program for the older population. Eriksson et al. (2010) estimated a cost per QALY gain ranging from $1,668 to $4,813 of an health intervention that consisted of similar group-based physical activity trainings and nutrition counselling. Comparing cost per QALY across all three racial and ethnic groups, cost effectiveness ratios indicated that it will cost more to achieve a QALY gain for non-Hispanic Whites compared to Blacks and Hispanics. Specifically, the average QALY gain of 0.158, 0.167 and 0.160 for non-Hispanic Whites, Blacks and Hispanics resulted in a cost per QALY gain for $1,452, $1,374 and $1,434 respectively. Thus, in comparison to an alternative strategy of no program, a physical activity and nutrition program such as the *Texercise Select* will require an investment ranging from $1,374 - $1,452 for each QALY gain.

Cost effectiveness ratios with the healthy days outcome ranged from $6 - $76 to achieve each individual improvement. Similarly, cost effectiveness ratios with the weekly physical activity and TUG outcomes ranged from $3 - $57 and $7 - $76 respectively. Results revealed that it will cost more to achieve each individual improvement in healthy days, days of physical activity each week and TUG scores for Hispanics and Blacks, compared to non-Hispanic Whites. This however could be attributed to the small number of Hispanics and Blacks in the final sample. Non-Hispanic Whites constituted the largest percentage, 79%, of the population.

To determine the robustness of the final results, sensitivity analyses are conducted by varying the workshop class size and calculating the value of volunteer time with the average hourly wage rate of community and social service occupational group for the

Bryan-College Station area. The class size of the program is varied by using the maximum class size of 25 participants and the lowest class size of 4 participants. Results stand up to all parameter variations as cost effectiveness ratios are comparable to the initial ratio. Using the maximum class size lowered the ICER to $1,442 while using the minimum class size increased the ICER to $1,453 per QALY gained. Finally, re-estimating the value of volunteer time lowered the ICER to $1,241 per QALY gained.

4.5 Discussion

This is the first attempt to evaluate the cost-effectiveness of the *Texercise Select* program. Thus, it adds to the literature on cost effectiveness of heath interventions for the older population. Program effectiveness was measured using QALY gained as well as health outcomes such as healthy days, physical activity days and Timed Up-and-Go (TUG) test scores. Preference-based (EQ-5D) scores are estimated from the number of healthy days reported by participants and converted into QALYs.

The average cost of the intervention per participant was $229. This cost appears to be inexpensive compared to similar one-time short time-horizon interventions to improve physical activity and prevent falls among older population. Timonen et al. (2008) reported an average cost of 568 EUR (corresponding to $636) per participant for a 10-week group-based exercise program to improve physical fitness and functional abilities in frail elderly women who had after discharge from hospital. Similarly, Rizzo et al. (1996) reported an average cost of $905 per participant for a fall-prevention program for an older community population. It should also be noted that volunteer cost constituted over 96% of the total program cost. Thus, policy-makers and health agencies considering the implementation of

the *Texercise Select* program may not have to pay the volunteer portion of the total cost out of pocket.

Results reveal the *Texercise Select* program to be cost-effective as the cost-effectiveness ratio ranged from $1,374 - $1,452 per QALY gain which is much lower when compared to the common cost-effectiveness threshold of $50, 000 and also in comparison to other health promotion interventions. Given the cost-effectiveness of the program, this chapter recommends an expansion of the program within the same counties and in other counties as well. However, some possible amendments may be helpful to ensure that observed positive changes in individual physical activity and nutrition choices are sustained in the long run and to help ensure a more robust future cost effectiveness analysis. For example, rather than a single follow-up at the end of the program, a detailed follow-up could also be conducted on all participants at the six-month and twelve-month period after program completion.

Further analyses on other physical activity and nutrition indicators at follow-up compared to baseline also indicated the positive effects from the program as participants showed a reduction in BMI, increased days of moderate to vigorous physical activity, increased fruit/vegetable intake, reduced fast food consumption and increased daily water intake. Overall, the positive outcomes from the *Texercise Select* could indicate that physical activity and nutrition-related interventions may be more beneficial if they are supervised in an organized setting or if a support system is available. Developing health promotion programs for older adults has raised concerns because of the perception that older adults may have difficulties following the physical activity and nutrition lifestyle changes after the intervention program ceases (Chernoff, R. 2001). Older adults may

require continuous collaborative partnership between the individual and a support system (facilitators) to ensure adherence to healthy lifestyle changes or plans.

Thus, in order to ensure long-term adherence to the positive lifestyle changes, a recommendation of this chapter in terms of future retention strategies is to encourage and ensure participants keep self-check sheets for a longer period of time after the program ends (six months and twelve months). In addition, participants could also be required to provide a monthly update on action goals or plans to assigned individual facilitators. Another beneficial amendment to the Texercise Select program is creating a control group in addition to the intervention group, where respondents in the control groups are provided general written and/or verbal information on required exercise and nutritional habits at baseline with no further on-site workshops or supervision. This could help estimate a better and more detailed cost effectiveness analyses where cost effectiveness ratios are estimated for the intervention group and compared with the control group. Pre and post-program program instruments could also be improved by including preference-based health measures in the assessment instrument, such as the EQ-5D health states. This will help eliminate any possible uncertainties from converting the non-preference CDC healthy days measure to preference based EQ-5D measures, in trying to calculate QALYs.

This cost effectiveness study is however not without its limitations. Some observed outcomes may be the results of other programs or events other than the one being analyzed. In addition, this analysis could be underestimating the total costs of the program as health care costs which might be avoided are not included in cost calculations. In addition, estimates of disease incidence avoided are not included. Both estimates are excluded due to the short time frame of the program. This analysis took a parsimonious

and conservative approach by assuming the short time–period of the *Texercise Select* program may not result in any significant savings in health care costs or reduction in disease incidence. Any cost underestimation, if any, will therefore be minimal and may not have a significant influence on these cost effectiveness results.

4.6 Conclusion

This analysis is clearly a limited analysis comparing the costs and outcomes of a physical activity and nutrition program for the older population. However despite the limitations, this is still the first cost-effectiveness analysis of an intervention focused on improving both physical activity and nutritional habits among the older population in Texas. Basic cost effectiveness analyses are conducted by comparing the actual direct costs of the Texercise Select program to the QALY gain and to other outcomes, the estimated number of respondents who reported an improvement in healthy days, days of physical activity each week and in TUG scores.

In addition, despite the conservative assumptions and the non-rigorous methodology, the observed significant health benefits from the program provides evidence of the benefits of physical activity and good nutritional habits in older people. The increasing life expectancy and the shift towards an older population has increased the need for maintaining or improving the health of the older population (Census Bureau 2014). Health policy-makers could therefore consider the potential of such (similar) programs in improving health and promoting healthy habits among this rapidly-increasing group in the population. This chapter helps provide an understanding of the financial resources needed to implement such a program and thereby help in achieving the CDC Healthy People 2020

objective of *"reducing the proportion of older adults who have moderate to severe functional limitations"* and *"increasing the proportion of older adults with reduced physical or cognitive function who engage in leisure-time physical activities"*(DHHS *2012).*

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Table 4. 1 Descriptive Statistics – baseline and follow-up

Variables	Baseline Mean (S.E)	Follow-up Mean (S.E)	Significance
Time-invariant variables			
Age (in years)	74.70 (8.41)		
Female (%)	84.09		
Non-Hispanic White (%)	79.07		
Hispanic (%)	7.75		
Blacks (%)	13.18		
Married (%)	40.45		
Education	3.61 (1.09)		
Number of Chronic conditions	2.40 (1.46)		
Time-varying variables			
TUG	13.03 (5.19)	11.53 (4.38)	***
Self-rated health (1 – 5)	3.02 (0.89)	3.28 (0.94)	***
Physical Activity days	2.79 (2.14)	3.96 (1.79)	***
Fast food consumption	2.03 (1.62)	1.80 (1.55)	*
Fruits/Vegetables consumption	3.34 (1.42)	3.70 (1.24)	**
Soda consumption	1.06 (1.34)	0.98 (1.29)	
Water consumption	5.49 (1.99)	6.03 (1.84)	**

N = 131. Standard errors in parentheses. Significance level: *** p<.01; **p<.05; *p<.10. QALY represents Quality adjusted life year (QALY), TUG represents Timed Up-and-Go and EQ-5D represents EuroQol scores. Source: *Texercise Select* data 2013.

Table 4. 2 Descriptive Statistics – HRQOL measures

HRQOL measures	Baseline Mean (S.E)	Follow-up Mean (S.E)	Significance
Healthy days (0 – 30)	20.27 (12.13)	22.71 (10.99)	**
EQ-5D (0-1)	0.75 (0.17)	0.77 (0.16)	*

N = 131. Standard errors in parentheses. Significance level: *** p<.01; **p<.05; *p<.10 Source: *Texercise Select* data 2013.

Table 4. 3 HRQOL measures by socio-demographic characteristics

Variables	Healthy days		EQ-5D	
	Baseline	Follow-up	Baseline	Follow-up
Sex				
Female	21.14 (11.57)	23.51 (10.24)	0.76 (0.17)	0.78 (0.14)
Male	15.67 (14.15)	18.48 (13.82)	0.70 (0.20)	0.72 (0.20)
Race and Ethnicity				
Non-Hispanic White	20.20 (12.22)	22.84 (11.02)	0.75 (0.17)	0.77 (0.15)
Hispanic	22.60 (10.10)	21.30 (11.68)	0.76 (0.13)	0.76 (0.17)
Blacks	21.35 (12.05)	25.12 (8.45)	0.78 (0.17)	0.82 (0.12)

N = 131. Standard errors in parentheses. EQ-5D represents EuroQol scores. Source: *Texercise Select* data 2013.

Table 4.4 Costs

	Per participant ($)	Per program ($)
Incentives [a]	6.91	1520.20
Recruitment and Outreach [b]	0.43	94.60
Personnel [c]	222.09	48,859.20
Total	229.43	50,474

Total program costs are calculated using a total participant number of 220. Full description of how each cost is estimated is available in the text. [a] Includes pedometers, handbooks, pledge sheets, resistance bands, t-shirts and certificates. [b] Cost was provided per class therefore per participant cost is calculated using an average class size of 19 participants. [c] Includes time spent on program awareness, participant recruitment, planning, preparing and conducting *Texercise* classes.

Table 4.5 Cost-effectiveness ratios

	Outcome	Cost-effectiveness ratio
Overall:		
QALY[a]	0.159	1,442.96
Healthy days (#)	50	4.59
Physical activity (#)	82	2.80
Timed Up-and-Go (#)	88	5.34
By racial and ethnic grouping:		
Non-Hispanic Whites		
QALY[b]	0.158	1,452.09
Healthy days (#)	39	5.88
Physical activity (#)	68	3.37
Timed Up-and-Go (#)	70	7.40
Blacks		
QALY[c]	0.167	1,373.83
Healthy days (#)	7	32.78
Physical activity (#)	9	25.49
Timed Up-and-Go (#)	9	28.68
Hispanics		
QALY [d]	0.160	1,433.94
Healthy days (#)	3	76.48
Physical activity (#)	4	57.36
Timed Up-and-Go (#)	7	76.48

Note: Cost effectiveness ratio = average cost/outcome measure. Non-Hispanic Whites N = 102, Blacks N = 17 and Hispanics N = 10. # signifies the number of participants who reported an increase in the outcomes.

a Incremental QALY overall = [(0.749 + 0.773) / 2 * 2.5/12 = 0.159]

b Incremental QALY overall = [(0.747 + 0.773) / 2 * 2.5/12 = 0.158]

c Incremental QALY overall = [(0.779 + 0.823) / 2 * 2.5/12 = 0.167]

d Incremental QALY overall = [(0.775 + 0.757) / 2 * 2.5/12 = 0.160]

Chapter 5: Concluding Remarks

5.1 Dissertation Summary

This dissertation presented three studies exploring racial and ethnic disparities in health outcomes among the aging population. Chapters 2 and 3 examined racial and ethnic disparities, and the impact of health and health-related behavioral factors on the valuation of health and on the trajectories of functional limitations among older adults. The fourth chapter was a cost effectiveness analysis of a sample health intervention program to help improve functional health, nutritional habits and overall quality of life among the older population. As proposed by the International Classification of Functioning, Disability and Health model which was the framework for this dissertation, overall results from this dissertation also indicate the significance of health conditions and health-related behavioral factors in determining health and functioning both at the individual and community level. The specific findings from each chapter are summarized below.

