Development, Validation, and Application of a Multidimensional Definition of Healthy Aging

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The progressive aging of the population corresponds with a movement in gerontology focusing on factors that promote the positive aspects of aging. The concept of healthy aging corresponds with the multifaceted nature of health, and has been a major focus of recent gerontological research. Investigations into this concept are guided by three main frameworks: biomedical, psychosocial, and lay perspectives. Few researchers have examined this concept using a multidimensional approach. The creation of a biopsychosocial definition of healthy aging draws on previous literature to determine important components and potential predictors. The major domains of this definition include physical health, cognitive health, social health, and psychological health. Using cross-sectional and longitudinal data from the Manitoba Study of Health and Aging (MSHA), the aim of this study was to develop a multidimensional construct of healthy aging based on the four components outlined above. The association between each of the four components and the overall construct of healthy aging was examined. A significant interaction was found between physical and cognitive health, indicating that each dimension of health must be assessed in the context of the other.

The definition was validated against the outcomes of mortality and institutionalization. Overall healthy aging was significantly associated with future mortality and institutionalization. In addition, healthy aging was compared with the construct of self-rated health to investigate if they are separate constructs. Results from these analyses indicated that they were overlapping constructs but each variable also had an independent effect on future mortality and institutionalization. Possible demographic, medical, and social predictors of healthy aging were also examined. Significant demographic predictors of

healthy aging at time 2 included younger age and higher education. A greater number of chronic conditions; the presence of vascular factors such as high blood pressure, stroke, heart problems, and chest pain; the presence of neurological factors such as memory problems and nerve trouble; and the presence of other conditions such as chronic pain, eye and ear trouble, and foot problems were also associated with not meeting criteria for healthy aging at time 2.

Overall the findings from this study provide support for the importance of a multidimensional definition of healthy aging that is distinct from the construct of self-rated health. The study findings also underscore the need to assess individual characteristics, such as age, sex, and education, when attempting to predict future health outcomes. A greater understanding of the factors that are associated with healthy aging may encourage opportunities to promote healthy aging. This research on healthy aging may have important implications for researchers, clinicians, and policymakers as they focus on improving quality of life for our aging population.

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1.0 Introduction and Overview

The population age structure is changing; today older adults constitute a larger segment of the population than at any other time in history (Satariano, 2006). Numerous factors are contributing to this progressive aging of our population, such as increases in life expectancy and lower fertility rates. According to Omran's classic Epidemiologic Transition Theory (1971), changes in age structure, such as increases in life expectancy, are largely due to the substitution of early-onset infectious diseases with more late-onset diseases such as heart disease and cancer. More specifically, this theory delineates three stages; namely the age of pestilence and famine, which was characterized by high mortality and high fertility rates; the age of receding pandemics; and the age of degenerative and man-made diseases, which is characterized by low mortality and low fertility rates. Proponents of the Epidemiologic Transition Theory maintain that it is the evolution from the first to the third stage that has resulted in the progressive aging of the population.

Between 1981 and 2005, the number of seniors in Canada increased from 2.4 to 4.2 million, while their share of the total population increased from 9.6% to 13.1%. The older adult population is expected to increase from 4.2 million to 9.8 million by 2036, with their overall share of the population expected to almost double, from 13.2% to 24.5%. In 2001, one Canadian in eight was aged 65 or over. By 2026, it is expected that one in five will be over the age of 65 (Health Canada, 2002).

Population aging is not a uniquely Canadian phenomenon. The proportion of individuals over the age of 60 has tripled in the last 50 years, and this number is projected to more than triple once more in the next 50 years (United Nations, 2002). In 2005, 13.1% of all Canadians were aged 65 and over, compared with 19.7% in Japan, 16% in the United

Kingdom, and 12.3% in the United States. Recent data indicate that the median age of the population in Canada is 39.1 years, compared with 43.3 years in Japan, 39.6 years in the United Kingdom, and 36.6 years in the United States (Central Intelligence Agency, 2007). According to the World Health Organization (WHO), in 2000 there were 600 million people over the age of 60: that number is expected to increase to 1.2 billion by 2025 and 2 billion by 2050 (WHO, n. d.).

In Western societies, since the middle of the 19th century, the average female life expectancy has increased from approximately 45 years to over 80 years, currently. Life expectancy for men has also risen substantially, but at a slower rate (Westendorp, 2006). According to the most recent WHO statistics, the average Canadian life expectancy (LE) is 83 years for females and 78 years for males. In contrast, the health-adjusted life expectancy (HALE), or the average number of years that a person — female or male — can expect to live in "full health," decreases to 74 and 70 years, respectively (WHO, 2007).

The difference between surviving to older ages in good health versus disability is highlighted in the "compression of morbidity" paradigm, first introduced by James Fries in 1980. This paradigm maintains that if the average age of disability or morbidity can be postponed at a greater rate than increases in life expectancy, or alternatively, if age-specific disability declines faster than age-specific mortality, then lifetime morbidity will be compressed (Fries, 1980; Fries, 2000). In essence, Fries maintains that because chronic diseases are occurring later in life and because there is a fixed lifespan, morbidity will be compressed. People will survive for longer periods before developing chronic disease, leading to shorter periods of disability. This theory corresponds with efforts to decrease the

substantial discrepancy between LE and HALE. This paradigm emphasizes increasing the quality of life and not merely the quantity of years lived.

Rates of disease and disability will continue to increase as the population ages — approximately 80% of people aged 65 and older have at least one chronic health condition and over 20% are living with a disability (Sarkisian, Hays, & Mangione, 2002; Fried, Freedman, Endres, & Wasik, 1997) — but there is an increasing awareness that a substantial proportion of the population continues to function at a high level (Glatt, Chayauichitsilp, Depp, Schork, & Jeste, 2007). Understanding the factors that contribute to the preservation of function throughout the aging process has become an increasingly popular area of research in gerontology during the past three decades (Phelan & Larson, 2002). This focus emphasizes the positive aspects of aging and corresponds with the WHO multidimensional construct of health, defined as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). In addition, the WHO recognizes health as "a resource for everyday life, not the object of living. It is a positive concept emphasizing social and personal resources as well as physical capabilities" (WHO, 1998).

The concept of healthy aging, also termed successful aging, aging well, positive aging, active aging, and optimal aging, corresponds with the positive concept of health outlined above. It emphasizes the importance of focusing on factors that not only extend health but also enhance it throughout the aging process (Depp, Glatt, & Jeste, 2007; Bowling & Dieppe, 2005). Studies of healthy aging focus on how individuals *should* age, rather than solely on how they do age, which contributes to health promotion strategies and helps maximize the ability of individuals to age in a healthy manner (Chapman, 2004; Phelan &

Larson, 2002). With our aging population, it is necessary to understand the determinants of healthy aging because of their potential implications for the burden of disease on the healthcare system — in 2000-2001, seniors accounted for 43% of the total health care expenditure in Canada (Health Canada, 2002) — and overall quality of life, given the associations between minor changes in certain areas of function and the impact they have on an individual's quality of life (Martel, Bélanger, Berthelot, & Carriére, 2005; Ball, Vance, Edwards, & Wadler, 2004).

The notion of self-rated health parallels current understandings of the construct of healthy aging in that it is thought to measure more than just the physical parameters of health. Measures of self-rated health appear to provide a more subjective approach to examining health status and provide information that may not be available from more objective measures such as levels of disease and disability. Exploration into the association between self-rated health and healthy aging is a novel area of research and it may provide insight into the importance of individuals' subjective aging experiences.

The primary purpose of this study was to create and validate a multidimensional definition of healthy aging using data from the Manitoba Study of Health and Aging (MSHA), a longitudinal population-based cohort study. The creation of the definition of healthy aging is based largely on findings from the comprehensive literature review. The overall construct of healthy aging was divided into specific components. In turn, the inter-relationships between the individual components and the relationship of each component with the overall construct of healthy aging were examined. The definition was validated against the outcomes of mortality and institutionalization. In addition, healthy aging was compared with the construct of self-rated health to explore if they are independent constructs.

A secondary objective of this study focused on the potential role that certain variables may play in predicting the likelihood of healthy aging.

2.0 Literature Review

2.1 The Aging Process

Human aging is a complex and heterogeneous process with substantial interplay existing among cognitive, physical, social, and psychological domains of functioning. Throughout history this period of the lifespan has been viewed as a time of inevitable decline and loss. Despite advances in health care often reported in medical and lay literature, as many as 60% of older adults still attribute chronic health conditions and disabilities to the normal aging process (Sarkisian et al., 2002). Individuals and researchers alike frequently use age as an explanatory variable or causal factor for worsening health status. Stoller (1998) found that over half (54%) of the respondents in their study attributed as least one of their symptoms to normal aging. This belief has helped perpetuate the biomedical model of aging and the negative societal perceptions that persist regarding the aging process (Grant, 1996).

There are certain changes in body systems that do occur as individuals age. Specific physiologic changes include alterations in cardiovascular structure, progressive declines in body mass, and decreases in strength per unit of muscle mass, accompanied by overall declines in organ reserve (Fries, 2000; Hartman-Stein & Potkanowicz, 2003; Topp, Fahlman, & Boardley, 2004). Although these changes in physiology are a normal part of aging, evidence indicates that many of the so-called disease processes can be modified and minimized through prevention techniques, such as improved diet and increased exercise (Grant, 1996; Topp et al., 2004).

As a general rule, normative aging changes do not directly interfere with daily functioning for older adults, but age-associated physiologic changes such as changes in muscle mass and declines in organ reserve often lead to changes in physical and cognitive

functioning. Physical functioning is most commonly measured through activities of daily living (ADL) and instrumental activities of daily living (IADL) scales (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). ADL scales measure an individual's ability to complete basic functions such as bathing, dressing, toileting, transferring, and eating. IADL scales assess abilities such as using the telephone, going shopping, preparing meals, and handling finances. Older adults are more likely to have limitations in IADLs rather than ADLs, as IADLs are generally more complex, more physically demanding, and involve higher order cognitive function (Aldwin & Gilmer, 2004). According to Canadian statistics, only 6% of men and 7% of women over the age of 65, living in the community in 2003, reported needing help to carry out any of the basic ADLs (Gilmour & Park, 2006). This dependency increased with age, with 20% of men and 23% of women over the age of 85 reporting dependencies on basic ADLs. While almost everyone who is ADL-dependent is also IADL-dependent, many who need help with IADLs do not need assistance with ADLs. In 2003, dependency in IADLs affected 15% of men and 29% of women over the age of 65 who were living in the community. The proportions reporting dependency also increased with increasing age, with 46% of men and 65% of women over the age of 85 requiring assistance with IADLs (Gilmour & Park, 2006).

Proper cognitive function is a necessity for daily functioning and declines in cognitive functioning are often one of the most feared aspects of aging (Lawton, Moss, Hoffman, Grant, & Kleban, 1999). Although a great deal of variability exists in the cognitive changes that occur with aging, there is some consensus in the literature on universal age-related losses (Vance & Crowe, 2004). Tasks that require multiple different perceptual and cognitive processes appear to be particularly vulnerable to age-related declines in performance

(Christensen et al., 1999; Kramer, Bherer, Colcombe, Dong, & Greenough, 2004; Whalley, Dearly, Appleton, & Starr, 2004). Crystallized or knowledge-based abilities, such as verbal knowledge or comprehension, remain relatively stable throughout the lifespan. On the other hand, fluid abilities — such as processing speed, reasoning, and working memory, which are independent of previous experience — are often subject to earlier age-related declines (Baltes, Staudinger, & Lindengerger, 1999; Kramer et al., 2004). In addition, executive functions such as planning, cognitive flexibility, and inhibitory responses are thought to be susceptible to age-related declines (Jurado & Rosselli, 2007; van Hooren et al., 2007). Although there are some consistencies in observed age-related cognitive declines, substantial inter-individual variability remains, with rapid declines in some individuals and little or no decline in others (Royall, Palmer, Chiodo, & Polk, 2005; Wilson et al., 2002). Exploring the factors that contribute to this differential decline in cognitive abilities in individuals as they age is an expanding field of research. In addition, increased interest is being placed on understanding not only pathological diseases that affect cognition, such as Alzheimer's disease, but also on mild cognitive deficits that are found in the general nondemented population (Satariano, 2006).

Although maintaining cognitive and physical functioning is of substantial importance to older adults as they age, other characteristics also play an important role in the aging process. Perceptions and attitudes about the process of aging have a profound impact on how people view themselves and others who are aging. Sarkinsian, Hays, and Mangione (2002) found that at least 50% of their sample of community-based older adults thought that worsening health was an expected part of aging. Holding lower expectations as a function of aging was associated with a belief that it was not important to seek health care for age-

associated conditions, such as depression, memory impairment, and urinary incontinence. These findings suggest that many older adults are unaware of the potential value of seeking health care for common problems of aging. Lower expectations may also impact actual participation in health promoting activities. Sarkisian, Prohaska, Wong, Jirsch, and Mangione (2005) examined the notion that low age expectations act as a barrier to participation in physical activity. They found that older adults with high expectations of the aging process reported significantly more physical activity in the previous week than those older adults with low expectations.

2.2 Evolution of the Concept of Healthy Aging

The concept of healthy aging has gained increasing popularity in the field of gerontology throughout the last three decades (Phelan & Larson, 2002). It is often used interchangeably with such terms as active aging, aging well, optimal aging, and the more popular term, emphasized in the work of Rowe and Kahn, successful aging (Jeste, 2005; Rowe & Kahn, 1987). A commentary by Holstein and Minkler (2003) stated that "successful aging is perhaps the single most recognized work in recent gerontology" (p.787).

The term "successful aging" first appeared in the gerontological literature in a 1961 issue of "The Gerontologist" (Havinghurst, 1961). Over the past 40 years, the development of this construct has been shaped by six main frameworks or theories. *Activity theory* purports that aging well means engaging in activities during midlife and maintaining these activities throughout later adulthood in order to remain socially engaged. In essence, the higher the level of activity, the more positive an individual's adjustment to advancing age (Havinghurst, 1961). According to *disengagement theory*, healthy aging requires both a

withdrawal from society by the individual and also a withdrawal from the individual by society. This mutual withdrawal is accomplished through decreasing involvement in productive activities or social interactions (Cummings & Henry, 1961). The *continuity theory* assumes that aging well is a process of personal adaptation reliant on an individual's personality characteristics. Older adults gradually adapt to change according to their own sense of self, relying on their past experiences to inform their present situation (Atchley, 1989). The *socio-environmental theory* emphasizes the influence of the environmental context of aging well. It highlights the unique social and personal environment of aging adults as the key component to their aging well (Gubrium, 1973). The *model of successful aging*, proposed by Rowe and Kahn (1987), contends that aging well includes avoiding disease and disability, maintaining physical and cognitive function, and continuing active engagement in life. Finally, the *selective optimization with compensation model*, proposed by Baltes and Baltes (1990), suggests that aging well is achieved by minimizing losses and maximizing gains through three processes: *selection* involves restriction of tasks with advancing age, *compensation* refers to employing alternative strategies to reach the same goal, and *optimization* refers to the enhancement of resources in selective areas.

Each model has strengths and weaknesses but a large majority of the available research has been guided by the Rowe and Kahn model of healthy aging. More recently, the selective optimization with compensation model has gained increasing popularity as a means to explain not only who can be classified as healthy aging, but how those individuals obtained healthy aging status.

2.3 Definitions of Healthy Aging

A variety of definitions of healthy aging exist in the literature. Health Canada (2002) defines it as a "lifelong process of maximizing opportunities for maintaining and preserving health, physical and mental well-being, independence, and quality of life" (p. 26). The Centers for Disease Control and Prevention (CDC) take a similar approach, defining healthy aging as the "development and maintenance of optimal physical, mental, and social well-being and function in older adults" (CDC, 2002). The World Health Organization (WHO) uses the term active aging and defines it as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002 p.12). As previously stated, Rowe and Kahn (1997) defined successful aging as including three main components: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement in life, while von Fabor and colleagues (2001) described successful aging as an optimal state of overall functioning and well-being.

The clear consensus, based on the above definitions, is that the emphasis of healthy aging is on maintaining positive functioning for as long as possible (Moody, 2005). It is also apparent that healthy aging is often conceptualized as a multifaceted construct that encompasses not only health, but also many other related concepts, such as well-being and social functioning. Although this multidimensional approach to healthy aging corresponds with the complexity of both health and the aging process, few studies have captured this multidimensionality in their operationalizations of healthy aging. It is also clear that no agreement exists on whether the indicators of healthy aging should be assessed by objective or subjective measures or by some combination of both (Reker, 2002). The lack of an

accepted definition of healthy aging has lead to dramatic variation in the components and predictors that are included in definitions of healthy aging, which in turn has made it difficult to compare results across studies. For example, depending on the definition of healthy aging used, the prevalence of study participants deemed to be "aging well" ranges from approximately 3% to over 80% (Bowling, 2007).

2.4 Dimensions and Determinants of Healthy Aging

The majority of existing operationalizations of healthy aging fall into three main categories: biomedical, psychosocial, and lay perceptions (Bowling, 2007; Bowling & Dieppe, 2005). Biomedical approaches stem from the research of Rowe and Kahn (1987) and are based on their three components of successful aging: low probability of disease and disease-related disability, high cognitive and physical function, and active engagement with life. Researchers who adopt this perspective generally conceive of healthy aging as a state of being that can be objectively measured (Duay & Bryan, 2006). Psychosocial approaches emphasize aspects of life satisfaction, social functioning, and personality characteristics, such as adaptation and coping ability (Bowling & Iliffe, 2006). Researchers employing psychosocial perspectives recognize healthy aging as a process rather than merely a state of being (Bowling & Dieppe, 2005). Finally, studies that examine individuals' perspectives of their own healthy aging are aimed at addressing gaps in the literature, namely the lack of multidimensionality in definitions of healthy aging. Theses lay perspectives include aspects of both biomedical and psychosocial theories (Bowling, 2006; Bowling & Dieppe, 2005).

2.4.1 Components of Healthy Aging

The most frequently cited components of researcher-defined definitions of healthy aging are summarized in Appendix A. The measures most commonly included in definitions of healthy aging include levels of disease and disability, and measures of physical and cognitive functioning. This biomedical approach to studying healthy aging has influenced a large body of research, namely the MacArthur Studies of Successful Aging. These studies are grounded in Rowe and Kahn's model and operationalize successful aging largely on physical components such as no disability on a seven-item scale of ADLs; no more than one disability on eight physical performance measures; the ability to hold a semi-tandem balance for 10 seconds; the ability to stand from a seated position five times in 20 seconds; and cognitive ability, whereby individuals must obtain a score of at least six or more correct on a nine-item short portable mental status questionnaire, and must recall three or more of six elements on a delayed recall test (Berkman et al., 1993; Karlamangla, Singer, McEwan, Rowe, & Seeman, 2002; Kubzansky, Berkman, & Glass, 1998; Reuben, Judd-Hamilton, & Seeman., 2003; Schoenfeld, Malmose, Blazer, Gold, & Seeman, 1994; Seeman et al., 1994; Seeman et al., 1995; Seeman, Bruce, & McAvay, 1996; Seeman, Rodin, & Albert, 1993; Seeman, Lusignolo, Albert, & Berkman, 2001; Seeman, McAvay, Merrill, Albert, & Rodin,1996; Seeman, Unger, McAvay, & Mendes de Leon 1999; Tabbarah, Crimmins, & Seeman, 2002; Unger, McAvay, Bruce, Berkman, & Seeman, 1999). Other studies have operationalized healthy aging using a similar biomedical approach. Newman and colleagues (2003) defined successful aging as being free from cardiovascular disease, cancer, and chronic obstructive pulmonary disease, and having intact physical and cognitive functioning. Similarly, Reed and colleagues (1998) defined successful aging as surviving to late life free

of major life-threatening illnesses and maintaining the ability to function physically and mentally. Tyas, Snowdon, Desrosiers, Riley, and Markesbery (2007) explored healthy aging based on measures of global cognition, short-term memory, ADL and IADL disability, and self-reported function. Strawbridge, Cohen, Shema, and Kaplan (1996) relied on thirteen basic physical activities and five physical performance measures, while Guralnik and Kaplan (1989) examined physical functioning only, and defined successful agers as those scoring in the top 20%.

Other studies have included more subjective measures, such as self-rated health, self-rated function, life satisfaction, and well-being, in their assessment of healthy aging. Jorm, Christiansen, and Henderson (1998) defined healthy aging as no disability in ADLs, a Mini-Mental State Examination (MMSE) score of 28 to 30, good or excellent self-rated health, and living in the community without disability. Tyas and colleagues (2007) included objective measures such as global cognitive function and performance-based measures of physical function but also included a more subjective measure of self-rated function. Reker (2002) included those with high physical and psychological well-being and good adjustment. In this study, high physical well-being was assessed through perceived physical well-being and physical health measures. Measures of life satisfaction and perceived psychological well-being were used to assess psychological well- being, while mental health and adaptive coping measures were used to assess adjustment. Day and Day (1993) relied almost exclusively on psychosocial measures — perceived well-being, capacity for independent activity, and a protective safety net — to define those who were aging well. Menec (2003) assessed measures of well-being, including life satisfaction and happiness; function, which was a composite measure based on physical and cognitive function; and mortality. Finally, Freud

and Baltes (1998) applied a purely psychosocial approach to healthy aging using measures of subjective well-being, positive emotion, and the absence of feelings of loneliness.

During the past decade, research on individuals' views of healthy aging has highlighted certain knowledge gaps in this area. These studies often ask individuals to identify the components important to healthy aging or, conversely, to rate the importance of components of researcher-defined definitions. The findings of studies that have examined lay perspectives of healthy aging are summarized in Appendix B.

The overwhelming consistency within these studies is the multidimensional perspective that individuals hold with respect to their conceptualizations of healthy aging (Bowling, 2007; Reichstadt, Depp, Palinkas, Folson, & Jeste, 2007). A common theme emerges throughout these studies, which maintains that despite decline and loss, many older adults embrace their own aging from a positive perspective. This optimistic approach is supported by the observation that many more people rate themselves as aging well than would a researcher-defined definition. Strawbridge, Wallhagen, and Cohen (2002) found that 50.3% of their sample rated themselves as aging successfully, while only 18.8% of the same population was classified as aging successfully based on Rowe and Kahn's criteria.

Lay definitions often encompass elements of functional health, social functioning, and psychosocial well-being (Bryant, Corbett, & Kutner, 2001; Tate, La, & Cuddy, 2003). Phelan, Anderson, LaCroix, and Larson (2004) asked individuals to rate the importance of various components of healthy aging identified in published literature. The participants rated almost two-thirds of the components as important. In addition, individuals rated psychological health as an important component, although it was rarely assessed in the literature. Using an open-ended, unprompted question, Bowling (2006) asked participants to

state the characteristics they thought were associated with successful aging. The findings were grouped into main themes, which included health and functioning; psychological factors; social roles and activities; financial and living circumstances; social relationships; neighborhood and community factors; and work and independence. Reichstadt and colleagues (2007) found that older adults placed less of an emphasis on factors such as longevity, disease/disability, and function but instead highlighted psychosocial factors, which were grouped into four major themes: attitude/adaptation, security/stability, health/wellness, and engagement/stimulation. In a qualitative study by Duay and Bryan (2006), participants' perceptions of successful aging included factors such as engaging with others; coping with changes; and maintaining physical, mental, and financial health. Finally, in a study involving participants from the Canadian Study of Health and Aging (CSHA), responses to the question "What do you think makes people live long and keep well?" were grouped into three major categories: personal factors, such as attitudes, health, and lifestyle; relationships with others, such as marriage and children; and system influences, such as financial resources (Bassett, Bourbonnais, & McDowell, 2007).

Studies addressing individuals' perceptions of healthy aging provide strong support for the multidimensionality of this construct. Lay perspectives help to clarify unknown constructs in the literature and they also serve to validate existing theories. They also help to improve the overall quality of the research by highlighting important insights that researchers may overlook. Lay involvement in studies may also increase the acceptance of research findings (Bowling, 2007). Including individuals' perceptions is helping to move this field in a direction that defines healthy aging based on multiple criteria, not merely physical health parameters, as was often the case in the past. Lay perceptions are particularly useful in the

context of healthy aging because of the lack of consensus regarding what components are essential to include in definitions. They emphasize that a definition of healthy aging should include aspects of social and psychological health as well as physical and cognitive health.

2.4.2 Predictors of Healthy Aging

Due to a lack of consistency in measurement, the range of predictors that have been examined varies dramatically, often creating a significant overlap with components of healthy aging. This has made it difficult to compare results across studies and has hindered the advancement of this field. For example, some studies include social functioning in their definition of healthy aging (Montross et al., 2006; Vaillant & Mukamal, 2001, von Faber et al., 2001), while others identify it as an important predictor (Berkman et al., 1993; Menec, 2003; Strawbridge et al., 1996). Other controversial variables include self-rated health and absence of disease (Ford et al., 2000). Reed and colleagues (1998) state that many studies focus on physical function as a component piece of their definition and use the presence of chronic conditions as a predictor variable. Appendix C summarizes significant predictors identified in the literature, divided into four main categories: demographic, medical, behavioural, and psychosocial factors. The division of predictors into these four domains captures the complexity of this construct and corresponds with a multifaceted definition of healthy aging.

2.5 A Biopsychosocial Definition of Healthy Aging

The available literature provides a strong foundation for the creation of a definition of healthy aging. Each established framework, be it a biological, psychosocial, or lay

perspective, provides evidence for the inclusion of numerous variables in the construction of a useful definition. In particular, studies on lay perspectives offer important evidence for researchers because they ensure that models have social significance and meaning. They also ensure that definitions do not rely exclusively on one specific theory, which may lead to oversight of other potentially important elements (Bowling, 2007).

The multidimensional definition in this study adapts a biopsychosocial approach to healthy aging as it includes aspects of physical, cognitive, social, and psychological health. The model of healthy aging is outlined in the figure below and the contributions of each component are discussed in turn.

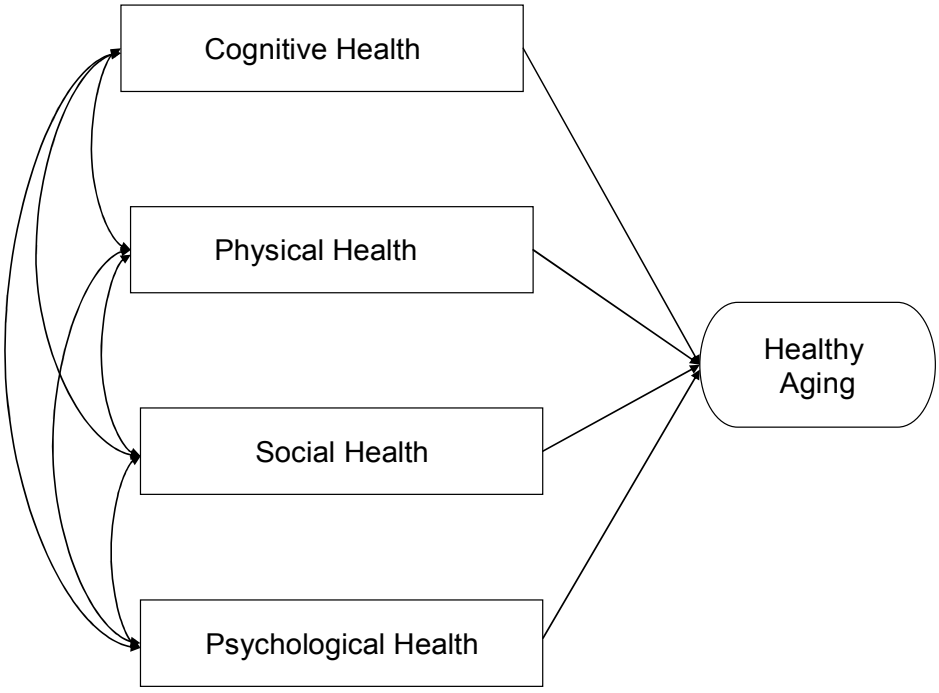

Figure 1. Model of Healthy Aging

2.5.1 Cognitive Health

Cognitive health is an essential component of healthy aging. Cognitive resources may arguably be the most important component for the maintenance of daily functioning (Poon et al., 1992) and general independence (Seeman et al., 2001). It may be possible to remain independent when cognitive capacity is intact, but in the face of cognitive dysfunction, it is often impossible to remain independent, despite one's physical capacity (Poon et al., 1992). The loss of mental function is one of the greatest concerns for older adults (Inelman et al., 2007). In fact, a study conducted by Lawton and colleagues (1999) found that the most devastating losses in late adulthood were cognitive in nature. Small changes in cognition may interfere with an individual's ability to successfully process information and to adapt to his or her environment (Vance & Crowe, 2006).

