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Development and Evaluation through Structural Equation Modeling of a Model of Healthy Behaviours in Older Adults

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Development and evaluation through structural equation modeling of a model of healthy behaviours in older adults.

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ABSTRACT

Unhealthy behaviours contribute significantly to chronic disease. Longitudinal studies report improvements in the health of older adults after positive changes in health behaviours.

A conceptual model of healthy behaviours in older adults was developed based on prospective evidence. Structural equation modeling was used to test specific hypotheses in a sample of 980 family practice patients over 65 years who attended a cardiovascular health awareness session.

A model was specified that included variables reflecting health status, health-related quality of life, physician counseling and patient knowledge ($p=0.02$, CFI=0.97, RMSEA=0.039). Health-related quality is the most important pathway to healthy lifestyle behaviours (beta=0.41). Physician counseling is the most important pathway to healthy self-care behaviours (beta=0.64).

This preliminary model provides evidence of the importance of health-related quality of life and physician counseling for influencing healthy behaviours among older adults.

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EXECUTIVE SUMMARY

Background

With the aging of a large proportion of the North American population, there is a strong impetus for research on older adults. Older adults carry the largest burden of chronic disease compared with other age groups in the population. Estimates from The Global Burden of Disease Study have found that unhealthy behaviours, such as smoking and physical inactivity, are responsible for a large proportion of chronic disease. Longitudinal studies report improvements in the health of older adults after positive changes in lifestyle behaviours. Therefore, it is important to understand determinants of healthy behaviours in older adults.

Data Sources

Healthy behaviours in older adults were studied using data collected during the Community Hypertension Awareness Trial (CHAT), a paired cluster randomized controlled trial evaluating the effectiveness of a cardiovascular health promotion program emphasizing blood pressure control and management. Thirty-nine percent of patients over the age of 65 who were invited by their family physician, attended a cardiovascular health awareness session at a community pharmacy (n=980 of 2493). Multiple sources of data were available on this population. At the pharmacy session, two self-report questionnaires collected information on healthy behaviours; health status; health-related quality-of-life; health services use; patient knowledge and beliefs related to high blood pressure; and the role of their family doctor in controlling and managing high blood pressure. As well, office health records were reviewed for a random sample of 55 patients over 65 years in each of the 28 participating family practices.

Objectives and Methods

This thesis had three purposes:

1. To compare the agreement between self-reported morbidity from patient questionnaires and health record review morbidity for older adults using performance measures of specificity, sensitivity, positive predictive values and likelihood ratios (LLR).
2. To quantify the contribution of behavioural risk factors (physical inactivity, immoderate alcohol consumption, smoking, high fat diet and high stress) and

physiological risk factors (obesity, high blood pressure and high cholesterol) to cardiovascular comorbidities and depression by estimating population attributable fractions.

3. To identify longitudinal population-based studies and randomized controlled trials that report on healthy behaviours in older adults and to specify an evidence-guided model of healthy behaviours in older adults that presents a unified picture of the relationships among determinants of healthy behaviours and to evaluate this model through structural equation modeling.

Results

The results of this analysis of healthy behaviours in older adults found that:

1. Agreement between self-report and health record review data was strongest for diabetes: LLR=56.5, Sensitivity=86%, Specificity=98%. Agreement was good for all other measures with the exception of hypertension diagnosis (LLR=3.6, Sensitivity=79.6%, specificity=78.2%) and taking hypertension medication (LLR=8.6, Sensitivity=83.0%, specificity=90.3%).
2. High blood pressure and physical activity were responsible for a large proportion of cardiovascular disease. Physical inactivity was related to 24% percent of stroke in the study population, 13% of diabetes and 15% of obesity. Similarly, high blood pressure was related to 43% of stroke in the population, 36% of obesity, 26% of diabetes, 24% of high cholesterol and 22% of heart attacks. Sixty-two percent of depression in the study population was associated with high stress and 17% of depression was associated with physical inactivity.
3. A comprehensive review of prospective studies of healthy behaviours in older adults identified health status, health-related quality of life, health services use, physician counseling and patient knowledge as important variables influencing healthy behaviours in older adults. An evidence-guided model of healthy behaviours in older adults was developed and structural equation modeling was used to test specific hypotheses. A model was specified that included variables reflecting health status, health-related quality of life, physician counseling and patient knowledge (p=0.02, CFI=0.97, RMSEA=0.039). Health-related quality is the most important pathway to healthy lifestyle behaviours (beta=0.41). Physician counseling is the most important pathway to healthy self-care behaviours (beta=0.64).

Conclusions

This analysis provided further evidence of the importance of healthy behaviours in successful aging. The specific conclusions based on this analysis of healthy behaviours in older adults using data collected on a practice-based sample of 983 Canadians over 65 years were that:

1. Self-report data from older adults agrees with health records for most conditions with the exception of hypertension. This may be, in part, due to the asymptomatic nature of high blood pressure.
2. The greatest opportunities to reduce the burden of cardiovascular disease may be through lowering high blood pressure and encouraging physical activity. Additionally, lowering stress and increasing physical activity may contribute to reducing depression among older adults.
3. This preliminary model demonstrates the importance of health-related quality of life and physician counseling for influencing healthy behaviours among older adults. Further work should be done with more variables relevant to healthy behaviours and in a larger sample to validate this model.

Policies to promote healthy aging must be based on the best available evidence. Additional work is required but the findings reported in this thesis can contribute to building an evidence base for health policy makers trying to improve population health by encouraging healthy behaviours and successful aging.

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1. INTRODUCTION

1.1 The Growing Burden of Chronic Disease

Chronic diseases are the main cause of death in the world and their prevalence is increasing. The Global Burden of Disease Study, first conducted in 1990 by the World Health Organization (WHO), provided estimates of the global burden of disease as quantified by disability-adjusted life years (DALY's), a composite measure of time lost due to premature mortality and time lived with disability (Murray & Lopez, 1996). These estimates found that the ten diseases or injuries responsible for the greatest percentage of the total global burden of disease in the developed world were: ischaemic heart disease (9.9%), unipolar major depression (6.1%), cerebrovascular disease (5.9%), road traffic accidents (4.4%), alcohol use (4.0%), osteoarthritis (2.9%), trachea, bronchus and lung cancers (2.9%), dementia and other degenerative and hereditary central nervous system (CNS) disorders (2.4%), self-inflicted injuries (2.3%) and congenital anomalies (2.2%) (Murray & Lopez, 1996).

Not only is chronic disease a major burden but its prevalence also increases with age. A recent study estimating the prevalence of chronic disease in a Canadian population found that among individuals 65 years and older in a primary care setting, the prevalence of chronic disease was 99% and the mean number of chronic conditions was 6.5 (Fortin, Bravo, Hudon et al., 2005). Similarly, Wolff, Starfield & Anderson (2002) found that 65% of all Americans 65 years and older in the United States have multiple chronic conditions, with the mean number of chronic conditions being 2.3.

1.2 The Growing Population of Older Adults

It is estimated that by 2011, Canada's total population will be approximately 33.9 million people, 4.8 million (14.4%) of whom will be over the age of 65 (Statistics Canada, 2005). The growing number of individuals over the age of 65 make this an important subset of individuals to study as they carry a large burden of chronic disease and they, subsequently, will have a large impact on the formal health care system in the coming years (Fortin, Bravo, Hudon et al., 2005). In recent years, the concept of "successful aging" has become prominent, emphasizing that older adults can play an active role in maintaining health (Kahn & Rowe, 1998). A systematic review identified eight longitudinal studies that followed individuals from two to 60 years. All studies reported improvements in the health status of older adults after positive changes in lifestyle behaviours such as alcohol consumption, physical activity, diet and tobacco use (Peel, McClure & Bartlett, 2005). Yet, little research has been done to understand the determinants of these healthy behaviors in older adults, possibly due to an attitude of ageism, which implies that older people will become sick regardless of any action they may take. The identification of determinants of healthy behaviours in older adults can contribute to better management of the growing burden of chronic disease and its economic impact (Yach, Hawkes, Gould et al., 2004). For example, better understanding the determinants of physical inactivity can lead to effective clinical and public health interventions to reduce the burden of cardiovascular disease (Yach, Hawkes, Gould et al., 2004). In 1986, the Ottawa Charter for Health Promotion called for a reorientation of health services towards the promotion of health, rather than simply treating disease. However, work still needs to be done to develop and implement evidence-guided policies for health promotion (WHO, 1986). For these reasons, it is important to identify determinants of whether or not older adults engage in healthy behaviours.

1.3 The Importance of Healthy Behaviours

Healthy behaviours encompass a multitude of different actions from lifestyle choices such as being physically active to self-care activities such as adhering to medications and monitoring one's own blood pressure levels. In this study, healthy behaviours were defined as any actions that an individual engages in for the purpose of improving his or her health. Among healthy behaviours, lifestyle behaviours refer to "...the set of habits and customs that is influenced, modified, encouraged, or constrained by the lifelong process of socialization. These habits include use of substances such as alcohol, tobacco, tea, coffee; dietary habits, exercise, etc., which have important implications for health" (Last, 1995). Self-care behaviours are generally considered ways in which an individual functions on his or her own behalf to prevent illness and to detect and treat disease when it occurs; lifestyle choices are sometimes considered a subset of self-care behaviours (Segall & Goldstein, 1989). Factors such as lifestyle behaviours and self-care behaviours can have a large impact on disease management and progression

(Gray, 2002). By engaging in these healthy behaviours, individuals can control and positively influence their health, thereby reducing the burden on the health care system. Recent trends in preventive and population health emphasize the importance of an individual's role in their healthcare (Gray, 2002). As a result, many individuals are taking greater responsibility for their health and it is important that healthcare policy makers recognize the growing importance of healthy behaviours.