Using the Health and Retirement Study (HRS) data, Heckman model results from Chapter 2 reveal that minorities are more likely to have a positive WTP than non-Hispanic Whites. However, WTP for minorities is found to be significantly lower than for non-Hispanic Whites. Specifically, results show that minorities are 26-30% more likely to want to pay a positive amount for improved health but their average WTP is 70% - 97% lower than for non-Hispanic Whites. However, when compared with non-Hispanic Whites, WTP for minorities constitute a higher percentage of household income (23% for minorities and 14% for Whites). Further analyses however reveal this result possibly only holds for the lower income groups with household income less than $25,000. For the middle and high

income categories, median WTP for minorities in both absolute and relative terms is lower that of Whites in the same categories. In addition, as proposed by the International Classification of Functioning, Disability and Health model, the importance of health conditions is also indicated by the model results. In particular, while health-related behaviors do not affect WTP for improved health, current morbidity or current health conditions affects whether or not an individual will have a positive WTP for improved health. Older adults with a previous diagnosis of cancer and lung diseases are more likely to have a positive WTP for improved health. This indicates that perhaps cancer and lung disease health interventions could be the most valued among older adults.

Using a 17–year longitudinal data from the HRS and a latent growth model analysis, model results from the third chapter reveal that Blacks and Hispanics are more likely to have functional limitations at the initial time period than non-Hispanic whites. However net of educational attainment and wealth, a "racial crossover" is observed in the baseline odds of functional limitations, where Whites are found to have a higher level of functional limitations compared to both minority groups. In addition, non-Hispanic Whites tend to have faster increases in the rate of change in functional limitations over time. Results also demonstrate the International Classification of Functioning, Disability and Health's model of health conditions and behavioral factors as determinants of functioning and disability. In particular, model results indicate that observed racial and ethnic disparities in functional health derive from racial/ethnic differences in health status and health-related risk factors. Smoking and being overweight/obese is associated with the onset of functional limitations in White and Black older adults. Also, Whites who are light drinkers had lower functional limitations at onset.

Cost effectiveness ratios for the *Texercise Select* program in Chapter 4 ranged from $1,374 - $1,452 per QALY gained, relative to no intervention. Results indicate that the *Texercise Select* program is a cost-effective strategy for increasing physical activity and improving healthy nutrition practices among the older population as compared to cost effectiveness ratios from other health promotion interventions and also in comparison to the common cost-effectiveness threshold of $50, 000 for a gained QALY. In addition, overall health was improved as significant improvement was observed in healthy days, physical activity, healthy nutritional habits and TUG scores from baseline to the follow-up period. This dissertation therefore supports the use of the *Texercise Select* program to improve physical activity and nutritional habits among the older population.

Overall findings from this dissertation provide evidence that willingness to pay for improved health varies systematically and significantly by disease type or morbidity. However, the same cannot be said for racial and ethnic groups as effects could depend on income categories and possibly, the choice of either relative or absolute effects. This dissertation also provides evidence that public health programs aimed at reducing or eliminating racial and ethnic disparities in health status and health-related risk factors are necessary foundations for minimizing or eliminating racial and ethnic disparities in functional health status and for improving functional health among older adults. In addition, public health programs interventions to promote physical activity, maintain normal body weight and reduce other risky health behaviors (such as smoking) implemented at the community level (like the *Texercise Select*) will also help improve both functional health and overall quality of life of the older population. Thus, ensuring that baby boomers age successfully. Specifically, these findings are of great importance to

achieving the Healthy People 2020 objectives of the DHHS especially as it relates to older adults. Two of these objectives are to "*Reduce the proportion of older adults with moderate to severe functional limitations*" and "*Increase the proportion of older adults who engage in light, moderate or vigorous physical activities*" (DHHS 2012).

5.2 Future Research

The findings and model results from this study invites future research on health of the older population. Future research in the WTP for improved health analysis could consider the impact of current diagnosis of each chronic condition on the individual's WTP rather than the lifetime diagnosis. Even though the HRS data utilized in this dissertation did not permit such analysis, the current diagnosis is important given that health status of some respondents previously diagnosed with illnesses may have improved with consistent usage of prescribed treatments and drugs.

Future research in the functional limitations analysis might also improve on the presented analysis by examining the association between each chronic illness with the level and trend of functional limitations rather than on the cumulative chronic count. Such knowledge will help provide more information about which specific chronic condition has the highest impact on functional limitations. It is also important to note the possibility of endogeneity bias in the relationship between body mass index and functional limitations. In other words, the observed overweight/obese body mass index categories found to be significant predictors of functional limitations in non-Hispanic Whites and Blacks could be the result of the individual's level of functional limitations. Thus, future research could take this possibility into consideration by modeling body mass index as a time-varying

predictor for the initial level and rate of change of functional limitations. Such possible causality problems can also be resolved by using other analytical techniques such as the instrumental variables (IV) regression technique.

Finally, in the cost effectiveness analysis, it is expected that incorporating long-time retention strategies can provide a better and more robust cost effectiveness analysis of the program. For example, rather than a single follow-up at the end of the program, a detailed follow-up assessment could also be conducted at the six-month and twelve-month period after program completion. The WTP framework can also be incorporated into the *Texercise Select* program assessment by examining older adults' willingness to pay for such specific public health interventions aimed at improving functional health and overall quality of life.