Cognitive function is a complex domain that reflects the integration of many components such as intelligence, executive functioning, memory and learning, and information processing (Ball et al., 2004). Cognitive health influences and is influenced by a wide range of changes that occur with increasing age (Teri, McCurry, & Logsdon, 1997). More specifically, cognitive function is highly inter-related with physical functioning and it plays a fundamental role in successfully carrying out most physical tasks (Tabbarah et al., 2002). Royall, Palmer, Chiodo, and Polk (2005) determined that small declines in executive functioning were associated with deficits in IADLs, with subsequent negative impacts on quality of life likely. McGuire, Ford, and Ajani (2006) reported that cognitive functioning was predictive of functional disability and IADL disability but not of ADL disability, while Steen, Son, and Borgesson-Hanson (2001) found that cognitive function was related to ADL performance. Reynolds and Silverstein (2003) concluded that deficits in cognitive function

were related to both ADL and IADL disability. Substantial evidence also indicates that cognitive function is a significant predictor of mortality (Anstey, Luszcz, Giles, & Andrews, 2001; McGuire et al., 2006; Steen et al., 2001), self-efficacy (Berkman et al., 1993), life satisfaction (Berkman et al., 1993), depression (Berkman et al., 1993), autonomy (Flicker, Lautenschlager, & Almeida, 2006), hospitalization (Chodash et al., 2004), institutionalization (Steen et al., 2001), and overall quality of life (Flicker et al., 2006).

Studies of healthy aging have generally assessed cognitive functioning through various global measures of cognitive functioning, such as the Mini-Mental State Examination (MMSE) (Depp & Jeste, 2006; Folstein, Folstein, & McHugh, 1975). Certain studies have chosen not to include cognitive functioning as a component (Day & Day, 1993; Freud & Bales, 1998; Michael, Colditz, Coakley, & Kawachi, 1999; Palmore, 1979; Strawbridge et al., 1996); however, the research outlined above concerning the fundamental role of cognition provides clear support for its inclusion as a component in definitions of healthy aging.

2.5.2 Physical Health

A major component of overall physical health is *physical functioning*. Physical functioning refers to the ability to perform tasks that are necessary for successful adaptation to daily life. Measures of physical functioning are included in the majority of studies of healthy aging, both in researcher-defined definitions and also by individuals themselves (Bowling & Depp, 2005; Duay & Bryan, 2006; Phelan et al., 2004; Tate et al., 2003; for a review of studies using researcher-defined definitions, see Bowling, 2007). The pervasiveness of this component in definitions reflects the popularity of Rowe and Kahn's

model and corresponds with the consistent associations that have been found between physical functioning and other dimensions of health status (Depp & Jeste, 2006). Maintaining physical functioning is associated with lower rates of mortality (Andrews, Clark, & Luszcz, 2002; Anstey et al., 2001; Palmore, 1979), lower rates of modifiable risk factors for common chronic diseases (Newman et al., 2003), increased life satisfaction (Berkman et al., 1993; Palmore, 1979), lower levels of depression (Berkman et al., 1993), and overall increases in quality of life (Flicker et al., 2006). Physical functioning is frequently assessed through measures of disease, disability, and physical performance. Functioning is commonly measured using ordinal, interval, or continuous scales, typically through assessing the level of difficulty to complete a task. The most commonly reported measures to assess disability are ADL and IADL scales (Depp & Jeste, 2006), which measure ability to complete self-care tasks and are used as general standards when measuring the health of older adults (Hansen-Kyle, 2005). ADL scales assess the extent an individual requires personal or technical assistance in basic tasks that are necessary for independence. On the other hand, IADL scales assess the ease of adaptation to the environment and generally require a number of different capacities such as physical, cognitive, personal, and social resources (Satariano, 2006). Some researchers also include self-assessed objective health conditions in their assessment of physical functioning (Frederikson et al., 2002; Newman et al., 2003; Reed et al., 1998; Vaillant & Mukamal, 2001). Several studies have used objective performance-based measures of physical functioning, such as upper and lower body extremity function, grip strength, stair climbing, walking, or performance on specific ADLs (Berkman et al., 1993; Burke et al., 2001; Frederikson et al., 2002; Newman et al., 2003; Strawbridge et al., 1996, Tyas et al., 2007).

2.5.3 Social Health

Social functioning is a fundamental component in the process of aging well (Antonucci & Akiyama, 1991). Measures of social functioning vary dramatically and often include elements such as social networks, social engagement, and social support (Bath & Deeg, 2005). Social networks have been examined in terms of size, composition (i.e., the types of relationships), and frequency of contact (van Tilburg, 1998). Social support is often measured in terms of instrumental and emotional support given and received (van Tilburg, 1998). Research on social functioning has highlighted that both the quantity and the quality of social relationships are important. Therefore, it is not only the number and frequency of social contact that is important but also individuals' perceptions about their social relationships. The various measures of social functioning have been associated with mortality (Glass, Mendes de Leon, Marottoli, & Berkman, 1999; Leviatan, 1999), disability (Mendes de Leon, Glass, & Berkman, 2003), cognitive functioning (Fratiglioni, Paillard-Borg, & Winblad, 2004; Seeman et al., 2001; Zunzunegui, Alvarado, Del Ser, & Otero, 2003), physical health (Seeman et al., 1996; Unger et al, 1999; Zunzunegui et al., 2004), general well-being (Antonucci & Akiyama, 1991; Leviatan, 1999), and self-rated health (Bennett, 2005; Zunzunegui et al., 2004).

Studies of healthy aging have varied widely in their measurement of social functioning, with little consensus on whether it should be a component or predictor of this concept (Bowling, 2007). Lay perspectives shed light on the relevance of this variable in multidimensional definitions of healthy aging. The majority of individuals rate variables such as social activity, interactions with others, having friends and family, and lack of feelings of loneliness or isolation as important (Fisher, 1995; Knight & Ricciardelli, 2003;

Phelan et al., 2004; Tate et al., 2003). These findings, coupled with the empirical evidence outlined above, provide support for the inclusion of social health in a definition of healthy aging.

2.5.4 Psychological Health

Psychological health can be conceptualized in various ways. It is often considered to be comprised of components of life satisfaction, general well-being, and overall quality of life. It can also refer to autonomy, feelings of control, coping abilities, and mental health status (Phelan et al., 2004). Life satisfaction has been the most frequently proposed and investigated measure of quality of life and well-being (Bowling, 2007). General well-being has also been assessed by self-rated health measures. These subjective measures of health status are consistently found to predict mortality, even when controlling for objective health status and known risk factors (Mossey & Shapiro, 1982).

Measures of depression are used to assess mental health, which can be included as a component of psychological health (Almeida, Norman, & Hankey, 2006; Garfein & Herzog, 1995). Depression is considered to be one of the leading comorbid conditions in older populations (Satariano, 2006). Reports of the prevalence of depressive symptoms among community-dwelling older adults range from 8% to 16% (Blazer, 2003). Depression has been associated with reduced physical functioning, reduced physical performance, and increased risk of chronic medical illness (Blazer, 2003; Satariano, 2006). In addition, depressive symptoms have been associated with decreased performance on tests of cognitive function (Yaffe et al., 1999).

The inclusion of psychological health in definitions of healthy aging has been influenced by psychosocial frameworks, such as the selective optimization with compensation theory (Baltes & Baltes 1990), and further reinforced by studies on lay perspectives. The inclusion of these subjective measures of general well-being in a definition of healthy aging is necessary in order to portray the complexity of this construct.

2.6 Predictors of a Biopsychosocial Definition of Healthy Aging

Identifying the essential components of a multifaceted definition of healthy aging allows potential predictors to be elucidated. As previously discussed, Appendix C outlines the various domains of predictors or determinants of healthy aging that have been examined in previous research. Demographic characteristics such as age, sex, and education have established associations with numerous health outcomes. In studies of healthy aging the most consistent predictor has been younger age. Depp and Jeste (2006) reported a significant relationship between younger age and the probability of healthy aging in 13 of 15 studies reviewed. In addition, older age is associated with an increase in mortality rates (Fried et al., 1998). Previous studies of healthy aging have reported inconsistent results for the association between sex and healthy aging (Deppe & Jeste, 2006). It is important to examine this variable as a potential predictor in order to provide insight into this inconsistency. Socioeconomic factors, such as higher levels of education, have been associated with decreased mortality rates (Fried et al., 1998; Nybo et al., 2003) and with healthy aging (Andrews et al., 2002; Strawbridge et al., 1996; Vaillant & Mukamal, 2001).

In addition to standard demographic characteristics, one potential predictor that may influence healthy aging is whether an individual is a rural or urban resident. Almost one-

quarter (22.6%) of Canada's senior population lives in rural areas (Statistics Canada, 2006). However, the relationship between healthy aging and rural/urban residential status is largely unexplored in the literature. Older adults living in rural areas may be especially vulnerable to factors such as inadequate access to health care, social isolation, decreased community involvement, reduced income, and lack of transportation (Howell & Cleary, 2007). Each of these factors may have a negative impact on overall quality of life and healthy aging.

The influence of medical characteristics, such as the number of chronic conditions and the presence of certain chronic conditions, on health outcomes such as mortality provides support for their inclusion as potential predictors of healthy aging (Fried et al., 1998). Previous studies of healthy aging have assessed both the overall number of conditions as well as the presence of certain conditions that are commonly reported in older populations. Fewer number of chronic conditions has been associated with an increased likelihood of healthy aging (Lamb & Myers, 1999; Garfein & Herzog, 1995), while the presence of certain conditions such as arthritis (Strawbridge et al., 1996; Guralnik & Kaplan, 1989), cardiovascular disease (Burke et al., 2001), and diabetes (Roos & Havens, 1991; Newman et al., 2003) has been associated with a decreased likelihood of healthy aging.

Another potentially interesting predictor, which has not been specifically examined in previous studies of healthy aging, is the presence of persistent pain. Persistent or chronic pain is common among older adults. Studies have suggested that 25 to 50% of community-dwelling adults suffer from pain problems. The consequences of pain in older adults are numerous. It has been associated with an increased risk of depression, anxiety, and impaired mobility (American Geriatrics Society, 2002). According to Topp and colleagues (2004), it is the symptom of pain that has the greatest impact on physical functioning in individuals

with chronic disease and not the actual presence of disease. Functional ability generally improves as the pain is relieved even though the presence of the chronic disease remains. Although the influence of certain chronic diseases on healthy aging has been explored, the association between pain and healthy aging has not been specifically examined. It is possible that pain plays a more important role in predicting healthy aging than the actual presence of chronic disease. This finding could have substantial implications for recognition of the importance of appropriate pain management and it could also highlight a significant modifiable risk factor that may impact an individual's ability to attain healthy aging.

2.7 Self-Rated Health

The evaluation of self-rated health status has become common practice in psychosocial, gerontological, and epidemiological surveys, largely due to its cost-efficiency and ease of administration (Kaplan & Baron-Epel, 2003; Lundberg & Manderbacka, 1996). Self-rated health is generally obtained through a single-item question, with an individual being asked to rate his or her health based on a four or five-point scale. This single global measure is considered to be a simple and direct indicator of health status and provides a reliable and valid method of capturing the diverse components and perceptions of health status (Kaplan & Baron-Epel, 2003; Krause & Jay, 1994). Kaplan and Baron-Epel (2003) asked individuals to rate their own health, based on a five-point scale ranging from excellent to bad, followed by an open-ended question about what influenced their evaluation. In this same study, subjects were also asked to rate a list of factors that may have influenced their evaluation, such as general feeling, tiredness, mood, presence/absence of disease, medication use, and difficulty in performing certain tasks. The researchers found that the factors

mentioned in the open-ended question were similar to those presented in the close-ended question. This finding supports the notion that a single close-ended question is a valid measure of self-rated health. When controlling for objective health measures, self-rated health has been shown to predict functional status (Mansson & Rastam, 2001), morbidity (Ferraro, Farmer, & Wybraniec, 1997), health care use (Menec & Chipperfield, 2001), and recovery from illness (Wilcox, Kasl, & Idler, 1996).

It has become widely accepted that how individuals perceive and evaluate their health provides additional information to that obtained by other objective health measures, such as physician records or disease and disability status measures (Idler & Benyamini 1997). In fact, self-rated health may provide a more accurate and inclusive measure of an individual's health status than more objective measures (Lundberg & Manderbacka, 1996). Data from the 1990 Ontario Health Survey revealed that 79% of individuals with chronic diseases reported that their health was good to excellent, as did 50% of those with long-term disabilities (Cott, Gignac, & Badley, 1999). The discrepancies between objective measures, such as medically obtained health status measures, and subjective measures of health, such as self-rated health, underscore the fact that individuals' perceptions of health are holistic in nature. They evaluate not only aspects of objective components, such as functional health, but also broader, subjective domains such as psychological and social health status (Kaplan & Baron-Epel, 2003).

2.7.1 Self-Rated Health and Mortality

The most clear and consistent finding reported in the self-rated health literature is its robust association with mortality. It has been suggested that no other single measure of health can more easily identify individuals at high risk for mortality (McMullen & Luborsky, 2006). The first clear, well-controlled demonstration of the association between self-rated health and mortality was reported in Mossey and Shapiro's 1982 study, which used data from the Manitoba Longitudinal Study. The researchers found that for those individuals who rated their health as poor, the risk of early mortality was 2.92 times that of those whose self-rated health was excellent, when controlling for objective health status, as reported by a physician, and other potential confounders, such as age, sex, life satisfaction, income, and urban/rural residence.

The examination of self-ratings of health as a predictor of mortality in community-based studies has flourished since Mossey and Shapiro's study. A review by Idler and Benyamini (1997) summarized the findings from 27 community studies that examined the association between self-rated health and mortality. In 23 of the 27 studies reviewed, self-rated health was independently associated with mortality. The probability of death was highest for those who rated their health as poor, less for those who rated their health as fair, and so on. Findings from an updated review by Benyamini and Idler (1999) were consistent with previous results. In 17 of the 19 studies reviewed, poor self-rated health was associated with a higher risk of mortality, even after controlling for numerous potential confounders. In a more recent review, DeSalvo, Bliser, Reynolds, He, and Muntner (2005) conducted a meta-analysis of community-based cohort studies published between January 1966 and September 2003 that included a measure of all-cause mortality and a question assessing self-rated health.

The findings from this study revealed a dose-response relationship between self-rated health and the relative risk of mortality, even after controlling for comorbid illness, functional status, cognitive status, and depression.

2.7.2 Self-Rated Health and Institutionalization

The relationship between self-rated health and mortality has been the most robust and consistent finding but researchers are becoming increasingly interested in examining the relationship of self-rated health to other outcomes. There is a rich literature that examines risk factors for institutionalization, with the strongest predictors being age, dependencies in ADLs, cognitive impairment, prior hospitalizations, and caregiver burden (Buhr, Kuchibhatla, & Clipp, 2006; Tomiak, Berthelot, Guimond, & Mustard, 2000; Yaffe et al., 2002). Few studies have specifically examined the association between self-rated health and institutionalization and the findings are inconsistent. Glazebrook and colleagues (1994) compared the characteristics of a population of older adults living in the community with those living in nursing homes. In this study, those who rated their health as less than excellent/good were more likely to be institutionalized. However, due to the limitations associated with case-control studies, such as the lack of control of potential biases, the results must be interpreted with caution. A longitudinal study by Wang, Mitchell, Smith, Cumming, and Leeder (2001) found that fair or poor self-rated health was significantly associated with an increased risk of nursing home placement over a five-year follow-up period. However, a population-based longitudinal study by Branch and Jette (1982) found no significant association between self-rated health and subsequent risk of institutionalization. Finlayson (2002) reported that changes in self-reported health over a seven-year period were associated

with increased use of home care services but no association was found with risk of institutionalization, while a study by Weinburger and colleagues (1986) found that poor self-rated health was a risk factor for both hospital admission and nursing home placement. In a review of studies that examined predictors of institutionalization, Miller and Wiessert (2000) found that worse self-rated health was significantly associated with an increased risk of institutionalization in 7 of the 22 studies they included in their review.

The inconsistencies in the findings coupled with our progressively aging population provide the rationale for further investigation into the association between self-rated health and institutionalization. Since 1981, the proportion of Canadians over the age of 65 living in institutions has remained fairly stable at around 7%, because the total number of individuals over the age of 65 has increased, the actual number of people living in institutions has also increased (from approximately 173,000 to more than 263,000) (Ramage-Morin, 2006). In addition, institutionalization is age-related, increasing from 2% among seniors aged 65 to 74 to 32% among those aged 85 and over (Statistics Canada, 2006). With the 85+ age group being the fastest growing segment of the population, determining whether self-rated health is a significant predictor of institutionalization is important for health care professionals and policy makers.

2.7.3 Qualitative Assessments of Self-Rated Health

In contrast to the abundance of quantitative studies of self-rated health, qualitative assessments of individuals' subjective evaluations of their health have not had the same degree of recognition in the literature (Idler, Hudson, & Leventhal, 1999). Qualitative approaches provide insight into unknown constructs, such as the meaning individuals attach

to their self-rated health evaluations, allowing researchers to capture the perceptions of respondents and identify the unknown dimensions of self-rated health (Idler et al. 1999; Simon et al., 2005).

In an analysis by Groves, Fultz, and Martin (1992), study participants were asked to rate their health and then to elaborate on their rating by answering the question "When you answered the last question about your health, what did you think of?" The findings yielded 10 categories, of which the absence/presence of illness was the most frequently mentioned (31%). Other categories included feelings (19%), physical performance ability (7%), and other (14%). Through in-depth interviews, Krause and Jay (1994) sought to examine what is actually measured using the global self-rated health item. The researchers found that younger people tended to use health behaviours more often, while older adults thought about self-rated health in terms of health problems. Kaplan and Baron-Epel (2003) also chose to examine the factors that respondents reported as influencing their self-rated health evaluation. Three general categories of responses emerged from the open-ended question including general subjective feelings, diseases and medical problems, and functional issues. Idler and colleagues (1999) grouped responses to an open-ended question on self-rated health into six categories: narrow biomedical criteria, such as physical health, diagnosis, and symptoms; aspects of functioning; health behaviours; ability to engage in social activities; social relationships; and finally psychological, emotional, or spiritual criteria. The researchers found that the majority of individuals drew upon numerous criteria when assessing their own health status. A recent study by McMullen and Laborsky (2006) conducted interviews with older adults and found their evaluation of health included four criteria: independent functioning, physical condition, personal responsibility and control, and

overall feeling. In their qualitative study of self-rated health, Simon and colleagues (2005) found that aspects of health could be broken down into five dimensions: physical status (presence of chronic diseases), functional status (ADLs), coping, well-being, and behaviour. While many of the respondents emphasized the physical dimension of health, 80% mentioned aspects from more than one dimension.

The qualitative studies that seek to explore the frames of reference individuals apply to their self-ratings of health correspond with and extend findings from quantitative studies. This serves to validate the use of a single self-rated health item in research because it summarizes the various components that make up the domain of health status. However, the findings from qualitative studies emphasize that individuals draw on information from various domains of health and not merely their physical health status. In essence, these qualitative studies demonstrate that the criteria individuals use in rating their health are complex and multidimensional (Simon et al., 2005).

It is possible that self-rated health reflects insight into individual's health status that can not be captured through more objective measures (Menec, Chipperfield, & Perry, 1999). Self-rated health reflects a dynamic perspective, with individuals including judgments on declines and improvements in various aspects of life, including changes in socioeconomic position, health behaviours, functional ability, and psychosocial health (Shooshtari, Menec, & Tate, 2007).

2.7.4 Self-Rated Health and Healthy Aging

Previous research has demonstrated that self-rated health is strongly associated with aspects of physical health and functioning, and that it serves as a powerful predictor of

mortality. More recent research, including examinations of individuals' perspectives on self-rated health, has demonstrated that it appears to be related to various domains of health, such as cognitive health and social and psychological well-being, in addition to physical functioning. These findings suggest that self-rated health is a multidimensional construct. Viewing self-rated health as a multifaceted construct not only corresponds with the WHO definition of health as a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 1948), but also with conceptualizations of healthy aging. A select number of studies examining the construct of healthy aging have included measures of self-rated health (Andrews, 2002; Ford et al., 2000; Garfein et al., 1995; Menec, 2003; Roos & Havens, 1991). The findings from these studies are mixed and difficult to compare due to major methodological differences. For example, in Roos and Haven's study (1991), self-rated health was incorporated in the definition of healthy aging while other researchers examined it as a predictor.

Few studies have specifically explored the relationship between the construct of healthy aging and self-rated health. Østbye and colleagues (2006) examined the association between ten dimensions of health, which were used to broadly define healthy aging, and their relationship with overall self-rated health. The ten dimensions included independent living, vision and hearing, ADLs, IADLs, absence of major physical illness, cognition, mood, social support and participation, religious participation and spirituality. In a cross-sectional analysis, the variables with the strongest association with self-rated health were the absence of disease, healthy mood and, to a lesser extent, independence in ADLs. The study demonstrates that self-rated health is related to various domains of health status. A study by Schoenfeld and colleagues (1994) examined the association between self-rated health and

mortality using data from the MacArthur Studies of Successful Aging. The researchers found a strong association for individuals who were defined as "successfully aging" but the MacArthur Studies' definition of successful aging is controversial because of the substantial focus on functional ability and the lack of inclusion of factors, such as social and psychological health, which have proven to be important components in a definition of healthy aging.

The lack of research in this area highlights the need to expand our understanding of the relationship between healthy aging and self-rated health. Given the substantial political attention, and subsequently, the financial resources that are being invested in healthy aging, it is important to establish whether it is in fact a distinct construct from other, more established paradigms such as self-rated health.

2.8 Summary

Healthy aging focuses attention on health promotion/disease prevention strategies as a means of improving quality of life (Minkler & Fadem, 2002). Its popularity has been largely influenced by the progressive population aging of both industrialized and developing countries. It highlights an expanding field of research interested in exploring factors that promote the positive aspects of aging. A lack of consensus exists regarding the operationalization of definitions of healthy aging, which leads to confusion when comparing studies. Many of the existing definitions do not reflect the heterogeneity and complexity of the aging process and rely on one-dimensional criteria to assess healthy aging. The creation of a multidimensional definition of healthy aging incorporating measures of physical, cognitive, social, and psychological health attempts to address some of the limitations of

previous research. It draws on research based on multiple theoretical frameworks and captures the spectrum of elements that are rated as important by older adults, making it applicable to researchers, public health policy makers, and lay people alike. Results from a study addressing these issues may significantly contribute to the growing field of healthy aging research and may have substantial implications for improving the health and well-being of our aging population.

The examination of self-rated health appears to conform to current views of health as a multidimensional construct. This finding is supported by individuals' evaluations of the important elements that contribute to their overall evaluation of their own health status. Although a substantial body of research purports that self-ratings of health are largely based on the evaluation of physical components of health, studies that directly ask individuals what factors they use when evaluating their health status find that various aspects of health are considered important, not merely physical health.

The association between healthy aging and self-rated health has not been explicitly evaluated in the literature. Due to the complexity of both constructs and conceptual similarities between these constructs a significant association could question the need for continued research in healthy aging.

3.0 Study Rationale and Research Objectives

3.1 Rationale

The overall purpose of this study was to create a multidimensional construct of healthy aging. The definition includes factors from various domains, all of which play important roles throughout the lifespan. The creation of this definition was informed by previous experimental research as well as various theoretical models. It applies findings from studies with a biomedical focus, those that examined healthy aging from a purely psychosocial perspective, as well as studies that have examined individual's perceptions of healthy aging. The definition should be broad enough in scope so that it is applicable to policy makers, public health practitioners, and lay people alike. It attempts to bridge a large gap that has formed between researcher-defined definitions of healthy aging and the elements that individuals perceive to be relevant to the construct of healthy aging. Application of this definition to examine demographic, medical and social predictors of healthy aging, is a secondary aim of this thesis project.

The construct of healthy aging was compared with self-rated health. Self-rated health has been found to be an important predictor of multiple health outcomes and individuals appear to rely on objective and subjective measures when evaluating their health status. The possible association between healthy aging and self-rated health has not been extensively explored in the literature, and this research offers insight into this relatively novel question. The possibility of an association between healthy aging and self-rated health has important research and policy implications. It is possible that self-rated health could serve an alternative measure to healthy aging, which would challenge the need for continued research and public attention on the construct of healthy aging.

The Manitoba Study of Health and Aging (MSHA) was an appropriate and strong dataset to explore this concept, because of the wide range of information collected and the longitudinal design that was employed. Collection of data over time allowed the establishment of a clear temporal sequence, which is not possible in cross-sectional research designs. The various research objectives outlined below used both longitudinal and cross-sectional analyses to examine the complex relationships between the various components of a multidimensional definition of healthy aging, the stability of both the components and the overall construct of healthy aging over time, and the association of healthy aging with mortality, institutionalization, and self-rated health. Demographic, medical, and social predictors of healthy aging were also explored.

3.2 Research Objectives

This study's four main research objectives were:

1) To develop a multidimensional definition of healthy aging;

2) To validate a multidimensional definition of healthy aging;

3) To explore the relationship between healthy aging and self-rated health;

4) To examine predictors of healthy aging.

The specific approach that was used to examine each objective is described in detail in Appendix G.

4.0 Methods

4.1 Literature Search

The purpose of the literature search was to thoroughly examine the available literature on the concept of healthy aging. The primary literature search identified peer-reviewed published studies from PubMed, PsycINFO, Scopus, and Ageline databases. Relevant articles were identified using the key terms "successful aging" or "healthy aging." A title/abstract/keyword search of scholarly journals was conducted in PubMed, which includes coverage since 1950. The PsycINFO search included peer-reviewed journal articles that were found using a keyword search strategy, while the terms were searched in Scopus based on article title, abstract, or keyword restriction. Both these databases contain articles from 1960 to present. Finally, the Ageline database search, which includes material from 1978, was limited to those publications aimed for a research/academic audience. All searches were restricted to studies published in English. The results of each search were manually examined to ensure that the selected literature pertained to the concept of healthy aging through the application of an operational definition of healthy aging to a particular population or the assessment of individuals' perceptions of healthy aging. In addition, commentary or review articles pertaining to the construct of healthy aging were included. The reference lists of key review articles—those that reviewed previous operational definitions of healthy aging—were also examined to ensure that relevant articles were retrieved. These restrictions yielded a total of 76 chosen articles, 41 of which specifically operationalized healthy aging and an additional 13 that examined lay perceptions of healthy aging. The remaining 22 articles were used to provide historical background and context for the critical review of this concept. Additional searches, on concepts other than healthy aging,

were conducted to provide supporting evidence for the inclusion of the chosen components of healthy aging.

Because of the lack of consensus on an accepted term for the construct of healthy aging and the lack of a specific Medical Subject Heading (MeSH) term, the search was very broad in scope. Many retrieved articles could be ruled out upon first glance, while others required closer examination of the abstract or the full-text article. The search was considered saturated when database and reference list searches cited already retrieved articles.