1.4 Unhealthy Behaviours and Population Attributable Risk

Recent global changes in lifestyle patterns such as decreased physical activity, poor diet and increased alcohol and tobacco consumption are thought to have contributed to a rise in chronic diseases (WHO, 2002). The impact of these unhealthy behaviours on the burden of disease can be quantified using the population attributable fraction, which is the proportion by which the incidence rate of the outcome, for example, mortality, in the entire population would be reduced if the exposure, for example, physical inactivity, were eliminated (Last, 1995). An analysis of population attributable risk conducted by the WHO found that in developed countries, at least one third of the chronic disease burden can be attributed to five risk factors: tobacco use, immoderate alcohol use, high blood pressure, high cholesterol and obesity (WHO, 2002). Similarly, The Global Burden of Disease Study identified tobacco use, high blood pressure, physical inactivity and immoderate alcohol use among the top ten risk factors contributing to morbidity and mortality in the developed world (See Table 1, The ten risk factors measured in The Global Burden of Disease Study and the population attributable fraction in the developed world, presented as the fraction of all-cause mortality and the fraction of all-cause disability-adjusted life years) (Murray & Lopez, 1996). Thus, a relatively small number of risk factors account for a large proportion of the global burden of disease and even modest changes in unhealthy behaviours such as physical inactivity and immoderate alcohol use will have a large benefit on population health (WHO, 2002). Therefore, the protection and improvement of health should emphasize identifying, quantifying and reducing major risk factors such as unhealthy behaviours (WHO, 2002). Estimating the population attributable fraction allows policy makers to determine the exposures that have the greatest impact on a given population and, thus, helps prioritize prevention activities as well as guide policy development and resource allocation (Aschengrau & Seage, 2004).

1.5 The Global Burden of Disease Study

The Global Burden of Disease Study was a landmark study in both its scope and its depth. It is unique in that it contains internally consistent, comprehensive and comparable assessments of the causes of death, the incidence and prevalence of

Table 1. The ten risk factors measured in The Global Burden of Disease Study (GBD) and the population attributable fraction in the developed world, presented as the fraction of all-cause mortality and the fraction of all-cause disability-adjusted life years (Murray & Lopez, 1996).

Ten Risk Factors Measured in the Global Burden of Disease Study	Population Attributable Risk Fractions in the Developed World	
	Fraction of Mortality	Fraction of DALY
Tobacco Use	0.145	0.121
Hypertension	0.129	0.047
Physical Inactivity	0.101	0.040
Air Pollution	0.025	0.015
Occupation	0.021	0.046
Alcohol Use	0.013	0.096
Unsafe Sex	0.008	0.021
Illicit Drug Use	0.003	0.019
Sanitation and Hygiene	0	0.001
Malnutrition	0	0

Note: DALY=disability-adjusted life years

disease and injury, projections of disease burden, and measures of risk factor burden. It provides global epidemiological estimates of the burden of disease for ten major risk factors in eight regions of the world. Furthermore, a comprehensive methodology was developed to obtain these estimates. Literature reviews were conducted to identify the diseases and risk factors to be investigated. The analysis maximized the use of existing information by developing mathematical models to adjust for the quality of data, some of which was incomplete or non-specific in many developing regions. The burden of disease and the population attributable fractions were assessed using disability-adjusted life years, a comprehensive metric that incorporates premature mortality as well as the prevalence, duration and severity of non-fatal diseases. These contributions represent a major achievement in epidemiology and are an invaluable resource for policymakers and researchers. For these reasons, population attributable fractions from the Global Burden of Disease Study were chosen as the standard with which to compare thesis estimates of population attributable fractions.

1.6 Rationale for Understanding and Modeling Healthy Behaviours Among Older Adults

Due to the large burden of chronic disease for which older adults are responsible and the influence of healthy behaviours on chronic disease burden, it is important that the determinants of healthy behaviours are identified and that the relationships among them are understood. Regression analyses are often used to identify variables associated with healthy behaviours but this analytical technique is limited in that it can only identify the direct effects of variables on healthy behaviours and may not adequately reflect the complexity underlying relationships among these variables (Musil, Jones & Warner, 1998). In order to think about the determinants of healthy behaviours among older adults in an integrated manner, models can be useful. Structural equation modeling is a tool that can be used to explore pathways among variables and so provide a greater understanding of how determinants of healthy behaviors in the elderly are related to each other (Hoyle, 1995). By modeling pathways, structural equation modeling is able to identify both direct and indirect effects of variables, on a dependent variable such as healthy behaviours. It is a powerful technique that allows multiple pathways among variables to be assessed simultaneously as well incorporating multiple measures that reflect a latent, or underlying, construct. For example, measures of the latent construct health-related quality of life could be self-reported mentally unhealthy days, physically unhealthy days and limited activity days (Fayers & Hand, 1997). Incorporating multiple measures of the same construct also allows error, the variance that is not explained by the underlying construct, to be correlated on the basis of similarities in systematic error among the multiple measures, thereby providing more accurate estimates of relationships between the latent construct and other model variables (Hoyle, 1995). In health research, the results of structural equation modeling can contribute to a better understanding of the relationships between biological, clinical and individual variables as they relate to health (Hays, Revicki & Coyne, 2005)

The ultimate purpose of modeling data is to describe the structure of observed data in such a way that it is understandable and interpretable. A model may have numerous definitions but the definition that is being applied in this study is a formalized expression of a theory that explains relationships among components of a system and that is regarded as having generated observed data (Last, 1995). An initial model may not be applicable to all populations and settings and it should be understood as a preliminary examination of relationships among relevant variables. Further investigations should always be conducted to verify and build upon initial models. It is also important to remember that structural equation models are "simplified approximations to reality" and that the full complexity of real world processes is rarely reflected in a structural equation model (McDonald & Ho, 2002).

A model that uses accumulated data to explain the relationships among determinants of healthy behaviours in older adults will be important in influencing policies and interventions aimed at reducing the burden of chronic disease among the elderly. There is a large quantity of data collected on healthy behaviours in population-based national health surveys such as the National Population Health Survey (NPHS) (http://www.statcan.ca/english/concepts/nphs/index.htm) and the National Health and Nutrition Examination Survey (NHANES) (http://www.cdc.gov/nchs/nhanes.htm). However, a unified evidence-guided model that incorporates all important variables and that quantitatively evaluates relationships among variables is required to integrate this information and provide insight on healthy behaviours. While conceptual frameworks related to healthy behaviours exist, they are either too complex to permit data to be modeled or are too narrowly focused to present a comprehensive understanding of healthy behaviours. Additionally, it is not known whether present frameworks and models are specific to older adults as they are typically based on the general population. Furthermore, existing frameworks used to predict healthy behaviours are unable to explain a large proportion of variability in healthy behaviours (Mackian, 2004). The best health policies are those based on scientific evidence. Therefore, a unified model of healthy behaviours among older adults, as proposed in this thesis, in which relationships among all important variables are specified using high-quality evidence from prospective population-based longitudinal studies and randomized controlled trials and that can be quantitatively evaluated will provide an important contribution to guiding healthcare policy for older adults.

1.7 Data Source(s)

Data were collected on 980 older adults in Ontario during the Community Hypertension Awareness Trial (CHAT), a paired cluster randomized controlled trial evaluating the effectiveness of an invitational cardiovascular health promotion program emphasizing blood pressure control and management (Chambers, Kaczorowski, Levitt et al., 2002; Chambers, Kaczorowski, Hendriks et al., 2005). Patients over the age of 65 were invited by their family physician to attend a cardiovascular health awareness session at a community pharmacy. At the pharmacy session, two questionnaires, the Blood Pressure Data Form and the Participant Questionnaire, were used to collect information on healthy behaviours; health status; health-related quality-of-life; health services use; patient knowledge and beliefs related to high blood pressure; and the role of their family doctor in controlling and managing high blood pressure. As well, office health records were reviewed for a random sample of 55 patients in each of the 28 participating family practices, allowing comparisons of health status between those who attended the pharmacy sessions and those who did not attend the pharmacy sessions. Finally, a questionnaire was completed by the participating physicians at the beginning of the study that provided information on physician demographics, practice characteristics and the control and management of high blood pressure in each practice.