Appendix: Stata and Mplus codes

A.2 Chapter 2 Stata codes

```
clear
set more off
cd H:\Chapter2
use H00M_R
keep HHID PN G7132 G7133 G7134 G7135 G7136 G7137 G7138 G7139
compress

gen long hhidpn = real(HHID + PN)
sort hhidpn
save healthvaluation, replace

clear
use rndhrs5k.dta
keep hhidpn  rawtsamp r5agey_e r5mstat inw5 rahispan raracem ragender raedegrm ///
          r5shlt  r5vigact r5hlthlm r5smokev r5smoken r5drink  r5drinkn r5hibpe r5diabe ///
           r5cancre  r5lunge  r5hearte  r5stroke h5itot h5atota r5liv75 r5liv10 ///

compress
sort hhidpn
merge 1:1 hhidpn using healthvaluation
keep if inw5==1
drop _merge
save rand2000, replace

*********************************************************************************
**********************************

/*Edit and rename*/
clear
use rand2000

gen marital=1 if r5mstat<=2
replace marital=0 if r5mstat>=3

rename r5agey_e age

rename rahispan hispanic
rename raracem ethnic
gen minrace= 1 if  ethnic>=2 & ethnic<=3
replace minrace= 0 if  ethnic==1
replace minrace= 1 if  hispanic==1
label var minrace "Minorities"

gen female=ragender==2
```

```
rename raedegrm education
tab education

gen degree=1 if educ==0
replace degree=2 if educ==1|educ==2|educ==3
replace degree=3 if educ>=4

rename r5shlt selfratehealth
recode selfratehealth (1=5) (5=1) (2=4) (4=2)


/*RISKY HEALTH BEHAVIOURS*/
*Tobacco consumption
rename r5smoken tobacco

*Alcohol Consumption
rename r5drink alcohol

/*HEALTH STATUS*/
rename r5hibpe hbp
rename r5diabe diabetes
rename r5cancre cancer
rename r5lunge lung
rename r5hearte heart
rename r5stroke stroke

/*Income*/
rename h5itot income
gen income1 = income/1000

gen incomecategory = 1 if income< 25000
replace incomecategory = 2 if income >= 25000 & income < 65000
replace incomecategory = 3 if income >=65000


*************************************************************************************
**********************
/*WILLINGNESS TO PAY CODING*/

*Selection WTP
*First general question
replace G7132=. if G7132>=8
gen wtp4health=1 if G7132==1
replace wtp4health=0 if G7132==5
sum wtp4health

*Outcome WTS
*Max WTP  (Open-ended) - Untrimmed
rename G7133 oe
replace  oe=. if  oe>=9999998
```

```
replace  oe= .5 if  oe==0
gen loe = ln(oe)
sum oe loe

*Max WTP  (Open-ended) - Trimmed
gen trimoe = oe
replace trimoe = .05*(income) if oe>.05*(income) & oe!=.
replace trimoe=.5 if trimoe==0
gen ltrimoe= ln(trimoe)
sum trimoe ltrimoe

*Transforming Dichotomous choice to Open-ended
rename G7134 wtp1000
rename G7135 wtp200
rename G7136 wtp50
rename G7137 wtp500
rename G7138 wtp2000
rename G7139 wtp5000

replace wtp1000=. if wtp1000>=8
replace wtp1000=0 if wtp1000==5

replace wtp200=. if wtp200>=8
replace wtp200=0 if wtp200==5

replace wtp50=. if wtp50>=8
replace wtp50=0 if wtp50==5

replace wtp500=. if wtp500>=8
replace wtp500=0 if wtp500==5

replace wtp2000=. if wtp2000>=8
replace wtp2000=0 if wtp2000==5

replace wtp5000=. if wtp5000>=8
replace wtp5000=0 if wtp5000==5

gen wtp=5000 if wtp5000==1
replace wtp=2000 if wtp5000==0&wtp2000==1&wtp1000==1
replace wtp=1000 if wtp1000==1&wtp2000==0
replace wtp=500 if wtp500==1&wtp200==1&wtp1000==0
replace wtp=200 if wtp500==0&wtp200==1&wtp1000==0
replace wtp=50 if wtp50==1&wtp200==0&wtp1000==0
replace wtp=0 if wtp50==0&wtp200==0&wtp1000==0

*DC+OE WTP - Untrimmed
gen dcoe=oe if oe<=1000000
replace dcoe=wtp if oe>=9999998
replace dcoe= .5 if dcoe==0
gen ldcoe =ln(dcoe)
```

```
*DC+OE  WTP - Trimmed
gen trimdcoe  = dcoe
replace trimdcoe  = .05*(income) if dcoe>.05*(income) & dcoe!=.
replace trimdcoe=.5 if trimdcoe==0
gen ltrimdcoe = ln(trimdcoe )
sum trimdcoe ltrimdcoe

*Minorities
sum wtp4health oe trimoe dcoe trimdcoe if minrace==1

*Non Hispanic Whites
sum wtp4health oe trimoe dcoe trimdcoe if minrace==0

*For Minorities
sum  hbp diabetes cancer lung heart stroke tobacco alcohol nophyact selfratehealth income1 education age minrace female marital if minrace==1

*For non-hispanic Whites
sum  hbp diabetes cancer lung heart stroke tobacco alcohol nophyact selfratehealth income1 education age minrace female marital if minrace==0

**********************************************************************************
**************************************************

/*REGRESSIONS*/
est clear

*ANNUAL WTP AS A PERCENTAGE OF ANNUAL HOUSEHOLD INCOME

*first calculate annual WTPs
gen annualoe = oe*12
gen annualtrimoe = trimoe*12
gen annualdcoe= dcoe*12
gen annualtrimdcoe = trimdcoe*12

*next calculate wtp as a percentage of income
gen annualoeper = annualoe/income
gen annualtrimoeper= annualtrimoe/income
gen annualdcoeper = annualdcoe/income
gen annualtrimdcoeper = annualtrimdcoe/income

sum annualoeper annualtrimoeper annualdcoeper annualtrimdcoeper
sum annualoeper annualtrimoeper annualdcoeper annualtrimdcoeper if minrace==1
sum annualoeper annualtrimoeper annualdcoeper annualtrimdcoeper if minrace==0

**********************************************************************************
**********************************************
 HECKMAN WTP Estimations
```

```
*Model 1- Outcome, Selection, Open ended only, No trim  = maxoe
heckman loe minrace hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol ///
        income1  degree age female marital  ///
         , select(wtp4health = minrace selfratehealth  hbp diabetes cancer lung heart stroke tobacco
alcohol income1 age marital degree female )  vce(robust) level(90)
eststo model1

*Model 2- Outcome, Selection, Open ended only(maxdollars), Trim = trimmaxoe
heckman ltrimoe minrace hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol ///
        income1  degree age female marital ///
         , select(wtp4health = minrace selfratehealth hbp diabetes cancer lung heart stroke tobacco
alcohol income1 age marital degree female )  vce(robust) level(90)
eststo model2

*Model 3- Outcome, Selection, Open ended + DC (maxwtp),No  Trim  = maxdcoe
heckman ldcoe minrace  hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol ///
         income1  degree  age female marital ///
        , select(wtp4health = minrace selfratehealth  hbp diabetes cancer lung heart stroke tobacco
alcohol income1 age marital degree female )  vce(robust) level(90)
eststo model3

*Model 4- Outcome, Selection, Open ended + DC (maxwtp), Trim  = trimmaxdcoe
heckman ltrimdcoe  minrace hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol ///
         income1  degree  age female marital ///
         , select(wtp4health = minrace selfratehealth  hbp diabetes cancer lung heart stroke tobacco
alcohol income1 age marital degree female )  vce(robust) level(90)
eststo model4

esttab model1 model2 model3 model4 using health.rtf, se(3) b(3) noparentheses wide obslast star(*
0.10 ** 0.05 *** .01) compress replace

**********************************************************************************
*****************************************************************

/*ROBUSTNESS CHECKS - with 2 percent of income trimming */

*Model 5- Outcome, Selection, Open ended only(maxdollars), Robust Trim = robtrimmaxoe
gen robtrimoe = oe
replace robtrimoe = .02*(income) if oe>.02*(income) & oe!=.
gen lrobtrimoe= ln(robtrimoe)

heckman lrobtrimoe hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol nophyact ///
        probof75 income1  education  age minrace female marital ///
         , select(wtp4health = selfratehealth probof75 hbp diabetes cancer lung heart stroke tobacco
alcohol nophyact income1 age marital minrace education female )  vce(robust) level(90)
```

```
*Model 6 - Outcome, Selection, Open ended + DC (maxwtp), Robust Trim  = robtrimmaxdcoe
gen robtrimdcoe  = dcoe
replace robtrimdcoe  = .02*(income) if dcoe>.02*(income) & dcoe!=.
gen lrobtrimdcoe = ln(robtrimdcoe)

heckman lrobtrimdcoe  hbp diabetes cancer lung heart stroke  ///
        tobacco alcohol nophyact ///
        probof75 income1  education  age minrace female marital ///
         , select(wtp4health = selfratehealth probof75 hbp diabetes cancer lung heart stroke tobacco
alcohol nophyact income1 age marital minrace education female )  vce(robust) level(90)


/* AVERAGE WTP & CONFIDENCE INTERVAL - COX METHOD*/

*1- maxoe

*Overall sample
sum loe
gen meanloe = r(mean) + .5*(r(sd)^2)
gen varloe = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdloe = sqrt(varloe)

gen oeupperci = exp(meanloe + 1.96*sdloe)
gen oelowerci = exp(meanloe - 1.96*sdloe)
gen meanoe=exp(meanloe)
gen medianoe=exp(r(mean))

display oeupperci
display oelowerci
dis meanoe
dis medianoe

*Minority
sum loe if minrace==1
gen meanloe_minority = r(mean) + .5*(r(sd)^2)
gen varloe_minority = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdloe_minority = sqrt(varloe_minority)

gen oeupperci_minority = exp(meanloe_minority + 1.96*sdloe_minority)
gen oelowerci_minority = exp(meanloe_minority - 1.96*sdloe_minority)
gen meanoe_minority=exp(meanloe_minority)
gen medianoe_minority=exp(r(mean))

display oeupperci_minority
display oelowerci_minority
dis meanoe_minority
dis medianoe_minority

*White
```

```
sum loe if minrace==0
gen meanloe_white = r(mean) + .5*(r(sd)^2)
gen varloe_white = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdloe_white = sqrt(varloe_white)

gen oeupperci_white = exp(meanloe_white + 1.96*sdloe_white)
gen oelowerci_white = exp(meanloe_white - 1.96*sdloe_white)
gen meanoe_white=exp(meanloe_white)
gen medianoe_white=exp(r(mean))

display oeupperci_white
display oelowerci_white
dis meanoe_white
dis medianoe_white

****************************************

*TrimMaxoe

*Overall sample
sum ltrimoe
gen meanltrimoe = r(mean) + .5*(r(sd)^2)
gen varltrimoe = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimoe = sqrt(varltrimoe)

gen trimoeupperci = exp(meanltrimoe + 1.96*sdltrimoe)
gen trimoelowerci = exp(meanltrimoe - 1.96*sdltrimoe)
gen meantrimoe=exp(meanltrimoe)
gen mediantrimoe=exp(r(mean))

display trimoeupperci
display trimoelowerci
dis meantrimoe
dis mediantrimoe

*Minority
sum ltrimoe if minrace==1
gen meanltrimoe_minority = r(mean) + .5*(r(sd)^2)
gen varltrimoe_minority = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimoe_minority = sqrt(varltrimoe_minority)

gen trimoeupperci_minority = exp(meanltrimoe_minority + 1.96*sdltrimoe_minority)
gen trimoelowerci_minority = exp(meanltrimoe_minority - 1.96*sdltrimoe_minority)
gen meantrimoe_minority=exp(meanltrimoe_minority)
gen mediantrimoe_minority=exp(r(mean))

display trimoeupperci_minority
display trimoelowerci_minority
dis meantrimoe_minority
dis mediantrimoe_minority
```

```
*White
sum ltrimoe if minrace==0
gen meanltrimoe_white = r(mean) + .5*(r(sd)^2)
gen varltrimoe_white = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimoe_white = sqrt(varltrimoe_white)

gen trimoeupperci_white = exp(meanltrimoe_white + 1.96*sdltrimoe_white)
gen trimoelowerci_white = exp(meanltrimoe_white - 1.96*sdltrimoe_white)
gen meantrimoe_white=exp(meanltrimoe_white)
gen mediantrimoe_white=exp(r(mean))

display trimoeupperci_white
display trimoelowerci_white
dis meantrimoe_white
dis mediantrimoe_white

**********************************************
*Maxdcoe

*Overall sample
sum ldcoe
gen meanldcoe = r(mean) + .5*(r(sd)^2)
gen varldcoe = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdldcoe = sqrt(varldcoe)

gen dcoeupperci = exp(meanldcoe + 1.96*sdldcoe)
gen dcoelowerci = exp(meanldcoe - 1.96*sdldcoe)
gen meandcoe=exp(meanldcoe)
gen mediandcoe=exp(r(mean))

display dcoeupperci
display dcoelowerci
dis meandcoe
dis mediandcoe

*Minority
sum ldcoe if minrace==1
gen meanldcoe_minority = r(mean) + .5*(r(sd)^2)
gen varldcoe_minority = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdldcoe_minority = sqrt(varldcoe_minority)

gen dcoeupperci_minority = exp(meanldcoe_minority + 1.96*sdldcoe_minority)
gen dcoelowerci_minority = exp(meanldcoe_minority - 1.96*sdldcoe_minority)
gen meandcoe_minority=exp(meanldcoe_minority)
gen mediandcoe_minority=exp(r(mean))

display dcoeupperci_minority
display dcoelowerci_minority
dis meandcoe_minority
dis mediandcoe_minority
```

```
*White
sum ldcoe if minrace==0
gen meanldcoe_white = r(mean) + .5*(r(sd)^2)
gen varldcoe_white = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdldcoe_white = sqrt(varldcoe_white)

gen dcoeupperci_white = exp(meanldcoe_white + 1.96*sdldcoe_white)
gen dcoelowerci_white = exp(meanldcoe_white - 1.96*sdldcoe_white)
gen meandcoe_white=exp(meanldcoe_white)
gen mediandcoe_white=exp(r(mean))

display dcoeupperci_white
display dcoelowerci_white
dis meandcoe_white
dis mediandcoe_white

*****************************

*TrimMaxdcoe

*Overall sample
sum ltrimdcoe
gen meanltrimdcoe = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe = sqrt(varltrimdcoe)

gen trimdcoeupperci = exp(meanltrimdcoe + 1.96*sdltrimdcoe)
gen trimdcoelowerci = exp(meanltrimdcoe - 1.96*sdltrimdcoe)
gen meantrimdcoe=exp(meanltrimdcoe)
gen mediantrimdcoe=exp(r(mean))

display trimdcoeupperci
display trimdcoelowerci
dis meantrimdcoe
dis mediantrimdcoe

*Minority
sum ltrimdcoe if minrace==1
gen meanltrimdcoe_minority = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_minority = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_minority = sqrt(varltrimdcoe_minority)

gen trimdcoeupperci_minority = exp(meanltrimdcoe_minority + 1.96*sdltrimdcoe_minority)
gen trimdcoelowerci_minority = exp(meanltrimdcoe_minority - 1.96*sdltrimdcoe_minority)
gen meantrimdcoe_minority=exp(meanltrimdcoe_minority)
gen mediantrimdcoe_minority=exp(r(mean))

display trimdcoeupperci_minority
display trimdcoelowerci_minority
dis meantrimdcoe_minority
```

```
dis mediantrimdcoe_minority

*White
sum ltrimdcoe if minrace==0
gen meanltrimdcoe_white = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_white = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_white = sqrt(varltrimdcoe_white)

gen trimdcoeupperci_white = exp(meanltrimdcoe_white + 1.96*sdltrimdcoe_white)
gen trimdcoelowerci_white = exp(meanltrimdcoe_white - 1.96*sdltrimdcoe_white)
gen meantrimdcoe_white=exp(meanltrimdcoe_white)
gen mediantrimdcoe_white=exp(r(mean))

display trimdcoeupperci_white
display trimdcoelowerci_white
dis meantrimdcoe_white
dis mediantrimdcoe_white

**********************************************************************************
*********
*WTP as a percentage of annual household wealth - COX WTP

*Minority
sum income if minrace==1
gen annual_meanoe_minority = meanoe_minority*12
gen meanmeanoe_minority_per = annual_meanoe_minority/r(mean)
dis meanmeanoe_minority_per

gen annual_meanltrimoe_minority = meanltrimoe_minority*12
gen meanltrimoe_minority_per = annual_meanltrimoe_minority/r(mean)
dis meanltrimoe_minority_per

gen annual_meandcoe_minority = meandcoe_minority*12
gen meandcoe_minority_per = annual_meandcoe_minority/r(mean)
dis meandcoe_minority_per

gen annual_meantrimdcoe_minority = meantrimdcoe_minority*12
gen meantrimdcoe_minority_per = annual_meantrimdcoe_minority/r(mean)
dis meantrimdcoe_minority_per

*White
sum income if minrace==0
gen annual_meanoe_white = meanoe_white*12
gen meanoe_white_per = annual_meanoe_white/r(mean)
dis meanoe_white_per

gen annual_meanltrimoe_white = meanltrimoe_white*12
gen meanltrimoe_white_per = annual_meanltrimoe_white/r(mean)
dis meanltrimoe_white_per
```

```
gen annual_meandcoe_white = meandcoe_white*12
gen meandcoe_white_per = annual_meandcoe_white/r(mean)
dis meandcoe_white_per

gen annual_meantrimdcoe_white = meantrimdcoe_white*12
gen meantrimdcoe_white_per = annual_meantrimdcoe_white/r(mean)
dis meantrimdcoe_white_per

*Additional Analysis

/* Comparing mean and median WTP with three income categories with preferred model - trimdcoe*/

*minority

*-Low income LI
sum ltrimdcoe if minrace==1 & incomecategory==1
*74   4.12    2.03
gen meanltrimdcoe_minority_LI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_minority_LI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_minority_LI = sqrt(varltrimdcoe_minority_LI)
gen trimdcoeupperci_minority_LI = exp(meanltrimdcoe_minority_LI + 1.96*sdltrimdcoe_minority_LI)
gen trimdcoelowerci_minority_LI = exp(meanltrimdcoe_minority_LI - 1.96*sdltrimdcoe_minority_LI)
gen meantrimdcoe_minority_LI =exp(meanltrimdcoe_minority_LI)
gen mediantrimdcoe_minority_LI =exp(r(mean))
display trimdcoeupperci_minority_LI
display trimdcoelowerci_minority_LI
dis meantrimdcoe_minority_LI
dis mediantrimdcoe_minority_LI
*AVERAGE WTP as % of income
sum income if minrace==1 & incomecategory==1
gen annual_meantrimdcoe_minority_LI = meantrimdcoe_minority_LI*12
gen meantrimdcoe_minority_per_LI = annual_meantrimdcoe_minority_LI/r(mean)
dis meantrimdcoe_minority_per_LI
*MEDIAN WTP as % of income
sum income if minrace==1 & incomecategory==1
gen annual_mdtrimdcoe_minority_LI = mediantrimdcoe_minority_LI*12
gen mdtrimdcoe_minority_per_LI = annual_mdtrimdcoe_minority_LI/r(mean)
dis mdtrimdcoe_minority_per_LI

*-Middle income MI
sum ltrimdcoe if minrace==1 & incomecategory==2
*29   4.56    2.10
gen meanltrimdcoe_minority_MI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_minority_MI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_minority_MI = sqrt(varltrimdcoe_minority_MI)
gen trimdcoeupperci_minority_MI = exp(meanltrimdcoe_minority_MI + 1.96*sdltrimdcoe_minority_MI)
```

```
gen trimdcoelowerci_minority_MI = exp(meanltrimdcoe_minority_MI -
1.96*sdltrimdcoe_minority_MI)
gen meantrimdcoe_minority_MI =exp(meanltrimdcoe_minority_MI)
gen mediantrimdcoe_minority_MI =exp(r(mean))
display trimdcoeupperci_minority_MI
display trimdcoelowerci_minority_MI
dis meantrimdcoe_minority_MI
dis mediantrimdcoe_minority_MI
*AVERAGE WTP as % of income
sum income if minrace==1 & incomecategory==2
gen annual_meantrimdcoe_minority_MI = meantrimdcoe_minority_MI*12
gen meantrimdcoe_minority_per_MI = annual_meantrimdcoe_minority_MI/r(mean)
dis meantrimdcoe_minority_per_MI
*MEDIAN WTP as % of income
sum income if minrace==1 & incomecategory==2
gen annual_mdtrimdcoe_minority_MI = mediantrimdcoe_minority_MI*12
gen mdtrimdcoe_minority_per_MI = annual_mdtrimdcoe_minority_MI/r(mean)
dis mdtrimdcoe_minority_per_MI

*-High income HI
sum ltrimdcoe if minrace==1 & incomecategory==3
*13   5.40    2.40
gen meanltrimdcoe_minority_HI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_minority_HI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_minority_HI = sqrt(varltrimdcoe_minority_HI)
gen trimdcoeupperci_minority_HI = exp(meanltrimdcoe_minority_HI +
1.96*sdltrimdcoe_minority_HI)
gen trimdcoelowerci_minority_HI = exp(meanltrimdcoe_minority_HI -
1.96*sdltrimdcoe_minority_HI)
gen meantrimdcoe_minority_HI =exp(meanltrimdcoe_minority_HI)
gen mediantrimdcoe_minority_HI =exp(r(mean))
display trimdcoeupperci_minority_HI
display trimdcoelowerci_minority_HI
dis meantrimdcoe_minority_HI
dis mediantrimdcoe_minority_HI
*AVERAGE WTP as % of income
sum income if minrace==1 & incomecategory==3
gen annual_meantrimdcoe_minority_HI = meantrimdcoe_minority_HI*12
gen meantrimdcoe_minority_per_HI = annual_meantrimdcoe_minority_HI/r(mean)
dis meantrimdcoe_minority_per_HI
*MEDIAN WTP as % of income
sum income if minrace==1 & incomecategory==3
gen annual_mdtrimdcoe_minority_HI = mediantrimdcoe_minority_HI*12
gen mdtrimdcoe_minority_per_HI = annual_mdtrimdcoe_minority_HI/r(mean)
dis mdtrimdcoe_minority_per_HI
************************************************************
*white

*-Low income LI
sum ltrimdcoe if minrace==0 & incomecategory==1
```

```
*153   4.81    1.63
gen meanltrimdcoe_white_LI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_white_LI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_white_LI = sqrt(varltrimdcoe_white_LI)
gen trimdcoeupperci_white_LI = exp(meanltrimdcoe_white_LI + 1.96*sdltrimdcoe_white_LI)
gen trimdcoelowerci_white_LI = exp(meanltrimdcoe_white_LI - 1.96*sdltrimdcoe_white_LI)
gen meantrimdcoe_white_LI =exp(meanltrimdcoe_white_LI)
gen mediantrimdcoe_white_LI =exp(r(mean))
display trimdcoeupperci_white_LI
display trimdcoelowerci_white_LI
dis meantrimdcoe_white_LI
dis mediantrimdcoe_white_LI
*AVERAGE WTP as % of income
sum income if minrace==0 & incomecategory==1
gen annual_meantrimdcoe_white_LI = meantrimdcoe_white_LI*12
gen meantrimdcoe_white_per_LI = annual_meantrimdcoe_white_LI/r(mean)
dis meantrimdcoe_white_per_LI
*MEDIAN WTP as % of income
sum income if minrace==0 & incomecategory==1
gen annual_mdtrimdcoe_white_LI = mediantrimdcoe_white_LI*12
gen mdtrimdcoe_white_per_LI = annual_mdtrimdcoe_white_LI/r(mean)
dis mdtrimdcoe_white_per_LI

*-Middle income MI
sum ltrimdcoe if minrace==0 & incomecategory==2
*29   4.56    2.10
gen meanltrimdcoe_white_MI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_white_MI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_white_MI = sqrt(varltrimdcoe_white_MI)
gen trimdcoeupperci_white_MI = exp(meanltrimdcoe_white_MI + 1.96*sdltrimdcoe_white_MI)
gen trimdcoelowerci_white_MI = exp(meanltrimdcoe_white_MI - 1.96*sdltrimdcoe_white_MI)
gen meantrimdcoe_white_MI =exp(meanltrimdcoe_white_MI)
gen mediantrimdcoe_white_MI =exp(r(mean))
display trimdcoeupperci_white_MI
display trimdcoelowerci_white_MI
dis meantrimdcoe_white_MI
dis mediantrimdcoe_white_MI
*AVERAGE WTP as % of income
sum income if minrace==0 & incomecategory==2
gen annual_meantrimdcoe_white_MI = meantrimdcoe_white_MI*12
gen meantrimdcoe_white_per_MI = annual_meantrimdcoe_white_MI/r(mean)
dis meantrimdcoe_white_per_MI
*MEDIAN WTP as % of income
sum income if minrace==0 & incomecategory==2
gen annual_mdtrimdcoe_white_MI = mediantrimdcoe_white_MI*12
gen mdtrimdcoe_white_per_MI = annual_mdtrimdcoe_white_MI/r(mean)
dis mdtrimdcoe_white_per_MI

*-High income HI
sum ltrimdcoe if minrace==0 & incomecategory==3
```

```
*13   5.40    2.40
gen meanltrimdcoe_white_HI = r(mean) + .5*(r(sd)^2)
gen varltrimdcoe_white_HI = ((r(sd)^2)/r(N))+ (.5*(r(sd)^4))/(r(N)+1)
gen sdltrimdcoe_white_HI = sqrt(varltrimdcoe_white_HI)
gen trimdcoeupperci_white_HI = exp(meanltrimdcoe_white_HI + 1.96*sdltrimdcoe_white_HI)
gen trimdcoelowerci_white_HI = exp(meanltrimdcoe_white_HI - 1.96*sdltrimdcoe_white_HI)
gen meantrimdcoe_white_HI =exp(meanltrimdcoe_white_HI)
gen mediantrimdcoe_white_HI =exp(r(mean))
display trimdcoeupperci_white_HI
display trimdcoelowerci_white_HI
dis meantrimdcoe_white_HI
dis mediantrimdcoe_white_HI
*AVERAGE WTP as % of income
sum income if minrace==0 & incomecategory==3
gen annual_meantrimdcoe_white_HI = meantrimdcoe_white_HI*12
gen meantrimdcoe_white_per_HI = annual_meantrimdcoe_white_HI/r(mean)
dis meantrimdcoe_white_per_HI
*MEDIAN WTP as % of income
sum income if minrace==0 & incomecategory==3
gen annual_mdtrimdcoe_white_HI = mediantrimdcoe_white_HI*12
gen mdtrimdcoe_white_per_HI = annual_mdtrimdcoe_white_HI/r(mean)
dis mdtrimdcoe_white_per_HI


*******************************************************************************
*End
```