A separate literature search was conducted to examine published literature on the construct of self-rated health. The search for peer-reviewed articles was conducted in PubMed, PsycINFO, and Scopus databases, with years of coverage synonymous with those described previously for the healthy aging literature search. The search was restricted to those articles published in English. A title/abstract/keyword search using various combinations of key terms such as "self-rated health", "predictors", "mortality", "institutionalization", and "healthy aging" was used in PubMed and PsycINFO, while the same keywords were used in Scopus based on article title, abstract, or keyword restriction. The chosen articles for this search were limited to those that examined self-rated health as a predictor of mortality, institutionalization, or healthy aging. The selected articles were also used to identify key articles to provide contextual background on the construct of self-rated health and self-perceptions of health.

4.2 Data Source: Manitoba Study of Health and Aging

4.2.1 Study Population

The Manitoba Study of Health and Aging (MSHA) is a population-based longitudinal study of aging and dementia in community-based and institutionalized adults aged 65 years and older. It is a parallel study to the Canadian Study of Health and Aging (CSHA) and used similar instruments for data collection and diagnosis (MSHA Research Group, 1995). In 1991, the population of Manitoba aged 65 years and older was 147,372, of whom 139,579 lived in the community and 7,793 in institutions. Study participants were randomly selected from a provincial list from Manitoba Health's administrative database, which is considered to be the most thorough listing of Manitoban residents. This sample excluded individuals living in correctional institutes, mental health hospitals, personal care homes, those who were members of the military or the R.C.M.P., and individuals living in the Norman and Thompson health regions of Manitoba, which are remotely populated regions of Manitoba (exception: individuals living in the towns of Flin Flon or The Pas). The original sample was stratified by Manitoba Health region and age group (65-74, 75-84, $\geq$85 years), with a deliberate over-sampling of individuals in the two older age strata. This thesis focuses only on the community-dwelling sample.

Of the 2,890 individuals in the community contacted for the screening interview, a total of 443 refused to participate, resulting in a refusal rate of 20% (refusal rate = refusals (443) / refusals (443) + completions (1763). Other reasons for non-participation included ineligibility (n=480), inability to make contact (n=162), or inability to screen (n=54). Although a total of 1,763 individuals were included in the MSHA-1 screening sample, 12 of these individuals did not complete the screening interview, and therefore have missing data

on all time 1 variable; thus baseline screening data were collected in 1,751 older adults in 1991/92 (MSHA Research Group, 1995).

In 1996/97, individuals who participated in the baseline evaluation were re-contacted and constituted the study population for the follow-up study (MSHA-2). The community sample for the MSHA-2 study consisted of individuals who were living in the community in 1991/92 and were still living in the community by 1996/97, as well as those individuals who had moved to an institution since the 1991/92 study (MSHA-2 Research Group, 1998).

A total of 275 older adults were not eligible for the follow-up (1996/97) screening interview prior to the start of data collection for various reasons such as death (n=224), diagnosis of dementia (n=45), and relocation outside of Manitoba (n=6). Of the remaining 1,488 participants eligible for the time 2 screening interview, there were 74 (5.0%) older adults who were unable to complete the interview due to deafness and speech problems; 95 (6.4%) who refused to participate in the screening interview because of various reasons such as not being interested, feeling too sick, having no time, feeling hassled, etc; and 190 (12.8%) who were found to be ineligible. Certain individuals, who were initially eligible for the 1996/97 screening, were consequently deemed ineligible during the study if they had died (n=154), were hospitalized (n=15), had moved outside of Manitoba (n=12), could not be contacted (n=6) or were away for the study period (n=3) (MSHA-2 Research Group, 1998).

4.2.2 Data Collection

The overall purpose of the MSHA was to study aging and dementia in Manitoba. The primary focus of the MSHA-1 study was to estimate the prevalence of and risk factors for dementia, to examine the burden associated with providing care to an individual with

dementia, and to examine patterns of service use for older adults with dementia and their caregivers (MSHA Research Group, 1995). The original objectives of the MSHA-2 study were to estimate the incidence of dementia in Manitoba, to identify risk factors for dementia, to examine change in cognitive status between MSHA-1 and MSHA-2, to estimate dependence in ADLs, to identify factors that predicted the development of frailty and ADL dependence, to examine factors associated with placement in a personal care home, and to examine community-based service use among caregivers and community-residing older adults (MSHA-2 Research Group, 1998).

During both waves of the study, data were collected on a wide range of topics through the process of interviews, self-reported questionnaires, and clinical and neuropsychological examinations. The screening interview focused on topics such as sociodemographic characteristics; social network/social support; life satisfaction; psychological well-being; depression; health status indicators, such as ADL and IADL scales; self-rated health; chronic illness; medication use; and health care service use. In addition, a screening test for cognitive impairment was included. An individual's score on this cognitive screening test, the Modified Mini-Mental State Examination (3MS) (Teng & Chui, 1987), determined whether they would subsequently be invited to participate in a full clinical evaluation. Individuals who screened positive for cognitive impairment on the 3MS (scores <78) were asked to complete the full clinical examination.

The clinical evaluations measured key variables through in-person interviews with the subject, telephone interviews with family members, physical examinations, and a series of neuropsychological tests with participants who scored $\geq$50 on the 3MS at the clinical examination. Consensus meetings were conducted with all members of the clinical team to

arrive at a final clinical diagnosis. In-person interviews were also conducted with selected primary caregivers of older adults at both waves of the study.

4.3 Current Thesis Project

4.3.1 Analytic Sample Population

The analyses were based on 1,751 community-dwelling individuals who completed the time 1 screening interview. Figure 2 outlines the derivation of the samples used in these analyses. Appendix D provides an in-depth description of missing data.

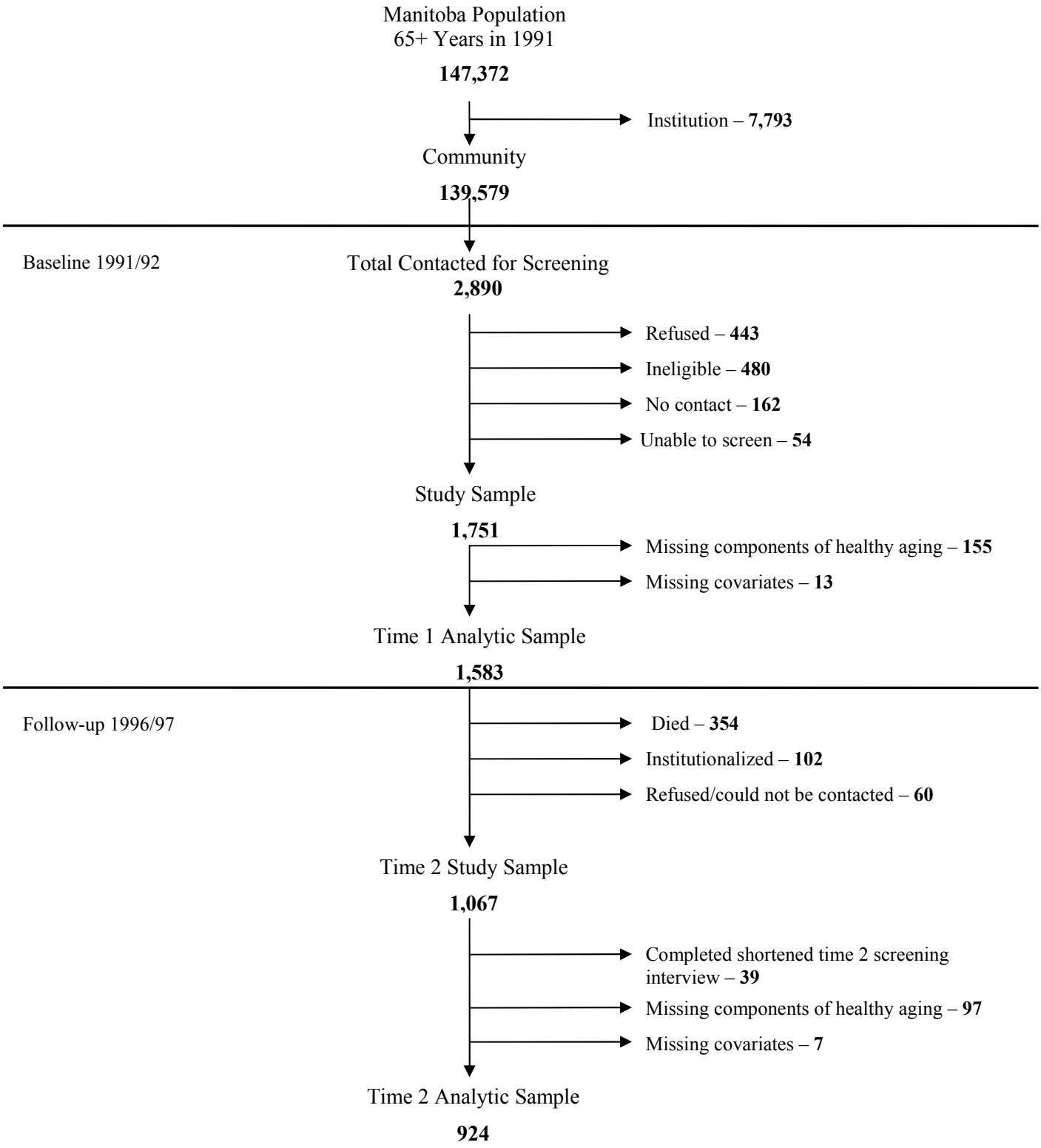

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Figure 2. Derivation of Analytic Samples

4.3.2 Variable Selection

The data used for this study were based on the screening interviews, which were conducted at both waves of the MSHA. The choice of specific variables of interest for the project was largely guided by findings from the literature review. In addition, the availability of specific variables within the datasets at both time 1 and time 2 influenced selection. The division of the construct of healthy aging into various components facilitated the selection of appropriate variables. Measures of mortality and institutionalization served to validate the overall construct of healthy aging.

4.4 Measures

4.4.1 Components of Healthy Aging

4.4.1.1 Cognitive Health

Global cognitive functioning was assessed through the 3MS (Teng & Chui, 1987), which is a screening test of global cognitive function. The development of the 3MS was based on the Mini-Mental State Examination (MMSE) (Folstein et al., 1975), a widely used tool to evaluate the cognitive status of older adults in clinical settings and in surveys. The modified version of this screening tool has demonstrated validity and reliability and has also proven to have slightly higher sensitivity (ability to detect those individuals with dementia) than the MMSE (Teng & Chui, 1987; McDowell, Kristjansson, Hill, & Hébert, 1997). The 3MS includes four additional items (date and place of birth, animal naming, similarities, and a second recall task) in order to sample a broader range of tasks and difficulty levels. In addition, a score approximately comparable to that of the MMSE can be derived from the 3MS for more direct comparisons. The purpose of the 3MS is not to serve as a clinical

diagnostic tool, but rather to screen for possible cognitive impairment. Scores range from 0 to 100 with a score of less than 78 indicating the possibility of cognitive impairment (Teng & Chui, 1987). The standard cut-off score of ≥78 was used to indicate participants who were in "good" cognitive health. Scores below 78 were used to identify individuals in "poor" cognitive health.

4.4.4.2 Physical Health

In order to evaluate physical functioning, the MSHA and MSHA-2 used various questions to assess participants' ability to perform basic and instrumental ADLs. The same items were measured at both time points, with the addition of two activities in the follow-up study (i.e., buttoning a sweater and caring for feet/toenails). The development of this section of the screening interview was largely based on information from the OARS (Older Americans Resources and Services) program at Duke University (Fillenbaum, 1988), as well as the ADL index by Katz and colleagues (1963). Participants were asked about their ability to perform basic ADLs such as eating, dressing, taking care of their appearance, walking, bathing, and toileting. The assessment of IADLs included items such as shopping, cooking, doing housework, taking medications, handling personal finances, using the telephone, and getting to places out of walking distance. The possible responses for ability to perform each item were: without any help, with some help from a device only, with some help from a person only, with some help from both a person and device, or being unable to do the activity.

The component of physical health was dichotomized into "good" physical health and "poor" physical health based on scores on the ADL and IADL items described above.

Individuals were deemed independent on a particular activity if they could perform that activity without any help or with help from a device only. The remaining three response categories were grouped together to indicate dependence on that task. A slightly different coding procedure was used for the heavy housework variable. Individuals were deemed independent if they could perform heavy housework without any help, with some help from a device only, or with some help from a person. Therefore, the criteria for independence in heavy housework were slightly less stringent compared with the other ADLs and IADLs, reflecting the greater physical demands of this task. In order to meet criteria for good physical health, individuals had to be independent on all ADLs and IADLs.

4.4.4.3 Social Health

The evaluation of social health characteristics has varied dramatically in previous studies of healthy aging. In the MSHA, there were no standardized assessment tools used to evaluate social health and no previous research with this dataset had examined this social health construct. However, there were numerous interview questions related to both objective measures of social health, which measured concrete items related to social relationships such as social network size and composition, and more subjective measures, which evaluated the perceived quality of social relationships, such as satisfaction with certain areas of social functioning.

Although there were objective social characteristics measured in the MSHA datasets, the social health component for this study was comprised of questions related to one's subjective experiences, such as satisfaction with social relationships and perceived availability of support. The questions that constituted the satisfaction with social

relationships category were measured using questions from the Terrible-Delightful scale, which measures overall general life satisfaction as well as domain-specific life satisfaction (Andrews & Withey, 1976). In the MSHA, older adults were asked to rate their current satisfaction on 12 domains of their life based on a seven-point scale, which included terrible, unhappy, mostly dissatisfied, mixed, mostly satisfied, pleased, and delighted. For the social health construct three domains were used: satisfaction with family, friendships, and recreational activities. The responses were grouped to create a dichotomy: individuals who reported being "mostly satisfied", "pleased" or "delighted" were classified as satisfied in each area while those who rated each domain as "mixed", "mostly dissatisfied", "unhappy", or "terrible" were classified as not being satisfied.

The availability of support was assessed through questions related to instrumental support and emotional support. Instrumental support was measured by the question "People often have one or more individuals they can count on for help and support. Can you think of someone like this?" At time 1, emotional support was assessed through the question "Do you receive emotional support from anyone or not? That is, do you have someone who you confide in, talk to about yourself, your concerns, etc.?" The wording for this question differed slightly at time 2 and emotional support was assessed through the question "Do you have someone you can count on to listen to you when you need to talk?" The possible responses for the questions related to instrumental and emotional support were "yes" or "no".

In order to meet the criteria for "good" social health, participants were required to have good ratings on each of the questions embedded within the social health variable (i.e., answered mostly satisfied, pleased, or delighted on each question assessing satisfaction with

social relationships and answered "yes" on the questions assessing the availability of instrumental and emotional support).

4.4.4.4 Psychological Health

The assessment of psychological health included measures of depressive symptoms, as indicated by the Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1977), and assessment of general life satisfaction through the application of the Terrible/Delightful scale (Andrews & Withey, 1976).

The CES-D scale is a commonly used measure of depressive symptoms in epidemiologic studies. Although not a diagnostic tool, it has been found to be an appropriate screening instrument (McDowell & Newell, 1996). For the assessment of depressive symptoms, older adults were asked how frequently 20 different statements described their feelings and behaviours in the last week, 16 of which covered components of depression, while four assessed positive affect. Scores ranged from 0 to 3 corresponding with the possible choices of: rarely or none of the time (0); some or a little of the time (1); occasionally or a moderate amount of the time (2); or most or all of the time (3). In community-based samples, the standard cutoff of 16 or more of a possible 60 points is commonly used to indicate depressive symptoms (McDowell & Newell, 1996) and was also used in this study.

The final question in the Terrible/Delightful scale was used as a measure of general life satisfaction. Older adults were asked to rate their current general life satisfaction through the question "How do you feel about your life as a whole right now?" Responses were based on a seven-point scale, which included terrible, unhappy, mostly dissatisfied, mixed, mostly

satisfied, pleased, and delighted. Individuals whose responses included “mostly satisfied”, “pleased”, or “delighted” were defined as having good general life satisfaction while those who responded with “terrible”, “unhappy”, “mostly dissatisfied”, or “mixed” were defined as having poor general life satisfaction.

In order to meet criteria for “good” psychological health, individuals had to have a score of <16 on the CES-D scale and have “good” general life satisfaction.

4.4.2 Overall Healthy Aging

The outcome of healthy aging was based on the four components described above (cognitive, physical, social, and psychological health). Participants were divided into two categories — those who met criteria for healthy aging and those did not — based on their values on these components. In order to meet criteria for healthy aging, participants were required to have good values on each of the four components. Figure 3 outlines the variables that constituted each of the components, which were combined to create the construct of healthy aging.

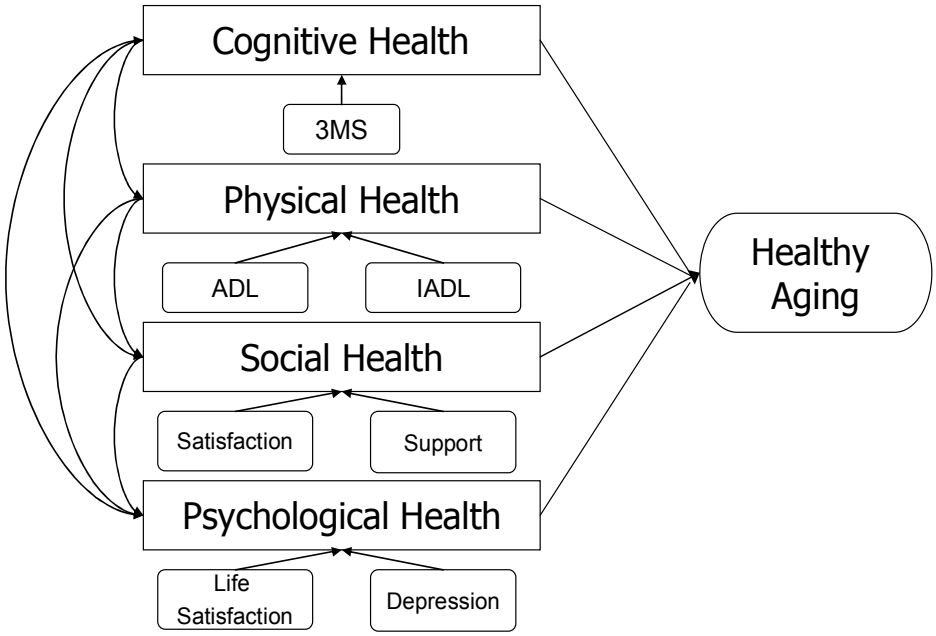

Figure 3. Components of Overall Healthy Aging Including Manitoba Study of Health and Aging Measures

4.4.3 Self-rated Health

Self-rated health was measured using the question "How would you say your health is these days? Would you say your health is very good, pretty good, not too good, poor, or very poor?" Good self-rated health included those individuals who rated their health as very good or pretty good, while poor self-rated health included those individuals who rated their health as not too good, poor, or very poor.

4.4.4 Mortality and Institutionalization

For certain research questions, outcomes of interest included whether an individual had died or been institutionalized by MSHA-2. MSHA researchers have done substantial research using both these variables; therefore, variables for death and institutionalization by MSHA-2 (yes/no) have already been derived and were included in the dataset. Individuals were considered deceased at time 2 if they had died prior to the start of MSHA-2, had died by the time of contact for the time 2 screening interview, or had died between completing the time 2 screening interview and the clinical assessment. Individuals were considered to be institutionalized if a move to an institution had taken place any time between the date of his or her 1991/92 interview and the date of the first re-contact attempt in 1996/97.

4.4.5 Predictors of Healthy Aging

The availability of a wide range of variables within this dataset permitted the examination of potential predictors of healthy aging. The variables of interest for this research have been chosen based on availability in the dataset and their established influence on health-related outcomes. Demographic predictors included the standard variables of sex, age, and educational level. Age was measured as a continuous variable with the exception that it was categorized into three groups in the analyses for research objective 2: those groups were 65 to 74, 75 to 84, and 85 years or greater. Educational level was measured as years of school completed and then dichotomized into less than 10 years of education and 10 years or greater. In addition, rural/urban residence was examined. The original measure of rural/urban residence was classified based on the 1991 Census of Canada, which defined urban areas as those with a population greater than 19,999, small town zones as those with a

population between 2,500 to 19,999, and predominantly rural areas as those with a population less than 2,500. For this study, small town zones and predominantly rural areas were combined to create a "rural" variable. In addition, a derived Winnipeg vs. non-Winnipeg variable was also used in these analyses.

Medical characteristics, such as the overall number of chronic diseases, the presence of persistent pain, and the presence of health problems or chronic conditions within the last year, were also investigated. Specific conditions included vascular risk factors such as high blood pressure, heart and circulation problems, stroke, chest problems, diabetes; neurological problems included Parkinson's disease, memory loss, trouble with nerves, and other neurological problems; other conditions included arthritis or rheumatism, eye trouble, ear trouble, dental problems, digestive problems, kidney trouble, loss of control over bladder or bowels, trouble with feet or ankles, skin problems, fractures, and cancer. There was also an option for individuals to list additional health problems that were not included in the list. Individuals had a yes/no response option for the questions on the presence of persistent pain in the past 30 days and presence of each of the health problem. The number of self-reported chronic health problems was created by summing across these 21 items and the "other" category.

In addition to the standard demographic and medical characteristics, various objective measures of social relationships were also available. Marital status included the response options of married, common-law married, never married, divorced, separated, or widowed. The responses of married or common-law married were combined to indicate that an individual was married at time 1. All other categories were combined for the not married at time 1 group. Other dichotomous variables included living alone (yes/no) and whether the

participant was acting as a main care provider (yes/no). The overall number of individuals living in the home and the number of visitors were measured as continuous variables.

4.5 Data Access Request Protocol

In order to access MSHA and MSHA-2 data, a formal request was made to the University of Manitoba's Center on Aging. The request included a brief summary of the proposed project, a proposed data analysis strategy, a timeline of expected completion dates, and a table of data sources and variables of interest. Approval to obtain access to the requested datasets was obtained on October 30, 2007. A copy of the data access approval is provided in Appendix E.

4.6 Ethics

The original MSHA and MSHA-2 received ethics approval from the Faculty of Medicine Committee on the Use of Human Subjects in Research at the University of Manitoba. The current study received University of Waterloo Office of Research Ethics approval on February 28, 2008. The data for these analyses were received from the University of Manitoba's Centre on Aging on March 4, 2008. A copy of the University of Waterloo ethics approval is provided in Appendix F.

5.0 Data Analysis

All analyses were conducted using SAS version 9.1 (SAS Institute Inc., Cary, North Carolina). The research questions and general methods that were employed are summarized in the following sections. A complete description of the analytic plan for each research question is provided in Appendix G.

5.1 Research Questions

In order to meet each research objective, various questions were developed. The figure below represents the conceptual organization of the research themes. The numbers on the diagram correspond with the numbering of the four research objectives:

1) To develop a multidimensional definition of healthy aging;

2) To validate a multidimensional definition of healthy aging;

3) To explore the relationship between healthy aging and self-rated health;

4) To examine predictors of healthy aging.

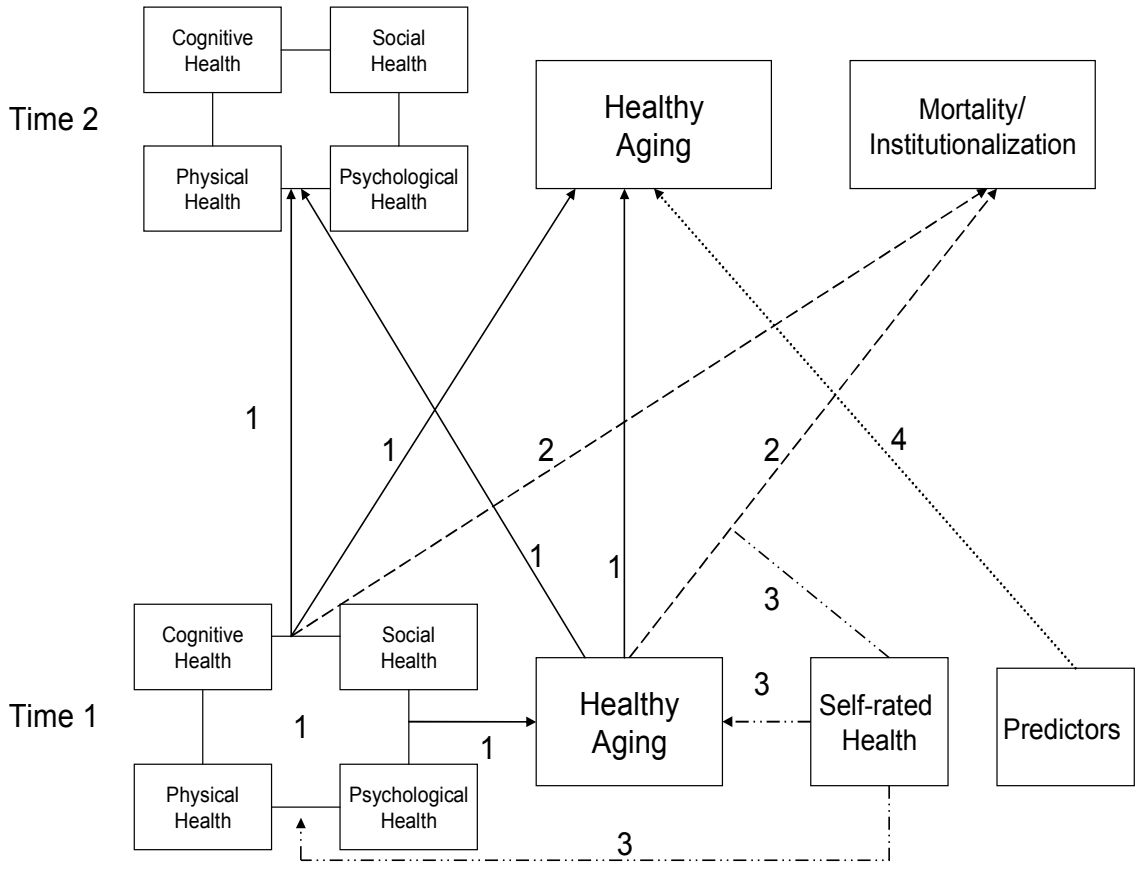

Figure 4. Conceptual Organization of Research Objectives

Research Objective 1: To develop a multidimensional definition of healthy aging

1. What proportion of the sample at time 1 and time 2 meet our criteria for good cognitive, physical, social, or psychological health, or overall healthy aging?

2. What proportion of the sample with good ratings on one component at time 1 also have good ratings on the other three components at time 1? For example what proportion of the sample with good *cognitive health* at time 1 also have:

a) good physical health at time 1?

b) good social health at time 1?

c) good psychological health at time 1?

3. Are there associations between each of the individual components of healthy aging at time 1?

4. Is each individual component at time 1 significantly associated with healthy aging at time 1?

5. a) What proportion of the sample with good ratings on each component at time 1 also has good ratings on that same component at time 2? b) Are good ratings at time 1 on one component associated with good ratings at time 2 on that same component?

6. Do the individual components of healthy aging at time 1 predict healthy aging at time 2 when examined:

a) individually (unadjusted and adjusted for covariates)?

b) collectively (unadjusted and adjusted for covariates)?

7. Is healthy aging at time 1 associated with healthy aging at time 2?

Research Objective 2: To validate a multidimensional definition of healthy aging

8. Are individuals who have died by time 2 less likely to have shown good cognitive, physical, social, psychological health, and overall healthy aging at time 1?

9. Are individuals who have been institutionalized by time 2 less likely to have shown good cognitive, physical, social, psychological health, and overall healthy aging at time 1?

Research Objective 3: To explore the relationship between healthy aging and self-rated health

10. Are individuals with good self-rated health at time 1 more likely to have shown good cognitive, physical, social, psychological health, and overall healthy aging at time 1 at time 1?

11. Of those individuals with good self-rated health at time 1:

a) what was their healthy aging status at time 1?

b) how did their characteristics vary by healthy aging status?