The CHAT multiple sources of data on the same population provided an opportunity to compare the agreement between self-report questionnaire data and data collected from office health record reviews. Agreement between these two methods of data collection is important as reviewing health records can be a laborious process and it is important to know: (1) if high-quality morbidity data can be collected through self-report methods, especially in an aging population whose cognitive functioning may be declining (Simpson, Boyd, Carlson et al., 2004) and (2) the value that is added to the quality of data by undertaking health record reviews. Furthermore, if discrepancies exist between self-reported and health record data and these are not considered, inappropriate health-care policies may be developed based on self-report data (Raina, Torrance-Rynard, Wong et al., 2002). While many studies report on the level of agreement between two sources using the kappa statistic, which measures how much of the possible agreement over and above chance the two measures have achieved (Pagano & Gavareau, 1994), more detailed information can be obtained by estimating performance measures such as specificity, sensitivity, positive predictive values and likelihood ratios. Sensitivity is the probability that a measure correctly classifies as positive, individuals who have a disease. Low sensitivity indicates a high number of false negative responses. Specificity is the probability that a measure correctly classifies as negative, individuals who do not have a disease. Low specificity indicates a high number of false positive responses. The positive predictive value (PPV+) identifies the proportion of individuals identified by the measure as having the disease, who truly do have the disease. The positive likelihood ratio (LLR) is the likelihood that a given test result would be expected in an individual with the disease. These measures are often used in medical practices to compare the performance of a diagnostic test compared with a gold standard but they can also be used to assess the level of agreement between two data sources where one, for example in this thesis, the office health record, is identified as the gold standard (Guyatt & Rennie, 2002). The likelihood ratio is an important measure as it incorporates both the specificity and sensitivity of measures and, therefore, can be used as a global measure that assesses the level of agreement between two data sources. If a low likelihood ratio, that is, less than 10, indicates that there is a lack of agreement, and therefore, misclassification, the direction of misclassification can then be assessed by examining the sensitivity, specificity and positive predictive values (Guyatt & Rennie, 2002). Likelihood ratios also permit comparisons among measures. For this thesis, if likelihood ratios are acceptable when comparing self-report data and health record review data, then both those data sources will be considered acceptable for estimating population attributable risk fractions and structural equation modeling.

Because the CHAT study collected data on four of the ten risk factors studied in the Global Burden of Disease Study (alcohol use, tobacco use, physical inactivity and high blood pressure) it was determined that it would be valuable to compare estimates of population attributable fractions from CHAT with the Global Burden of Disease estimates. Additional population attributable risk fractions for other risk factors not studied in the Global Burden of Disease Study (obesity, high cholesterol, high stress and high fat diet) can also be estimated using the CHAT dataset and compared with other important studies such as the WHO report on reducing health risks (WHO, 2002). Estimating population attributable risk fractions in the CHAT study population will demonstrate the impact of healthy behaviours on health status and, therefore, the importance of a unified model of healthy behaviours among older adults.

Finally, because multiple variables relevant to healthy behaviours were available from the different CHAT data sources, this appeared to be an appropriate dataset to specify a structural equation model of healthy behaviours among older adults.

1.8 Purpose of This Study

This thesis had four goals.

1. The first goal was to identify prospectively designed studies of older adults, that is, longitudinal population-based studies and randomized controlled trials, that report on healthy behaviours (engaging in physical activity, moderate alcohol use, not smoking, low fat diet, low stress and blood pressure self-monitoring), determinants of healthy behaviours (for example, physical and mental health, health-related quality-of-life, health services use, physician influence and patient knowledge) and the relationships among these determinants of healthy behaviours.
2. The second goal was to compare the agreement between self-reported morbidity from patient questionnaires and health record review morbidity for older adults using performance measures of specificity, sensitivity, positive predictive values and likelihood ratios.
3. The third goal was to quantify the contribution of behavioural risk factors (physical inactivity, immoderate alcohol consumption, smoking, high fat diet and high stress) and physiological risk factors (obesity, high blood pressure and high cholesterol) to cardiovascular comorbidities and depression by estimating population attributable fractions.
4. The fourth goal was to specify an evidence-guided model of healthy behaviours in older adults that presents a unified picture of the relationships and pathways among determinants of healthy behaviours and then to evaluate this model through structural equation modeling.

1.9 Study Hypotheses

1. It is hypothesized that there will be good agreement between morbidity data collected through self-reported patient questionnaire data and office health record reviews as measured by the likelihood ratio. Additionally, it is hypothesized that if the likelihood ratio is not high the direction of misclassification can be determined using sensitivity, specificity and positive predictive values.
2. It is hypothesized that the population attributable fractions of cardiovascular comorbidities and depression to selected behavioural risk factors (physical inactivity, immoderate alcohol consumption, smoking, high fat diet and high stress) and selected physiological risk factors (obesity, high blood pressure, and high cholesterol) will be of similar to those found in the Global Burden of Disease study.
3. It is hypothesized that a model can be developed and evaluated through structural equation modeling that will outline and quantify meaningful pathways among determinants of healthy behaviours in older adults.

1.10 Summary

There is a strong impetus for research on older adults with the aging of a large proportion of the North American population (Statistics Canada, 2005; Moore, Rosenberg & McGuinness, 1997). Knowing which diseases can be accurately quantified through self-report questionnaires for older adults and which agree with data in health records will permit more efficient planning of research studies. As well, the validity of basing health policies on self-report morbidity data can be determined. Furthermore, assessing the burden of cardiovascular comorbidities and depression that is attributable to unhealthy behaviours through population attributable fractions will be important in prioritizing healthcare and health promotion resources. It will also underscore the importance of understanding the determinants of healthy behaviours in older adults, for example, through specifying a structural equation model of healthy behaviours in older adults. With a rapidly aging population that is being encouraged to take greater responsibility for its own health, it is important to understand the relative contributions of determinants of healthy behaviours among older adults. Longitudinal studies report that older adults who engage in healthy behaviours enjoy improved health status (Peel, McClure & Bartlett, 2005), which may alleviate strain on the formal health care system.

The development of a unified evidence-guided model of healthy behaviours in older adults that can be quantitatively evaluated will contribute to understanding the determinants of healthy behaviours. The results of this thesis will contribute to policy initiatives that promote healthy behaviours of older adults and to priority setting for preventive health care.

2. DETERMINANTS OF HEALTHY BEHAVIOURS AMONG OLDER ADULTS

2.1 Healthy Behaviours as an Important Determinant of Health

The importance of healthy behaviours as a determinant of health was first brought to the attention of Canadian policymakers with the report, "A New Perspective on the Health of Canadians", commonly referred to as the Lalonde report (Lalonde, 1974). This was a seminal report because it was the first recognition by policy makers that factors other than healthcare services are important determinants of health. It presented a framework for population health that included the influences of biological health, the environment and behavioural determinants such as healthy lifestyle behaviours, as well as the healthcare system. While this was an important advance in conceptualizing population health, this framework did not attempt to outline the complex relationships among the determinants of health. Building on the Lalonde report, Evans and Stoddart (1990), developed the "health fields concept", which identifies additional determinants of health, such as well-being, prosperity and the social environment, and which acknowledges the complexity of relationships among the determinants of health (Evans & Stoddart, 1990). While the health fields concept presents a more comprehensive view of health, the complexity of this framework and the number of feedback loops in the framework makes it difficult to evaluate quantitatively (Hoyle, 1995). Finally, while population health frameworks are important, more specific frameworks and models that focus on healthy behaviours and their determinants are also required for guiding health promotion activities.

2.1.1 A Survey of Some Frameworks That Identify Determinants of Healthy Behaviours

One established framework identifying determinants of healthy behaviours is Anderson's behavioural model of health services use, which was developed to explain why individuals seek healthcare (Anderson & Newman, 1973; Anderson, 1995). Anderson's model identifies three important groups of variables: need factors, which include subjective and objective physical health needs, for example, chronic disease status; enabling factors, which are those circumstances that facilitate or prevent the use of services, for example, accessibility; and predisposing factors, which are individual characteristics that influence the perception of needs, for example, ethnicity. Many studies have observed that this framework is unable to explain a large proportion of the variance in health-seeking behaviours (Mechanic, 1979) and that the effects of enabling and predisposing factors are negligible when health needs are taken into account (Coulton & Frost, 1982).

Most recently, cognitive models, which identify psychological determinants of behaviours, have dominated health behaviour research. These models emphasize the role that motivations, perceptions and beliefs of the individual play in determining whether or not individuals engage in healthy behaviours. Examples of social-cognitive models are The Health Belief Model (Becker, 1974), The Theory of Planned Behavior (Ajzen, 1991), The Health Locus of Control Theory (Norman & Bennett, 1996) and the Transtheoretical Theory of Change (Prochaska, DiClemente & Norcross, 1992). For example, the health belief model proposes that health behaviours occur as a result of individuals perceptions of: their susceptibility to illness, the severity of their illness and the costs and benefits of engaging in the healthy behaviour. Also, the health belief model also identifies cues to action such as symptoms or educational materials as important determinants of healthy behaviours. A meta-analysis of the relationships among the variables included in the health beliefs model did not find consistent relationships among these variables and healthy behaviours (Harrison, Mullen & Green, 1992).