A.3a Chapter 3 Stata codes

```
clear
set more off
cd H:\Chapter3
use rndhrs_m

keep hhidpn ragender rahispan raracem rabyear radyear raedyrs  raedegrm  rameduc rafeduc
rawtsamp r*iwstat r*proxy inw* ///
        r*walksa r*joga r*walk1a r*sita r*chaira r*climsa r*clim1a r*stoopa r*lifta r*dimea
r*armsa r*pusha ///
        r*agey_e  r*agem_e      r*mstath r*cenreg r*wthh r*wtresp r*shlt  r*bmi  r*smokev
r*smoken r*drink  r*drinkn r2drinkr  r*hibpe  r*diabe r*cancre r*lunge ///
        r*hearte r*stroke r*psyche r*arthre  r*conde  h*atota h*atotw  h*itot r*covr r*covs
r*higov r*hiltc r*hiothp r*amstot r*acgtot r*mstot r*cogtot

reshape long r@proxy r@walksa r@joga r@walk1a r@sita r@chaira r@climsa r@clim1a
r@stoopa r@lifta r@dimea r@armsa r@pusha ///
                r@iwstat inw@ r@agey_e r@agem_e r@mstath r@cenreg r@wthh r@wtresp
r@shlt  r@bmi  ///
                r@smokev r@smoken r@drink  r@drinkn r@drinkr  r@hibpe  r@diabe
r@cancre r@lunge ///
                r@hearte r@stroke r@psyche r@arthre  r@conde  h@atota h@atotw  h@itot
r@covr r@covs  r@higov r@hiltc r@hiothp r@amstot r@acgtot r@mstot r@cogtot, ///
                 i(hhidpn ragender raracem  rabyear radyear raedyrs raedegrm  rameduc rafeduc
rahispan ) j(wave)

 xtset hhidpn wave
drop if wave==1  /**Baseline = Wave 2(1994)*/
xtset

*rename all variables*

*******************************************************************************
gen wave2age = 1993 - birthyear if wave==2
replace age_years = wave2age if wave==2 & age_years==.
drop wave2age

*Functional Limitations Index
egen flindex = rowtotal (walksevblks jog walkoneblk sittwohrs upchair climbsevsta climbonesta
stoop lift dime arms push), missing
label var flindex "Functional Limitations Index"

gen female = gender==2
label var female "Female"

*Race and ethnicity (NonHispanic Whites, Blacks, Hispanics)
gen nonhispwhite = race==1 & hispanic == 0
label var nonhispwhite "Non Hispanic Whites"
```

```
gen black = race == 2
label var black "Blacks"
label var hispanic "Hispanics"
gen otherrace = nonhispwhite==0 & black==0 & hispanic==0
drop if otherrace==1

gen raceethnicity = nonhispwhite==1
replace raceethnicity = 2 if black ==1 /* Blacks*/
replace raceethnicity = 3 if hispanic==1 /*Hispanics*/
tab raceethnicity if wave==2

xttab marital
gen married= marital<=2
label var married "Married"

replace health = . if health==.m

xttab selfratehealth
recode selfratehealth (1=5) (5=1) (2=4) (4=2), gen(selfratehealth1)
xttab selfratehealth1  /*the higher the value, the better the health*/
replace selfratehealth1 = . if selfratehealth1 ==.d
replace selfratehealth1 = . if selfratehealth1 ==.m

*bmi
gen underw = bmi < 18.5
gen normal = bmi > = 18.5 & bmi <= 24.99
gen overw = bmi >= 25 & bmi <= 29.99
gen obese = bmi >= 30

*Smoking
xtsum eversmoke smokenow
gen nsmoke = eversmoke==0 & smokenow==0
gen fsmoke = eversmoke==1 & smokenow==0
gen csmoke = eversmoke==1 & smokenow==1
*nsmoke = neversmoke, fsmoke = formersmoke, csmoke = currentsmoke

*Drinking
xtsum everdrink drinkperday
gen ndrink = drinkperday==0
gen ldrink = drinkperday>=1 & drinkperday<3
gen hdrink = drinkperday>=3
*ndrink = nodrinker, ldrink = lightdrinker, hdrink = heavydrinker

*Census region
xttab censusregion
gen northeast = censusregion==1
gen midwest = censusregion==2
gen south = censusregion==3
gen west = censusregion==4
```

```
sum totalwealth
gen wealth = abs(totalwealth)
gen lwealt = ln(wealth)
replace lwealt = 0 if wealth==0
replace lwealt = -1*lwealt if totalwealth<0

*Centering education at 12years (the mean)
gen c_educyears= educyears - 12

*To center age at the minimum age
gen c_age_years = age_years - 55
gen S_age_years = age_years^2

*******************************************************************************
* Controlling for attrition
gen wave10participant = 1 if wave==10 & proxy == 0
replace wave10participant = 0 if wave==10 & proxy == 1
sum wave10participant

logit  wave10partic selfratehealth1 age_years female health black hispanic
predict p1, xb
generate phi = (1/sqrt(2*_pi))*exp(-(p1^2/2))
generate capphi = normal(p1)
generate invmills = phi/capphi

*1) Drop if baseline (wave 2) age < 55
gen basewave = wave == 2 & age_years <55 if age_years!=.
bysort hhidpn (basewave): drop if basewave[_N] /* this means I drop an individual (all his
waves) if <55 at baseline wave)*/
*bysort hhidpn (basewave): drop if basewave==1
sort hhidpn (wave)

*2) Calculating Attrition
tab interviewstatus if wave == 2
count if wave==2 /*n = 5223*/
count if wave == 10 & proxy ==1 /*by the end of wave 10, 9.6%(499)  had proxy reporting for
them. */
****************************************
*GRAPHS
xtgraph flindex , group(raceethnicity) av(am) bar(ci)

**********
*Cronbach Alpha - to test for internal consistency
alpha walksevblks jog walkoneblk sittwohrs upchair climbsevsta climbonesta stoop lift dime
arms push

bysort wave: alpha walksevblks jog walkoneblk sittwohrs upchair climbsevsta climbonesta stoop
lift dime arms push, detail

***
```

```
*Baseline Race and Ethnicity
tab1 nonhispwhite black hispanic if wave==2

*Functional Limitations
bysort wave raceethnicity: xtsum flindex

bysort wave: oneway flindex raceethnicity ,  bonferroni
fstar flindex raceethnicity
wtest flindex raceethnicity

*Baseline health factors
bysort raceethnicity: sum health selfratehealth1 if wave==2
oneway health raceethnicity ,  bonferroni
oneway selfratehealth1 raceethnicity ,  bonferroni

bysort raceethnicity: sum underw normal overw obese if wave==2
oneway underw raceethnicity ,  bonferroni
oneway normal raceethnicity ,  bonferroni
oneway overw raceethnicity ,  bonferroni
oneway obese raceethnicity ,  bonferroni

**Baseline behavioral factors
bysort raceethnicity: sum nsmoke fsmoke csmoke if wave==2
oneway nsmoke raceethnicity ,  bonferroni
oneway fsmoke raceethnicity ,  bonferroni
oneway csmoke raceethnicity ,  bonferroni

bysort raceethnicity: sum ndrink ldrink hdrink if wave==2
oneway ndrink raceethnicity ,  bonferroni
oneway ldrink raceethnicity ,  bonferroni
oneway hdrink raceethnicity ,  bonferroni

*Baseline demographic factors
bysort raceethnicity: sum age_years female married if wave==2
oneway age_years raceethnicity ,  bonferroni
oneway female raceethnicity ,  bonferroni
oneway married raceethnicity ,  bonferroni

bysort raceethnicity: sum northeast midwest south west if wave==2
oneway northeast raceethnicity ,  bonferroni
oneway midwest raceethnicity ,  bonferroni
oneway south raceethnicity ,  bonferroni
oneway west raceethnicity ,  bonferroni

*Baseline adult SES
bysort raceethnicity: sum educyears c_educyears lwealt if wave==2
oneway educyears raceethnicity ,  bonferroni
oneway lwealt raceethnicity ,  bonferroni

*Cognitive Index
```

```
bysort raceethnicity: sum cog1 cog2 if wave==2
*******

keep hhidpn wave flindex age_years c_age_years S_age_years female ///
                nonhispwhite black hispanic raceethnicity married health selfratehealth1 ///
                underw normal overw obese nsmoke fsmoke csmoke ndrink ldrink hdrink ///
                educyears c_educyears northeast midwest south west cog1 cog2 ///
                lwealt numberofwaves
*invmills

reshape wide flindex age_years c_age_years S_age_years married health selfratehealth1 cog1
cog2 underw normal overw obese ///
                nsmoke fsmoke csmoke ndrink ldrink hdrink ///
                northeast midwest south west lwealt, i(hhidpn) j(wave)

profileplot flindex2 flindex3 flindex4  flindex5 flindex6 flindex7 flindex8 flindex9 flindex10,
by(raceethnicity) xtitle(Functional Limitations Index) ///
        xlabel(1 "2" 2 "3" 3 "4" 4 "5" 5 "6" 6 "7" 7 "8" 8 "9" 9 "10")

replace cog12 = . if cog12==.q
replace cog24 = . if cog24==.n
replace cog25 = . if cog25==.n
replace cog26 = . if cog26==.n
replace cog27 = . if cog27==.n
replace cog28 = . if cog28==.n
replace cog29 = . if cog29==.n

/* Imputing missing cognitive values */
*non-hisp white  female
sum cog12 if female ==1 & raceethnicity ==1

*black Female
sum cog12 if female ==1 & raceethnicity ==2

*Hispanic Female
sum cog12 if female ==1 & raceethnicity ==3

* non-hisp white Male
sum cog12 if female ==0 & raceethnicity ==1

*black Male
sum cog12 if female ==0 & raceethnicity ==2

*Hispanic  Male
sum cog12 if female ==0 & raceethnicity ==3

replace cog12 = 23.7 if cog12==.  & female ==1 & raceethnicity ==1
replace cog12 = 18.9  if cog12==.  & female ==1 & raceethnicity ==2
replace cog12 = 18.3  if cog12==.  & female ==1 & raceethnicity ==3
replace cog12 = 23.2  if cog12==.  & female ==0 & raceethnicity ==1
```

```
replace cog12 = 16.3  if cog12==.  & female ==0 & raceethnicity ==2
replace cog12 = 19.5  if cog12==.  & female ==0 & raceethnicity ==3

bysort raceethnicity: sum cog12
oneway cog12 raceethnicity

save newrandhrs_m, replace

/* CONVERTING FILE TO MPLUS FORMAT*/
stata2mplus using newrandhrs_m, replace


*******************************************************************************
*End
```