12. Does healthy aging at time 1 predict mortality at time 2 beyond the effects of self-rated health at time 1?

13. Does healthy aging at time 1 predict institutionalization at time 2 beyond the effects of self-rated health at time 1?

Research Objective 4: To examine predictors of healthy aging

14. Are demographic characteristics at time 1 associated with healthy aging at time 2?

15. Are medical characteristics at time 1, adjusted for demographic characteristics, associated with healthy aging at time 2?

16. Are social characteristics at time 1, adjusted for demographic characteristics, associated with healthy aging at time 2?

5.2 Descriptive Analyses

Exploratory analyses were conducted using univariate and bivariate procedures. Univariate analyses were conducted for all measures, including the general sample

characteristics, the individual variables that constitute each component of healthy aging, and the potential predictor variables. The distribution of variables by healthy aging status at both study time points is presented in Table 1. Additional sample comparisons are available in Appendix H. For the bivariate analyses, Pearson chi-square tests, with Yates continuity correction, were used to measure associations between categorical variables; the significance level was obtained from Fisher's exact test when more than 25% of the cells had expected values less than five. Where appropriate, the strength of an association was assessed using odds ratios (OR) and 95% confidence intervals (CI). Odds ratios represent the ratio of the odds of exposure among cases to the odds of exposure among controls. Odds ratios of one suggest no relationship, ORs greater than one indicate that the exposure increases the odds of the outcome (i.e., is a significant risk factor) and ORs less than one suggest that the exposure decreases the odds of the outcome (i.e., is a protective factor). Independent samples t-tests were used to examine the association between continuous and dichotomous variables.

5.3 Multivariate Modeling

The relative influence of multiple exposure variables and potential confounders on the outcomes of interest was assessed using multiple logistic regression procedures. All categorical variables were coded as indicator variables with the first level of each variable selected as the reference category (i.e., 0, 1 coding for dichotomous variables). Age was analyzed as a continuous variable when possible for all analyses except those from research objective 2, where it was necessary to recode it as a categorical variable. In these analyses, it was coded as a three-level categorical variable (with 65 to 74 years serving as the reference

group) to address the small sample sizes created by multiple strata when significant interactions were found and stratified analyses had to be conducted.

Hierarchical backward elimination was the method of variable selection for the logistic regression models. Previous research has concluded that backward elimination is preferable to forward selection techniques in multiple linear regression analyses because the mean square error (difference between the observed and expected value for the variables in the model) was generally less for backward elimination (Kennedy & Bancroft, 1971). The significance (α) levels for the backward elimination regression models were set at 0.15 for main effects and 0.05 for interactions. Interactions between exposure variables and covariates were tested, but no covariate by covariate interactions were included in these analyses because of sample size limitations. Models that included interaction terms were hierarchically well-formulated (i.e., all main effects were forced into the model when testing an interaction term). In addition, models were stratified based on significant interactions. Whenever possible, the models were stratified by the covariate component of the significant interaction term in order to obtain final models that included estimates of the effect of the exposure variable on the outcome.

Logistic regression models were adjusted for the effects of the potential confounders age, sex, and education. These covariates, as well as the exposure variables, were forced into all final models in order to produce estimates of the impact of exposures on the outcome of interest, adjusted for covariates. The Hosmer-Lemeshow Goodness of Fit (H-L GOF) statistic was performed on each model; models were rejected when $p<0.05$ for the H-L GOF statistic. The degree of multicollinearity among the independent variables was assessed using the PROC REG procedure in SAS. Residual diagnostics were performed on all models

that showed poor fit and all final models using the INFLUENCE and IPLOTS command in PROC LOGISTIC. The various residual diagnostics that were examined included DFBETAs, which measure the change in parameter estimates when the particular observation is deleted, and C and CBAR, which measure the degree of overall change in the regression coefficients. The cut-off value of ±1.96, which corresponds to a significance level of 0.05, was used to indicate values that may have significant influence on the overall fit of the model. For further description of the multivariate modeling techniques, see Tyas, Koval, & Pederson (2000).

6.0 Results

6.1 Sample Description

The characteristics of the analytic samples used for these analyses are presented in Table 1 by healthy aging status. (See Figure 2 for a description of the sampling frame.) This table presents values, in the form of means or percentages, for the time 1 (n=1,583) and time 2 (n=924) samples that met and did not meet criteria for healthy aging. In addition, analytic subsamples were compared with the full samples at time 1 and time 2 to assess representativeness of the subsamples (Appendix H).

At the time of the baseline interview, 168 participants could not be classified by healthy aging status because of missing values on covariates or variables used to create the construct of healthy aging. At time 2, 143 individuals from the available time 2 sample (n=1,067) could not be classified by healthy aging status. (See Appendix H for full sample characteristics for the time 1 and time 2 analytic samples and for the excluded subjects).

At time 1, 574 of 1,583 participants (36.2%) met criteria for healthy aging. By time 2, 361 of 924 participants (39.1%) met criteria for healthy aging. The characteristics of these samples and the p-values for sample comparisons are presented in Table 1. There were numerous differences between individuals based on their healthy aging status, which is not surprising given that we were comparing "healthy" individuals with "less healthy" individuals. T-test and chi-square tests of significance indicated that, at both time points, in addition to being less likely to report "good" scores for all the variables that make up the components of healthy aging, individuals who did not meet criteria for healthy aging were significantly more likely to be older, less educated, widowed, live alone, and to report higher numbers of chronic conditions, chronic pain, and poor health. With the exception of eating

(time 1 only), getting out of bed, and using the washroom, individuals who did not meet our criteria for healthy aging were more likely to be dependent on all ADLs and IADLs than those individuals who met criteria for healthy aging.

Table 1. Baseline and follow-up characteristics of participants by healthy aging status, Manitoba Study of Health and Aging, 1991-1996

Participant Characteristics	Time 1		Time 2	
	Healthy Aging (n=574)	Not Healthy Aging (n=1009)	Healthy Aging (n=361)	Not Healthy Aging (n=563)
Demographic				
Age (mean)	75.0	78.6***[1]	78.1	81.4***
Sex (% female)	55.1	60.1*	59.3	61.6
Education (% >10 years)	60.5	41.6***	60.9	49.4***
Rural/Urban Status (% rural)	37.8	39.6	N/A[2]	N/A
Components of Healthy Aging				
Cognitive Health				
3MS (mean)	90.7	83.5***	90.2	82.0***
Physical Health (%)				
Activities of Daily Living[3]				
Eat	100	99.7	100	97.5***
Dress	100	97.9***	100	92.9***
Take care of appearance	100	98.8***	100	97.5***
Walk	100	96.6***	100	96.8***
Get out of bed	100	99.4	100	98.6
Bathe or Shower	100	88.2***	100	78.9***
Toilet	100	99.6	100	98.6
Instrumental Activities of Daily Living[3]				
Phone	100	97.5***	100	94.5***
Places out of walking distance	100	81.3***	100	65.2***
Shop	100	72.9***	100	57.2***
Prepare meals	100	87.0***	100	76.9***
Heavy housework[4]	100	83.8***	100	80.5***
Handle finances	100	88.6***	100	79.0***
Take medication	100	95.7***	100	90.2***
Social Health (%)				
Receives instrumental support	100	95.4***	100	92.4***
Receives emotional support	100	57.5***	100	88.8***
Satisfaction with family[5]	100	89.3***	100	90.1***
Satisfaction with friends[5]	100	87.8***	100	88.3***
Satisfaction with recreational activities[5]	100	79.1***	100	69.8***
Psychological Health (%)				
Good general life satisfaction[5]	100	81.1***	100	82.2***
CES-D (<16)	100	80.1***	100	77.1***

Participant Characteristics	Time 1		Time 2	
	Healthy Aging (n=574)	Not Healthy Aging (n=1009)	Healthy Aging (n=361)	Not Healthy Aging (n=563)
Predictors of Healthy Aging				
Medical				
Number of conditions (mean)	3.4	4.9***	4.0	5.9***
Presence of conditions (%)				
High blood pressure	31.6	35.3	33.5	41.7*
Heart trouble	21.4	34.2***	26.6	37.1**
Stroke	3.1	8.7***	2.8	10.3***
Arthritis	56.8	63.5**	59.6	67.7*
Parkinson's disease	1.1	2.0	0.55	2.8*
Other neurological problems	3.7	4.4	4.4	5.3
Eye trouble	20.7	36.8***	28.6	40.7***
Ear trouble	26.3	37.0***	30.2	43.5***
Dental problems	14.4	22.4***	13.6	17.8
Chest problems	13.9	24.7***	13.6	28.8***
Stomach problems	22.0	30.9**	19.7	30.0***
Kidney problems	7.3	16.3***	8.9	19.6***
Bladder trouble	7.2	15.7***	11.6	21.5**
Bowel trouble	3.3	5.8*	1.9	5.2*
Diabetes	5.6	9.8**	6.4	11.9**
Foot problems	32.8	43.3***	28.0	41.2***
Nerve problems	12.9	27.8***	10.6	22.6***
Skin problems	14.5	17.6	17.7	19.7
Fractures	4.6	5.0	6.7	10.8*
Cancer	7.5	6.4	8.6	9.4
Memory trouble	14.9	31.0***	6.7	17.8***
Chronic pain	19.9	32.0***	N/A	N/A
Social				
Marital status (% married)	62.7	45.9***	52.9	42.1**
Living alone (%)	31.7	47.1***	45.2	50.1*
Number in household (mean)	0.86	0.70	1.1	1.3
Participants acting as primary caregiver (%)	20.0	15.6**	21.3	13.9***
Number of companions (mean)	6.9	5.2***	12.2	9.4***
Other				
Good self-rated health (%)	90.6	68.3***	91.6	70.3***

* p<0.05, ** p<0.01, *** p<0.001

[1] Statistical significance reflects the differences between the sample who met criteria for healthy aging and those that did not.

[2] Rural/urban status was not available at time 2.

[3] % able to perform task independently or with the help of a device

[4] % able to perform task independently, with the help of a device, or with the help of a person and a device

[5] % Delighted/Very satisfied/Satisfied

6.2 Research Objective 1: To Develop a Multidimensional Definition of Healthy Aging

Based on the time 1 analytic sample (n=1,583), 83.3% met criteria for good cognitive health, 73.5% for good physical health, 56.4% for good social health, and 80.5% for good psychological health. Over one-third (36.3%) of the sample met criteria for good health on all four components and thus met criteria for overall healthy aging. Five years later, 924 participants could be classified by healthy aging status (i.e., did not have missing values on any of the components of healthy aging or covariates). Of this time 2 analytic sample (n=924), 81.4% had good cognitive health, 62.9% had good physical health, 68.6% had good social health, and 80.3% had good psychological health. The proportion of the sample that met our criteria for overall healthy aging at time 2 was 39.1%. The five-year change in the proportion of the sample that met criteria for good ratings on each component of healthy aging and overall healthy aging was examined by restricting the sample to those individuals in both the time 1 and time 2 analytic samples (i.e., the same sample as the time 2 analytic sample). At time 1, 841 participants (91.0%) of the time 2 analytic sample had been in good cognitive health, 764 (82.7%) had been in good physical health, 560 (60.6%) had been in good social health, 793 (85.8%) had been in good psychological health, and 414 (44.8%) met criteria for overall healthy aging. With the exception of the social health variable, there were declines in the proportion of individuals who met criteria for each component and for overall healthy aging between time 1 and time 2.

6.2.1 Associations between the Four Components of Healthy Aging

The association between the individual components of healthy aging was explored using bivariate analyses. More specifically, the proportion of the sample that had good

ratings on one component and also met criteria for good ratings on the other three components at time 1 was determined. Pearson chi-square tests were calculated to examine the statistical significance of these associations (Table 2). A good rating on each component at time 1 was significantly associated with good ratings on the other three components at time 1. For example, those individuals with good cognitive health were also significantly more likely to have good physical, social, and psychological health. The pattern persisted across each of the four components, with all combinations showing statistically significant associations.

Table 2. The relationship among the components of healthy aging at time 1 and overall healthy aging at time 1, Manitoba Study of Health and Aging, 1991 (n=1,583)

		Time 1				
Time 1		Good cognitive health (%)	Good physical health (%)	Good social health (%)	Good psychological health (%)	Healthy aging (%)
	Good cognitive health (%)		**78.8****	**58.0***	**83.1****	**43.6****
	Good physical health (%)	**89.2****		**60.5****	**86.2****	**49.3****
	Good social health (%)	**85.8****	**78.9****		**88.2****	**64.4****
	Good psychological health (%)	**85.9****	**78.7****	**61.7****		**45.0****

This table should be read by row. For example, of those with good cognitive health at time 1, 78.8% had good physical heath, 58.0% had good social health, 83.1% had good psychological health and 43.6% met criteria for healthy aging at time 1.
* $p<0.01$, ** $p< 0.001$

6.2.2 Associations between the Components of Healthy Aging and Healthy Aging at Time 1

The proportion of the sample with good ratings on each component who met criteria for healthy aging at time 1 is presented in the final column of Table 2. Of those with good cognitive health, 43.6% met criteria for healthy aging; of those with good physical health, 49.3% met criteria for healthy aging; of those with good social health, 64.4% met criteria for

healthy aging; and of those with good psychological health, 45.0% met criteria for healthy aging. Chi-square tests were used to examine the association between each component and overall healthy aging. Each component was strongly associated with overall healthy aging. This is not surprising given that each individual component is embedded within the construct of healthy aging.

6.2.3 Stability of Components between Time 1 and Time 2

The stability over time of each component of healthy aging and overall healthy aging was examined; the proportion of the sample who met criteria for healthy aging or good ratings on each component at both time 1 and time 2 is reported in Table 3. For those individuals who met criteria for healthy aging at time 1, 89.4% were in good cognitive health, 74.4% were in good physical health, 77.1% were in good social health, 87.0% were in good psychological health at time 2, and 52.4% met criteria for healthy aging at time 2. Good ratings on each component significantly predicted good ratings on that same component five years later. Overall healthy aging at time 1 was significantly associated with good ratings on each time 2 component and overall healthy aging at time 2 (Table 4).

Table 3. The proportion of sample with good ratings on components of healthy aging and overall healthy aging at time 1 and time 2, Manitoba Study of Health and Aging, 1991-1996 (n=924)

		Time 2				
		Good cognitive health (%)	Good physical health (%)	Good social health (%)	Good psychological health (%)	Healthy aging (%)
Time 1	Good cognitive health (%)	**86.9**				
	Good physical health (%)		**71.9**			
	Good social health (%)			**76.3**		
	Good psychological health (%)				**84.9**	
	Healthy aging (%)	**89.4**	**74.4**	**77.1**	**87.0**	**52.4**

The table is read as follows: "For those with good cognitive health at time 1, 86.9% had good cognitive health at time 2.

Table 4. The proportion of sample with good ratings on components of healthy aging and overall healthy aging at time 1 and time 2, Manitoba Study of Health and Aging, 1991-1996 (n=924)

		Time 2				
		Good cognitive health	Good physical health	Good social health	Good psychological health	Healthy aging
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Time 1	Good cognitive health	**19.62*** (11.50-33.46)				
	Good physical health		**10.21*** (6.72-15.52)			
	Good social health			**2.44*** (1.83-3.24)		
	Good psychological health				**5.04*** (3.40-7.47)	
	Healthy aging	**2.82*** (1.94-4.08)	**2.52*** (1.90-3.34)	**2.08*** (1.55-2.78)	**2.23*** (1.58-3.17)	**2.13*** (2.80-3.68)

* $p<0.001$

Logistic regression models were developed to examine whether each time 1 component of healthy aging, both unadjusted and adjusted for covariates (age, sex, and education), was associated with healthy aging status at time 2 (Table 5). With each

increasing year of age, an individual's chance of meeting criteria for healthy aging decreased (OR=0.91; 95% CI: 0.89-0.93), while higher education (≥10 years) increased the odds of meeting criteria for healthy aging (OR=1.60; 95% CI: 1.22-2.09). Sex did not significantly predict healthy aging status at time 2 (OR=1.10; 95% CI: 0.84-1.45). Each time 1 component of healthy aging was significantly associated with overall healthy aging at time 2 in both the unadjusted and adjusted models. The strongest effect for an individual component was seen for physical health. Those individuals who met criteria for healthy aging at time 2 were over six times (OR=6.91; 95% CI: 4.06-12.60) more likely to have been in good physical health at time 1 than those individuals who did not meet criteria for healthy aging at time 2, after adjusting for the effects of age, sex, and education. When all of the healthy aging components at time 1 were examined together in the same model each remained significant, with cognitive (OR=4.47; 95% CI: 2.06-11.21) and physical health (OR=5.32; 95% CI: 3.09-9.78) being the strongest predictors of healthy aging at time 2. In this model, younger age (OR=0.92; 95% CI: 0.89-0.94) remained a significant predictor of time 2 healthy aging.

Table 5. The association between the components of healthy aging at time 1 and overall healthy aging at time 2, Manitoba Study of Health and Aging, 1991-1996 (n=924)

Model	Good cognitive health	Good physical health	Good social health	Good psychological health	Age[1]	Sex[2]	Education[3]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	—	—	—	—	**0.91***** (0.89-0.93)	—	—
Sex	—	—	—	—	—	**1.10** (0.84-1.45)	—
Educ	—	—	—	—	—	—	**1.60***** (1.22-2.09)
Cog1	**7.89***** (3.86-19.02)	—	—	—	—	—	—
Cog2	**6.08***** (2.89-14.94)	—	—	—	**0.91***** (0.89-0.94)	**1.16** (0.87-1.54)	**1.26** (0.95-1.68)
Phys1	—	**8.00***** (4.77-14.44)	—	—	—	—	—
Phys2	—	**6.91***** (4.06-12.60)	—	—	**0.92***** (0.89-0.94)	**0.89** (0.67-1.20)	**1.40*** (1.05-1.88)
Soc1	—	—	**1.70***** (1.29-2.24)	—	—	—	—
Soc2	—	—	**1.64***** (1.23-2.19)	—	**0.91***** (0.89-0.93)	**1.08** (0.81-1.43)	**1.45*** (1.09-1.92)
Psych1	—	—	—	**2.66***** (1.74-4.21)	—	—	—
Psych2	—	—	—	**2.90***** (1.86-4.66)	**0.91***** (0.88-0.93)	**0.99** (0.74-1.32)	**1.44*** (1.09-1.92)
Tot1	**5.59***** (2.65-13.71)	**6.16***** (3.62-11.21)	**1.48***** (1.11-1.99)	**1.85*** (1.16-3.00)	—	—	—
Tot2	**4.47***** (2.06-11.21)	**5.32***** (3.09-9.78)	**1.41*** (1.04-1.90)	**2.06**** (1.28-3.39)	**0.92***** (0.89-0.94)	**0.91** (0.67-1.23)	**1.18** (0.87-1.59)

* p<0.05, ** p<0.01, *** p<0.001

[1] Measured as continuous.

[2] Reference category is female.

[3] Reference category is <10 years.

6.2.4 Association between Time 1 Healthy Aging and Time 2 Healthy Aging

Logistic regression models were used to explore whether healthy aging at time 1 was a significant predictor of healthy aging at time 2. The unadjusted model showed a significant association between healthy aging at time 1 and healthy aging at time 2 (OR=2.80; 95% CI: 2.13-3.68). After adjusting for the effects of age, sex, and education, the association between these two variables was attenuated but remained significant (OR=2.43; 95% CI: 1.83-3.24). Thus, individuals who met criteria for healthy aging at time 2 were over twice as likely as individuals who did not meet these criteria to have also met criteria for healthy aging at time 1.

6.3 Research Objective 2: To Validate a Multidimensional Definition of Healthy Aging

6.3.1 Healthy Aging and Its Components as Predictors of Mortality

The association of overall healthy aging and each of the components of healthy aging with the five-year outcome of mortality was examined using logistic regression modeling (Table 6). At the time of the follow-up screening interview, 471 (23.8%) of the original sample (n=1,751) had died; based on the time 1 analytic sample (n=1,583), 354 individuals had died by time 2. The regression models for this research objective examined age as a three-category variable (65-74, 75-84, and 85+), with the youngest age group (65-74 years) serving as the reference category. The rationale for the decision to categorize age was described in the methods section and reflects limitations in sample size when addressing multiple interactions through stratification. The outcome of interest for this analysis was survival by time 2, and thus ORs less than one indicate those variables associated with a lower likelihood of survival to time 2. Age, sex, and education were all significant predictors

of mortality when examined in individual regression models. Compared with those individuals who had died by time 2, individuals who were alive by time 2 were more likely to be younger, female, and have a higher level of education (Table 6).

Overall healthy aging was significantly associated with five-year mortality: those individuals who were alive by time 2 were more likely to have met criteria for healthy aging at time 1. This effect was seen in the unadjusted models (OR=2.65; 95% CI: 2.01-3.53) and also after adjustment for the effects of age, sex, and education (OR=2.18; 95% CI: 1.63-2.95). The presence of interactions between healthy aging and covariates was assessed but no significant interactions were found. Therefore, the significant variable in the final model for healthy aging as a predictor of mortality included healthy aging, age, and sex (Table 6).

Table 6. The association of healthy aging and covariates at time 1 with survival by time 2, Manitoba Study of Health and Aging, 1991-1996 (n =1,583)

Model	Healthy aging	Age[1]		Sex[2]	Education[3]
		74-84	85+		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	—	**0.48*** ** (0.36-0.65)	**0.18*** ** (0.13-0.26)	—	—
Sex	—	—	—	**0.59*** ** (0.46-0.75)	—
Educ	—	—	—	—	**1.57*** ** (1.23-2.00)
HA1	**2.65*** ** (2.01-3.53)	—	—	—	—
HA2	**2.18*** ** (1.63-2.95)	**0.51*** ** (0.38-0.70)	**0.21*** ** (0.15-0.30)	**0.52*** ** (0.40-0.67)	**1.11** (0.85-1.43)

* p<0.05, ** p<0.01, *** p<0.001

[1] Reference category is 65-74 years.

[2] Reference category is female.

[3] Reference category is <10 years.

In addition to assessing the influence of overall healthy aging on survival by time 2, the individual effect of each component of healthy aging on predicting five-year mortality was assessed (i.e., each component was entered in separate models, both unadjusted and adjusted for age, sex, and education). Each component was significantly associated with mortality after adjusting for the effects of age, sex, and education (Table 7).

Table 7. The association of healthy aging components at time 1 with survival by time 2, Manitoba Study of Health and Aging, 1991-1996 (n=1,583)

Model	Good cognitive health	Good physical health	Good social health	Good psychological health	Age[1]		Sex[2]	Education[3]
					74-84	85+		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cog1	**2.49***** (1.87-3.30)	—	—	—	—	—	—	—
Cog2	**1.67**** (1.22-2.29)	—	—	—	**0.48***** (0.35-0.65)	**0.20***** (0.14-0.28)	**0.57***** (0.44-0.73)	**1.11** (0.85-1.44)
Phys1	—	**3.09***** (2.41-3.97)	—	—	—	—	—	—
Phys2	—	**2.55***** (1.92-3.36)	—	—	**0.52***** (0.38-0.71)	**0.25***** (0.17-0.35)	**0.48***** (0.37-0.62)	**1.14** (0.88-1.48)
Soc1	—	—	**1.43**** (1.13-1.82)	—	—	—	—	—
Soc2	—	—	**1.31*** (1.02-1.68)	—	**0.48***** (0.35-0.64)	**0.18***** (0.13-0.26)	**0.55***** (0.43-0.71)	**1.22** (0.94-1.56)
Psych1	—	—	—	**1.68***** (1.27-2.22)	—	—	—	—
Psych2	—	—	—	**1.71***** (1.27-2.29)	**0.47***** (0.35-0.64)	**0.18***** (0.13-0.26)	**0.53***** (0.41-0.68)	**1.19** (0.92-1.54)

* p<0.05, ** p<0.01, *** p<0.001

[1] Reference category is 65-74 years.

[2] Reference category is female.

[3] Reference category is <10 years.

As a supplementary analytic strategy, the four components of healthy aging were entered into the same model to examine their relative impact on mortality when adjusting for the effects of the other three components. This model showed a poor fit as indicated by a significant Hosmer-Lemeshow Goodness of Fit statistic (χ^2=15.79; p=0.008). Attempts to assess the reasons for the lack of model fit included tests for multicollinearity and assessment of interactions among the components of healthy aging. Predictor variables were not highly correlated, but the model with all first-order interactions between components indicated a significant interaction between cognitive and physical health (p=0.001).

The sample was then stratified to assess the impact on subsequent mortality by time 2 (i.e., stratified by physical health to obtain ORs for cognitive health and also stratified by cognitive health to obtain ORs for physical health). When stratified by physical health status, cognitive health was only a significant predictor of mortality for those with good physical health (OR=3.04; 95% CI: 2.01-4.55) and not for those with poor physical health (OR=1.14; 95% CI: 0.75-1.73) (Table 8). When stratified by cognitive health status, physical health was only a significant predictor for those with good cognitive health (OR=3.47; 95% CI: 2.58-4.67) and not for those with poor cognitive health (OR=1.30; 95% CI: 0.79-2.16) (Table 9). The pattern of significance remained the same but the effects were attenuated when age, sex, and education were taken into account. In these adjusted models, cognitive health was a significant predictor for those with good physical health (OR=2.68; 95% CI: 1.76-4.18) and physical health was a significant predictor for those with good cognitive health (OR=3.05; 95% CI: 2.21-4.22). In summary, the interaction between cognitive and physical health demonstrated that, compared with individuals who had died by time 2, individuals who were alive by time 2 and were in good physical health at time 1 were also significantly more likely

to have been in good cognitive health at time 1. In addition, those who were in good cognitive health at time 1 were more likely to have been in good physical health at time 1.

Table 8. The association of physical health at time 1 with survival by time 2, stratified by cognitive health status, Manitoba Study of Health and Aging, 1991-1996 (n=1,583)

Model	Good cognitive health	Good physical health	Age[1]		Sex[2]	Education[3]
			74-84	85+		
	OR (95%CI)	OR (95% CI)	OR (95%CI)	OR (95%CI)	OR (95% CI)	OR (95% CI)
Good cognitive health						
Unadjusted	—	**3.04**** (2.01-4.55)	—	—	—	—
Adjusted	—	**2.68**** (1.70-4.18)	**0.60*** (0.42-0.86)	**0.23**** (0.15-0.37)	**0.57**** (0.41-0.79)	**0.74** (0.52-1.05)
Poor cognitive health						
Unadjusted	—	**1.14** (0.75-1.73)	—	—	—	—
Adjusted	—	**0.68** (0.42-1.09)	**0.37*** (0.19-0.70)	**0.21**** (0.10-0.40)	**0.34**** (0.21-0.53)	**1.83**** (1.16-2.90)

* p<0.01, ** p<0.001

[1] Reference category is 65-74 years.

[2] Reference category is female.

[3] Reference category is <10 years.

Table 9. The association of cognitive health at time 1 with survival by time 2, stratified by physical health status, Manitoba Study of Health and Aging, 1991-1996 (n=1,583)

Model	Good cognitive health	Good physical health	Age[1]		Sex[2]	Education[3]
			74-84	85+		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95%CI)	OR (95%CI)	OR (95% CI)
Good physical health						
Unadjusted	**3.47**** (2.58-4.67)	—	—	—	—	—
Adjusted	**3.05**** (2.21-4.22)	—	**0.60*** (0.42-0.84)	**0.25**** (0.17-0.38)	**0.54**** (0.40-0.74)	**1.04** (0.78-1.40)
Poor physical health						
Unadjusted	**1.30** (0.79-2.16)	—	—	—	—	—
Adjusted	**1.24** (0.71-2.18)	—	**0.32*** (0.14-0.67)	**0.20**** (0.09-0.45)	**0.33**** (0.18-0.56)	**1.03** (0.51-2.13)

* p<0.01, ** p<0.001
[1] Reference category is 65-74 years.
[2] Reference category is female.
[3] Reference category is <10 years.