An example of a social-cognitive framework that highlights the influence of biological and environmental variables on healthy behaviours is Pender's Model of Health Promotion (Pender, 1975). This model proposes that engaging in healthy lifestyle behaviours is determined by perceptions, for example, perceived control of health; modifying factors, for example, urban environment; and variables affecting the likelihood of action, for example, addictions history. Many other frameworks exist such as Parson's Sick Role Model (Segall, 1976), Leininger's Theory of Cultural Care Diversity and Universality (Leninger, 1998), Mechanic's Model of Illness Behaviour (Mechanic, 1995), Orem's Model of Self Care (Hartweg, 1990) and Bandura's Model of Self-Efficacy (Bandura, 1977) but it is beyond the scope of this thesis to review all existing frameworks related to healthy behaviours. Nonetheless, there are general criticisms that are applicable to all current healthy behaviour frameworks: a lack of consensus on important variables and the language used across frameworks; the use of cross-sectional study designs to evaluate these frameworks and, most importantly, there is little evidence that these models adequately explain healthy behaviours (Mackian, 2004).

2.1.2. Structural Equation Modeling And Determinants Of Healthy Behaviours

While conceptual frameworks are important for thinking about multi-faceted issues such as healthy behaviours, unified models of healthy behaviours that can be quantitatively evaluated can provide quantitative evidence that healthcare policy makers can use to direct priority setting (Evans & Stoddart, 1990). Some attempts to specify models of healthy behaviours and quantitatively evaluate them through structural equation modeling have been made. For example, pathways were specified for Pender's model of health promoting lifestyles and evaluated through path analysis in a population of rural elderly Taiwanese women (Wang, 1999). This study found that pathways from social support and self-care agency are pivotal influences related to engaging in healthy behaviours and thus concluded that interventions targeting social support may increase engagement in healthy behaviours in this subpopulation of elderly women. Similarly, structural equation modeling was also applied to four different social-cognitive models, including the health belief model, to understand reproductive health behaviours in developing countries and found that all four of the models adequately explained these behaviours (Murray-Johnson, Witte, Boulay et al., 2001).

Some structural equation models have not been guided by a pre-existing conceptual framework but have been specified based on a review of evidence for the determinants of healthy behaviours (Barkley, 2005; Resnick, 2003; Kostner, 1996). For example, based on a review of evidence, a unified model of healthy behaviours was specified that included variables reflecting biological factors (age, sex, race), environmental factors (socioeconomic status), psychosocial factors (stress) and behavioural factors (the sum of 19 healthy behaviors) (Kostner, 1996). This model was tested among United States Army personnel and found that stress and socioeconomic status had the strongest influences on healthy behaviours. The generalizability of this analysis to the general population as well as to older adults is questionable, though. Another attempt to specify a unified model of healthy behaviours was a model including mental factors such as cognitive functioning and mental health, physical factors, social support, socioeconomic status, socio-cultural factors and stress (Barkley, 2005). This model was evaluated in various age groups using data from the National Health and Nutrition Examination, Third Survey (NHANES III), which was collected between 1988 and 1994. This study could not identify a model that explained healthy behaviours, though. This was most likely due to inaccuracies in specifying paths and defining variables that were included in the model. A third structural equation model to explain participation in health promotion activities was specified based on a review of cross-sectional studies conducted in older adults (Resnick, 2003). This model included age, marital status, cognition, mental heath, chronic illnesses and physical heath as determinants of healthy behaviours and was evaluated in a small group of older adults living in a continuing care retirement community. Each of these variables was found to have direct or indirect effects on health promoting activities among older adults.

2.1.3. Summary of Existing Frameworks and Models Related to Healthy Behaviours

Healthy behaviors are now recognized as an important component of health status. Conceptual frameworks developed to understand healthy behaviours, such as the health belief model, are sometimes narrowly focused frameworks that may fail to identify important variables that determine whether or not individuals will engage in healthy behaviours. Additionally, there are frameworks like the health fields concept, whose complexity makes quantitative evaluation difficult. Structural equation modeling has been used to quantify effects and to gain further insight on healthy behaviours. Yet, the evidence used to specify these models has been largely cross-sectional and may not always be relevant to older adults in the general population. Therefore, the specification of a model of healthy behaviours in older adults based on prospective evidence and its quantitative evaluation through structural equation modeling would provide a valuable contribution to research on healthy behaviours and policies for health promotion among older adults.

2.2. Search For High-Quality Studies Reporting On The Determinants Of Healthy Behaviours In Older Adults

2.2.1. Search Strategy

Studies reporting on the determinants of healthy behaviours in older adults were identified using the following inclusion criteria:

1. The studies had a prospective design, that is, a longitudinal cohort or randomized controlled trial.
2. The studies were population-based or provided evidence that the study population was representative of the general population (This criterion was relaxed for studies examining physician counseling, as only primary care based studies provided this evidence).
3. Data were analyzed prospectively and the statistical significance of associations was reported.
4. Only individuals 65 years or older were included in analysis.

These inclusion criteria were selected in order to identify high-quality studies reporting on healthy behaviours. The first criterion of only including prospective studies was important because this is a strong study design that can establish the temporal relationship between two variables (Hill, 1991). Cross-sectional studies, on the other hand, can only report that an association exists between two variables (Hill, 1991). The second criterion of only including population-based studies was important because, as a potential tool for population health policy makers, an evidence-guided model of healthy behaviours in older adults should be based on the general population. It should not be guided by evidence related to specific subpopulations, for example, diabetics, or on populations that are skewed with respect to important variables such as physical health, access to health services or socio-economic status (Aschengrau & Seage, 2004). These biases are likely when subjects are selected based on volunteer recruitment strategies, attendance at clinics or being a Medicare beneficiary. The third criterion of only including prospectively analyzed data that reported statistical significance was established because many longitudinal studies have published cross-sectional analyses based on only one wave of data, which would not allow the determination of the temporal relationship between two variables. Additionally, the statistical significance of relationships should be reported to evaluate the stability of the association between variables (Aschengrau & Seage, 2004). The final criterion of only including adults 65 years and older was established because this is a milestone age in Canadian society, marked by important transitions such as receiving pensions and retirement.

Once the included studies were identified, the following data were extracted: the dependent and independent variables studied; the analytical technique used and the magnitude, direction and statistical significance of the relationships among variables; and characteristics of the study including the setting, study design, age of the population at baseline, the sample size and the follow-up period.

2.2.2. Search Results

Fifty three longitudinal studies including older populations (See Table 2, A listing of longitudinal studies on aging classified by population-based study design and whether data on healthy behaviours was collected), were identified through the National Institute on Aging's database on longitudinal studies (National Institute on Aging, 2006) and through a review conducted during the development of the Canadian Longitudinal Study on Aging (P Raina, personal communication, September 2005). Study designs were screened to identify which longitudinal studies were population-based (n=43) as well as which of these studies had collected data on healthy behaviours (n=41 of 43). Complete and up-to-date publication lists were obtained for these 41 studies through the study website, by contacting the primary investigator or through searches of the PubMed database. Randomized controlled trials (n=207) were identified through searches in the PubMed database using the text word "health behaviors". Applied limits were: randomized controlled trials, the English language and populations 65 years and older. Finally, bibliographies of relevant articles that were collected during the search were scanned for additional studies that might meet the inclusion criteria. Identified studies were screened for healthy behaviour outcomes and the inclusion criteria were applied (See Figure 1, Results of an executed search strategy and an outline of inclusion criteria that were applied to select high-quality evidence of determinants of healthy behaviours in older adults).

Forty-one population-based longitudinal studies on aging have collected data on healthy behaviours including well-known studies such as the Alameda County Study, the National Population Health Survey and the McArthur Studies of Successful Aging. Despite, this only five publications, three randomized controlled trials (Fink, Elliot & Tsai, 2005; Kerse, Elley, Robinson et al., 2005; Lowe, Raynor, Purvis et al., 2000) and two longitudinal studies (Haveman-Nies, De Groot & Van Staveren, 2003; Armstrong &

Table 2. A listing of longitudinal studies on aging classified by population-based study design and whether data on healthy behaviours was collected.