A.3b Chapter 3 Mplus codes

```
!Model 1 - Unconditional Quadratic
Title:
  Functional limitations HRS data - Multi-group Unconditional LGM

  Three group Unconditional Quadratic Model

  Stata2Mplus conversion for H:\Chapter3\rndhrs_m.dta
  List of variables converted shown below

Data:
  File is H:\Chapter3\newrandhrs_m.dat ;

Variable:
  Names are
    hhidpn age_years2 health2 cog22 cog12 flindex2 married2 selfratehealth12
    underw2 normal2 overw2 obese2 nsmoke2 fsmoke2 csmoke2 ndrink2 ldrink2
    hdrink2 northeast2 midwest2 south2 west2 lwealt2 c_age_years2 S_age_years2
    age_years3 health3 cog23 cog13 flindex3 married3 selfratehealth13
    underw3 normal3 overw3 obese3 nsmoke3 fsmoke3 csmoke3 ndrink3 ldrink3
    hdrink3 northeast3 midwest3 south3 west3 lwealt3 c_age_years3 S_age_years3
    age_years4 health4 cog24 cog14 flindex4 married4 selfratehealth14
    underw4 normal4 overw4 obese4 nsmoke4 fsmoke4 csmoke4 ndrink4 ldrink4
    hdrink4 northeast4 midwest4 south4 west4 lwealt4 c_age_years4 S_age_years4
    age_years5 health5 cog25 cog15 flindex5 married5 selfratehealth15
    underw5 normal5 overw5 obese5 nsmoke5 fsmoke5 csmoke5 ndrink5 ldrink5
    hdrink5 northeast5 midwest5 south5 west5 lwealt5 c_age_years5 S_age_years5
    age_years6 health6 cog26 cog16 flindex6 married6 selfratehealth16
    underw6 normal6 overw6 obese6 nsmoke6 fsmoke6 csmoke6 ndrink6 ldrink6
    hdrink6 northeast6 midwest6 south6 west6 lwealt6 c_age_years6 S_age_years6
    age_years7 health7 cog27 cog17 flindex7 married7 selfratehealth17
    underw7 normal7 overw7 obese7 nsmoke7 fsmoke7 csmoke7 ndrink7 ldrink7
    hdrink7 northeast7 midwest7 south7 west7 lwealt7 c_age_years7 S_age_years7
    age_years8 health8 cog28 cog18 flindex8 married8 selfratehealth18
    underw8 normal8 overw8 obese8 nsmoke8 fsmoke8 csmoke8 ndrink8 ldrink8
    hdrink8 northeast8 midwest8 south8 west8 lwealt8 c_age_years8 S_age_years8
    age_years9 health9 cog29 cog19 flindex9 married9 selfratehealth19
    underw9 normal9 overw9 obese9 nsmoke9 fsmoke9 csmoke9 ndrink9 ldrink9
    hdrink9 northeast9 midwest9 south9 west9 lwealt9 c_age_years9 S_age_years9
    age_years10 health10 cog210 cog110 flindex10 married10 selfratehealth110
    underw10 normal10 overw10 obese10 nsmoke10 fsmoke10 csmoke10 ndrink10
    ldrink10 hdrink10 northeast10 midwest10 south10 west10 lwealt10 c_age_years10
    S_age_years10 educyears hispanic female nonhispwhite black raceethnicity
    c_educyears numberofwaves;
  Missing are all (-9999) ;

  Usevariables are flindex2 flindex3 flindex4 flindex5 flindex6 flindex7 flindex8
                   flindex9 flindex10 raceethnicity;
```

```
  GROUPING = raceethnicity(1= WHITES 2 = BLACKS 3 = HISPANICS);
MODEL:
   I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
   flindex8@.6 flindex9@.7 flindex10@.8;

MODEL BLACKS:
   I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
   flindex8@.6 flindex9@.7 flindex10@.8;

MODEL HISPANICS:
   I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
   flindex8@.6 flindex9@.7 flindex10@.8;

OUTPUT:  tech1;
PLOT: TYPE = plot3

!Model 1 – Conditional Quadratic LGM – with socio-demographic factors
Title:
  Stata2Mplus conversion for H:\Chapter3\newrandhrs_m.dta

  Data:
  File is H:\Chapter3\newrandhrs_m.dat ;

Variable:
  Names are
    hhidpn age_years2 health2 cog22 cog12 flindex2 married2 selfratehealth12
    underw2 normal2 overw2 obese2 nsmoke2 fsmoke2 csmoke2 ndrink2 ldrink2
    hdrink2 northeast2 midwest2 south2 west2 lwealt2 c_age_years2 S_age_years2
    age_years3 health3 cog23 cog13 flindex3 married3 selfratehealth13
    underw3 normal3 overw3 obese3 nsmoke3 fsmoke3 csmoke3 ndrink3 ldrink3
    hdrink3 northeast3 midwest3 south3 west3 lwealt3 c_age_years3 S_age_years3
    age_years4 health4 cog24 cog14 flindex4 married4 selfratehealth14
    underw4 normal4 overw4 obese4 nsmoke4 fsmoke4 csmoke4 ndrink4 ldrink4
    hdrink4 northeast4 midwest4 south4 west4 lwealt4 c_age_years4 S_age_years4
    age_years5 health5 cog25 cog15 flindex5 married5 selfratehealth15
    underw5 normal5 overw5 obese5 nsmoke5 fsmoke5 csmoke5 ndrink5 ldrink5
    hdrink5 northeast5 midwest5 south5 west5 lwealt5 c_age_years5 S_age_years5
    age_years6 health6 cog26 cog16 flindex6 married6 selfratehealth16
    underw6 normal6 overw6 obese6 nsmoke6 fsmoke6 csmoke6 ndrink6 ldrink6
    hdrink6 northeast6 midwest6 south6 west6 lwealt6 c_age_years6 S_age_years6
    age_years7 health7 cog27 cog17 flindex7 married7 selfratehealth17
    underw7 normal7 overw7 obese7 nsmoke7 fsmoke7 csmoke7 ndrink7 ldrink7
    hdrink7 northeast7 midwest7 south7 west7 lwealt7 c_age_years7 S_age_years7
    age_years8 health8 cog28 cog18 flindex8 married8 selfratehealth18
    underw8 normal8 overw8 obese8 nsmoke8 fsmoke8 csmoke8 ndrink8 ldrink8
    hdrink8 northeast8 midwest8 south8 west8 lwealt8 c_age_years8 S_age_years8
    age_years9 health9 cog29 cog19 flindex9 married9 selfratehealth19
    underw9 normal9 overw9 obese9 nsmoke9 fsmoke9 csmoke9 ndrink9 ldrink9
    hdrink9 northeast9 midwest9 south9 west9 lwealt9 c_age_years9 S_age_years9
```

```
 age_years10 health10 cog210 cog110 flindex10 married10 selfratehealth110
 underw10 normal10 overw10 obese10 nsmoke10 fsmoke10 csmoke10 ndrink10
 ldrink10 hdrink10 northeast10 midwest10 south10 west10 lwealt10 c_age_years10
 S_age_years10 educyears hispanic female nonhispwhite black raceethnicity
 c_educyears numberofwaves;

    !Time invariant covariates (measured at baseline)are:
!c_age_years2 c_educyears female married2 northeast2 midwest2 south2 west2;

 !Time varying covariates are: health2-10, selfratehealth2-10, underw2-10,
 !normal2-10, overweight2-10, obese2-10, nsmoke2-10, fsmoke2-10,
 !csmoke2-10, ndrink2-10, ldrink2-10, hdrink2-10, lwealt2-10


 USEVARIABLES ARE flindex2 flindex3 flindex4 flindex5 flindex6 flindex7
          flindex8  flindex9 flindex10 raceethnicity
           c_age_years2 female married2 northeast2 west2 midwest2
           cog12  c_educyears lwealt2 numberofwaves;
           !health2 selfh2 underw2 overw2 obese2
           !csmoke2 fsmoke2 ldrink2 hdrink2;

 MISSING are all (-9999);
GROUPING = raceethnicity(1= WHITES 2= BLACKS 3= HISPANICS);

 !Model 2 (Predictors are socio-demographic factors)
 MODEL:
 I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
      flindex8@.6 flindex9@.7 flindex10@.8;

 I S q ON c_age_years2 female married2 northeast2 west2 midwest2
    c_educyears lwealt2 cog12 numberofwaves;
 ![cog12]

OUTPUT:
  Sampstat Mod(3.84);
Plot:
  Type is  Plot3;
  Series = flindex2 flindex3 flindex4 flindex5 flindex6 flindex7
       flindex8 flindex9 flindex10(*);


Model 3 – Conditional quad lgm – with health and health-related behaviors
Title:
 Stata2Mplus conversion for H:\Chapter3\newrandhrs_m.dta

Data:
 File is H:\Chapter3\newrandhrs_m.dat ;

Variable:
 Names are
```

```
 hhidpn age_years2 health2 cog22 cog12 flindex2 married2 selfratehealth12
 underw2 normal2 overw2 obese2 nsmoke2 fsmoke2 csmoke2 ndrink2 ldrink2
 hdrink2 northeast2 midwest2 south2 west2 lwealt2 c_age_years2 S_age_years2
 age_years3 health3 cog23 cog13 flindex3 married3 selfratehealth13
 underw3 normal3 overw3 obese3 nsmoke3 fsmoke3 csmoke3 ndrink3 ldrink3
 hdrink3 northeast3 midwest3 south3 west3 lwealt3 c_age_years3 S_age_years3
 age_years4 health4 cog24 cog14 flindex4 married4 selfratehealth14
 underw4 normal4 overw4 obese4 nsmoke4 fsmoke4 csmoke4 ndrink4 ldrink4
 hdrink4 northeast4 midwest4 south4 west4 lwealt4 c_age_years4 S_age_years4
 age_years5 health5 cog25 cog15 flindex5 married5 selfratehealth15
 underw5 normal5 overw5 obese5 nsmoke5 fsmoke5 csmoke5 ndrink5 ldrink5
 hdrink5 northeast5 midwest5 south5 west5 lwealt5 c_age_years5 S_age_years5
 age_years6 health6 cog26 cog16 flindex6 married6 selfratehealth16
 underw6 normal6 overw6 obese6 nsmoke6 fsmoke6 csmoke6 ndrink6 ldrink6
 hdrink6 northeast6 midwest6 south6 west6 lwealt6 c_age_years6 S_age_years6
 age_years7 health7 cog27 cog17 flindex7 married7 selfratehealth17
 underw7 normal7 overw7 obese7 nsmoke7 fsmoke7 csmoke7 ndrink7 ldrink7
 hdrink7 northeast7 midwest7 south7 west7 lwealt7 c_age_years7 S_age_years7
 age_years8 health8 cog28 cog18 flindex8 married8 selfratehealth18
 underw8 normal8 overw8 obese8 nsmoke8 fsmoke8 csmoke8 ndrink8 ldrink8
 hdrink8 northeast8 midwest8 south8 west8 lwealt8 c_age_years8 S_age_years8
 age_years9 health9 cog29 cog19 flindex9 married9 selfratehealth19
 underw9 normal9 overw9 obese9 nsmoke9 fsmoke9 csmoke9 ndrink9 ldrink9
 hdrink9 northeast9 midwest9 south9 west9 lwealt9 c_age_years9 S_age_years9
 age_years10 health10 cog210 cog110 flindex10 married10 selfratehealth110
 underw10 normal10 overw10 obese10 nsmoke10 fsmoke10 csmoke10 ndrink10
 ldrink10 hdrink10 northeast10 midwest10 south10 west10 lwealt10 c_age_years10
 S_age_years10 educyears hispanic female nonhispwhite black raceethnicity
 c_educyears numberofwaves;

 !Time invariant covariates (measured at baseline)are:
!c_age_years2 c_educyears female married2 northeast2 midwest2 south2 west2;
!health2 selfratehealth12 underw2 overw2 obese2;
!csmoke2 fsmoke2 ldrink2 hdrink2

 !Time varying covariates are: health2-10, wealt2-10

USEVARIABLES ARE flindex2 flindex3 flindex4 flindex5 flindex6 flindex7
          flindex8 flindex9 flindex10 raceethnicity
           c_age_years2 female married2 northeast2 west2 midwest2
           cog12  c_educyears lwealt2
           health2 selfratehealth12 underw2 overw2 obese2
           csmoke2 fsmoke2 ldrink2 hdrink2;

 MISSING are all (-9999);
GROUPING = raceethnicity(1= WHITES 2= BLACKS 3= HISPANICS);

 !Model 3 (Predictors are demographic, socioeconomic. health and behavioral factors)
 MODEL:
I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
```

```
        flindex8@.6 flindex9@.7 flindex10@.8;

      I S q ON c_age_years2 female married2 northeast2 west2 midwest2
          c_educyears lwealt2 cog12
          health2 selfratehealth12 underw2 overw2 obese2
          csmoke2 fsmoke2 ldrink2 hdrink2;

    OUTPUT:
  Sampstat Mod(3.84);

!tech1
!Sampstat Mod(3.84) standardized;;

  Plot:
   Type is  Plot3;
  ! Series = flindex2 flindex3 flindex4 flindex5 flindex6 flindex7
        !flindex8 flindex9 flindex10(*);

!Model 4 – Conditional quadratic lgm – with time varying predictors
Title:
  Stata2Mplus conversion for H:\Chapter3\newrandhrs_m.dta

  Data:
  File is H:\Chapter3\newrandhrs_m.dat ;

Variable:
  Names are
    hhidpn age_years2 health2 cog22 cog12 flindex2 married2 selfratehealth12
    underw2 normal2 overw2 obese2 nsmoke2 fsmoke2 csmoke2 ndrink2 ldrink2
    hdrink2 northeast2 midwest2 south2 west2 lwealt2 c_age_years2 S_age_years2
    age_years3 health3 cog23 cog13 flindex3 married3 selfratehealth13
    underw3 normal3 overw3 obese3 nsmoke3 fsmoke3 csmoke3 ndrink3 ldrink3
    hdrink3 northeast3 midwest3 south3 west3 lwealt3 c_age_years3 S_age_years3
    age_years4 health4 cog24 cog14 flindex4 married4 selfratehealth14
    underw4 normal4 overw4 obese4 nsmoke4 fsmoke4 csmoke4 ndrink4 ldrink4
    hdrink4 northeast4 midwest4 south4 west4 lwealt4 c_age_years4 S_age_years4
    age_years5 health5 cog25 cog15 flindex5 married5 selfratehealth15
    underw5 normal5 overw5 obese5 nsmoke5 fsmoke5 csmoke5 ndrink5 ldrink5
    hdrink5 northeast5 midwest5 south5 west5 lwealt5 c_age_years5 S_age_years5
    age_years6 health6 cog26 cog16 flindex6 married6 selfratehealth16
    underw6 normal6 overw6 obese6 nsmoke6 fsmoke6 csmoke6 ndrink6 ldrink6
    hdrink6 northeast6 midwest6 south6 west6 lwealt6 c_age_years6 S_age_years6
    age_years7 health7 cog27 cog17 flindex7 married7 selfratehealth17
    underw7 normal7 overw7 obese7 nsmoke7 fsmoke7 csmoke7 ndrink7 ldrink7
    hdrink7 northeast7 midwest7 south7 west7 lwealt7 c_age_years7 S_age_years7
    age_years8 health8 cog28 cog18 flindex8 married8 selfratehealth18
    underw8 normal8 overw8 obese8 nsmoke8 fsmoke8 csmoke8 ndrink8 ldrink8
    hdrink8 northeast8 midwest8 south8 west8 lwealt8 c_age_years8 S_age_years8
    age_years9 health9 cog29 cog19 flindex9 married9 selfratehealth19
    underw9 normal9 overw9 obese9 nsmoke9 fsmoke9 csmoke9 ndrink9 ldrink9
```

```
 hdrink9 northeast9 midwest9 south9 west9 lwealt9 c_age_years9 S_age_years9
 age_years10 health10 cog210 cog110 flindex10 married10 selfratehealth110
 underw10 normal10 overw10 obese10 nsmoke10 fsmoke10 csmoke10 ndrink10
 ldrink10 hdrink10 northeast10 midwest10 south10 west10 lwealt10 c_age_years10
 S_age_years10 educyears hispanic female nonhispwhite black raceethnicity
 c_educyears numberofwaves;

    !Time invariant covariates (measured at baseline)are:
!c_age_years2 c_educyears female married2 northeast2 midwest2 south2 west2;
!health2 selfratehealth12 underw2 overw2 obese2;
!csmoke2 fsmoke2 ldrink2 hdrink2

 !Time varying covariates are: health2-10, wealt2-10

 USEVARIABLES ARE flindex2 flindex3 flindex4 flindex5 flindex6 flindex7 flindex8
          flindex9 flindex10 raceethnicity
          female married2 northeast2 west2
          midwest2 c_educyears cog12 lwealt2
          health2 health3 health4 health5 health6 health7
          health8 health9 health10
          overw2 overw3 overw4 overw5 overw6
          overw7 overw8 overw9 overw10
          obese2 obese3 obese4 obese5 obese6
          obese7 obese8 obese9 obese10
          age_years2 age_years3 age_years4 age_years5
          age_years6 age_years7 age_years8
          age_years9 age_years10
          selfratehealth12
          csmoke2 fsmoke2 ldrink2 hdrink2;

 MISSING are all (-9999);
GROUPING = raceethnicity(1= WHITES 2= BLACKS 3= HISPANICS);

 !Model 3 (Predictors are demographic, socioeconomic. health and behavioral factors)
 MODEL:
 I S q| flindex2@0 flindex3@.1 flindex4@.2 flindex5@.3 flindex6@.4 flindex7@.5
      flindex8@.6 flindex9@.7 flindex10@.8;

   I S q ON female married2 northeast2 west2
      midwest2 c_educyears cog12 selfratehealth12
      lwealt2
      csmoke2 fsmoke2 ldrink2 hdrink2;

flindex2 ON health2 overw2 obese2 age_years2;
flindex3 ON health3 overw3 obese3 age_years3;
flindex4 ON health4 overw4 obese4 age_years4;
flindex5 ON health5 overw5 obese5 age_years5;
flindex6 ON health6 overw6 obese6 age_years6;
flindex7 ON health7 overw7 obese7 age_years7;
flindex8 ON health8 overw8 obese8 age_years8;
```

```
flindex9 ON health9 overw9 obese9 age_years9;
flindex10 ON health10 overw10 obese10 age_years10;

  OUTPUT:
 Sampstat Mod(3.84);

 Plot:
  Type is  Plot3;
 ! Series = flindex2 flindex3 flindex4 flindex5 flindex6 flindex7
        !flindex8 flindex9 flindex10(*);
```