To further expand the above analyses, which only assessed component by component interactions, all possible first-order interactions between the components and covariates were examined. Significant interactions were found between cognitive health and physical health (p<0.001), cognitive health and psychological health (p=0.04), and also between physical health and education (p<0.001). Based on these interactions, models were stratified by cognitive health; a final model for those with poor cognitive health was obtained, which included significant main effects of age (75-84: OR=0.32, 95% CI: 0.14-0.68; 85+: OR=0.19; 95% CI: 0.08-0.41) and sex (OR=0.34; 95% CI: 0.19-0.57). For individuals with good cognitive health, however, a significant interaction between physical health and education (p<0.001) remained in the stratified model. This model was then stratified by education. For individuals with good cognitive health who reported less than ten years of education, significant main effects of physical health (OR=5.18; 95% CI: 3.24-8.37), psychological

health (OR=2.13; 95% CI: 0.19-0.57), age (75-84: OR=0.54; 95% CI: 0.31-0.81; 85+: OR=0.23; 95% CI: 0.12-0.42), and sex (OR=0.39; 95% CI: 0.25-0.62) remained in the model. More specifically, individuals belonging to this group who were alive by time 2 were more likely to be younger, female and in good physical and psychological health at time 1 when compared with those who had died by time 2. For those individuals in good cognitive health with more than 10 years of education, age remained the only significant predictor of survival by time 2, with those between the ages of 75 and 85 (OR=0.60; 95% CI: 0.38-0.94) and those 85 years or older (OR=0.22; 95% CI: 0.12-0.38) less likely to have survived to time 2 compared with individuals between 65 and 74 years of age.

6.3.2 Healthy Aging and Its Components as Predictors of Institutionalization

The association of each of the components of healthy aging and overall healthy aging with the five-year outcome of institutionalization was examined using logistic regression modeling. Of the original time 1 sample (n=1,751), 224 (12.8%) were living in an institution by time 2. Based on the analytic sample (n=1,583), 185 individuals were living in an institution by follow-up. Being younger and reporting higher education at time 1 was significantly associated with remaining in the community by time 2 (Table 10). Sex was not a significant predictor of institutionalization.

Overall healthy aging was significantly associated with institutionalization five years later, with those individuals who were living in the community by time 2 more likely than individuals who had moved to an institution to have met criteria for healthy aging at time 1. This effect was seen in the unadjusted model (OR=3.77; 95% CI: 2.52-5.87) and also the model that was adjusted for the effects of age, sex, and education (OR=2.56; 95% CI: 1.67-

4.05). Interactions between healthy aging and covariates were assessed but no significant interactions were found. Therefore, the significant variables in the final model for healthy aging as a predictor of institutionalization included healthy aging and age (Table 10).

Table 10. The association of healthy aging and covariates at time 1 with living in the community at time 2, Manitoba Study of Health and Aging, 1991-1996 (n=1,578)

Model	Healthy Aging	Age[1]		Sex[2]	Education[3]
		74-84	85+		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95%CI)	OR (95% CI)
Age	—	**0.37***** (0.23-0.60)	**0.08***** (0.05-0.13)	—	—
Sex	—	—	—	**1.36** (0.99-1.88)	—
Educ	—	—	—	—	**1.68**** (1.23-2.31)
HA1	**3.77***** (2.52-5.87)	—	—	—	—
HA2	**2.56***** (1.67-4.05)	**0.43***** (0.26-0.69)	**0.11***** (0.06-0.17)	**1.33** (0.94-1.89)	**1.22** (0.87-1.73)

* p<0.05, ** p<0.01, *** p<0.001
[1] Reference category is 65-74 years.
[2] Reference category is female.
[3] Reference category is <10 years.

All four components of healthy aging were examined individually, both unadjusted and adjusted for age, sex, and education. Each component was a significant predictor of institutionalization five years later (Table 11). Compared with those who had moved to an institution by time 2, those individuals who remained in the community were more likely to have been in good cognitive health (OR=2.27; 95% CI: 1.54-3.31), good physical health (OR=2.74; 95% CI: 1.95-3.87), good social health (OR=1.56; 95% CI: 1.12-2.16), and good psychological health (OR=1.81; 95% CI: 1.25-2.61), when adjusted for the effects of age, sex, and education.

All components were also entered into the same model to examine the impact of each component on institutionalization when adjusting for the effects of the other three components. This procedure was repeated taking into account the effects of age, sex, and education. Based on the backward elimination selection method for the adjusted analyses, good cognitive health (OR=1.77; 95% CI: 1.18-2.62), good physical health (OR=2.28; 95% CI: 1.59-3.28), and younger age (75-84 years: OR=0.45; 95% CI: 0.27-0.72; 85+: OR=0.13; 95% CI: 0.08-0.22) were significant predictors of remaining in the community five years later (Table 11).

Table 11. The association of components of healthy aging at time 1 with living in the community at time 2, Manitoba Study of Health and Aging, 1991-1996 (n=1,578)

Model	Good cognitive health	Good physical health	Good social health	Good psychological health	Age[1]		Sex[2]	Education[3]
					74-84	85+		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cog1	**3.45***** (2.46-4.81)	—	—	—	—	—	—	—
Cog2	**2.27***** (1.54-3.31)	—	—	—	**0.40***** (0.24-0.65)	**0.10***** (0.06-0.17)	**1.47*** (1.03-2.08)	**1.14** (0.80-1.62)
Phys1	—	**4.53***** (3.30-6.23)	—	—	—	—	—	—
Phys2	—	**2.74***** (1.95-3.87)	—	—	**0.45***** (0.27-0.72)	**0.13***** (0.07-0.20)	**1.22** (0.86-1.74)	**1.24** (0.88-1.76)
Soc1	—	—	**1.78***** (1.31-2.44)	—	—	—	—	—
Soc2	—	—	**1.56**** (1.12-2.16)	—	**0.39***** (0.24-0.63)	**0.09***** (0.05-0.14)	**1.38** (0.98-1.96)	**1.30** (0.93-1.84)
Psych 1	—	—	—	**1.99***** (1.41-2.80)	—	—	—	—
Psych 2	—	—	—	**1.81**** (1.25-2.61)	**0.39***** (0.23-0.62)	**0.09***** (0.05-0.14)	**1.33** (0.95-1.90)	**1.29** (0.92-1.82)
Comp 1	**2.30***** (1.60-3.28)	**3.49***** (2.48-4.90)	**1.42*** (1.02-1.98)	**1.12** (0.76-1.64)	—	—	—	—
Comp 2	**1.77**** (1.18-2.62)	**2.28***** (1.59-3.28)	**1.36** (0.96-1.92)	**1.25** (0.83-1.85)	**0.45**** (0.27-0.72)	**0.13***** (0.08-0.22)	**1.28** (0.90-1.84)	**1.10** (0.77-1.58)

* p<0.05, ** p<0.01, *** p<0.001

[1] Reference category is 65-74 years.

[2] Reference category is female.

[3] Reference category is <10 years.

Following the assessment of the relationship of each of the individual components with five-year institutionalization, the possibility of interactions among the components was assessed. There were no significant interactions between the four components. All possible first-order interactions between components and covariates were then assessed, with results indicating significant interactions between cognitive health and sex ($p=0.03$) and psychological health and sex ($p=0.01$). In addition, physical health remained as a significant main effect in this model ($p<0.001$).

Upon discovery of the significant interactions noted above, all attempts were made to elucidate final models through stratification techniques. Due to small sample sizes when models were stratified, no final models could be established for the effects of component by covariate interactions on five-year institutionalization. For example, when stratified by sex only 65 men had been institutionalized by time 2 compared with 120 women. Significant interactions remained in the models that were stratified by sex and further stratification led to inadequate sample sizes to calculate accurate measures of association. This finding persisted when the order of stratification was changed. For example, a stratified analysis by cognitive health at the first stage (instead of sex) led to very small sample sizes, with only 67 individuals with good cognitive health living in an institution by time 2. An interaction between physical health and social health remained for the group with good cognitive health and further stratification by physical health status led to only 45 individuals with poor physical health and 22 with good physical heath that were living in an institution by time 2. The inability to obtain final models for institutionalization when interactions between components and covariates were assessed underscores the complexity of the relationship

between the components of healthy aging and also highlights the importance of individual characteristics such as age, sex, and education on predicting this health outcome.

6.4 Research Objective 3: To Examine the Relationship between Healthy Aging and Self-Rated Health

6.4.1 Association of Time 1 Healthy Aging and Its Components with Self-Rated Health at Time 1

The association of self-rated health with both the components of healthy aging and overall healthy aging at time 1 was examined using logistic regression modeling. Because all variables were measured at time 1, it was only possible to indicate whether an association existed, not whether ratings on one variable were influencing or causing ratings on another variable. To explore this association, models were created to examine whether individuals with good self-rated health at time 1 were more likely to also have shown good cognitive, physical, social, and psychological health at time 1, and also if they were more likely to have met criteria for healthy aging at time 1 (Table 12). Younger age (OR=0.98; 95% CI: 0.96-0.99) and higher education (OR=2.01; 95% CI: 1.58-2.56) were significantly associated with good self-rated health. Sex did not appear to significantly influence self-rated health (OR=1.19; 95% CI: 0.94-1.52). The models, adjusted for the effects of age, sex, and education, for each of the components of healthy aging and their association with good self-rated health indicated those individuals with good-self-rated health were more likely to be in good cognitive (OR=2.20; 95% CI: 1.62-2.98), physical (OR=4.91; 95% CI: 3.74-6.48), social (OR=2.07; 95% CI: 1.63-2.62), or psychological (OR=7.00; 95% CI: 5.31-9.25) health compared with those who rated their health as poor. In addition, individuals with good self-

rated health were also more likely to have met criteria for overall healthy aging (OR=4.12; 95% CI: 3.02-5.72).

Table 12. The association of good self-rated health at time 1 with healthy aging components and overall healthy aging at time 1, Manitoba Study of Health and Aging, 1991-1996 (n=1,580)

Model	Good cognitive health	Good physical health	Good social health	Good psychological health	Overall healthy aging	Age[1]	Sex[2]	Education[3]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	—	—	—	—	—	**0.98**** (0.96-0.99)	—	—
Sex	—	—	—	—	—	—	**1.19** (0.94-1.52)	—
Educ	—	—	—	—	—	—	—	**2.01***** (1.58-2.56)
Cog1	**2.58***** (1.93-3.42)	—	—	—	—	—	—	—
Cog2	**2.20***** (1.62-2.98)	—	—	—	—	**1.00** (0.98-1.01)	**1.38*** (1.08-1.77)	**1.74***** (1.35-2.25)
Phys1	—	**4.68***** (3.65-6.01)	—	—	—	—	—	—
Phys2	—	**4.91***** (3.74-6.48)	—	—	—	**1.02*** (1.00-1.04)	**1.08** (0.84-1.40)	**1.84***** (1.43-2.87)
Soc1	—	—	**2.17***** (1.72-2.76)	—	—	—	—	—
Soc2	—	—	**2.07***** (1.63-2.62)	—	—	**0.99** (0.97-1.01)	**1.29*** (1.01-1.65)	**1.95***** (1.53-2.01)
Psych1	—	—	—	**7.23***** (5.54-9.55)	—	—	—	—
Psych2	—	—	—	**7.00***** (5.31-9.25)	—	**0.99** (0.97-1.01)	**1.10** (0.85-1.44)	**1.90***** (1.46-2.49)
HA1	—	—	—	—	**4.47***** (3.31-6.15)	—	—	—
HA2	—	—	—	—	**4.12***** (3.02-5.72)	**1.00** (0.99-1.02)	**1.23** (0.96-1.58)	**1.74***** (1.35-2.24)

* p<0.05, ** p<0.01, *** p<0.001

[1] Measured as continuous.

[2] Reference category is female.

[3] Reference category is <10 years.

6.4.2 Discrepancy between Healthy Aging and Self-Rated Health at Time 1

Bivariate analyses were conducted between overall healthy aging at time 1 and self-rated health at time 1. The results indicated that, of those individuals who met our time 1 criteria for healthy aging (n=574), 90.6% (n=524) reported good self-rated health. A significant discrepancy in healthy aging status was observed for those individuals reporting good self-rated health. Of the 1,207 individuals with good self-rated health at time 1, 57% (n=687) did not meet criteria for healthy aging. Cognitive health was poor for 23.1%, physical health was poor for 32.8%, social health was poor for 68.6%, and psychological health was poor for 19.1%. Select sample characteristics by healthy aging status for individuals with good self-rated health are presented in Table 13. Demographic, medical, and social characteristics differed significantly by healthy aging status for these individuals. For example, among individuals who reported good self-rated health, those who met criteria for healthy aging were more likely to be younger, married, and have greater availability of emotional support than those who did not meet criteria for healthy aging. However, there were no significant differences between the groups for sex, rural/urban status, chronic pain, and role as a main care provider.

Table 13. Sample characteristics for individuals with good self-rated health at time 1 by time 1 healthy aging status, Manitoba Study of Health and Aging, 1991 (n=1,207)

Participant Characteristics	Met Criteria for Healthy Aging (n=520)	Did not Meet Criteria for Healthy Aging (n=687)	p-value
Age (mean)	75.0	78.6	<0.001
Sex (% male)	45	40.8	0.16
Education (% ≥10 years)	62.1	45.0	<0.001
Rural/urban status (% rural)	37.5	41.0	0.24
Chronic conditions (mean)	3.2	4.0	<0.001
Presence of chronic pain (%)	17.0	21.4	0.06
Marital status (% married)	62.0	46.1	<0.001
Living alone (%)	32.3	47.5	<0.001
Companions (mean)	7.0	5.5	0.03
General life satisfaction[1]	100	88.7	<0.001
Receiving emotional support (mean)	3.8	1.9	<0.001
Acting as care provider (%)	20.0	16.5	0.13

[1] % Delighted/Very satisfied/Satisfied

6.4.3 Self-Rated Health and Healthy Aging as Predictors of Mortality

The ability of healthy aging and self-rated health to independently predict the five-year outcome of mortality was examined using logistic regression modeling (i.e., self-rated health and healthy aging were entered in separate regression models). In addition, both variables were analyzed in the same model to examine the relative effects of each of the variables on future mortality, when controlling for the other variable. When examined independently, and controlling for the effects of age, sex and education, healthy aging at time 1 and self-rated health at time 1 were both significantly associated with being alive by time 2 (i.e., each variable was a significant predictor when examined in separate models). Compared with individuals who had died by time 2, individuals who were alive at time 2 were twice as likely to have met criteria for healthy aging (OR=2.07; 95% CI: 1.54-2.80) and to have had good self-rated health (OR=1.99; 95% CI: 1.50-2.63) at time 1 (Table 14).

The effect of both healthy aging and self-rated health on future mortality, after adjusting for the effects of covariates as well as either healthy aging or self-rated health, was examined by entering all variables in the same model. When controlling for the effects of self-rated health and covariates, healthy aging remained a significant predictor of mortality; those individuals who were alive by time 2 were almost twice as likely to have met criteria for healthy aging at time 1 (OR=1.85; 95% CI: 1.36-2.52). When controlling for the effects of healthy aging and covariates, good self-rated health at time 1 was also significantly associated with being alive by time 2 (OR=1.76; 95% CI: 1.32-2.33).

Table 14. The association of healthy aging and self-rated health with survival by time 2, Manitoba Study of Health and Aging, 1991-1996 (n=1,580)

Model	Healthy aging at time 1	Good self-rated health at time 1	Age[1]	Sex[2]	Education[3]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
1a	**2.65*** (2.01-3.53)	—	—	—	—
1b	**2.07*** (1.54-2.80)	—	**0.91*** (0.90-0.93)	**0.51*** (0.40-0.66)	**1.09** (0.84-1.41)
2a	—	**2.01*** (1.55-2.60)	—	—	—
2b	—	**1.99*** (1.50-2.63)	**0.91*** (0.89-0.92)	**0.51*** (0.40-0.66)	**1.01** (0.98-1.05)
3a	**2.40*** (1.79-3.19)	**1.63*** (1.24-2.13)	—	—	—
3b	**1.85*** (1.36-2.52)	**1.76*** (1.32-2.33)	**0.91*** (0.90-0.93)	**0.50*** (0.38-0.64)	**1.00** (0.97-1.04)

* $p<0.001$
[1] Measured as continuous.
[2] Reference category is female.
[3] Reference category is <10 years.

The possibility of effect modification between self-rated health and healthy aging on five-year mortality was assessed but no significant interaction effects were found. When the covariates were added into the model (i.e., all possible first-order interactions), a significant

interaction between healthy aging and age was found (p=0.01). Consequently, the models were stratified by age; collapsing age into standard ten-year age categories (65-74, 75-84, and 85+ years) was required to allow sufficient sample size to produce final models in the stratified sample (Table 15). Sex was a significant predictor for all age groups, with time 2 survivors more likely to be women. Individuals in the youngest age group (65-74 years), who had survived to time 2, were not significantly more likely at time 1 to have met criteria for healthy aging (OR=1.38; 95% CI: 0.80-2.37) or to have reported good self-rated health (OR=1.76; 95% CI: 0.96-3.14), compared with those who had died by time 2 in that age group. Individuals between the ages of 75-84, who had survived to time 2, were more likely to have met criteria for healthy aging (OR=1.90; 95% CI: 1.24-2.98) and to have reported good self-rated health (OR=2.15; 95% CI: 1.44-3.21) at time 1 compared with those in this age group who had died by time 2. Finally, individuals who were 85 years and older and who had survived to time 2 were more likely to have met criteria for healthy aging at time 1 (OR=4.04; 95% CI: 1.96-9.04) compared with those in this age group who had died by time 2 but they were not more likely to have reported good self-rated health (OR=1.14; 95% CI: 0.66-1.96). An interesting trend became apparent in these analyses with healthy aging acting as a stronger predictor of survival in each increasing age category. This trend was not present for time 1 self-rated health as a predictor of survival by time 2.

Table 15. The association of healthy aging and self-rated health with survival by 10-year age categories, Manitoba Study of Health and Aging, 1991-1996 (n=1,580)

Model	Healthy aging at time 1	Good self-rated health at time 1	Age	Sex[1]	Education[2]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age 65-74	**1.38** (0.80-2.37)	**1.76** (0.96-3.14)	—	**0.41 **** (0.24-0.68)	**0.88** (0.52-1.48)
Age 75-84	**1.90**** (1.24-2.98)	**2.15**** (1.44-3.21)	—	**0.50**** (0.34-0.72)	**1.02** (0.70-1.49)
Age 85+	**4.04**** (1.96-9.04)	**1.14** (0.66-1.96)	—	**0.63** (0.39-1.05)	**1.34 *** (0.79-2.31)

* p< 0.05, **p<0.001
[1] Reference category is female.
[2] Reference category is <10 years.

6.4.4 Self-Rated Health and Healthy Aging as Predictors of Institutionalization

The ability of healthy aging and self-rated health to independently predict the five-year outcome of institutionalization was examined using logistic regression modeling (i.e., healthy aging and self-rated health were entered into separate regression models). In addition, the variables were analyzed in the same model to examine the relative effects of each variable on future institutionalization, when controlling for the other variable. Healthy aging was independently associated with institutionalization by time 2: those individuals who were living in the community at time 2 were twice as likely to have met criteria for healthy aging at time 1, when controlling for the effects of age, sex, and education (OR=2.36; 95% CI: 1.54-3.75) (Table 16). However, they were not significantly more likely to have had good self-rated health at time 1 (OR=1.44; 95% CI: 1.00-2.06).

The effect of both healthy aging and self-rated health on future institutionalization, after adjusting for the effects of covariates as well as either healthy aging or self-rated health, was examined by entering all variables in the same model. When controlling for the effects of self-rated health and covariates, healthy aging remained a significant predictor of

institutionalization: those who were living in the community at time 2 were over twice as likely to have met criteria for healthy aging at time 1 (OR=2.26; 95% CI: 1.46-3.61). However, self-rated health was not significantly associated with living in the community at time 2 after controlling for the effects of healthy aging and covariates (OR=1.25; 95% CI: 0.86-1.79).

Table 16. The association of healthy aging and self-rated health with living in the community by time 2, Manitoba Study of Health and Aging, 1991-1996 (n=1,575)

Model	Healthy aging at time 1	Good self-rated health at time 1	Age[1]	Sex[2]	Education[3]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
1a	**3.77**** (2.52-5.87)	—		—	—
1b	**2.36**** (1.54-3.75)	—	**0.88**** (0.85-0.90)	**1.33** (0.94-1.89)	**1.21** (0.85-1.71)
2a	—	**1.62*** (1.15-2.25)	—		—
2b	—	**1.44** (1.00-2.06)	**0.87**** (0.85-0.89)	**1.36** (0.96-1.93)	**1.27** (0.90-1.79)
3a	**3.61**** (2.39-5.66)	**1.22** (0.86-1.71)	—	—	
3b	**2.26**** (1.46-3.61)	**1.25** (0.86-1.79)	**0.88**** (0.85-0.90)	**1.31** (0.93-1.87)	**1.17** (0.83-1.67)

* p<0.01, ** p<0.001
[1] Measured as continuous.
[2] Reference category is female.
[3] Reference category is <10 years.

The possibility of effect modification between self-rated health and healthy aging, and between healthy aging, self-rated health and the covariates age, sex, and education was assessed for the institutionalization analyses. In both the unadjusted and adjusted models there were no significant interactions with self-rated health, healthy aging or any of the covariates. Therefore, the final model for institutionalization included healthy aging and age as the only significant predictors.

6.5 Research Objective 4: To Examine Predictors of Healthy Aging

6.5.1 Demographic Predictors of Healthy Aging

The ability of demographic characteristics to predict healthy aging at time 2 was assessed using logistic regression analyses. Supplementary analyses that examined the associations of each variable with time 1 healthy aging are reported in Appendix I. When each demographic predictor was examined independently, younger age, and higher education were significant predictors of healthy aging at time 2 but sex and rural or urban residence did not have a significant effect on time 2 healthy aging status (Table 17). An additional variable to examine the effect of residential status on healthy aging at time 2 was examined. Those individuals who met criteria for healthy aging were significantly more likely to have been residents of Winnipeg as opposed to non residents of Winnipeg (OR=1.44; 95% CI=1.08-1.92) compared with those who did not meet criteria for healthy aging.

Table 17. The association between demographic characteristics at time 1 and healthy aging at time 2, Manitoba Study of Health and Aging, 1991-1996 (n=924)

Model	Age[1]	Sex[2]	Education[3]	Rural/urban Status[4]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	**0.91*** ** (0.89-0.93)	—	—	—
Sex	—	**1.10** (0.84-1.45)	—	—
Educat	—	—	**1.60*** ** (1.22-2.09)	—
Res1	—	—	—	**0.71*** (0.54-0.93)
Tot	**0.91*** ** (0.89-0.93)	**1.08** (0.81-1.43)	**1.39*** (1.04-1.87)	**0.78** (0.58-1.05)

* p <0.05, ** p<0.001
[1] Measured as continuous.
[2] Reference category is female.
[3] Reference category is <10 years.
[4] Reference category is urban.

6.5.2 Medical Predictors of Healthy Aging

The ability of medical characteristics to predict healthy aging at time 2 was assessed using logistic regression analyses. Supplementary analyses that examined the associations of each variable with time 1 healthy aging are reported in Appendix I. In contrast to all previous analyses, which modeled the probability of meeting criteria for healthy aging when healthy aging was the outcome of interest, the analyses assessing medical predictors modeled the probability of not meeting criteria for healthy aging. The decision for this change was based on the desire to report odds ratios above one, which are easier to interpret. Individuals who did not meet criteria for healthy aging at time 2 were more likely to have reported a greater overall number of chronic conditions (OR=1.22; 95% CI: 1.15-1.29). They were also more likely to have experienced various vascular conditions; such as high blood pressure, stroke, heart problems, and chest problems; and neurological conditions such as nerve trouble and memory loss (Table 18). The presence of general medical conditions such as chronic pain, eye and ear trouble, dental problems, kidney problems, diabetes, and skin problems were also significantly associated with an increased likelihood of not meeting criteria for healthy aging (Table 18).

Table 18. The association between medical conditions at time 1 and healthy aging at time 2, Manitoba Study of Health and Aging, 1991-1996 (n= 924) [1]

Medical Characteristics	Condition	Age[2]	Sex[3]	Education[4]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Number of conditions				
Unadjusted	**1.25***** (1.18-1.33)			
Adjusted	**1.22***** (1.15-1.29)	**1.09***** (1.06-1.12)	**1.09** (0.81-1.47)	**0.74*** (0.55-0.99)
Vascular Risk Factors				
High Blood Pressure				
Unadjusted	**1.48**** (1.12-1.97)			
Adjusted	**1.53**** (1.14-2.07)	**1.10***** (1.07-1.13)	**0.97** (0.73-1.29)	**0.66**** (0.49-0.87)
Heart Problems				
Unadjusted	**1.53**** (1.13-2.09)			
Adjusted	**1.42*** (1.03-1.96)	**1.10***** (1.07-1.13)	**0.96** (0.72-1.27)	**0.67**** (0.51-0.89)
Stroke				
Unadjusted	**2.59*** (1.29-5.08)			
Adjusted	**2.59*** (1.25-5.91)	**1.10***** (1.07-1.13)	**0.92** (0.69-1.22)	**0.68**** (0.51-0.90)
Chest problems				
Unadjusted	**2.43***** (1.68-3.60)			
Adjusted	**2.30***** (1.57-3.45)	**1.10***** (1.07-1.13)	**0.93** (0.70-1.24)	**0.69**** (0.52-0.91)
Neurological Risk Factors				
Parkinson's Disease				
Unadjusted	**3.26** (0.85-21.27)			
Adjusted	**3.41** (0.87-22.51)	**1.10***** (1.07-1.13)	**0.91** (0.68-1.21)	**0.67**** (0.50-0.88)
Nerve Trouble				
Unadjusted	**2.61***** (1.81-3.83)			
Adjusted	**2.70***** (1.84-4.01)	**1.10***** (1.08-1.13)	**1.06** (0.79-1.42)	**0.72*** (0.54-0.96)
Memory Problems				
Unadjusted	**2.22***** (1.55-3.23)			
Adjusted	**1.84**** (1.27-2.72)	**1.09***** (1.07-1.12)	**0.92** (0.69-1.22)	**0.70*** (0.53-0.93)

Medical Characteristics	Condition	Age[2]	Sex[3]	Education[4]
Other Neurological Problems				
Unadjusted	**1.14** (0.61-2.18)			
Adjusted	**1.30** (0.69-2.54)	**1.10***** (1.07-1.13)	**0.92** (0.70-1.23)	**0.67***** (0.51-0.89)
Other Chronic Conditions				
Presence of chronic pain				
Unadjusted	**2.41***** (1.74-3.39)			
Adjusted	**2.48***** (1.77-3.53)	**1.10***** (1.08-1.13)	**0.96** (0.72-1.28)	**0.67**** (0.50-0.89)
Arthritis				
Unadjusted	**1.34*** (1.02-1.75)			
Adjusted	**1.25** (0.94-1.65)	**1.10***** (1.07-1.13)	**0.94** (0.71-1.26)	**0.68**** (0.52-0.90)
Eye Trouble				
Unadjusted	**1.83***** (1.34-2.52)			
Adjusted	**1.42*** (1.02-1.99)	**1.10***** (1.07-1.12)	**0.95** (0.71-1.26)	**0.68**** (0.51-0.90)
Ear Trouble				
Unadjusted	**1.89***** (1.40-2.58)			
Adjusted	**1.39*** (1.01-1.93)	**1.09***** (1.07-1.12)	**0.91** (0.68-1.20)	**0.68**** (0.52-0.90)
Dental Problems				
Unadjusted	**1.63**** (1.15-2.34)			
Adjusted	**1.66**** (1.15-2.41)	**1.10***** (1.07-1.13)	**0.93** (0.70-1.23)	**0.68**** (0.51-0.90)
Kidney Problems				
Unadjusted	**2.20**** (1.39-3.58)			
Adjusted	**1.75*** (1.09-2.89)	**1.10***** (1.07-1.12)	**0.93** (0.70-1.24)	**0.67**** (0.51-0.90)
Bladder Problems				
Unadjusted	**1.67*** (1.08-2.65)			
Adjusted	**1.49** (0.94-2.42)	**1.10***** (1.07-1.13)	**0.94** 0.71-1.26)	**0.67***** (0.51-0.90)
Bowel Problems				
Unadjusted	**1.66** (0.84-3.53)			
Adjusted	**1.73** (0.85-3.77)	**1.10***** (1.07-1.13)	**0.93** (0.70-1.24)	**0.67**** (0.50-0.88)

Medical Characteristics	Condition	Age[2]	Sex[3]	Education[4]
Diabetes				
Unadjusted	**1.76** (1.01-3.20)			
Adjusted	**1.89*** (1.07-3.51)	**1.10***** (1.07-1.13)	**0.91** (0.69-1.21)	**0.67**** (0.51-0.89)
Foot Trouble				
Unadjusted	**1.82***** (1.38-2.41)			
Adjusted	**1.65**** (1.23-2.22)	**1.10***** (1.07-1.12)	**1.02** (0.76-1.36)	**0.70*** (0.53-0.93)
Skin Problems				
Unadjusted	**1.62**** (1.16-2.62)			
Adjusted	**1.71**** (1.15-2.60)	**1.10***** (1.07-1.13)	**0.94** (0.71-1.25)	**0.67**** (0.49-0.87)
Fractures				
Unadjusted	**1.21** (0.67-2.31)			
Adjusted	**1.08** (0.57-2.11)	**1.10***** (1.07-1.13)	**0.93** (0.70-1.24)	**0.67**** (0.51-0.90)
Cancer				
Unadjusted	**1.34** (0.75-2.49)			
Adjusted	**1.43** (0.78-2.69)	**1.10***** (1.07-1.13)	**0.91** (0.69-1.21)	**0.66**** (0.50-0.87)

*p<0.05, **p<0.01, *** p<0.001
[1] Modeling the probability of not meeting criteria for healthy aging
[2] Measured as continuous.
[3] Reference category is female.
[4] Reference category is <10 years.