Longitudinal Studies on Aging	Population-Based (Yes or No)	Collects Data on Healthy Behaviours (Yes or No)
Age, Gene/Environment Susceptibility Study (AGES)	Yes	Yes
Aging in Manitoba (AIM)	Yes	Yes
Alameda County Study (Alameda)	Yes	Yes
Australian Longitudinal Study on Ageing (ALSA)	Yes	Yes
Baltimore Longitudinal Study on Aging (BLSA)	Yes	Yes
Bangor Longitudinal Study of Ageing (BLSA)	Yes	Yes
Berlin Aging Study (BASE)	Yes	Yes
Betula Project (Betula)	Yes	Yes
Canadian Multicentre Osteoporosis Study (CaMos)	Yes	Yes
Canadian Study of Health and Aging (CSHA)	Yes	Yes
English Longitudinal Study of Aging (ELSA)	Yes	Yes
Established Populations for Epidemiologic Studies of the Elderly (EPESE)	Yes	Yes
Fredericton 80+ Study (Fredericton)	Yes	Yes
Gothenburg Study (Göteborg) (H70)	Yes	Yes
Health and Retirement Study (HRS)	Yes	Yes
Health, Aging & Body Composition Study (Health ABC)	Yes	Yes
Honolulu-Asia Aging Study (HAAS)	Yes	Yes
Interdisciplinary Longitudinal Study of Adult Development (ILSE)	Yes	Yes
Italian Longitudinal Study on Aging (ILSA)	Yes	Yes
Longitudinal Aging Study Amsterdam (LASA)	Yes	Yes
Longitudinal Study of Ageing in Africa (LSAA)	Yes	Yes
Longitudinal Study of Aging I (LSOA II)	Yes	Yes
Longitudinal Study of Aging II (LSOA II)	Yes	Yes
Lund 80+ (LUND)	Yes	Yes
Maastricht Aging Study (MAAS)	Yes	Yes
MacArthur Study of Successful Aging (McArthur)	Yes	Yes
Melton Mowbray Ageing Project (MMAP)	Yes	Yes
National Population Health Survey (NPHS)	Yes	Yes
NHANES I Epidemiologic Follow-up Study (NHEFS)	Yes	Yes
Nottingham Longitudinal Study of Activity and Ageing (NLSAA)	Yes	Yes
Ontario Longitudinal Study of Aging (OLSA)	Yes	Yes
Rancho Bernardo Study (Bernardo)	Yes	Yes
Rotterdam Study Rotterdam	Yes	Yes
Survey in Europe on Nutrition and the Elderly: A Concerted Action (SENECA)	Yes	Yes
Southampton Ageing Project (SAP)	Yes	Yes
Survey on Health, Ageing and Retirement in Europe (SHARE)	Yes	Yes
Tampere Longitudinal Study on Aging (TamELSA)	Yes	Yes
The National Longitudinal Survey Original Cohorts (NLS)	Yes	Yes
The Study of Women's Health Across the Nation (SWAN)	Yes	Yes
Victoria Longitudinal Study (VLS)	Yes	Yes
Wisconsin Longitudinal Study (WLS)	Yes	Yes
Duke Longitudinal Study of Normal Aging (DLSNA)	Yes	No
Duke Longitudinal Study of Normal Aging II (DLSNA II)	Yes	No
Cardiovascular Health Study (CHS)	No	Yes
Manitoba Follow-up Study (MFUS)	No	Yes
National Long Term Care Survey (NLTCS)	No	Yes
New Mexico Aging Process Study (NMAPS)	No	Yes
Normative Aging Study (NAS)	No	Yes
Nun Study (NUN)	No	Yes
Retirement History Study (RHS)	No	Yes
Seattle Longitudinal Study (SLS)	No	Yes
Women's Health & Aging Study (WHAS)	No	Yes
Bogalusa Heart Study (BHS)	No	No
Bonn Longitudinal Study of Aging (BOLSA)	No	No

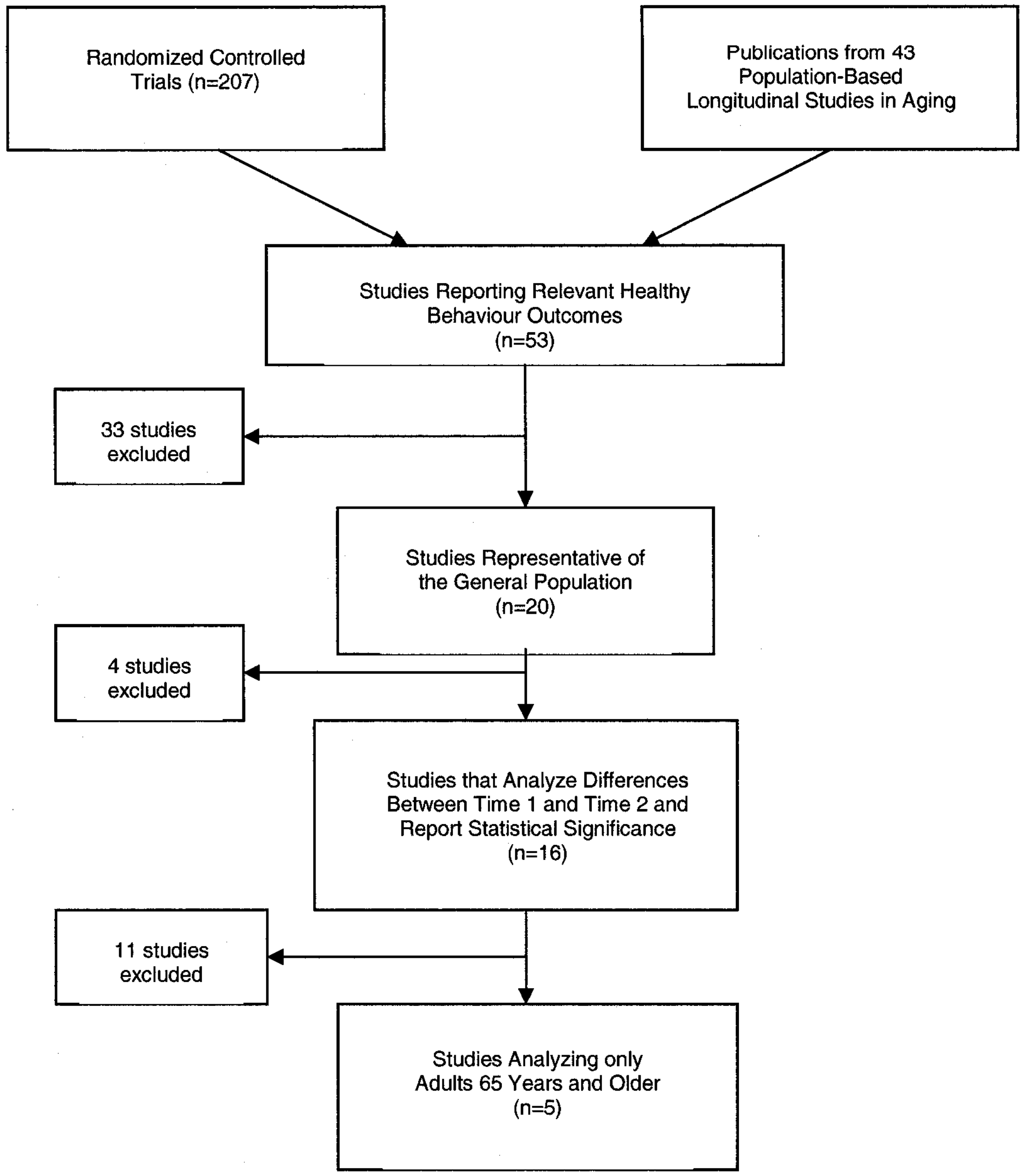


Figure 1. Results of an executed search strategy and an outline of inclusion criteria that were applied to select high-quality evidence of determinants of healthy behaviours in older adults.

Morgan, 1998), were identified that studied healthy behaviours as an outcome and that met this thesis' inclusion criteria (See Table 3, A summary of evidence for variables related to healthy behaviours in adults 65 years and older from population-based longitudinal cohort studies and randomized controlled trials). The randomized controlled trials were conducted in a representative sample of patients from primary care practices in New Zealand (Kerse, Elley, Robinson et al., 2005), the United States (Fink, Elliot & Tsai, 2005) and the United Kingdom (Lowe, Raynor, Purvis et al., 2000) while the two longitudinal studies were both based on European populations (Haveman-Nies, De Groot & Van Staveren, 2003; Armstrong & Morgan, 1998). Four of the studies, included subjects who were 65 years and older at baseline but in one of the population-based longitudinal studies, only subjects who were 70-75 years at baseline were included (Haveman-Nies, De Groot & Van Staveren, 2003). Sample sizes ranged from 161 to 665 for the five studies. Follow-up periods ranged from one to 12 months for the randomized controlled trials and the longitudinal cohort studies reported on changes in healthy behaviours at eight and 10 years.

Of the five studies identified, two reported on changes in physical activity levels (Kerse, Elley, Robinson et al., 2005; Armstrong & Morgan, 1998), one reported on changes in alcohol consumption (Fink, Elliot & Tsai, 2005) and two reported on self care behaviours as measured by adherence to prescription medication (Lowe, Raynor, Purvis et al., 2000) and activities of daily living (Haveman-Nies, De Groot & Van Staveren, 2003). The three randomized controlled trials studied the effects of physician or, in one case, pharmacist counseling (Lowe, Raynor, Purvis et al., 2000) on healthy behaviours. All of these counseling interventions included a component related to patient education regarding health status and the importance of healthy behaviours. Other relationships that were studied included the influence of sex on participation in different types of physical activity (Armstrong & Morgan, 1998) and the relationship between healthy lifestyle behaviours and self-care behaviours (Haveman-Nies, De Groot & Van Staveren, 2003). Most reported relationships were in the expected direction and significant at $p < 0.05$ but the magnitude of the effect was small in four of the studies. For example, while effect of one physician counseling intervention was highly significant, it only increased leisure time energy expenditure by 2.67 kcal/kg/week ($p<0.0004$) and leisure time activity by 0.67 hours/week ($p<0.008$) more than usual care (Kerse, Elley, Robinson et al., 2005). The largest observed effect for any reported relationship was that between sex and type of physical activity with women engaging in significantly more indoor activities over a period of 8 years (β=8.77) (Armstrong & Morgan, 1998). The statistical significance of the relationship between physical activity and self-care behaviours (OR=2.6) fell in only a 90% confidence interval and a 95% confidence interval was required in this thesis review (Haveman-Nies, De Groot & Van Staveren, 2003).