A.4 Chapter 4 Stata codes

```
clear all

/* post-program/followup data*/
clear
set more off
cd "H:\Chapter4"

/*
tempfile postdata
save `postdata', emptyok
import excel using " Texercise_Data_Post_v4_Final_RECODE_Folake.xls", describe
return list
local n_sheets `r(N_worksheet)'
forvalues j = 1/`n_sheets' {
        local sheet`j' `r(worksheet_`j')'
        }

forvalues j = 1/`n_sheets' {
        import excel using "
H:\Chapter4\Texercise_Data_Post_v4_Final_RECODE_Folake.xls",sheet(`"`sheet`j'"') firstrow
clear
        append using `postdata'
        save `"`postdata'"', replace
        }
*/

import excel using " H:\Chapter4\Texercise Post Data_Folake.xlsx", firstrow
describe

label var TUG "TUG"
label var PA1 "rarely or never do any physical activities"
label var PA2 "light or moderate physical activities but not every week"
label var PA3 "light physical activity every week"
label var PA4 "moderate physical activity every week"
label var PA5 "30 minutes or more per day of moderate physical activity, 5 or more days per week"
label var PA6 "vigorous physical activities every week, but for less than 5 days per week or less
than 20 minutes a time"
label var PA7 "20 minutes or more per day of vigorous physical activities, 3 ore more days per
week"
label var PA8 "do activities to increase muscle strength, such as lifting weights or calisthenics, once
a week or more"
label var PA9 "do activities to improve flexibility, such as stretching or yoga, once a week or more"
label var PA10 "Over the past 7 days, how many days did you do moderate to vigorous physical
activity?"
label var PA11 "On those days that you engage in moderate to vigorous physical activity, how
many minutes, on average, do you exercise at this level?"
label var PA12 "Over the past 7 days, how many times did you eat fastfood meals or snacks?"
```