First-order interactions between each predictor variable and covariate were assessed. Significant interactions were found between heart disease and sex (p=0.02), stroke and sex (p=0.03), bowel and age (p=0.04), diabetes and education (p=0.04), and fractures and age (p=0.03). The models were then stratified by the covariate in order to obtain estimates for the exposure variables of interest. For the interaction between heart disease and sex, a final model was found for women but the model for men had a significant H-L GOF statistic (χ^2 = 18.06, p = 0.02), indicating that the model did not fit the data. The lack of model fit for men

was not due to multicollinearity or influential outliers. The occurrence of stroke was a significant predictor of not meeting criteria for healthy aging at time 2 for females (OR=7.84; 95% CI: 2.24-49.73) after adjusting for the effects of age and education but it was not a significant predictor for males (OR=1.12; 95% CI: 0.41-3.22). The model for bowel problems as a predictor of healthy aging at time 2 was stratified into 10-year age categories but final models could not be found for individuals between 65-74 years and those over 85 years because of small sample sizes (a total of 39 individuals in the time 2 analytic sample reported experiencing bowel trouble). The significant interaction between diabetes and education was addressed by stratifying by education, which also lead to an inability to find a model that fit the data for those individuals with 10 years of education or higher ($\chi^2 = 19.32$, $p = 0.01$). Finally, the significant interaction between fractures and age led to stratification based on 10-year age categories. There were problems with the validity of the model for those individuals greater than 85 years due to small sample sizes (only 11 out of 86 individuals in this age group met criteria for healthy aging with only one of the 11 reporting a fracture); therefore final models could not be found.

6.5.3 Social Predictors of Healthy Aging

The ability of social characteristics to predict healthy aging at time 2 was assessed using logistic regression analyses. Supplementary analyses that examined the association of each variable with time 1 healthy aging are reported in Appendix I. The analyses described below are modeling the probability of meeting criteria for healthy aging at time 2. Being married, living alone, acting as a primary caregiver, the number of individuals living in the household, and the number of visitors did not significantly predict healthy aging status at

time 2 after controlling for the effects of age, sex, and education (Table 19). This finding is interesting considering the fact being married (OR=1.41; 95% CI: 1.10-1.80), and living alone (OR=0.72; 95% CI: 0.57-0.92) were significantly associated with healthy aging at time 1 (Appendix I).

Table 19. The association between social characteristics at time 1 and healthy aging at time 2, Manitoba Study of Health and Aging, 1991-1996 (n= 924) [1]

Social Characteristics	Characteristic	Age[2]	Sex[3]	Education[4]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Marital status				
Unadjusted	**1.49**** (1.14-1.95)	—	—	—
Adjusted	**1.04** (0.76-1.42)	**0.91***** (0.89-0.93)	**1.07** (0.79-1.44)	**1.50**** (1.13-1.98)
Living alone				
Unadjusted	**0.79** (0.60-1.04)	—	—	—
Adjusted	**1.18** (0.86-1.61)	**0.90***** (0.88-0.93)	**1.14** (0.84-1.53)	**1.51**** (1.14-2.00)
Acting as primary caregiver				
Unadjusted	**1.32** (0.95-1.84)	—	—	—
Adjusted	**1.05** (0.74-1.48)	**0.91***** (0.89-0.92)	**1.08** (0.81-1.44)	**1.49**** (1.13-1.97)
Number in household				
Unadjusted	**1.01** (0.86-1.19)	—	—	—
Adjusted	**0.84** (0.68-1.01)	**0.91***** (0.88-0.93)	**1.15** 0.86-1.54)	**1.50**** (1.14-1.99)
Number of visitors				
Unadjusted	**1.02** (1.00-1.03)	—	—	—
Adjusted	**1.01** (1.00-1.03)	**0.91***** (0.89-0.93)	**1.10** (0.82-1.46)	**1.47**** (1.11-1.96)

*p<0.05, **p<0.01, *** p<0.001
[1] Modeling the probability of meeting criteria for healthy aging
[2] Measured as continuous.
[3] Reference category is female.
[4] Reference category is <10 years.

7.0 Discussion

Healthy aging represents a shift in perspective from historically viewing aging as an inevitable period of disease and decline. It is a positive concept that highlights what older adults can do as they age as opposed to focusing on what they are unable to do (Chapman, 2004). The literature review provided the foundation for the creation of a multidimensional definition of healthy aging, which attempts to address important gaps that remain in the literature on healthy aging. The overall aim in creating this definition was to incorporate various domains necessary to maintaining overall functioning. Developing and applying an inclusive and multifaceted definition of healthy aging has rarely been adequately carried out in previous studies on healthy aging. The definition of healthy aging used in this study is an attempt to bridge a large gap that has formed between researcher-defined definitions of healthy aging and the elements that individuals themselves perceive to be important components of a construct of healthy aging. The inclusion of four distinct components of healthy aging was largely guided by subjective studies of healthy aging, which reinforced the importance of social and psychological health although they are often excluded in researcher-defined definitions. The analytic strategy employed in this study was more comprehensive and thorough than is typical for most previous quantitative studies of healthy aging. However, the results of this study should be interpreted in the context of the study limitations, which include factors related to the sample population, study design, and nature of the exposure and outcome variables of interest.

7.1 Overall Findings

The literature review provided the context for creating a definition of healthy aging that included four domains of functioning, largely guided by the three main theoretical frameworks that have influenced previous research on healthy aging, namely biomedical, psychosocial, and lay perspectives (Bowling, 2007; Bowling & Dieppe, 2005). The first research objective, which developed the construct of healthy aging, was largely descriptive in nature but the findings reinforce the importance of including various elements in a definition of healthy aging, as each of the four components was a significant predictor of healthy aging at time 2. This is not surprising given that each component is embedded in the time 2 construct of healthy aging. However, the findings from the second research objective, which validated the definition against the outcomes of mortality and institutionalization, clearly demonstrate that each component plays a significant role, as each was significantly associated with future survival and three of the four components were associated with remaining in the community.

The prevalence of healthy aging at time 1 (36.3%) is consistent with findings from previous studies on healthy aging. Depp and Jeste (2006) reported the mean proportion across studies; approximately one-third of the older adults sampled met researchers' criteria for healthy aging. However, because of the lack of consistency in the measurement of healthy aging, the range of the proportion of the samples that meet criteria for healthy aging is very broad. For example, a review by Bowling (2007) indicated that the prevalence of those meeting criteria for healthy aging varied dramatically across studies ranging from 3% to over 80%; while Depp and Jeste (2006) reported that the proportion of individuals that met

criteria for successful aging ranged from 0.4% to 95% across the various studies that were included in their review.

Relatively few studies have examined healthy aging over time (Ford et al., 2000; Reker, 2001) but instead, have only provided a cross-sectional perspective on the factors related to the concept of healthy aging or have focused on predictors of healthy aging (Li et al., 2005; Chou & Chi, 2002; Jorm et al., 1998; Strawbridge et al., 1996; Guralnik & Kaplan, 1989). These cross-sectional studies cannot provide information on the stability of healthy aging and its components over time. However, the design of the MSHA allowed the stability over time of overall healthy aging and its components to be assessed. The proportion of the sample that met criteria for healthy aging increased from 36.3% at time 1 to 39.1% at time 2. When the stability of each individual component over time was examined, all components, with the exception of social health, showed a decline in the proportion of the sample that met criteria for good function; these declines in function are expected over a five-year period (Gilmore & Park, 2006; Royall et al., 2005). For example, among individuals in both time 1 and time 2 analytic samples, 91.1% had good cognitive health at time 1 but this decreased to 81.4% by time 2. The same pattern was evident for physical and psychological health. However, instead of seeing this same decrease in those who met criteria for good social health between time 1 and time 2, the proportion of individuals who met criteria for good social health increased from 60.6% at time 1 to 68.6% by time 2. It is possible that perceptions of social health could increase with as individuals age or alternatively, this finding could indicate that the time 1 and time 2 social health component used in the definitions of healthy aging may not actually be measuring the same domains as was

assumed when the definition was created. This may be problematic if assumptions about time 2 healthy aging are based on the time 1 definition.

The time 1 definition of healthy aging was validated against the outcomes of mortality and institutionalization. The covariates age, sex, and education were significant predictors of mortality, and age and education were significant predictors of institutionalization. These findings correspond with well-established associations reported in the literature (Fried et al., 1998, Branch & Jette, 1982). Based on the findings from this study and previous studies, the decision to force age, sex, and education into all final models was made.

The overall construct of healthy aging developed in this thesis was a significant predictor of both five-year mortality and institutionalization, which provides support for the value of this definition. Few studies have examined the ability of healthy aging to predict future health outcomes such as mortality and institutionalization (Andrews et al., 2002; Menec, 2003; Tyas et al., 2007). In this study, each component of healthy aging was also a significant predictor of mortality and institutionalization when examined individually, even after adjusting for the effects of age, sex, and education. This corresponds with previous studies, which have shown that physical, cognitive, social, and psychological health are independently associated with mortality and institutionalization (Anstey et al., 2001; Andrews et al., 2002; Glass et al., 1999; Glazebrook & Rockwood, 1994; Miller & Weissert, 2000).

The analysis of effect modification between the components and covariates provides a level of detail that has rarely been explored in previous studies of healthy aging. In fact, no study that was examined in the literature review explicitly reported assessing for possible

interactions, although this has been reported to be an important factor to include in logistic regression analyses (Bagley, White, & Golomb, 2001; Ottenbacher, Ottenbacher, Tooth & Ostir, 2004). The significant interaction found between physical and cognitive health when predicting mortality highlights the complexity of healthy aging and serves to emphasize the importance of including both these components in a valid definition of healthy aging. In previous research, physical and cognitive health have been found to be highly related (Tabbarah et al., 2002) and it is apparent from the present study that physical functioning must be assessed in the context of cognitive health while at the same time, cognitive health must be assessed in the context of physical health. The results indicated that poor physical health was a significant predictor of mortality for those with good cognitive health but not for those with poor cognitive health and similarly, poor cognitive health was a significant predictor of mortality for those with good physical health but not for those with poor physical health. This interaction suggests that if an individual is in poor physical health then that may be a strong enough predictor of mortality that cognitive health does not add any further significant predictive power. The same situation is true for those individuals with poor cognitive health; physical health does not add significant predictive power when an individual has suboptimal cognitive health. The underlying theme that is evident through this interaction is that poor health is a more simplistic construct than good health. These core analyses cannot indicate whether declines in cognitive health precede declines in physical health but previous studies suggest that this may be the case (Tabbarah et al., 2002).

The significant interactions found between the components of healthy aging and covariates also highlight the importance of taking individual characteristics such as age, sex, and education into account when attempting to predict future health outcomes. The factors

that predict mortality and institutionalization are clearly different for those who met criteria for good ratings on certain components compared with those who did not. For example, for those individuals with poor cognitive health, sex and age were significant predictors of mortality whereas predicting mortality for those with good cognitive health was more complex and included an interaction between physical health and education. This finding is supported by previous research that has suggested that the determinants of good health are much more complex and more poorly understood than the determinants of poor health (Mackenbach, van den Bos, Joung, van de Mheen, & Stronks, 1994). The complexity of the interactions among components and covariates provides further evidence that multiple domains must be included when attempting to accurately predict future health outcomes.

The desire to examine the relationship between the constructs of healthy aging and self-rated health was largely influenced by subjective studies of healthy aging. These studies clearly indicate that individuals' perceptions of healthy aging are multidimensional in nature. In a parallel manner, subjective studies on self-rated health have found that individuals rely on a complex set of factors when they are rating their own health status, as opposed to focusing solely on physical health and functioning, which is often the case in more objective studies (Simon et al., 2005). It seemed possible that these two constructs could be highly associated and may in fact be measuring the same construct.

Examining the association between self-rated health and healthy aging is a relatively novel area of research. A select number of studies have included self-rated health in their definition of healthy aging (Roos & Havens, 1991), while others have measured it is as a predictor of healthy aging (Andrews, 2002; Ford et al., 2002; Menec, 2003). Østbye and colleagues (2006) specifically examined the association between self-rated health and 10

dimensions of health, used to loosely define healthy aging, and found that self-rated health was related to various domains of health status. In the cross-sectional analysis in the present study, self-rated health was significantly associated with the overall construct of healthy aging and with each individual component, with the strongest association found between psychological health and self-rated health. This corresponds with findings from subjective studies on self-rated health and supports the notion that individuals are relying on more than just physical health status when they are evaluating their health status (Mackenbach et al., 1994).

The association between self-rated health and healthy aging was further explored through investigation of the discrepancy between the two constructs. While less than 10% of the sample who met criteria for healthy aging reported poor self-rated health, almost 60% of the sample with good self-rated health did not meet criteria for healthy aging. This finding corresponds with an established phenomenon termed the "disability paradox", first identified by Albrecht and Deviliger (1999), which has been used to characterize individuals in poor health who report good to excellent self-rated health. The discrepancy found in the present study also parallels previous studies reporting that self-ratings of health do not necessarily match objective assessments of health, but instead include consideration of a broad range of factors including social and psychological characteristics (Idler et al., 1999). The fact that individuals base their responses on more than just physical health when they are rating their own health status is further demonstrated in this study by the substantial proportion (one-third) of the sample with good self-rated health who did not meet criteria for healthy aging due to poor physical health.

This commonly reported inconsistency between objective health and self-perceived health, often found in lay studies of healthy aging and self-rated health, is reinforced by the findings from this study. The high proportion of the sample with good self-rated health emphasizes the fact that despite decline and loss, many older adults embrace their own aging as a positive experience. This draws attention to the possible role that adaptive mechanisms, such as resiliency or social comparisons, may play in the aging process. It is possible that individuals evaluate their health based on what they can reasonably expect in light of certain circumstances (Henchoz, Cavalli, & Girardin, 2008). Expectations regarding the aging process may substantially influence how individuals rate their own health but they may not accurately reflect an individual's true health status and thus, may not act as the most precise predictor of future health status.

Both self-rated health and healthy aging were significant predictors of future mortality, with healthy aging being a slightly stronger predictor of mortality, after controlling for the effects of self-rated health and age, sex, and education. When both variables were included in the same model, the strength of the association of each variable on predicting future mortality was attenuated, but both variables remained significant predictors of mortality. These findings emphasize that healthy aging and self-rated health are overlapping constructs yet each have distinctive features because each variable plays a significant role in predicting survival after controlling for the effects of the other. It is evident that individuals are assessing more than cognitive, physical, social, and psychological health when they are assessing their own health status. The factors are most likely specific to each individual and their life circumstances. Due to the nature of the data, it was not possible to elucidate these factors in this study. For the institutionalization analyses, healthy aging was a significant

predictor but self-rated health was not a significant predictor when healthy aging, age, sex, and education were taken into account. This could indicate that predicting institutionalization is much more complex than predicting mortality. This notion is supported by the complex interactions that were found between variables when predicting institutionalization.

The influence of demographic, medical, and social characteristics on future healthy aging status highlights an area of research that lacks consistency presumably because no gold standard of healthy aging is available. The significant effect of age and education on future healthy aging corresponds with findings from many previous studies (Depp et al., 2006). The non-significant effect of sex on predicting healthy aging status corresponds with certain studies (Roos & Haven, 1991; Garfein & Herzog, 1995) but not others (Reker, 2001, Vaillant & Mukamal, 2001). Although sex was not a significant predictor of healthy aging status, being female was significantly associated with mortality, which corresponds with well-established findings in the literature (Idler & Benyamini, 1997).

In the present study, the results related to rural/urban residence reflect the impact of different definitions of rural and urban status. Living in an urban environment, as defined by Statistics Canada, was not significantly associated with healthy aging. However, when living outside Winnipeg was compared with living in Winnipeg, Winnipeg was a significant predictor of meeting criteria for healthy aging at time 2. This finding is interesting because the sole difference between these two variables (i.e., the Winnipeg/non-Winnipeg and urban/rural variables) is that the community of Brandon was included in the non-Winnipeg sample but was defined as an urban community according to Statistics Canada. Brandon is a community of approximately 43,000 people located 130 miles west of Winnipeg. In contrast,

Winnipeg is a capital city with a population of over 700,000. The results of the analyses suggest that Brandon is more similar to rural communities and combining it with Winnipeg reduces the difference between urban and rural communities. Including Brandon as an urban community, when it is clearly different from Winnipeg, may mask the positive impact that living in an urban community such as Winnipeg has on overall healthy aging. These findings underscore the importance of the environmental context to healthy aging and highlight the need for increased research in this area.

The role of medical conditions on healthy aging status represents an area that is under some degree of personal control and thus, more modifiable than other characteristics such as age or sex. The clear influence of vascular risk factors is evident as the presence of each characteristic was significantly associated with not meeting criteria for healthy aging. This finding corresponds with a previous study that has examined cardiovascular risk factors and healthy aging (Burke et al., 2001). Many of the vascular risk factors that were examined in this study are modifiable through proper exercise and diet regimes. If total prevention of the condition is not possible then proper health appraisals and subsequent treatment options are necessary and may have a positive impact on healthy aging status. It is clear that managing chronic conditions throughout the lifespan could have a significant impact on healthy aging in later life.

The importance of pain management is highlighted in findings from this study as those individuals who did not meet criteria for healthy aging at time 2 were over twice as likely to have reported chronic pain at time 1. Pain is a prevalent condition in this study population with 25.6% (n=236) of the time 2 analytic sample reporting the presence of chronic pain at time 1. Pain also has been found to have a substantial impact on physical

functioning and often functional ability improves as the pain is relieved even if other chronic conditions remain (Topp et al., 2004). When controlling for the effect of overall number of conditions and age, sex, and education, pain remained a significant predictor of healthy aging status (OR=1.71; 95% CI: 1.18-2.50). Appropriate pain management is clearly an important predictor of meeting criteria for future healthy aging status.

The influence of social characteristics on healthy aging is a controversial area of research and the findings from this study provide interesting information. None of the social characteristics that were examined in this study were significant predictors of healthy aging at time 2; however, select characteristics such as being married and not living alone were associated with healthy aging at time 1. Marital status is a widely measured predictor in studies of healthy aging but, like demographic and medical predictors, there is a lack of consistency in the findings. For example, in a study by Jorm et al. (1998), where healthy aging was defined as the absence of disability, a high score on a cognitive screening test, excellent or good self-rated health, and living in the community, marital status was not a significant predictor of healthy aging. Other studies have found that greater social contacts were significant predictors of aging well (Strawbridge et al., 1996). The present study considered the number of visitors as an indicator of social contacts; higher numbers of social contacts showed a trend toward predicting healthy aging status but this trend did not meet statistical significant when age, sex, and education were taken into account. Further research is necessary to elucidate the role that social characteristics play in healthy aging status.

7.2 Study Limitations

There are certain limitations that should be highlighted with respect to the available data and the various methods that have been used. The following sections address several major limitations that must be taken into account when interpreting the results of this study.

7.2.1 Sample Differences

Data for the proposed project were limited to individuals who were living in the community at the time of the baseline (MSHA) screening interview. Although selected data were available on some participants who were institutionalized by MSHA-2, these individuals were excluded from the analytic sample. Thus, the results of this study are most appropriately generalized to community-dwelling older adults. This restriction was deemed necessary for this study, and led to an analytic sample that was expected to be healthier than those excluded from the analyses as well as healthier than all adults 65+ years in Manitoba. The more detailed examination of the various sample characteristics provides evidence that individuals who were included in the analytic samples at time 1 and time 2 were significantly healthier than those individuals who were excluded from the analytic samples due to missing values on components or covariates (Appendix H). These systematic differences between samples introduced a potential selection bias into this study and may lead to problems in generalizing the findings to a broader population. Although the presence of a selection bias constitutes a central limitation of this study, it was unavoidable due to the sample restrictions that were made. For example, the analytic samples were restricted to those individuals who had values on each of the covariates and components of healthy aging. Individuals who

chose not to answer certain questions may have different traits than those who chose to answer that same question.

7.2.2 Components and Overall Definition of Healthy Aging

The selection of the components within this multidimensional definition of healthy aging was largely informed by a systematic review of the existing literature, but the particular variables that constituted each component of healthy aging was partially limited by the availability of measures within the dataset. An effort was made to create time 1 and time 2 definitions of healthy aging that were comparable, and therefore questions were chosen based on their inclusion in both time 1 and time 2 screening interviews. It is possible that the chosen measures may not accurately represent the key elements of a definition of healthy aging. Where possible, standard cut-off scores for tests, such as the 3MS and CES-D, were used; however, standard cut-off scores have not been established for all variables.

The creation of the social health variable may be especially problematic as no standardized test was employed and no previous research with this dataset has specifically examined social health in this manner. The wording of the social health questions was slightly different between the two time points and thus the interpretation of the question by participants may systematically differ. This possibility is supported by the analytic sample comparisons, which provide evidence for a substantial difference in the proportion of the time 1 (71.4%) and time 2 (92.5%) samples that reported receiving emotional support (Appendix I).

The decision to choose more "subjective" measures of social health, such as the availability of support and satisfaction with social relationship, was based partially on the

inherent problems associated with arbitrarily creating cut-off points for more objective measures. For example, the number of companions varies across participants: what number of companions meets criteria for good social health? In addition, there are substantial individual differences in perceptions of "good" social health and therefore a more subjective evaluation seemed appropriate for this component. Although there may be problems with this specific measure of social health, the inclusion of subjective measures of social health supports findings from lay definitions. It also makes this definition of healthy aging unique from previous definitions as it attempted to account for individuals' subjective experiences even though no question specifically addressing healthy aging was available.

The physical health component may also be subject to certain limitations due to the method used to separate participants into good or poor physical health. The decision to classify subjects into good or poor physical health was based on previous literature and supported by the underlying theoretical basis of the concept of healthy aging. Previous studies of healthy aging have been extremely stringent in their physical health criteria, with most requiring no disability in any ADLs and IADLs (i.e., participant was completely independent on the task) (Ford, 2000; Reed, 1998; Strawbridge, 1996; Garfein, 1995; Lamb, 1991). This led to relatively low proportions (<20%) of the sample populations that met criteria for healthy aging. In this study, the decision to combine the two responses "help from a device only" and "able to perform the task independently" to indicate those individuals in good physical health was an attempt to create a less stringent, more meaningful definition of healthy aging that reflects independence and more accurately represents the abilities of older adults living in the community. It is possible that this relatively arbitrary

division may have created an artificial depiction of the physical functioning capabilities of this sample.

The lack of performance-based measures of physical functioning is also a potential limitation of the physical health variable. Relying solely on a participant's assessment of his or her level of dependency may not fully capture overall physical functioning. The response options that were available for the ADL and IADL questions may be subject to different interpretations by participants and this may create problems for the validity of the measurement of physical functioning. For example, it is not explicitly apparent what participants would define as a "device" in certain questions, such as the ability to take care of personal appearance or taking medication.

Although choosing the components of healthy aging was largely influenced by the body of research that examines individual's perspectives on healthy aging, this study lacks data that specifically addresses healthy aging. The participants of this study were not directly asked about the elements they would rate as fundamental in a definition of healthy aging; therefore the choice of components may not truly reflect all the dimensions of healthy aging relevant to this population.

Another important potential limitation is the dichotomization of healthy aging. This historical dichotomization has been the subject of substantial debate in the literature (Scheidt et al., 1999). It is possible that employing this dichotomization may lead to very small numbers of individuals who "achieve" healthy aging, thus questioning the applicability of this definition to community-residing older adults. Including only one alternative — healthy aging or not healthy aging — may create an artificial situation and most likely does not reflect the complexity of this construct. As previously mentioned, it is also possible that the

time 1 and time 2 definitions differ systematically leading to the measurement of slightly different constructs. It should also be noted that the time 1 definition was validated against the outcomes of mortality and institutionalization (research objective 2) but the time 2 definition, which was employed in the analyses of predictors of healthy aging (research objective 4), could not be validated using the available data because there was only one follow-up period.

7.2.3 Data Analyses

The analyses for this thesis project relied on the use of previously collected data. Conducting analyses of secondary data has limitations such as reliance on the quality of previously collected data, which were not intended to address the specific research objectives of the proposed study. In addition, certain questions involved the analysis of data at one time period. The cross-sectional nature of certain analyses must be acknowledged as they cannot establish a causal relationship and thus can merely indicate a possible association.

The relatively small sample size in certain analyses contributed to the inability to find final models in a number of circumstances (i.e., institutionalization analyses and certain predictor models). The number of individuals who had been institutionalized by time 2 (n=185) was not large enough to elucidate the complex interactions that were found between the covariates, individual components and overall healthy aging. The same problem was found for certain medical characteristics such as heart disease, stroke, bowel problems, diabetes, and fractures. Although final models could not be found, these findings have important implications as they clearly indicate the complexity of human aging and the need for continued research in this area.

7.3 Strengths

Despite the various limitations previously discussed, there are important strengths of this project. Although analysis of secondary data may be a limiting factor in some circumstances, it is particularly appropriate for a Master's thesis project because it does not require the time or financial resources that are often associated with primary data collection. Analyzing data from a population-based study, such as the MSHA, permits greater generalizability of the findings. The availability of data from two time points allows for the potential establishment of causation as a clear temporal sequence exists between the exposure and outcome variables. This is a primary strength of this particular study because a large majority of studies on healthy aging are cross-sectional and cannot clearly establish a cause-effect relationship.

The MSHA assessed a breadth of measures including sociodemographic characteristics, social network/social support, psychological well-being, life satisfaction, depression, pain, ADLs and IADLs, self-rated health, chronic illnesses, medication use, health care service use, and a screening test for cognitive impairment. The wide range of variables available supports the development of a truly multidimensional definition of healthy aging. In addition to assessing numerous factors, the screening interviews used in the MSHA employed, to a large extent, standardized, validated, and reliable measures, which increase confidence in the quality of the data collected. The high response rates for the screening interviews are also strengths of this dataset, with the refusal rates for the MSHA and the MSHA-2 at 20% and 7.3%, respectively.