In addition to reporting on healthy behaviours outcomes, some randomized trials reported additional differences between the intervention and control groups. For example, the physician counseling intervention to improve physical activity in older adults also reported an increase in health-related quality of life ($p < 0.005$) and a decrease in hospitalizations ($p < 0.03$) over the 12-month follow-up period (Kerse, Elley, Robinson et al., 2005). While hospitalizations are a measure of health services use, they can also be considered a measure of health status, as it is usually those in poor health who are hospitalized. Thus, this intervention appears to have indirectly influenced both objective and subjective health status by increasing physical activity. The randomized controlled trial reporting on a pharmacist counseling intervention found that not only was adherence to medication significantly increased in the intervention group compared to the control group (91% vs. 79%, respectively) but that the change in knowledge in the intervention group was also greater, as measured by the number of individuals who could correctly explain the purpose of their medications ($p < 0.0001$) (Lowe, Raynor, Purvis et al., 2000). This provides support for the concept that learning by patients about their health and healthy behaviours increases participation in healthy behaviours.

2.2.3. Summary of the Search for Determinants of Healthy Behaviours Among Older Adults

Overall, results reported in these five studies suggest that attempts to change patient behaviours through physician counseling can have a small but important influence on healthy lifestyle behaviours, such as being physically active and moderate alcohol consumption, and self-care behaviours, such as adhering to medications (Kerse, Elley, Robinson et al., 2005; Fink, Elliot & Tsai, 2005; Lowe, Raynor, Purvis et al., 2000). Improvements in health-related quality of life, health status and resulting health services use and patient knowledge may also be important determinants of healthy behaviours

Table 3. A summary of evidence for variables related to healthy behaviours in adults 65 years and older from population-based longitudinal cohort studies and randomized controlled trials.

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	COMMENTS
PHYSICAL ACTIVITY										
Kerse, Elley, Robinson et al., 2005 [a]										
Change in leisure time energy expenditure (kcal/kg/week)	Physician physical activity counseling intervention	Δ=2.67 more kcal/kg/week compared with the control group	+	P < 0.004 (Regression model)	42 primary care clinics (117 physicians) in New Zealand	RCT	≥ 65 years	270	12 months	A physician-led counseling intervention can increase physical activity levels.
Change in leisure time moderate activity (hours/week)	Physician physical activity counseling intervention	Δ=0.67 more hours/week compared with control group	+	P < 0.008 (Regression model)						
Armstrong & Morgan, 1998 [b]										
Indoor Physical Activity	Sex (Female)	β=8.77	+	P ≤ 0.001 (Linear regression)	Nottingham Longitudinal Study of Activity and Ageing, United Kingdom, 1985-93	Longitudinal Cohort	≥ 65 years	410	8 years	Sex differences exist in the types of physical activity participated in over time but not in changes in overall physical activity levels.
Outdoor Physical Activity	Sex (Female)	OR=0.39	-	P ≤ 0.001						
Leisure Time Physical Activity	Sex (Female)	OR=0.61	-	P ≤ 0.001						
Walking	Sex (Female)	OR=0.65	-	P ≤ 0.01 (Logistic regressions)						

ANOVA: Analysis of variance; CI: Confidence interval; NS: Not statistically significant at $p < 0.05$; OR: Odds Ratio; RCT: Randomized controlled trial

ALCOHOL CONSUMPTION										
Fink, Elliot & Tsai, 2005[c]										
Number of drinks per week	Intervention: physicians receive risk reports based on patients alcohol use and health risks	Reference (Usual care)			23 physicians with community primary care practices, USA, 2000-2003	RCT	≥ 65 years	665	12 months	Physician counseling can decrease alcohol consumption.
		β=1.14 (Physician and patient receive risk report)	-	P < 0.05						
		β=0.33 (Patient receives risk report)	NS	NS (Linear regression)						
SELF-CARE BEHAVIOURS										
Haveman-Nies, De Groot & Van Staveren, 2003[d]										
Women's Self-Care Behaviours	Physical Activity	OR=2.6 90%CI=1.4, 4.9	+	P < 0.10 (Logistic Regression)	Survey in Europe on Nutrition and the Elderly: A Concerted Action,	Population-Based Longitudinal Cohort	70-75 years	Men = 216 Women=264	10 years	Possible association between self-care behaviours and lifestyle behaviours such as physical activity in women
Lowe, Raynor, Purvis et al., 2000[e]										
% Compliant with Medication	Patient education intervention by pharmacist	91%(Intervention) 79% (Control)	+	P < 0.0001 (X^2 test)	Suburban general practice in the United Kingdom	RCT	≥ 65 years	161	1 month	Interventions to increase patient knowledge can improve self-care behaviours such as medication compliance

ANOVA: Analysis of variance; CI: Confidence interval; NS: Not statistically significant at p < 0.05; RCT: Randomized controlled trial

[a] The intervention did not significantly (p < 0.05) change total energy expenditures or blood pressure levels. The intervention group also reported greater increases in health-related quality of life (p<0.005) and decrease in hospitalizations (p <0.03) compared with the control group.

[b] Multivariate regression models were adjusted for age. Decline in physical activity over time was assessed but statistical significance was not reported and magnitude of sex-specific estimates appear to be similar, therefore differences in change between men and women were assumed to be non-significant ($p > 0.05$).
[c] The % change in drinking classification (non-hazardous, hazardous or harmful), was not significantly different at $p < 0.05$. Results were adjusted for baseline drinking classification, race, smoking status, number of medical conditions influenced by alcohol and a diabetes mellitus indicator.
[d] Multivariate logistic regressions were adjusted for age and country. Statistical significance was only reported based on 90% confidence intervals. Self-care behaviours in men were not significantly associated with physical activity, smoking habits or dietary quality. Self-care behaviours in women were not significantly ($p < 0.10$) associated with dietary quality. The relationship between self-care behaviours and smoking habits in women could not be assessed due to low sample sizes.
[e] A significantly greater increase in knowledge was also observed in the intervention group compared with the control group, as measured by the number of individuals who could correctly explain the purpose of their medications ($p < 0.0001$).

(Kerse, Elley, Robinson et al., 2005; Lowe, Raynor, Purvis et al., 2000). Sex also appears to be an important demographic characteristic related to healthy behaviours as observed by changes in patterns of physical activity over time that differ between men and women (Armstrong & Morgan, 1998). Finally, there may be a relationship between healthy lifestyle behaviours such as physical activity and self-care behaviours (Haveman-Nies, De Groot & Van Staveren, 2003).

Due to the emphasis placed on obtaining evidence from high-quality studies, a number of variables that are often discussed as important variables influencing healthy behaviours in older adults but were not found to be correlated with healthy behaviours in this thesis. For example, only cross-sectional studies have reported associations of healthy behaviours with health beliefs (for example Resnick & Spellbirg, 2000), with social support (for example Kritz-Silverstein et al., 2001), with socioeconomic status (for example Kaplan, Newsom, McFarland et al., 2001) and with marital status (for example Schone & Weinick, 1998). Cross-sectional evidence was not included when specifying the thesis model because, as described previously, cross-sectional studies are considered weaker evidence than prospective studies because they can only report that an association exists between two variables and not the temporal order of two variables (Hill, 1991). Nonetheless, the development of a model of healthy behaviours in older adults will allow for the quantitative evaluation of the model in different demographic subpopulations, such as ever-married versus never-married and male versus female.

In summary, randomized controlled trials and prospective population-based studies of adults 65 years and older that reported on changes in healthy behaviours identified five potential determinants of healthy behaviours: physician counseling and resulting patient knowledge, health-related quality of life, health status and possibly health services use.

2.3. Relationships Among Five Determinants Of Healthy Behaviours: Physician Counseling, Patient Knowledge, Health-Related Quality of Life, Health Status and Health Services Use

If each of these determinants (physician counseling, patient knowledge, health-related quality of life, health status and health services use) is to be included in a unified, evidence-guided model of healthy behaviours among older adults, it is important that the relationships among these determinants is explored, for example, the relationship between health-related quality of life and health status or the relationship between health services use and physician counseling.

2.3.1. Search Strategy

In order to identify relationships among identified determinants of healthy behaviours (physician counseling, patient education, health-related quality of life, health status and health services use), the same inclusion criteria and search strategy as was outlined for healthy behaviours were applied: studies were limited to prospective population-based studies in adults 65 years and older. Longitudinal studies were identified using publication lists obtained as previously described. The PubMed database was searched using combinations of the following text words: "physician counseling", "patient education", "health status", "health services use" and "health-related quality-of-life". Studies that met this thesis' inclusion criteria were screened for those that reported on relevant relationships among the five identified determinants of healthy behaviours. One study reporting on physician counseling as an outcome was identified, one study reporting on patient knowledge was identified, five studies reporting on health-related quality of life were identified, 11 studies reporting on health status were identified and eight studies reporting on health services use were.