label var PA13 "Over the past 7 days, how many servings of fruits/vegetables did you eat each day?"
label var PA14 "Over the past 7 days, how many soda or sugar sweetened drinks (regular, not diet) did you drink each day?"
label var PA15 "In the average day, how many cups of water do you drink each day?"
label var G1 "goals about physical activity"
label var G2 "goals about eating"
label var G3 "goals about managing your chronic conditions"
label var S1 "How many people in your life give you social support?"
label var S2_1 "How often do you get social support for the following activities - planning physical activity goals"
label var S2_2 "How often do you get social support for the following activities - planning dietary goals"
label var S2_3 "How often do you get social support for the following activities - keeping physical activity goals"
label var S2_4 "How often do you get social support for the following activities - keeping dietary goals"
label var S2_5 "How often do you get social support for the following activities - reducing barriers to physical activity"
label var S2_6 "How often do you get social support for the following activities - reducing barriers to healthy eating"
label var S3_1 "feel safe exercising at home"
label var S3_2 "feel safe being physically active in my neighborhood"
label var S3_3 "know of outdoor places near my home where I can be physically active (e.g., parks)"
label var S3_4 "know of facilities near my home where I can be physically active (e.g., gyms or recreational centers)"
label var S3_5 "Memberships at facilities where I can be physically active (e.g., gyms or recreational centers) are affordable"
label var B_1 "How confident are you that you can do moderate or vigorous exercises most days a week"
label var B_2 "confident are you that you can eat a healthy diet most days of the week?"
label var B_3 "confident are you that you can manage your chronic conditions on daily basis?"
label var B_4 "confident are you that you can use the internet to get health information?"
label var H1 "Self rated health"
label var H2 "Physical unhealthy days"
label var H3 "Mental unhealthy days"
label var H4 "days poor physical or mental kept ou from doing usual activities"
label var H5 "On a scale of 0 to 10, how much stress you have been experiencing in he last 7 days?"
label var H6_1 "Over the past 2 weeks, how often have you been bothered by these problems? - feeling nervous, anxious, or on edge"
label var H6_2 "Over the past 2 weeks, how often have you been bothered by these problems? - Not being able to stop or control worrying"
label var H6_3 "Over the past 2 weeks, how often have you been bothered by these problems? - Feeling down, depressed, or hopeless"
label var H6_4 "Over the past 2 weeks, how often have you been bothered by these problems? - little interest or pleasure in doing things"
label var H7_1 "do you have a chronic condition?"
label var H7_2 "Type 2 Diabetes"
label var H7_3 "Asthma"

```
label var H7_4 "Chronic Bronchities, Emphysema, or COPD"
label var H7_5 "other lunng disease"
label var H7_6 "High Blood Pressure or Hypertension"
label var H7_7 "Heart Disease"
label var H7_8 "Arthritis or Other Rheumatic Disease"
label var H7_9 "Cancer"
label var H7_10 "Other Chronic Condition"
label var H7_5_Re "Describe the chronic lung disease"
label var H7_7_Re "Describe the heart disease"
label var H7_8_Re "Describe the heart disease"
label var H7_9_Re "Describe the cancer"
label var H7_10_Re "Desribe other chronic conditions"
label var Race_1 "American Indian or Alaska Native"
label var Race_2 "Asian"
label var Race_3 "Black or African American"
label var Race_4 "Native Hawaiian or other Pacific Islander"
label var Race_5 "White"

rename (SiteI SiteII Group Date TUG_Admin Leaders ChairHeight ArmRests TUG PA1 PA1_RE
PA2 PA3 PA4 PA5 PA6 PA7 PA8 PA9 PA10 PA11 PA12 PA13 PA14 PA15 ///
        G1 G2 G3 S1 S2_1 S2_2 S2_3 S2_4 S2_5 S2_6 S3_1 S3_2 S3_3 S3_4 S3_5 B_1 B_2 B_3
B_4 H1 H2 H3 H4 H5 H6_1 H6_2 H6_3 H6_4 H7_1 H7_2 H7_3 H7_4 H7_5 ///
        H7_6 H7_7 H7_8 H7_9 H7_10 H7_1_Re H7_2_Re H7_3_Re H7_4_Re H7_5_Re
H7_6_Re H7_7_Re H7_8_Re H7_9_Re H7_10_Re H7_5_exp H7_7_exp H7_8_exp H7_9_exp
H7_10_exp ///
        Height_ft Height_in Weight Bmon Bday Byear Gender Marital Household Hispanic
Race_1 Race_2 Race_3 Race_4 Race_5 Education Zip CommentsI CommentsII) ///
        (SiteI_Post SiteII_Post Group_Post Date_Post TUG_Admin_Post Leaders_Post
ChairHeight_Post ArmRests_Post TUG_Post PA1_Post PA1_RE_Post PA2_Post PA3_Post ///
        PA4_Post PA5_Post PA6_Post PA7_Post PA8_Post PA9_Post PA10_Post PA11_Post
PA12_Post PA13_Post PA14_Post PA15_Post G1_Post G2_Post G3_Post S1_Post ///
        S2_1_Post S2_2_Post S2_3_Post S2_4_Post S2_5_Post S2_6_Post S3_1_Post S3_2_Post
S3_3_Post S3_4_Post S3_5_Post B_1_Post B_2_Post B_3_Post B_4_Post ///
        H1_Post H2_Post H3_Post H4_Post H5_Post H6_1_Post H6_2_Post H6_3_Post
H6_4_Post H7_1_Post H7_2_Post H7_3_Post H7_4_Post H7_5_Post H7_6_Post H7_7_Post ///
        H7_8_Post H7_9_Post H7_10_Post H7_1_Re_Post H7_2_Re_Post H7_3_Re_Post
H7_4_Re_Post H7_5_Re_Post H7_6_Re_Post H7_7_Re_Post H7_8_Re_Post H7_9_Re_Post ///
        H7_10_Re_Post H7_5_exp_Post H7_7_exp_Post H7_8_exp_Post H7_9_exp_Post
H7_10_exp_Post Height_ft_Post Height_in_Post Weight_Post Bmon_Post Bday_Post ///
        Byear_Post Gender_Post Marital_Post Household_Post Hispanic_Post Race_1_Post
Race_2_Post Race_3_Post Race_4_Post Race_5_Post Education_Post Zip_Post ///
        CommentsI_Post CommentsII_Post)


rename (H1_Post H2_Post H3_Post H7_2_Post H7_3_Post H7_4_Post H7_5_Post H7_6_Post
H7_7_Post H7_8_Post H7_9_Post H7_10_Post Race_1_Post Race_2_Post Race_3_Post
Race_4_Post Race_5_Post PA10_Post PA12_Post PA13_Post PA14_Post PA15_Post) ///
        (selfratehealth_Post physical_Post mental_Post diabetes_Post asthma_Post
copd_Post otherlung_Post hbp_Post heart_Post arthritis_Post cancer_Post othercondition_Post
```

```
americanindian_Post asian_Post black_Post native_Post white_Post  physicalactivitydays_Post fastfood_Post fruitveg_Post soda_Post water_Post)

sort Participant_ID
save Texercise_Complete, replace

/* pre-program/baseline data*/
clear
set more off
cd "H:\Chapter4\Data Testing"

import excel using " H:\Chapter4\Texercise_Data_Pre_v9_FInal_RECODE_Folake.xls", sheet("Texercise_Baseline") firstrow

/*
label var TUG "TUG"
label var PA1 "rarely or never do any physical activities"
label var PA2 "light or moderate physical activities but not every week"
label var PA3 "light physical activity every week"
label var PA4 "moderate physical activity every week"
label var PA5 "30 minutes or more per day of moderate physical activity, 5 or more days per week"
label var PA6 "vigorous physical activities every week, but for less than 5 days per week or less than 20 minutes a time"
label var PA7 "20 minutes or more per day of vigorous physical activities, 3 ore more days per week"
label var PA8 "do activities to increase muscle strength, such as lifting weights or calisthenics, once a week or more"
label var PA9 "do activities to improve flexibility, such as stretching or yoga, once a week or more"
label var PA10 "Over the past 7 days, how many days did you do moderate to vigorous physical activity?"
label var PA11 "On those days that you engage in moderate to vigorous physical activity, how many minutes, on average, do you exercise at this level?"
label var PA12 "Over the past 7 days, how many times did you eat fastfood meals or snacks?"
label var PA13 "Over the past 7 days, how many servings of fruits/vegetables did you eat each day?"
label var PA14 "Over the past 7 days, how many soda or sugar sweetened drinks (regular, not diet) did you drink each day?"
label var PA15 "In the average day, how many cups of water do you drink each day?"
label var G1 "goals about physical activity"
label var G2 "goals about eating"
label var G3 "goals about managing your chronic conditions"
label var S1 "How many people in your life give you social support?"
label var S2_1 "How often do you get social support for the following activities - planning physical activity goals"
label var S2_2 "How often do you get social support for the following activities - planning dietary goals"
label var S2_3 "How often do you get social support for the following activities - keeping physical activity goals"
label var S2_4 "How often do you get social support for the following activities - keeping dietary goals"
```