The traditional approach to exploring healthy aging, largely influenced by Rowe and Kahn (1997), has examined the criteria using a hierarchical approach. According to this

approach, avoiding disease, disability, and risk factors for disease and disability allows an individual to preserve physical and cognitive functioning, which in turn, helps maintain active engagement in life (Rowe & Kahn, 1997). Choosing a hierarchical approach immediately assumes that certain variables are more important than others, but results from lay studies clearly indicate that individuals rate both the elements of physical health, such as disease and disability, and those of psychosocial health, such as maintaining social contact and good mental health, as being of critical importance to healthy aging (Bowling & Iliffe, 2006). This study did not adopt a hierarchical approach to healthy aging as each of the four components was considered to be necessary to achieve overall healthy aging. This perspective may provide a more accurate reflection of individuals' perceptions regarding the relevant constituents of a definition of healthy aging.

The analytic strategy (Appendix G) provided substantial detail on the manner in which this study addressed the overall research objectives of developing, validating, and applying a multidimensional construct of healthy aging. This approach allowed for exploration into the stability of this construct over time, its relationship with the construct of self-rated health, and its influence on health outcomes such as mortality and institutionalization. Adapting this comprehensive approach to examining both the individual components and the overall construct of healthy aging helps to provide a detailed picture of the manner in which various elements are related.

7.4 Implications

Research on healthy aging is an important area for continued investigation given the current and expected increases in the proportion of older adults in the general population. It

encompasses a growing area of research, which strives to understand aging as a multidisciplinary process that is influenced by a variety of factors throughout the lifespan. It also emphasizes that in order to better understand aging, health, and function, research efforts should focus on individuals who age in a healthy manner. No single epidemiologic study can definitively establish the association of healthy aging, its components, and self-rated health with outcomes such as mortality and institutionalization. However, this study has highlighted some pertinent issues in the field and underscores the importance of assessing multiple domains of functioning. This study has also emphasized the significant role that individual characteristics such as age, sex, and education play when assessing the ability of healthy aging to predict future health outcomes. An understanding of the specific factors associated with healthy aging leads to the identification of opportunities to promote healthy aging through the development of health policies and programs that enhance health and function and that generally enrich the lives of older adults (Bassett et al., 2007; Byles, 2007).

Research on healthy aging may also help to reorient perceptions of aging. A study by Levy, Slade, Kunkel, and Kasl (2002) found that positive self-perceptions of aging had an impact on mortality. Specifically, individuals with positive perceptions lived approximately 7.5 years longer than those individuals with lower perceptions of aging, when controlling for age, functional health, gender, and socioeconomic status. This study did not report if general health status differed between those with good perceptions and those with poor perceptions. However, another study by Levy and colleagues (2004), using this same sample, reported the longitudinal benefit of positive perceptions of aging on functional health. This study demonstrates that individual's subjective experiences have a profound impact on their health status. Changing older adults' perceptions about the process of aging may encourage

individuals to take a more active role in maintaining their overall health as they age. Focusing on factors that are associated with healthy aging may help change older adults' attitudes toward aging may also help influence researchers and policy makers to adopt a more optimistic approach to research on aging, consequently diverting attention away from the pessimistic biomedical model of aging. A more positive approach to aging by both policy makers and older adults alike could also help dispel ageist stereotypes that persist in our society.

The association of healthy aging with the concept of self-rated health has not been thoroughly explored in the literature. The association between these two constructs may have substantial research and policy implications, such as increasing awareness of the role of individuals' subjective evaluations of their health status, as opposed to focusing solely on objective measures. Østbye and colleagues (2006) found that the factors associated with self-rated health were distinct from predictors of survival. The factors associated with self-rated health were highly related to social participation, while survival was associated with age, cognition, and independent living. The strong association between self-rated health and healthy aging underscores the influence of social determinants of health throughout the aging process as opposed to focusing primarily on personal health practices, such as initiatives to promote physical activity, which have become a primary focus for many researchers and policy makers.

The exploration of demographic, medical, and social predictors of healthy aging may provide insight into the role of certain modifiable and non-modifiable risk factors in maintaining function in later years of life. The significant effect that certain factors have on future healthy aging status is of significant public health importance. The strong associations

found between vascular risk factors, which are modifiable to some degree, may impact preventative public health strategies and may provide valuable evidence for future program planning initiatives.

As discussed in the introduction, there is a substantial discrepancy between health-adjusted life expectancy (HALE) and life expectancy (LE), with a difference of almost ten years for females and eight for males (WHO, 2007). The desire to reconcile this difference corresponds with Fries' (1980) notion of "compression of morbidity" and is evident through increased research and political interest in improving the quality not merely the quantity of years lived. Research in the area of healthy aging addresses issues that impact an individual's overall functional ability and well-being. The complex interplay between measures of functional ability, such as cognitive and physical health, and psychosocial measures, such as social and cognitive health, may provide evidence for policy and program development aimed at decreasing the considerable disparity that exists between HALE and LE.

7.5 Future Research Directions

Future studies on healthy aging should explore this construct as more of a continuum rather than merely a dichotomization. As complex and dynamic beings, humans rarely separate neatly into two discrete groups; therefore, different cut-off points should be used to delineate individuals who fall into different levels or ranges of healthy aging. The existing literature and the findings from this study support the notion that all four components should be assessed but less stringent cut-off points could be employed to represent individuals who would still be classified as meeting some standard of healthy aging yet may not meet the

most stringently-defined level of healthy aging. It is likely that exploring levels of healthy aging will more accurately reflect the overall construct of healthy aging. In addition to examining levels of healthy aging, it would be beneficial to include performance-based measures of physical functioning. Compared to self-report measures of physical functioning, performance-based measures have been found to have greater face validity for the task being assessed, greater sensitivity to change, and are less influenced by cognitive ability (Guralnik, 1989).

A greater understanding of the complex inter-relationships among the components of healthy aging could lead to the development of public health initiatives that promote healthy aging. For example, this research underscores the intimate relationship between cognitive and physical health, which must be taken into account in public health initiatives to promote healthy aging. In addition, larger sample sizes are needed to elucidate some of the interactions that could not be resolved because of small cell sizes in both the institutionalization analyses and the analyses that examined time 1 predictors of healthy aging at time 2. A more thorough examination of social health characteristics could add significant depth to a definition of healthy aging as social characteristics have been found to have substantial implications on individuals' subjective assessments of health status.

Future studies of healthy aging should focus on adaptive mechanisms such as resiliency, which may help elucidate the discrepancy that was found between healthy aging and self-rated health. The past decade has seen substantial research focus on concepts such as resiliency and validated tools are available to effectively measure this construct. Including adaptive measures to explain why individuals may or may not meet criteria for healthy aging is in line with conceptualizations of healthy aging that view aging as a process as opposed to

merely a state of being (Baltes & Baltes, 1990). Including a more complex assessment of psychological mechanisms may provide a greater understanding of how individuals cope with the constraints and adversity that often accompany aging.

This study merely skims the surface on the role that certain variables may play in predicting healthy aging. A lifespan approach to healthy aging requires longitudinal studies to examine the impact of various demographic, medical, social, and lifestyle influences on overall healthy aging from early to late life. The created definition of healthy aging is likely culturally specific: studies examining the impact of cultural diversity on healthy aging are needed. It would also be interesting to explore how the relative importance of the individual components changes as individuals progress from young-old to middle-old to oldest-old.

The underlying optimistic view of the concept of healthy aging provides a strong framework for continued research and increased momentum to replace the biomedical model of aging. Most importantly, it may help to convince the general public that aging does not need to be viewed as a period of inevitable decline and loss but instead should be valued as a period of development that, like any other stage of human development, has both challenges and rewards.

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Appendices

Appendix A: Common Components of Research-Defined Definitions of Healthy Aging

Components of Healthy Aging Definitions	First Author, Year		Notes on Operationalization of Components
Low levels of Disease or Disability	Andrews, 2002 Berkman, 1993 Bowling, 2006 Burke, 2001 Chou, 2002 Frederikson, 2002 Jorm, 1998 Karlamangla, 2002 Kubzansky, 1998 Lamb, 1999 Li, 2005 Newman, 2003 Phelan, 2004 Reker, 2002	Reuben, 2003 Roos 1991 Schoenfeld, 1994 Seeman, 1993 Seeman, 1994 Seeman, 1995 Seeman, 1996 Seeman, 1996 Seeman, 1999 Seeman, 2001 Strawbridge, 2002 Tabbarah, 2002 Unger, 1999 Vaillant, 2001	▪ Self-assessed objective health conditions ▪ Disability in ADLs and IADLs
Physical Functioning	Andrews, 2002 Berkman, 1993 Burke, 2001 Chou, 2002 Duay, 2006 Frederikson, 2002 Guralnik, 1989 Hogan, 1999 Karlamangla, 2002 Kubzansky, 1998 Menec, 2003 Michael, 1999 Newman, 2003 Palmore, 1979	Reuben, 2003 Roos, 1991 Rowe, 1997 Schoenfeld, 1994 Seeman, 1993 Seeman, 1994 Seeman, 1995 Seeman, 1996 Seeman, 1996 Seeman, 1999 Seeman, 2001 Strawbridge,1996 Tabbarah, 2002 Tyas, 2007	▪ ADL scales ▪ Upper and lower body extremity function ▪ Physical performance measures (e.g.: grip strength, climbing stairs, walking a set distance)

	Phelan, 2004 Reed, 1998	Unger, 1999 Uotinen, 2003 von Faber, 2001	
Cognitive Functioning	Almeida, 2006 Andrews, 2002 Berkman, 1993 Chou, 2002 Frederikson, 2002 Garfein, 1995 Jorm, 1998 Karlamangla, 2002 Kubzansky, 1998 Li, 2005 Newman, 2003 Reed, 1998 Reuben, 2003 Roos, 1991	Rowe 1997 Schoenfeld, 1994 Seeman, 1993 Seeman, 1994 Seeman, 1995 Seeman, 1996 Seeman, 1996 Seeman, 1999 Seeman, 2001 Tabbarah, 2002 Tyas, 2007 Unger, 1999 Uotinen, 2003 von Fabor, 2001	▪ Cognitive screening tests (e.g.: MMSE, CASE) ▪ Self-rated memory ability
Productive Functioning	Chou, 2002 Garfein, 1995	Strawbridge, 2002	▪ Defined in various ways: paid and unpaid work, helping activities
Positive Adaptation	Baltes, 1990 Crosnoe, 2002	Reker, 2002 Duay, 2006	▪ Ability to adapt to change
Social Engagement	Crosnoe, 2002 Day, 1993 Duay, 2006 Strawbridge, 2002	Unger, 1999 Vaillant, 2001 von Faber, 2001	▪ Connections with friends and relatives ▪ Social support (provided and received)
Personal Growth/Learning	Duay, 2006 Knight, 2003	Montross, 2006	▪ Engaging in learning as a coping strategy ▪ Feelings of personal control

Well-Being/Life Satisfaction	Bowling, 2006 Day, 1993 Frederiksen, 2003 Freud, 1998 Holahan, 2001 Jorm, 1998 Litwin 2005 Menec, 2003	Michael, 1999 de Moreas, 2005 Montross 2006 Reker, 2002 Strawbridge, 2002 Tyas, 2007 Vaillant, 2001 von Faber, 2001	▪ Subjective satisfaction in multiple domains (ex: overall satisfaction, satisfaction with social networks, satisfaction with financial situation etc.) ▪ Self-rated health ▪ Quality of life measures
Psychocognitive Functioning	Garfein, 1995 Phelan, 2004 Li, 2005	Palmore, 1979 Reker, 2002 Uotinen, 2003	▪ Depression scales ▪ Mood status
Longevity	Hogan, 1999 Knight, 2003 Menec, 2003 Palmore, 1979	Reed, 1998 Roos, 1991 Vaillent, 2001	▪ Most commonly measured in years of life but also measured as years of active life (no disability)
Independent Living/Activity	Day, 1993 Ford, 2000 Hogan, 1999 Montross, 2002	Reed, 1998 Roos, 1991	▪ Not a resident of a nursing home ▪ No help from formal or informal services with any ADL or IADL ▪ Level of mobility

Appendix B: Components of Lay Definitions of Healthy Aging

Reference	Components/Characteristics of Healthy Aging	Notes
Bowling, 2006	▪ Health and functioning ▪ Psychological functioning ▪ Social roles and activities ▪ Financial stability ▪ Social relationships	▪ Open-ended question "what do you think are the things associated with successful aging?" ▪ Two-thirds of respondents defined it in terms of health and functioning and almost half defined is psychologically
Bassett et al., 2007	▪ Personal factors ▪ Relationships with others ▪ System influences	▪ Open-ended question "what do you think makes people live long and keep well?"
Bryant et al., 2001	▪ Physical condition ▪ Security (financial and mental) ▪ Ability to do things and be with people ▪ Personal internal characteristics (attitude)	▪ Semi-structured and open-ended questions concerning factors associated with healthy aging
Chong et al., 2006	▪ Good health ▪ Positive attitude ▪ Active participation ▪ Social support ▪ Financial security ▪ Residential stability	▪ Focus groups to explore participants interpretations of the concept of positive aging
Duay & Bryan, 2006	▪ Engaging with others ▪ Coping with changes ▪ Maintaining physical, mental, and financial health	▪ Interviews to gain an understanding of feelings and interpretations of successful aging ▪ Results from this study support biomedical and psychosocial theories

Fisher, 1995	▪ Interactions with others ▪ A sense of purpose ▪ Self-acceptance ▪ Personal growth ▪ Autonomy	▪ Interviews to identify the meanings that older people attach to successful aging ▪ Life satisfaction as a precursor for successful aging
Knight & Ricciardelli, 2003	▪ Health ▪ Activity ▪ Personal growth ▪ Happiness/contentment ▪ Relationships ▪ Independence ▪ Appreciation/valuation of life ▪ Longevity	▪ Interview to investigate older adults' perceptions of successful aging and the relationship to researcher-defined definitions ▪ Open-ended question "what do you think successful aging is?" prior to discussing definitions in literature ▪ Most important criteria from literature: health, happiness and mental capacity
Montross et al., 2006	▪ Rate degree of successful aging on a scale of 1-10 ▪ Agreement with the statement "I am aging well"	▪ Researchers operationalized healthy aging based on seven criteria: independent living, positive adaptation, active engagement in life, mastery/growth, life satisfaction/well-being, freedom from disability, absence of disease ▪ Many more people rated themselves as successfully aging compared to researcher-defined criteria
Phelan et al, 2004	▪ Remaining in good health until close to death ▪ Having friends and family ▪ Staying involved ▪ Ability to make life choices ▪ Ability to meet all needs ▪ Not feeling lonely or isolated ▪ Feeling good ▪ Coping with challenges ▪ Remaining free of chronic disease ▪ Continuing to learn new things	▪ Survey of twenty attributes from successful aging literature ▪ Participants rated the importance of these attributes

Reichstadt et al., 2007	▪ Attitude/adaptation ▪ Security/stability ▪ Health/wellness ▪ Engagement/stimulation	▪ Semi-structured focus groups asking individuals how they would define successful aging and what are the necessary components of successful aging
Strawbridge, 2002	▪ Self-rated successful aging measured by single question: How strongly did participants agree with the statement "I am aging successfully (or aging well)?"	▪ Self-rated successful aging was compared with Rowe and Kahn measures of successful aging ▪ Half rated themselves as aging successfully but less then 20% were rated so using Rowe and Kahn criteria ▪ Biggest difference between the two was in number of chronic condition and maintaining physical and mental functioning
Tate et al., 2003	▪ Health and disease ▪ Happy life or satisfying lifestyle ▪ Keeping active (physically and mentally) ▪ Positive outlook ▪ Family ▪ Independence ▪ Acceptance	▪ Open-ended questions "What is your definition of successful aging?" and "Would you say you have aged successfully?"
Von Faber et al., 2001	▪ Adaptation ▪ Physical and cognitive functioning ▪ Social contacts	▪ In-depth interviews to examine perceptions of the concept of successful aging and the role of health in successful aging ▪ Participants valued well-being and social functioning more than physical and psychocognitive functioning

Appendix C: Significant Predictors of Healthy Aging

Predictor Category	First Author, Year		Notes
Demographic Factors			
▪ Age	Widely measured predictor.*		
▪ Sex	Andrews, 2002 Chou, 2002 Ford, 2000 Guralnik, 1989 Li, 2005	Litwin, 2005 Montross, 2006 Newman, 2000 Roos, 1991 Strawbridge, 1996	▪ Conflicting findings
▪ Income	Berkman, 1993 Chou, 2002 Ford, 2000 Guralnik, 1989 Li, 2005	Litwin, 2005 Montross, 2006 Palmore, 1979 Strawbridge, 1996 Uotinen, 2003	▪ Conflicting findings ▪ Measured in different ways: adequate vs. inadequate income
▪ Education	Almeida, 2006 Andrews, 2002 Berkman, 1993 Uotinen, 2003 Burke, 2001	Chou, 2002 Litwin, 2005 Strawbridge, 1996 Vaillant, 2001	
▪ Marital Status	Almeida, 2006 Berkman 1993 Ford, 2000 Guralnik, 1989	Li, 2005 Litwin 2005 Strawbridge, 1996 Vaillant, 2001	▪ Lack of consistency ▪ Would be possible to also look at satisfaction with current marriage as an additional predictor
Medical Factors			
▪ Overall Number of Medical Conditions	Berkman, 1993 Ford, 2000	Lamb, 1999	

▪ Presence of Chronic Conditions	Berkman, 1993 Garfein, 1995 Guralnik, 1989 Newman, 2003 Lamb, 1999	Palmore, 1979 Reker, 2002 Roos, 1991 Strawbridge, 1996 Holahan, 2001	▪ Examine the presence of certain conditions usually reported as self-reported physician assessed chronic conditions including: diabetes, asthma, stroke, arthritis, respiratory conditions, hearing problems, cancer, hypertension
▪ Health Service Utilization	Garfein, 1995		▪ Conflicting findings ▪ Rarely measured predictor
▪ Biomedical Markers	Berkman, 1993	Reed, 1998	
Behavioural Factors**			
▪ Smoking Status	Berkman, 1993 Ford, 2000 Guralnik, 1989 Michael, 1999 Burke, 2001	Newman, 2003 Reed, 1998 Strawbridge, 1996 Vaillant, 2001	▪ Smoking status has been measured in various ways: pack-years or current or ever smoker (yes/no)
▪ Alcohol Consumption	Almeida, 2006 Berkman, 1993 Guralnik, 1989	Michael, 1999 Vaillant, 2001	▪ Alcohol consumption has been measured in various ways: abuser of alcohol, moderate alcohol consumption, drinks/month
▪ Exercise	Burke, 2001 Ford, 2000 Litwin, 2005 Michael, 1999 Newman, 2003	Reed, 1998 Strawbridge, 1996 Vaillant, 2001 Uotinen, 2003	▪ Exercise has been measured in various ways: regular vs. not regular exerciser, walking for exercise
▪ Leisure Activities	Li, 2005 Litwin, 2005 Menec, 1993	Strawbridge, 2002 Palmore, 1979	▪ Not a commonly measured predictor ▪ Measured as participation in various activities during the last week
▪ BMI	Guralnik, 1989 Michael, 1999	Reed, 1998 Vaillant, 2001	
▪ Hours of Sleep	Garfein, 1995 Guralnik, 1989	Li, 2005	▪ Measured as usual number of hours of sleep in 24 hours or attaining between 7-8 hours of sleep/night

Psychosocial			
▪ Self-rated Health	Berkman, 1993 Bowling, 2006 Chou, 2002 Freud, 1998 de Moreas, 1999	Garfein, 1995 Montross, 2006 Roos, 1991 Hogan, 1999 Holahan, 2001	
▪ Depression	Andrews, 2002 Litwin, 2005 Strawbridge, 1996	Strawbridge, 2002 Vaillant, 2001	▪ Researchers have used depression scales or have dichotomized depression into often vs. never depressed
▪ Life Satisfaction	Berkman, 1993 Chou, 2002 Fisher, 1995 Garfein, 1995	Newman, 2003 Li, 2005 Menec, 2003 Holahan, 2001	▪ Have examined overall life satisfaction and different domains of life satisfaction
▪ Social Network/Social Resources	Berkman, 1993 Garfein, 1995 Litwin, 2005 Menec, 2003 Holahan, 2001	Michael, 1999 Reker, 2002 Strawbridge, 1996 Uotinen, 2003	▪ Often measured as number of friends/relatives and frequency of contact
▪ Attitude	Duay, 2006 Ford, 2000 Lamb, 1999	Palmore, 1979 Reker, 2002	▪ Positive outlook, happiness ▪ Determination to remain independent ▪ Purpose in life
▪ Personality Characteristics	Berkman, 1993 Freud, 1998[3] Garfein, 1995 Montross, 2006	Strawbridge, 2002 Vaillant, 2001 Holahan, 2001	▪ Previous variables examined include: coping ability, adaptation to change, resiliency, self-efficacy, adaptive defenses
Other			
▪ Genetics	Glatt, 2007		▪ Focused on the genetic basis of longevity and genes associated with age-associated pathological process (Apolipoprotein E)

Notes: * For review of studies that have examined age see Depp, 2006. ** For review of studies that have examined various behavioral predictors of healthy aging see Peel, 2005.

Appendix D: Assessment of Missing Data

The four components that constitute the construct of healthy aging were assessed using various techniques as described in the Methods section. In turn, because a value on each component was required in order to be classified by healthy aging status, participants with missing data at either study time point on one or more of the variables within the healthy aging construct or on one of the covariates, were excluded from these analyses.

At the time of the baseline assessment, there were a total of 1,751 participants available but the analytic sample was reduced to 1,583 when subjects with missing data were excluded. There were no missing values on sex but age was missing for one subject and years of education were missing for 12 subjects. There were no missing data on 3MS scores, which constituted the cognitive health component. The physical health component, which included ADL and IADL measures, also had low levels of missing data with only 8 subjects with missing data. The social and psychological health components had much higher proportions of missing data. The social health component had a total of 53 participants missing values, while the psychological health had 107 participants missing values on at least one variable. Within the social health component, there was one participant missing values for both the instrumental and emotional support questions; 17 participants missing values for both satisfaction with friends and family; and 25 participants missing values for satisfaction with recreational activities. Within the psychological health component, there were 96 participants missing values on CES-D items and 17 participants missing responses for general life satisfaction.

At follow-up, there were a total of 1,067 participants available for study. Again, there were no missing data on 3MS scores, and thus no missing data on overall cognitive health. The physical health component had low levels of missing data with only one participant missing a value for ADLs or IADLs. There were 28 individuals missing data on psychological health, 26 missing data for the CES-D and two missing data for general life satisfaction. An additional 39 individuals were also missing CES-D information because they completed the shortened screening interview (screening version 2), which did not include assessment of depressive symptoms. There were a total of 70 participants missing values for the variables within the social health component.

The effect of missing data was assessed by comparing subjects who had complete information for all covariates and components of healthy aging (i.e., could be classified by healthy aging status), with those who were missing data on one or more of these variables. Differences in the characteristics of these two groups were assessed using independent samples t-tests with unequal variance for continuous variables and Pearson chi-square tests for categorical variables at both time 1 and time 2. Results for these sample comparisons are summarized in Appendix H.

Appendix E: Data Access Approval

UNIVERSITY OF MANITOBA | Centre on Aging

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December 12, 2007

Dr. Suzanne Tyas and Ms. Madelon Cheverie
Department of Health Studies and Gerontology
University of Waterloo
200 University Avenue West
Waterloo, ON N2L 3G1

Dear Dr. Tyas and Ms. Cheverie:

I am pleased to notify you that your request for access to the Manitoba Study of Health and Aging (MSHA-1 and MSHA-2) data, as outlined in your proposal of October 24th, 2007, has been approved. Release of the data is subject to receipt of ethics approval from the University of Waterloo. Attached are copies of the ethics approvals for MSHA; please note that the study is referred to CSHA as the MSHA was the Manitoba-specific component of the Canadian Study of Health and Aging.

As you know, the following are conditions associated with access to these data:

1. You will include the following acknowledgement(s) in your published work/presentations based on these data:

MSHA-1: *The Manitoba Study of Health and Aging (MSHA-1) was funded primarily by Manitoba Health, with additional funding provided through the Canadian Study of Health and Aging by the Seniors Independence Research Program of the National Health Research and Development Program of Health Canada (Project No. 6606-3954-MC[S]).*

MSHA-2: *The Manitoba Study of Health and Aging (MSHA-2) was funded primarily by Manitoba Health's Healthy Communities Development Fund with additional funding provided through the Canadian Study of Health and Aging by the Seniors Independence Research Program of the National Health Research and Development Program of Health Canada (Project No. 6606-3954-MC[S]).*

…2/

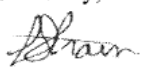
2. The following disclaimer must be included in your published work/presentations:

> *The results and conclusions are those of the author and no official endorsement by the Centre on Aging or Manitoba Health is intended or should be inferred.*

3. Individuals will provide the Centre on Aging with a final copy of their published work/ presentations. All data files will be returned to the Centre on Aging upon completion of the research.

Best wishes with your research. Please do not hesitate to contact me or Audrey Blandford if you have any questions or require further information.

Sincerely,



Laurel A. Strain, PhD
MSHA Principal Investigator

Cc: A. Blandford

Appendix F: University of Waterloo Ethics Approval

UNIVERSITY OF WATERLOO
OFFICE OF RESEARCH ETHICS

Feedback on Ethics Review of Application to Conduct Research with Humans

All research involving human participants at the University of Waterloo must be carried out in compliance with the Office of Research Ethics Guidelines for Research with Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

ORE File #: 14593

Project Title: Development, Validation, and Application of a Multidimensional Definition of Healthy Aging

Faculty Supervisor: Suzanne Tyas **Department/School:** Health Studies & Gerontology
Student Investigator: Madelon Cheverie **Department/School:** Health Studies & Gerontology

---

The above research application has undergone ethics review through the Office of Research Ethics and received the following ethics review category:

☑ **Full Ethics Clearance**. The application is considered acceptable on ethical grounds and complies with ORE Guidelines for Research with Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. No revisions are required.

☐ **Full Ethics Clearance***. The application is considered acceptable on ethical grounds and complies with ORE Guidelines for Research with Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. * **Minor/editorial revisions are required** as outlined in a transmitted email. Revised materials must be provided for the ORE file.

CONDITIONS ASSOCIATED WITH FULL ETHICS CLEARANCE:
1. Ethics clearance is valid for four years from the date FULL ethics clearance is granted.
2. Projects must be conducted in accordance with the description in the application for which full ethics clearance is granted. All subsequent modifications to the protocol must receive prior ethics clearance through the Office of Research Ethics.
3. An annual progress report (ORE Form 105) must be submitted for ethics review for each year of an ongoing project.
4. Any events, procedures, or unanticipated problems that adversely affect participants must be reported to the ORE using ORE Form 106.

☐ **Provisional Ethics Clearance**. The following revisions and/or additional information must be provided for ethics review and are requested within **10 days**. A study may not begin until it receives FULL ethics clearance.

- ☐ Information Letter was not provided and is required for ethics review.
- ☐ Information Letter provided is incomplete and requires revisions outlined in transmitted email.
- ☐ Information Letter and Consent Form were not provided and are required for ethics review.
- ☐ Information Letter and Consent Form provided are incomplete and require revisions outlined in transmitted email.
- ☐ Copy of interview/survey questions was not provided and is required for ethics review.
- ☐ Other revisions/information are required as outlined in transmitted email.