2.3.2. Physician Counseling

Only one prospective study was identified that studied physician counseling (Kerse, Flicker, Jolley et al., 1999). A randomized controlled trial was conducted of a multi-faceted educational intervention for Australian physicians that educated them about the importance of healthy behaviours for older adults. The intervention consisted of a variety of education sessions over 2-3 months and physicians were encouraged to share with their elderly patients the knowledge that they gained regarding the benefits of older adults engaging in healthy behaviours. After one year, older patients from the intervention practices reported increased physical activity (44 minutes/week more than control, $p<0.03$) and 20% more in the intervention group reported better self-rated health ($p<0.03$). While the frequency of physician counseling was not directly measured in this study, these endpoints are considered evidence that the educational intervention for physicians did increase physician lifestyle counseling. Therefore, the only variable found to influence physician counseling is educational interventions aimed at physicians.

2.3.3. Patient Education

The one study that met this thesis' inclusion criteria and that reported on patient knowledge as an outcome was a previously identified study that also reported on the healthy self-care behaviour, medication adherence (Lowe, Raynor, Purvis et a., 2000). As previously described, this study reported that more individuals in the group that had received pharmacist counseling could correctly explain the purpose of their medications than the control group. At the beginning of the study, 58% of intervention group patients and 67% of control group patients were able to correctly explain the purpose of their medications but at study completion, 88% of intervention group patients and 70% of control group patients were able to complete this task ($p<0.0001$). Therefore, patient knowledge is strongly influenced by health professional counseling interventions.

2.3.4. Health-Related Quality of Life

As described in Table 4 (A summary of evidence for variables related to health-related quality of life in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials), four longitudinal cohort studies (Haveman-Nies, De Groot & Van Staveren, 2003; Ostbye, Tayler & Jung, 2002; Hoeymans Feskens, Kromhout et al., 1999; Shapiro & Roos, 1982) and one randomized controlled trial (Kerse, Elley, Robinson et al., 2005) reported on health-related quality of life. Of the four longitudinal studies, two were conducted in European populations, one in an American population and one in a Canadian population. Three studies included subjects 65 years and older at baseline, one study included subjects 70 years and older at baseline and one study only included subjects 70-75 years old at baseline. Sample sizes ranged from 216 to 5037, with only two studies reporting on more than 1000 individuals. The follow-up period for the cohort studies ranged from 27 months to 10 years while the randomized controlled trial followed-up subjects at 12 months.

Of the five studies, three measured health-related quality of life using a five-point scale of self-rated health (Haveman-Nies, De Groot & Van Staveren, 2003; Ostbye, Tayler & Jung, 2002; Hoeymans Feskens, Kromhout et al., 1999 ; Shapiro & Roos, 1982) and one measured health-related quality of life using the Short-Form 36 (SF-36) (Kerse,

Table 4. A summary of evidence for variables related to health-related quality of life in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials.

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
Kerse, Elley, Robinson et al., 2005[a]										
General Health	Physician physical activity counseling intervention	Δ score =5.46	+	P < 0.005	42 primary care clinics in New Zealand	RCT	≥ 65 years	270	12 months	Larger positive changes in self-rated health were reported in patients receiving physical activity counseling
Vitality		Δ score=4.43	+	P < 0.004						
Haveman-Nies, De Groot & Van Staveren, 2003 [b]										
Men's Good Self Rated-Health	Physical Activity	OR=2.8 90%CI=1.3, 6.2	+	P < 0.10	Survey in Europe on Nutrition and the Elderly: A Concerted Action, 7 small towns in 7 European countries	Population-Based Longitudinal Cohort	70-75 years	Men = 216 Women=264	10 years	Physically active men have better self-rated health
Ostbye, Taylor & Jung, 2002[c]										
Poor Self-Rated Health	Smoking		+	P < 0.05	Asset and Health Dynamics among the Oldest Old survey, 1993-1998	Population-Based Longitudinal Cohort	≥ 70 years	5037	5 years	Unhealthy behaviours are associated with poor self-rated health
	Never	Reference								
	Current	OR=1.55								
	Former	OR=1.13								
	Body mass index		+	P < 0.05						
	18.5-30 kg/m^2	Reference								
	< 18.5 $kg.m^2$	NS								
	≥ 30 kg/m^2	OR=1.43								
	Alcohol Consumption		-	P < 0.05						
	Never	Reference								
	Light	OR=0.62								
	Heavy	OR=0.65								
	Past Drinking Problem	NS								

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	COMMENTS
	Age		+	P < 0.05						
	< 75 years	Reference								
	75-84 years	OR=1.26								
	≥ 85 years	OR=1.44								
	Race (white)	OR=0.76	-	P < 0.05						
	Education	OR=0.92	-	P < 0.05						
Hoeymans, Feskens, Kromhout et al., 1999 [d]										
Men's Poor Self-Rated Health	Heart Disease	OR=1.5	+	P < 0.05	Zutphen Elderly Study, The Netherlands, 1990-95	Population-Based Longitudinal Cohort	≥ 65 years	340	5 years	Being able to perform activities of daily living has a greater influence on men's health-related quality of life than disease status.
	Stroke	OR=2.5	+	P < 0.05						
	Respiratory Illness	OR=1.9	+	P < 0.05						
	Muskoskeletal Disorders	OR=1.5	+	P < 0.05						
	Activities of Daily Living and Mobility	OR=7.0	+	P < 0.05 (Regression Analysis)						
Shapiro & Roos, 1982										
% Rating health as excellent or good	Employment Status		+	P < 0.001 (X^2 test)	Manitoba Longitudinal Study on Aging, 1971-76	Longitudinal, Population-Based Cohort	≥ 65 years	2211	27 months	Being employed was associated with better self-rated health
	Employed	72.9%								
	Retired	62.6%								

NS = Not statistically significant at p < 0.05; RCT= Randomized Controlled Trial

[a] Other scales of the Short Form 36 (SF-36) were not significant at p < 0.05 (physical functioning, role physical, bodily pain, social function, role emotional and mental health)
[b] Self-rated health in men was not significantly associated (p < 0.10) with dietary quality or smoking habits. Self-rated health in women was not significantly associated (p < 0.10) with physical activity or dietary quality; the relationship with smoking habits could not be assessed due to small sample sizes.
[c] Variables not significant at p < 0.05 were sex and marital status.
[d] Variables not significant at p < 0.05 were diabetes and cancer.

Elley, Robinson et al., 2005). Variables whose relationship with health-related quality of life was studied included physician counseling, healthy behaviours, physical health, activities of daily living and demographics. The magnitude of estimates was not large, ranging from 0.62 to 2.8 for studies that reported odds ratios (Haveman-Nies, De Groot & Van Staveren, 2003; Ostbye, Tayler & Jung, 2002; Hoeymans Feskens, Kromhout et al., 1999). For example, poor self-rated health in men was associated with heart disease (OR=1.5), stroke (OR=2.5), respiratory illnesses (OR=1.9) and musko-skeletal disorders (OR=1.5) (Haveman-Nies, De Groot & Van Staveren, 2003). The largest relationship observed was between self-rated health and the ability to perform activities of daily living, with an odds ratio of 7.0 (Haveman-Nies, De Groot & Van Staveren, 2003). Additionally, one study also reported that 10% more employed older adults than retired older adults reported good self-rated health (Shapiro & Roos, 1982). Most relationships were in the expected direction except that one study reported that those with a lower education had better health-related quality of life. The magnitude of this association, although statistically significant at $p < 0.05$, was not large (OR=0.92) (Ostbye, Taylor & Jung, 2002). All studies reported statistical significance at $p < 0.05$. Two studies found that the relationships investigated were only significant in men and not in women (Haveman-Nies, De Groot & Van Staveren, 2003; Hoeymans, Feskens, Kromhout et al., 1999). The relationships of health-related quality of life with physician counseling (Kerse, Elley, Robinson et al., 2005) and with employment (Shapiro & Roos, 1982) were highly significant ($p < 0.0001$ for both). Therefore, physician counseling, healthy behaviours, health status and employment status appear to be potential determinants of health-related quality of life in older adults.

2.3.5. Health Status

As described in Table 5 (A summary of evidence for variables related to health status in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials), eleven studies (Petrella, Koval, Cunningham et al., 2003; Diehr & Beresford, 2003; Lampinen & Hikkinen, 2002; Ostbye, Taylor, Krause et al., 2002; Pennix, Leveille, Ferruci et al., 1999; Morgan & Bath, 1998; Idler & Kasl, 1995; Seeman, Berkman, Charpentier et al., 1994; Kaplan, Strawbridge, Camacho et al., 1993; Jagger, Clarke & Cooke, 1989; Shaprio & Roos, 1982) reported on relevant relationships of health status with determinants of healthy behaviours, only one of which was a randomized controlled trial (Petrella, Koval, Cunningham et al., 2003). The longitudinal

Table 5. A summary of evidence for variables related to health status in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials.