label var S2_5 "How often do you get social support for the following activities - reducing barriers to physical activity"
label var S2_6 "How often do you get social support for the following activities - reducing barriers to healthy eating"
label var S3_1 "feel safe exercising at home"
label var S3_2 "feel safe being physically active in my neighborhood"
label var S3_3 "know of outdoor places near my home where I can be physically active (e.g., parks)"
label var S3_4 "know of facilities near my home where I can be physically active (e.g., gyms or recreational centers)"
label var S3_5 "Memberships at facilities where I can be physically active (e.g., gyms or recreational centers) are affordable"
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label var B_3 "confident are you that you can manage your chronic conditions on daily basis?"
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label var H1 "Self rated health"
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label var H5 "On a scale of 0 to 10, how much stress you have been experiencing in he last 7 days?"
label var H6_1 "Over the past 2 weeks, how often have you been bothered by these problems? - feeling nervous, anxious, or on edge"
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label var H6_3 "Over the past 2 weeks, how often have you been bothered by these problems? - Feeling down, depressed, or hopeless"
label var H6_4 "Over the past 2 weeks, how often have you been bothered by these problems? - little interest or pleasure in doing things"
label var H7_1 "do you have a chronic condition?"
label var H7_2 "Type 2 Diabetes"
label var H7_3 "Asthma"
label var H7_4 "Chronic Bronchities, Emphysema, or COPD"
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label var H7_5_Re "Describe the chronic lung disease"
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label var Race_3 "Black or African American"
label var Race_4 "Native Hawaiian or other Pacific Islander"
label var Race_5 "White"

```
rename (H1 H2 H3 H7_2 H7_3 H7_4 H7_5 H7_6 H7_7 H7_8 H7_9 H7_10 Race_1 Race_2 Race_3 Race_4 Race_5 PA10 PA12 PA13 PA14 PA15) ///
                (selfratehealth physical mental diabetes asthma copd otherlung hbp heart arthritis cancer othercondition americanindian asian black native white physicalactivitydays fastfood fruitveg soda water)

sort Participant_ID
save Texercise_Baseline, replace

*merging both data sets
merge 1:1 Participant_ID using Texercise_Complete
keep if _merge==3
***
gen age = 2013 - Byear
replace age = 2013- Byear_Post if age==.

egen chroniccond = rowtotal (diabetes asthma copd otherlung hbp heart arthritis cancer othercondition), missing
egen chroniccond_Post = rowtotal (diabetes_Post asthma_Post copd_Post otherlung_Post hbp_Post heart_Post arthritis_Post cancer_Post othercondition_Post), missing

gen unhealthydays = physical + mental
replace unhealthydays = 30 if unhealthydays > 30
gen healthydays = 30 - unhealthydays
replace healthydays = round(healthydays)

gen unhealthydays_Post = physical_Post + mental_Post
replace unhealthydays_Post = 30 if unhealthydays_Post > 30
gen healthydays_Post = 30 - unhealthydays_Post
replace healthydays_Post = round(healthydays_Post)

*Calculating EQ-5D scores based on the number of healthy days and age categories
*EQ-5D baseline
gen eq5d = 0.968 if age >=45 & age <= 64 & healthydays == 30
replace eq5d = 0.834 if age >=45 & age <= 64 & healthydays == 29
replace eq5d = 0.827 if age >=45 & age <= 64 & healthydays == 28
replace eq5d = 0.823 if age >=45 & age <= 64 & healthydays == 27
replace eq5d = 0.818 if age >=45 & age <= 64 & healthydays == 26
replace eq5d = 0.809 if age >=45 & age <= 64 & healthydays == 25
replace eq5d = 0.803 if age >=45 & age <= 64 & healthydays == 24
replace eq5d = 0.800 if age >=45 & age <= 64 & healthydays == 23
replace eq5d = 0.797 if age >=45 & age <= 64 & healthydays == 22
replace eq5d = 0.795 if age >=45 & age <= 64 & healthydays == 21
replace eq5d = 0.787 if age >=45 & age <= 64 & healthydays == 20
replace eq5d = 0.778 if age >=45 & age <= 64 & healthydays == 19
replace eq5d = 0.777 if age >=45 & age <= 64 & healthydays == 18
replace eq5d = 0.776 if age >=45 & age <= 64 & healthydays == 17
replace eq5d = 0.773 if age >=45 & age <= 64 & healthydays == 16
replace eq5d = 0.767 if age >=45 & age <= 64 & healthydays == 15
```

```
replace eq5d = 0.761 if age >=45 & age <= 64 & healthydays == 14
replace eq5d = 0.759 if age >=45 & age <= 64 & healthydays == 13
replace eq5d = 0.757 if age >=45 & age <= 64 & healthydays == 12
replace eq5d = 0.755 if age >=45 & age <= 64 & healthydays == 11
replace eq5d = 0.717 if age >=45 & age <= 64 & healthydays == 10
replace eq5d = 0.709 if age >=45 & age <= 64 & healthydays == 9
replace eq5d = 0.708 if age >=45 & age <= 64 & healthydays == 8
replace eq5d = 0.708 if age >=45 & age <= 64 & healthydays == 7
replace eq5d = 0.707 if age >=45 & age <= 64 & healthydays == 6
replace eq5d = 0.706 if age >=45 & age <= 64 & healthydays == 5
replace eq5d = 0.705 if age >=45 & age <= 64 & healthydays == 4
replace eq5d = 0.705 if age >=45 & age <= 64 & healthydays == 3
replace eq5d = 0.704 if age >=45 & age <= 64 & healthydays == 2
replace eq5d = 0.704 if age >=45 & age <= 64 & healthydays == 1
replace eq5d = 0.464 if age >=45 & age <= 64 & healthydays == 0


replace eq5d = 0.905 if age >=65 & age <= 74 & healthydays == 30
replace eq5d = 0.823 if age >=65 & age <= 74 & healthydays == 29
replace eq5d = 0.817 if age >=65 & age <= 74 & healthydays == 28
replace eq5d = 0.809 if age >=65 & age <= 74 & healthydays == 27
replace eq5d = 0.802 if age >=65 & age <= 74 & healthydays == 26
replace eq5d = 0.796 if age >=65 & age <= 74 & healthydays == 25
replace eq5d = 0.784 if age >=65 & age <= 74 & healthydays == 24
replace eq5d = 0.779 if age >=65 & age <= 74 & healthydays == 23
replace eq5d = 0.776 if age >=65 & age <= 74 & healthydays == 22
replace eq5d = 0.776 if age >=65 & age <= 74 & healthydays == 21
replace eq5d = 0.773 if age >=65 & age <= 74 & healthydays == 20
replace eq5d = 0.770 if age >=65 & age <= 74 & healthydays == 19
replace eq5d = 0.769 if age >=65 & age <= 74 & healthydays == 18
replace eq5d = 0.768 if age >=65 & age <= 74 & healthydays == 17
replace eq5d = 0.765 if age >=65 & age <= 74 & healthydays == 16
replace eq5d = 0.740 if age >=65 & age <= 74 & healthydays == 15
replace eq5d = 0.711 if age >=65 & age <= 74 & healthydays == 14
replace eq5d = 0.711 if age >=65 & age <= 74 & healthydays == 13
replace eq5d = 0.710 if age >=65 & age <= 74 & healthydays == 12
replace eq5d = 0.710 if age >=65 & age <= 74 & healthydays == 11
replace eq5d = 0.708 if age >=65 & age <= 74 & healthydays == 10
replace eq5d = 0.707 if age >=65 & age <= 74 & healthydays == 9
replace eq5d = 0.706 if age >=65 & age <= 74 & healthydays == 8
replace eq5d = 0.706 if age >=65 & age <= 74 & healthydays == 7
replace eq5d = 0.706 if age >=65 & age <= 74 & healthydays == 6
replace eq5d = 0.705 if age >=65 & age <= 74 & healthydays == 5
replace eq5d = 0.705 if age >=65 & age <= 74 & healthydays == 4
replace eq5d = 0.705 if age >=65 & age <= 74 & healthydays == 3
replace eq5d = 0.704 if age >=65 & age <= 74 & healthydays == 2
replace eq5d = 0.703 if age >=65 & age <= 74 & healthydays == 1
replace eq5d = 0.453 if age >=65 & age <= 74 & healthydays == 0
```

```
replace eq5d = 0.883 if age >=75 & healthydays == 30
replace eq5d = 0.811 if age >=75 & healthydays == 29
replace eq5d = 0.806 if age >=75 & healthydays == 28
replace eq5d = 0.795 if age >=75 & healthydays == 27
replace eq5d = 0.782 if age >=75 & healthydays == 26
replace eq5d = 0.778 if age >=75 & healthydays == 25
replace eq5d = 0.776 if age >=75 & healthydays == 24
replace eq5d = 0.773 if age >=75 & healthydays == 23
replace eq5d = 0.770 if age >=75 & healthydays == 22
replace eq5d = 0.769 if age >=75 & healthydays == 21
replace eq5d = 0.764 if age >=75 & healthydays == 20
replace eq5d = 0.758 if age >=75 & healthydays == 19
replace eq5d = 0.756 if age >=75 & healthydays == 18
replace eq5d = 0.753 if age >=75 & healthydays == 17
replace eq5d = 0.716 if age >=75 & healthydays == 16
replace eq5d = 0.708 if age >=75 & healthydays == 15
replace eq5d = 0.706 if age >=75 & healthydays == 14
replace eq5d = 0.706 if age >=75 & healthydays == 13
replace eq5d = 0.705 if age >=75 & healthydays == 12
replace eq5d = 0.705 if age >=75 & healthydays == 11
replace eq5d = 0.704 if age >=75 & healthydays == 10
replace eq5d = 0.702 if age >=75 & healthydays == 9
replace eq5d = 0.701 if age >=75 & healthydays == 8
replace eq5d = 0.700 if age >=75 & healthydays == 6
replace eq5d = 0.699 if age >=75 & healthydays == 5
replace eq5d = 0.695 if age >=75 & healthydays == 4
replace eq5d = 0.694 if age >=75 & healthydays == 3
replace eq5d = 0.692 if age >=75 & healthydays == 2
replace eq5d = 0.689 if age >=75 & healthydays == 1
replace eq5d = 0.441 if age >=75 & healthydays == 0

**************************
*EQ-5D Post
gen eq5d_Post = 0.968 if age >=45 & age <= 64 & healthydays_Post == 30
replace eq5d_Post = 0.834 if age >=45 & age <= 64 & healthydays_Post == 29
replace eq5d_Post = 0.827 if age >=45 & age <= 64 & healthydays_Post == 28
replace eq5d_Post = 0.823 if age >=45 & age <= 64 & healthydays_Post == 27
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replace eq5d_Post = 0.767 if age >=45 & age <= 64 & healthydays_Post == 15
```

```
replace eq5d_Post = 0.761 if age >=45 & age <= 64 & healthydays_Post == 14
replace eq5d_Post = 0.759 if age >=45 & age <= 64 & healthydays_Post == 13
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replace eq5d_Post = 0.708 if age >=45 & age <= 64 & healthydays_Post == 7
replace eq5d_Post = 0.707 if age >=45 & age <= 64 & healthydays_Post == 6
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replace eq5d_Post = 0.689 if age >=75 & healthydays_Post == 1
replace eq5d_Post = 0.441 if age >=75 & healthydays_Post == 0

*****
tab selfratehealth selfratehealth_Post
recode selfratehealth (1=5) (5=1) (2=4) (4=2)
recode selfratehealth_Post  (1=5) (5=1) (2=4) (4=2)

*Time invariant variables - gender, race, education, marital,
replace Education = Education_Post if Education==. & Education_Post!=.
replace Education_Post = Education if Education_Post==. & Education!=.

replace Hispanic = Hispanic_Post if Hispanic==. & Hispanic_Post!=.
replace Hispanic_Post = Hispanic if Hispanic_Post==. & Hispanic!=.

replace americanindian = americanindian_Post if americanindian==. & americanindian_Post!=.
replace americanindian_Post = americanindian if americanindian_Post==. & americanindian!=.

replace black = black_Post if black==. & black_Post!=.
replace black_Post = black if black_Post==. & black!=.

replace white = white_Post if white==. & white_Post!=.
replace white_Post = white if white_Post==. & white!=.
```

```
replace marital = Marital_Post if marital==. & Marital_Post!=.
replace Marital_Post = marital if Marital_Post==. & marital!=.

replace Gender = Gender_Post if Gender==. & Gender_Post!=.
replace Gender_Post = Gender if Gender_Post==. & Gender!=.

gen female = Gender==0

gen race = 1 if white ==1 & Hispanic==0 /* white*/
replace race = 2 if black==1 & Hispanic==0 /* black*/
replace race = 3 if Hispanic ==1  /* hispanic*/
tab race

********
*Table 1
*Demographics
tab race
sum age race female Hispanic marital Education TUG TUG_Post selfratehealth selfratehealth_Post
chroniccond chroniccond_Post physicalactivitydays
physicalactivitydays_Post fastfood fastfood_Post fruitveg fruitveg_Post soda soda_Post
water water_Post

ttest TUG == TUG_Post
ttest selfratehealth == selfratehealth_Post
ttest physicalactivitydays == physicalactivitydays_Post
ttest chroniccond == chroniccond_Post
ttest fastfood == fastfood_Post
ttest fruitveg == fruitveg_Post
ttest soda == soda_Post
ttest water == water_Post

sum healthydays healthydays_Post eq5d eq5d_Post
ttest healthydays == healthydays_Post
ttest eq5d == eq5d_Post

bysort female: sum eq5d eq5d_Post healthydays healthydays_Post
bysort female: ttest healthydays == healthydays_Post
bysort female: ttest eq5d == eq5d_Post
bysort race: sum eq5d eq5d_Post healthydays healthydays_Post
bysort race: ttest eq5d == eq5d_Post
bysort race: ttest healthydays ==healthydays_Post

*******
*outcome 1 : QALY

*(A) Overall
*QALY Calclulations

gen QALY = [(eq5d + eq5d_Post)/2] * [2.5/12]
sum QALY
```

```
*selected health and physical activity measures
*Healthy days
count if healthydays_Post > healthydays

*Physical Activity
count if physicalactivitydays_Post > physicalactivitydays

*TUG (people who reported improvement in TUG)
count if TUG_Post< TUG

*(B) by racial and ethnic group

*QALY
*Non-Hispanic Whites
*QALY overall = [(0.747 + 0.773) / 2  *   2.5/12  =  0.158 ]
sum QALY if race==1
count if healthydays_Post > healthydays & race==1
count if physicalactivitydays_Post > physicalactivitydays & race==1
count if TUG_Post< TUG & race==1

*Blacks
sum QALY if race==2
count if healthydays_Post > healthydays & race==2
count if physicalactivitydays_Post > physicalactivitydays & race==2
count if TUG_Post< TUG & race==2

*Hispanics
sum QALY if race==3
count if healthydays_Post > healthydays & race==3
count if physicalactivitydays_Post > physicalactivitydays & race==3
count if TUG_Post< TUG & race==3

*********************************************************************************
*End
```

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