☐ **No ethics clearance status assigned.** Due to the level and/or number of questions and concerns raised during the ethics review process no ethics clearance status was assigned at this time. Comments are summarized in the attached ethics review feedback. A new application is required.

Susanne Santi

Susan E. Sykes, Ph.D., C.Psych.
Director, Office of Research Ethics
OR
Susanne Santi, M. Math
Manager, Research Ethics

2/28/08
Date

Appendix G: Analytic Plan

Research Objective 1: To develop a multidimensional definition of healthy aging

1. What proportion of the sample at time 1 and time 2 meets our criteria for:

    a) good cognitive health?

    b) good physical health?

    c) good social health?

    d) good psychological health?

    e) overall healthy aging?

    Statistical method - Univariate Analysis – Frequency Distribution

2. a) What proportion of the sample with good *cognitive health* at time 1 also have:

    i) good physical health at time 1?

    ii) good social health at time 1?

    iii) good psychological health at time 1?

  b) What proportion of the sample with good *physical health* at time 1 also have:

    i) good cognitive health at time 1?

    ii) good social health at time 1?

    iii) good psychological health at time 1?

  c) What proportion of the sample with good *social health* at time 1 also have:

    i) good cognitive health at time 1?

    ii) good physical health at time 1?

    iii) good psychological health at time 1?

d) What proportion of the sample with good *psychological health* at time 1 also have:

i) good cognitive health at time 1?

ii) good physical health at time 1?

iii) good social health at time 1?

Statistical method – Bivariate Analysis – Frequency Distribution

3. Are there associations between each of the individual components of healthy aging at time 1?

Statistical method – Bivariate Analysis – Pearson's Chi-Square Test

4. Are each of the individual components at time 1 significantly associated with healthy aging at time 1?

Statistical Method – Bivariate Analysis – Pearson's Chi-Square Test

5. a) What proportion of the sample with good ratings on one component at time 1 also has good ratings on that same component at time 2?

b) Are there significant associations between the time 1 and time 2 components?

Statistical Method – a) Bivariate Analysis – Frequency Distribution

b) Logistic Regression

6. Do the individual components of healthy aging at time 1 predict healthy aging at time 2 when examined:

a) individually (unadjusted and adjusted for covariates)?

b) collectively (unadjusted and adjusted for covariates)?

a)Model Cog1: **Statistical method:** logistic regression

Outcome variable: healthy aging at time 2 (yes/no)

Explanatory variable: good *cognitive health* (yes/no)

Covariates: none

Model Cog2:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *cognitive health* (yes/no)
	Covariates:	age, sex, and education
Model Phys1:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	none
Model Phys2:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	age, sex, and education
Model Soc1:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	none
Model Soc2:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	age, sex, and education
Model Psych1:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	none

Model Psych2: **Statistical method:** logistic regression

Outcome variable: healthy aging at time 2 (yes/no)

Explanatory variable: good *psychological health* (yes/no)

Covariates: age, sex, and education

b)Model Tot1: **Statistical method:** logistic regression

Outcome variable: healthy aging at time 2 (yes/no)

Explanatory variables: good *cognitive health* (yes/no)

good *physical health* (yes/no)

good *social health* (yes/no)

good *psychological health* (yes/no)

Covariates: none

Model Tot2: **Statistical method:** logistic regression

Outcome variable: healthy aging at time 2 (yes/no)

Explanatory variables: good *cognitive health* (yes/no)

good *physical health* (yes/no)

good *social health* (yes/no)

good *psychological health* (yes/no)

Covariates: age, sex, and education

7. Is healthy aging at time 1 associated with healthy aging at time 2?

Model HA1: **Statistical method:** logistic regression

Outcome variable: healthy aging at time 2 (yes/no)

Explanatory variable: healthy aging at time 1 (yes/no)

Model HA2:	**Statistical method:**	logistic regression
	Outcome variable:	healthy aging at time 2 (yes/no)
	Explanatory variable:	healthy aging at time 1 (yes/no)
	Covariates:	age, sex, and education

Research Objective 2: To validate a multidimensional definition of healthy aging

8. Are individuals who have died by time 2 less likely to have shown at time 1:

a) good cognitive health?

b) good physical health?

c) good social health?

d) good psychological health?

e) overall healthy aging?

Model Cog1:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *cognitive health* (yes/no)
	Covariates:	none
Model Cog2:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *cognitive health* (yes/no)
	Covariates:	age, sex, and education
Model Phys1:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	none

Model Phys2:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	age, sex, and education
Model Soc1:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	none
Model Soc2:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	age, sex, and education
Model Psych1:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	none
Model Psych2:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	age, sex, and education
Model HA1:	**Statistical method:**	logistic regression
	Outcome variable:	died by time 2 (yes/no)
	Explanatory variable:	overall *healthy aging* (yes/no)
	Covariates:	none

Model HA2: **Statistical method:** logistic regression

Outcome variable: died by time 2 (yes/no)

Explanatory variable: overall *healthy aging* (yes/no)

Covariates: age, sex, and education

9. Are individuals who have been institutionalized by time 2 less likely to have shown at time 1:

a) good cognitive health?

b) good physical health?

c) good social health?

d) good psychological health?

e) overall healthy aging?

Model Cog1: **Statistical method:** logistic regression

Outcome variable: institutionalized by time 2 (yes/no)

Explanatory variable: good *cognitive health* (yes/no)

Covariates: none

Model Cog2: **Statistical method:** logistic regression

Outcome variable: institutionalized by time 2 (yes/no)

Explanatory variable: good *cognitive health* (yes/no)

Covariates: age, sex, and education

Model Phys1: **Statistical method:** logistic regression

Outcome variable: institutionalized by time 2 (yes/no)

Explanatory variable: good *physical health* (yes/no)

Covariates: none

Model Phys2:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	age, sex, and education
Model Soc1:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	none
Model Soc2:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	age, sex, and education
Model Psych1:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	none
Model Psych2:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	age, sex, and education
Model HA1:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	overall *healthy aging* (yes/no)
	Covariates:	none

Model HA2:	**Statistical method:**	logistic regression
	Outcome variable:	institutionalized by time 2 (yes/no)
	Explanatory variable:	overall *healthy aging* (yes/no)
	Covariates:	age, sex, and education

Research Objective 3: To explore the relationship between healthy aging and self-rated health

10. Are individuals with good self-rated health at time 1 more likely to have shown at time 1:

a) good cognitive health?

b) good physical health?

c) good social health?

d) good psychological health?

e) overall healthy aging?

Model Cog1:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *cognitive health* (yes/no)
	Covariates:	none
Model Cog2:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *cognitive health* (yes/no)
	Covariates:	age, sex, and education
Model Phys1:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	none

Model Phys2:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *physical health* (yes/no)
	Covariates:	age, sex, and education
Model Soc1:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	none
Model Soc2:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *social health* (yes/no)
	Covariates:	age, sex, and education
Model Psych1:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	none
Model Psych2:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	good *psychological health* (yes/no)
	Covariates:	age, sex, and education
Model HA1:	**Statistical method:**	logistic regression
	Outcome variable:	good self-rated health (yes/no)
	Explanatory variable:	overall *healthy aging* (yes/no)
	Covariates:	none

Model HA2: **Statistical method:** logistic regression

Outcome variable: good self-rated health (yes/no)

Explanatory variable: overall *healthy aging* (yes/no)

Covariates: age, sex, and education

11. Of those individuals with good self-rated health at time 1:

a) what was their healthy aging status?

b) how did their characteristics vary by healthy aging status?

Statistical method – Bivariate Analysis – Pearson's Chi-Square Test and Independent Samples T-tests

12. Does healthy aging at time 1 predict mortality at time 2 beyond the effects of self-rated health at time 1?

Model 1a: **Statistical method:** logistic regression

Outcome: died by time 2 (yes/no)

Explanatory variable: *healthy aging* at time 1 (yes/no)

Covariates: none

Model 1b: **Statistical method:** logistic regression

Outcome: died by time 2 (yes/no)

Explanatory variable: *healthy aging* at time 1 (yes/no)

Covariates: age, sex, and education

Model 2a: **Statistical method:** logistic regression

Outcome: died by time 2 (yes/no)

Explanatory variable: good *self-rated health* at time 1 (yes/no)

Covariates: none

Model 2b:	**Statistical method:**	logistic regression
	Outcome:	died by time 2 (yes/no)
	Explanatory variable:	good *self-rated health* at time 1 (yes/no)
	Covariates:	age, sex, and education
Model 3a:	**Statistical method:**	logistic regression
	Outcome:	died by time 2 (yes/no)
	Explanatory variable:	*healthy aging* at time 1 (yes/no)
		good *self-rated health* at time 1 (yes/no)
	Covariates:	none
Model 3b:	**Statistical method:**	logistic regression
	Outcome:	died by time 2 (yes/no)
	Explanatory variables:	*healthy aging* at time 1 (yes/no)
		good *self-rated health* at time 1 (yes/no)
	Covariates:	age, sex, and education

13. Does healthy aging at time 1 predict institutionalization at time 2 beyond the effects of self-rated health at time 1?

Model 1a:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variable:	*healthy aging* at time 1 (yes/no)
	Covariates:	none
Model 1b:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variable:	*healthy aging* at time 1 (yes/no)
	Covariates:	age, sex, and education

Model 2a:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *self-rated health* at time 1 (yes/no)
	Covariates:	none
Model 2b:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variable:	good *self-rated health* at time 1 (yes/no)
	Covariates:	age, sex, and education
Model 3a:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variables:	*healthy aging* at time 1 (yes/no)
		good *self-rated health* at time 1 (yes/no)
	Covariates:	none
Model 3b:	**Statistical method:**	logistic regression
	Outcome:	institutionalized by time 2 (yes/no)
	Explanatory variables:	*healthy aging* at time 1 (yes/no)
		good *self-rated health* at time 1 (yes/no)
	Covariates:	age, sex, and education

Research Objective 4: To examine predictors of healthy aging

14. Are demographic (i.e. age, sex, education, rural/urban status) characteristics at time 1 associated with:

a) healthy aging at time 1?

b) healthy aging at time 2?

Model age1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*age*
Model sex1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*sex*
Model educ1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*education*
Model res1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*rural/urban status*
Model demo1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*age*
		sex
		education
		rural/urban status
b) Model age2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*age*
Model sex2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*sex*

Model educ2: **Statistical method:** logistic regression

Outcome: healthy aging at time 2 (yes/no)

Explanatory variable: *education*

Model res2: **Statistical method:** logistic regression

Outcome: healthy aging at time 2 (yes/no)

Explanatory variable: *rural/urban status*

Model demo2: **Statistical method:** logistic regression

Outcome: healthy aging at time 2 (yes/no)

Explanatory variables: *age*

sex

education

rural/urban status

15. Are medical characteristics (i.e. number of chronic conditions, specific chronic conditions, pain) at time 1, unadjusted and adjusted for demographic characteristics, associated with:

a) healthy aging at time 1?

b) healthy aging at time 2?

a) Model num1: **Statistical method:** logistic regression

Outcome: healthy aging at time 1 (yes/no)

Explanatory variable: *number of chronic conditions*

Covariates: none

Model num2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*number of chronic conditions*
	Covariates:	age
		sex
		education
		rural/urban status
Model cond1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*presence of a specific condition*
	Covariates:	none
Model cond2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*presence of a specific condition*
	Covariates:	age
		sex
		education
		rural/urban status

*There are individual models for each chronic condition thought to influence healthy aging (i.e. arthritis, heart disease, cancer, etc.) using the strategy of cond1 and cond2 models.

Model pain1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*persistent pain* (yes/no)
	Covariates:	none

Model pain2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*persistent pain* (yes/no)
	Covariates:	age
		sex
		education
		rural/urban status
b) Model num1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*number of chronic conditions*
	Covariates:	none
Model num2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*number of a specific condition*
	Covariates:	age
		sex
		education
		rural/urban status
Model cond1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*presence of a specific condition*
	Covariates:	none

Model cond2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variables:	*presence of a specific condition*
	Covariates:	age
		sex
		education
		rural/urban status

*There are individual models for each chronic condition thought to influence healthy aging (i.e. arthritis, heart disease, cancer, etc.) using the strategy of cond1 and cond2 models.

Model pain1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variables:	*persistent pain* (yes/no)
	Covariates:	none
Model pain2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variables:	*persistent pain* (yes/no)
	Covariates:	age
		sex
		education
		rural/urban status

15. Are social characteristics (i.e. marital status, living alone, and acting as a main caregiver) at time 1, unadjusted and adjusted for demographic characteristics, associated with:

a) healthy aging at time 1?

b) healthy aging at time 2?

a) Model mar1: **Statistical method:** logistic regression

	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*married (yes/no)*
	Covariates:	none
Model mar2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*married (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status
Model alon1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*live alone (yes/no)*
	Covariates:	none
Model alon2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*live alone (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status
Model care1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variable:	*acting as caregiver (yes/no)*
	Covariates:	none

Model care2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 1 (yes/no)
	Explanatory variables:	*acting as caregiver (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status
b) Model mar1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*married (yes/no)*
	Covariates:	none
Model mar2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*married (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status
Model alon1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*live alone (yes/no)*
	Covariates:	none

Model alon2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variables:	*live alone (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status
Model care1:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variable:	*acting as caregiver (yes/no)*
	Covariates:	none
Model care2:	**Statistical method:**	logistic regression
	Outcome:	healthy aging at time 2 (yes/no)
	Explanatory variables:	*acting as caregiver (yes/no)*
	Covariates:	age
		sex
		education
		rural/urban status

Appendix H: Time 1 and Time 2 Analytic Sample Characteristics

Table H1. Baseline and follow-up characteristics of participants for the full and analytic samples, Manitoba Study of Health and Aging, 1991-1996

Participant Characteristics	Time 1			Time 2		
	Total Sample (n=1751)	Analytic Sample (n=1583)	Excluded Subjects (n=72-168)[1]	Total Sample (n=1067)	Analytic Sample (n=924)	Excluded Subjects (n=78-143)[1]
Demographic						
Age (mean)	77.5	77.3	80.0***[2]	80.7	80.1	84.4***
Sex (% female)	58.5	58.4	59.5	60.5	60.7	59.4
Education (%≥10 years)	47.7	48.5	39.5*	52.4	53.9	42.2
Rural/Urban Status (% rural)	39.8	38.9	47.9*	N/A[3]	N/A	N/A
Components of Healthy Aging						
Cognitive Health						
3MS (mean score)	85.3	86.1	77.8**	83.6	85.3	73.3***
Physical Health (%)						
Activities of Daily Living[4]						
Eat	99.6	99.8	97.6***	98.3	98.5	97.2
Dress	98.5	98.7	96.4	94.1	95.7	83.9***
Take care of appearance	99.1	99.2	97.6	97.6	98.5	91.6***
Walk	97.8	97.9	97.6	95.2	98.1	76.9***
Get out of bed	99.5	99.6	98.2	97.7	99.1	88.1***
Bathe or Shower	91.7	92.5	84.4***	86.0	87.1	76.0**
Toilet	99.6	99.8	98.2*	97.7	99.1	88.1***
Instrumental Activities of Daily Living[4]						
Phone	98.0	98.4	94.0***	95.3	96.7	86.7***
Places out of walking distance	86.1	88.1	67.1***	78.0	78.8	71.2
Shop	80.7	82.8	60.8***	73.1	73.9	65.4
Prepare meals	90.9	91.7	83.9**	85.3	85.9	79.8
Heavy housework[5]	88.5	89.6	77.1***	87.1	88.1	77.9**
Handle finances	92.1	92.7	86.3**	83.8	87.2	61.3***
Take medication	96.6	97.3	89.8***	92.6	94.1	79.8***
Social Health (%)						
Receives instrumental support	96.7	97.1	93.4*	94.6	95.4	89.3**
Receives emotional support	71.4	72.9	56.9***	92.5	93.2	87.9*
Satisfied with family[6]	93.0	93.2	90.7	93.6	93.9	89.4
Satisfied with friends[6]	91.5	92.2	83.4***	92.2	92.9	85.1*
Satisfied with recreational activitities[6]	86.3	86.7	82.5	81.5	81.6	80.0
Psychological Health (%)						
Good general life satisfaction[6]	86.8	87.9	75.2***	88.5	89.2	80.9*
CES-D (<16)	86.7	87.3	72.2***	85.5	86.0	79.5

Predictors of Healthy Aging						
Medical						
Number of conditions (mean)	4.4	4.4	5.0**	5.2	5.2	5.3
Presence of conditions (%)						
High blood pressure	33.6	34.0	29.8	37.3	38.5	29.3*
Heart trouble	30.0	29.6	34.5	33.7	33.0	38.6
Stroke	6.9	6.7	8.4	8.5	7.4	15.7**
Arthritis	60.9	61.1	59.3	63.4	64.5	56.4
Parkinson's disease	1.6	1.7	1.2	2.3	2.0	4.3
Other neurological problems	4.0	4.1	2.4	5.0	5.0	5.0
Eye trouble	31.6	31.0	37.5	36.8	36.0	42.5
Ear trouble	33.5	33.1	36.9	38.4	38.3	38.6
Dental problems	19.5	19.4	20.6	17.2	16.4	24.3*
Chest problems	21.0	20.8	23.2	22.7	22.8	22.1
Stomach problems	27.7	27.7	28.0	26.3	26.0	28.6
Kidney problems	13.5	13.1	18.0	16.0	15.4	22.0
Bladder trouble	13.0	12.6	16.7	18.8	17.6	26.4*
Bowel trouble	5.1	4.9	7.2	4.4	3.9	7.9
Diabetes	8.6	8.3	12.1	9.9	9.7	10.9
Foot problems	40.4	39.5	49.4*	36.7	36.0	40.7
Nerve problems	22.9	22.4	27.4	17.8	17.9	17.0
Skin problems	16.6	16.5	17.9	19.5	18.9	23.0
Fractures	5.2	4.8	9.0*	8.9	9.2	7.1
Cancer	6.9	6.8	8.4	9.2	9.1	9.9
Memory trouble	26.2	25.1	35.8**	14.2	13.4	20.8
Chronic pain	27.6	26.9	33.3	N/A	N/A	N/A
Social						
Marital status (% married)	50.9	52.0	39.9**	44.1	46.3	30.1***
Living alone (%)	42.4	41.5	51.2*	48.7	48.2	53.9
Number in household (mean)	0.77	0.76	0.93	1.2	1.2	1.4*
Participants acting as primary caregiver (%)	16.9	17.2	13.8	16.5	16.8	13.6
Number of companions (mean)	5.8	5.8	6.3	10.4	10.5	9.5
Other						
Good self-rated health (%)	75.3	76.4	64.7**	77.2	78.7	67.4**

* p<0.05, ** p<0.01, *** p<0.001

[1] Sample size for excluded samples varies due to missing values on covariates or variables used to create the construct of healthy aging construct.

[2] Statistical significance reflects the differences between the analytic sample and the excluded subjects for time 1 and time 2.

[3] Rural/urban status was not available at time 2.

[4] % Able to perform task independently or with the help of a device

[5] % Able to perform task independently, with the help of a device only, or with the help of a person and a device

[6] % Delighted/Very satisfied/Satisfied

Appendix I: Association of Demographic, Medical, and Social Characteristics with Time 1 Healthy Aging

Table I1. The association between demographic characteristics at time 1 and healthy aging at time 1, Manitoba Study of Health and Aging, 1991-1997 (n=1,583)

Model	Age[1]	Sex[2]	Education[3]	Rural/urban Status
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	**0.92**** (0.91-0.94)	—	—	—
Sex	—	**1.24*** (1.01 1.53)	—	—
Educat	—	—	**2.14**** (1.74-2.64)	—
Res1	—	—	—	**0.93** (0.75-1.15)
Res2	—	—	—	—
Tot	**0.93**** (0.91-0.94)	**1.31*** (1.05-1.63)	**2.04**** (1.63-2.57)	**1.13** (0.90-1.41)

* p <0.05, ** p<0.001
[1] Measured as continuous.
[2] Reference category is females.
[3] Reference category is <10 years.

Table I2. The association between time 1 medical conditions and healthy aging at time 1, Manitoba Study of Health and Aging, 1991 (n=1,583)[1]

Medical Characteristics	**Condition**	**Age**[2]	**Sex**[3]	**Education**[4]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Number of conditions				
Unadjusted	**1.24***** (1.19-1.29)			
Adjusted	**1.18***** (1.13-1.24)	**1.06***** (1.05-1.08)	**0.85** (0.68-1.06)	**0.55**** (0.44-0.68)
Vascular Risk Factors				
High Blood Pressure				
Unadjusted	**1.18** (0.95-1.47)			
Adjusted	**1.14** (0.91-1.43)	**1.08***** (1.06-1.09)	**0.78*** (0.62-0.97)	**0.50***** (0.40-0.62)
Heart Problems				
Unadjusted	**1.91***** (1.51-2.42)			
Adjusted	**1.71***** (1.34-2.20)	**1.07***** (1.06-1.09)	**0.79*** (0.63-0.99)	**0.50***** (0.40-0.62)
Stroke				
Unadjusted	**2.95***** (1.80-5.11)			
Adjusted	**2.62***** (1.57-4.61)	**1.08***** (1.06-1.09)	**0.75**** (0.60-0.93)	**0.52***** (0.41-0.64)
Chest problems				
Unadjusted	**2.02***** (1.54-2.68)			
Adjusted	**1.96***** (1.48-2.62)	**1.08***** (1.06-1.09)	**0.76*** (0.61-0.95)	**0.51***** (0.41-0.64)
Diabetes				
Unadjusted	**1.84**** (1.23-2.82)			
Adjusted	**2.02**** (1.33-3.15)	**1.08***** (1.06-1.10)	**0.75**** (0.60-0.93)	**0.51***** (0.41-0.63)
Neurological Risk Factors				
Parkinson's Disease				
Unadjusted	**1.91** (0.81-5.26)			
Adjusted	**2.06** (0.85-5.78)	**1.08***** (1.06-1.09)	**0.75*** (0.61-0.94)	**0.50***** (0.40-0.94)
Memory Problems				
Unadjusted	**2.57***** (1.98-3.37)			
Adjusted	**2.03***** (1.54-2.69)	**1.07***** (1.05-1.09)	**0.74**** (0.59-0.92)	**0.52***** (0.42-0.65)

Nerve Trouble				
Unadjusted	**2.59***** (1.97-3.45)			
Adjusted	**2.55***** (1.91-3.44)	**1.08***** (1.06-1.10)	**0.87** (0.69-1.09)	**0.54***** (0.43-0.67)
Other Neurological Problems				
Unadjusted	**1.20** (0.72-2.08)			
Adjusted	**1.47** (0.86-2.60)	**1.08***** (1.06-1.10)	**0.77*** (0.61-0.95)	**0.50***** (0.40-0.61)
Other Chronic Conditions				
Presence of chronic pain				
Unadjusted	**1.80***** (1.42-2.31)			
Adjusted	**1.86***** (1.44-2.41)	**1.08***** (1.06-1.10)	**0.78*** (0.63-0.98)	**0.50***** (0.40-0.62)
Arthritis				
Unadjusted	**1.34**** (1.08-1.63)			
Adjusted	**1.16** (0.93-1.44)	**1.08***** (1.06-1.09)	**0.78*** (0.62-0.97)	**0.51***** (0.41-0.63)
Eye Trouble				
Unadjusted	**2.22***** (1.76-2.83)			
Adjusted	**1.65*** (1.28-2.13)	**1.07***** (1.05-1.09)	**0.79*** (0.63-0.98)	**0.51***** (0.41-0.63)
Ear Trouble				
Unadjusted	**1.65***** (1.32-2.07)			
Adjusted	**1.22** (0.96-1.56)	**1.07***** (1.06-1.09)	**0.75**** (0.60-0.93)	**0.51***** (0.41-0.64)
Dental Problems				
Unadjusted	**1.76***** (1.34-2.34)			
Adjusted	**1.73***** (1.30-2.32)	**1.08***** (1.06-1.10)	**0.75*** (0.61-0.94)	**0.51***** (0.41-0.63)
Kidney Problems				
Unadjusted	**2.46***** (1.74- 3.54)			
Adjusted	**2.00**** (1.40-2.93)	**1.07***** (1.06-1.09)	**0.76*** (0.61-0.95)	**0.51***** (0.41-0.63)
Bladder Problems				
Unadjusted	**2.41***** (1.70-3.49)			
Adjusted	**2.15***** (1.49-3.16)	**1.08***** (1.06-1.09)	**0.80*** (0.64-1.00)	**0.51***** (0.41-0.63)

Bowel Problems				
Unadjusted	**1.78*** (1.07-3.10)			
Adjusted	**1.63** (0.96-2.90)	**1.08***** (1.06-1.09)	**0.77*** (0.61-0.95)	**0.50***** (0.40-0.62)
Foot Trouble				
Unadjusted	**1.56***** (1.26-1.94)			
Adjusted	**1.35**** (1.08-1.69)	**1.08***** (1.06-1.09)	**0.80*** (0.64-0.99)	**0.52***** (0.42-0.64)
Nerve Trouble				
Unadjusted	**2.59***** (1.97-3.45)			
Adjusted	**2.55***** (1.91-3.44)	**1.08***** (1.06-1.10)	**0.87** (0.69-1.09)	**0.54***** (0.43-0.67)
Skin Problems				
Unadjusted	**1.26** (0.95-1.68)			
Adjusted	**1.24** (0.92-1.67)	**1.08***** (1.06-1.09)	**0.77*** (0.61-0.95)	**0.50***** (0.40-0.63)
Fractures				
Unadjusted	**1.10** (0.68-1.81)			
Adjusted	**0.89** (0.54-1.50)	**1.08***** (1.06-1.10)	**0.75*** (0.61-0.94)	**0.50***** (0.40-0.63)
Cancer				
Unadjusted	**0.84** (0.56-1.26)			
Adjusted	**0.80** (0.53-1.23)	**1.08***** (1.06-1.10)	**0.76*** (0.61-0.94)	**0.50***** (0.40-0.62)

*p<0.05, **p<0.01, *** p<0.001

[1] Modeling the probability of not meeting criteria for healthy aging

[2] Measured as continuous.

[3] Reference category is females.

[4] Reference category is <10 years.

Table I3. The association between social characteristics and healthy aging at time 1, Manitoba Study of Health and Aging, 1991-1996 (n=1,583)[1]

Social Characteristic	Characteristic	Age[2]	Sex[3]	Education[4]
	OR (95% CI)	OR (95% CI)	OR (95%CI)	OR (95% CI)
Marital Status				
Unadjusted	**1.98***** (1.60-2.44)	—	—	—
Adjusted	**1.41**** (1.10-1.80)	**0.94***** (0.92-0.95)	**1.16** (0.91-1.47)	**1.96***** (1.57-2.44)
Living Alone				
Unadjusted	**0.52***** (0.42-0.65)	—	—	—
Adjusted	**0.72**** (0.57-0.92)	**0.94***** (0.92-0.95)	**1.19** (0.95-1.50)	**1.97***** (1.58-2.45)
Acting as primary caregiver				
Unadjusted	**1.36*** (1.04-1.77)	—	—	—
Adjusted	**1.07** (0.81-1.42)	**0.93***** (0.91-0.95)	**1.31*** (1.05-1.64)	**1.99***** (1.60-2.47)
Number in household				
Unadjusted	**1.09** (1.00-1.22)	—	—	—
Adjusted	**1.03** (0.95-1.12)	**0.93***** (0.91-0.95)	**1.30**** (1.04-1.62)	**1.99***** (1.60-2.48)
Number of visitors				
Unadjusted	**1.01*** (1.00-1.02)	—	—	—
Adjusted	**1.01*** (1.00-1.02)	**0.93***** (0.91-0.95)	**1.33*** (1.06-1.66)	**1.95***** (1.57-2.43)

*p<0.05, **p<0.01, *** p<0.001

[1] Modeling the probability of meeting criteria for healthy aging

[2] Measured as continuous.

[3] Reference category is females.

[4] Reference category is <10 years.