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (Analysis used and p-value)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
Diehr & Beresford, 2003										
Years of healthy life	Diet				Cardiovascular Health Study	Longitudinal, Population-Based Cohort	≥ 70 years	4610	10 years	
	Healthy Diet	5.95 years	+	P< 0.05 (X^2 test)						
	Unhealthy Diet	6.92 years								
Petrella, Koval, Cunningham et al., 2003										
Aerobic Fitness as measured by VO_2 max	Intervention of exercise prescription by a physician	7% greater increase in VO_2 max in intervention group	+	P < 0.01 (X^2 test)	4 large academic primary care practices	RCT	≥ 65 years	N=241	6 months	Exercise counseling can improve health outcomes, most likely by increasing physical activity.
Lampinen & Hikkinen, 2002 [a]										
Depression	Age	β=0.09	+	P < 0.005 (Linear Regression)	Jyvakyla, Finland	Longitudinal Population-Based Cohort	≥ 65 years	384	8 years	
Ostbye, Taylor, Krause et al., 2002 [b]										
Full Lower Body Mobility	Smoking				Asset and Health Dynamics Among the Oldest Old Study, 1993-1998	Longitudinal, Population-Based Cohort	≥ 70years	8124	5 years	Older adults engaging in healthy behaviours have greater mobility.
	Never	Reference								
	Current	OR=0.56	-	P < 0.05						
	Former	OR=0.83	-	P < 0.05 (Logistic Regression)						
	Body Mass Index									
	18.5-24.9 kg/'m^2	Reference								
	< 18.5 kg/'m^2	OR=0.66	-	P < 0.05						
	25.0-29.9 kg/'m^2	OR=0.71	-	P < 0.05						
	30.0-34.9 kg/'m^2	OR=0.41	-	P < 0.05						
	≥ 35 kg/'m^2	OR=0.18	-	P < 0.05						
	Alcohol Consumption									
	Never drink	Reference								
	≤ 2 drinks/day	OR=1.47	+	P < 0.05						
	> 2 drinks/day	NS	NS	NS						
	Past drinking problem	NS	NS	NS						

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (Analysis used and p-value)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
	Age									
	75-84 years	Reference								
	< 75 years	OR=1.80	+	$P < 0.05$						
	≥ 85 years	0.41	-	$P < 0.05$						
	Race (White)	OR=1.25	+	$P < 0.05$						
	Sex (Male)	OR=2.01	+	$P < 0.05$						
	Marital Status (Married)	OR=1.09	+	$P < 0.05$						
	Education									
	High School	Reference								
	< High School	OR=0.68	-	$P < 0.05$						
	College	OR=1.15	+	$P < 0.05$						
	Chronic Lung Disease	OR=0.41	-	$P < 0.05$						
	Myocardial Infarction	OR=0.48	-	$P < 0.05$						
	Angina Pectoris	OR=0.44	-	$P < 0.05$						
	Stroke	OR=0.41	-	$P < 0.05$						
Pennix, Leville, Ferrucci et al., 1999 [c]										
Activities in Daily Living Disability	Depression	RR=1.33	+	$P < 0.001$ (X^2 test)	Established Populations for Epidemiologic Studies of the Elderly, 1982-1988	Longitudinal Population-Based	≥ 65 years	6247	6 years	Older adults with depression have greater physical disabilities.
Mobility Disability	Depression	RR=1.37	+	$P < 0.0001$ (X^2 test)						
Morgan & Bath, 1998										
Depression	Heath Index Score	OR=1.25	+	$P < 0.001$ (Logistic Regression)	All general practices in Nottingham, UK, 1985-93	Longitudinal cohort representative of the general population	≥ 65 years	496	4 years	Poor physical health and prior depression is associated with future depression
	Physical Activity Level	OR=0.92	-	$P < 0.05$						
	Age	OR=0.40	+	$P = 0.013$						
	Depression at Baseline	OR=7.37	+	$P < 0.001$						
	Social Engagement Score	OR=0.82	-	$P < 0.001$						Life satisfaction is associated with prior levels of life satisfaction, social engagement and physical health
Life Satisfaction Index	Life Satisfaction at Baseline	β=0.49	+	$P < 0.001$ (Linear Regression)						
	Social Engagement Score at Baseline	β=0.32	+	$P < 0.001$						
	Health Index	β=-0.14	-	$P < 0.001$						
	Age	β=0.14	+	$P < 0.001$						
	Time spent walking	β=0.12	+	$P < 0.001$						

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (Analysis used and p-value)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
	Current Social Engagement Score	β=-0.12	-	P = 0.014						
	Current marital status	β=-0.26	-	P < 0.001						
	Marital Status at Baseline	β=0.22	+	P < 0.001						
	Level of Indoor Activity at Baseline	β=0.090	+	P < 0.01						
Idler & Kasl, 1995 [d]										
Change in Physical Functioning	Self-Rated Health	β =0.39	+	P < 0.01 (Multivariate Linear Regression)	Established Populations for Epidemiologic Studies of the Elderly, 1982-1988	Longitudinal Population-Based	≥ 65 years	1424	6 years	Self-rated health and objective physical health status are important determinants of a change in physical functioning. Age and sex are important variables influencing change in cognitive functioning
	Baseline Physical Functioning	β =0.38	+	P < 0.01						
	Stroke	β =0.57	+	P < 0.01						
	Diabetes	β =0.37	+	P < 0.01						
	Parkinson's	β =0.69	+	P < 0.01						
	Leg Amputation	β =-0.92		P < 0.05						
	Number of prescription medications	β =0.06	+	P < 0.01						
	Congestive Heart Failure	β =0.29	+	P < 0.01						
Change in Cognitive Functioning	Female	β =-0.32	-	P < 0.01						
	Age	β =0.07	+	P < 0.01						
Seeman, Chapentier, Berkman et al., 1994 [e]										
Change in Physical Performance	Baseline physical performance	β=0.49	+	P ≤ 0.001 (Linear Regression)	McArthur Studies of Successful Aging, 1988-1991	Longitudinal Population-Based	70-79 years	843	3 years	Sex and income explained the greatest amount of change in physical performance
	Female	β =-0.45	-	P ≤ 0.05						
	Baseline Age	β =-0.022	-	P ≤ 0.001						
	Education	β =-0.078	-	P ≤ 0.05						
	Income	β =-0.12	-	P ≤ 0.01						
	Body mass index	β =-0.013	-	P ≤ 0.01						
	Peak Respiratory Flow	β =0.001	+	P ≤ 0.001						
	Diabetes	β =-0.096	-	P ≤ 0.05						
	Cancer	β =0.12	+	P ≤ 0.001						

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (Analysis used and p-value)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
	Baseline Cognitive Score	β =0.007	+	P ≤ 0.001						
	Hospitalizations	β =-0.14	-	P ≤ 0.001						
Kaplan, Strawbridge, Camacho et al., 1993 [f]										
Change in Physical Functioning	Age	β =-0.58	-	P = 0.01 (Linear Regression)	Alameda County Study, 1984-1990	Longitudinal Population-Based	≥ 65 years	N=356	6 years	Decline in physical functioning is most strongly influence by baseline physical health, social support and self-rated health
	Family Income	β =-4.45	+	P = 0.01						
	Self-Rated Health	β =-3.32	+	P = 0.02						
	Number of Chronic Conditions	β =-3.39	+	P = 0.04						
	Stroke	β =-5.93	+	P = 0.03						
	Exercise Scale Score	β =0.27	-	P = 0.01						
	Number of Times Go Out per Week	β =1.38	+	P = 0.01						
	Social Network Index Score	β =-5.48	+	P = 0.02						
	Marital Status	β =-5.02	+	P = 0.05						
	Depression	β =-2.98	+	P = 0.04						
	Internal Locus of Control	β =0.76	-	P = 0.04						
Jagger, Clarke & Cook, 1989 [g]										
Mean Change in Cognitive Functioning Score	Age				Community-based survey in Melton Mowbry, UK, 1980-1985	Longitudinal, Population-Based Cohort	≥ 75 years	594	5 years	Age and sex are important determinants of physical and cognitive function.
	75-79 years	Δ= -0.42	-	P < 0.001 (ANOVA)						
	80-84 years	Δ=-0.99	-							
	> 85 years	Δ=-1.36	-							
Mean Change in Physical Functioning Score	Age									
	75-79 years	Δ=0.21	+	P < 0.001 (ANOVA)						
	80-84 years	Δ=0.63	+							
	> 85 years	Δ=0.96	+							
	Sex									
	Men 75-79 years	Δ=0.24	+	Reported as a significant interaction between sex and age						
	Women 75-79 years	Δ=0.18	+							
	Men 80-84 years	Δ=0.29	+							
	Women 80-84years	Δ=0.72	+							
	Men >85 years	Δ=-0.29	-							
	Women >85 years	Δ=1.13	+							

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (Analysis used and p-value)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
Shaprio & Roos, 1982										
% Reporting No Health Problems	Employment Status Employed Retired	 25.6% 17.6%	+	$P < 0.001$ (X^2 test)	Manitoba Longitudinal Study on Aging, 1971-76	Longitudinal, Population-Based Cohort	≥ 65 years	2211	27 months	Employed individuals have better physical health than retired individuals but this is primarily due to men aged 65-74 years.

NS = Not significant at $p < 0.05$; RCT=Randomized controlled trial; OR=Odds Ratio; RR=Relative Risk

[a] Statistically non-significant variables ($p > 0.05$) were physical activity, mobility, sex, education and number of chronic diseases
[b] Variables not significant at $p < 0.05$ were having had cancer.
[c] Relative risks were adjusted for age, sex, education, income, baseline chronic conditions, physical activity and number of relatives.
[d] Statistically non-significant variables ($p > 0.05$) for the association with change in physical functioning were arthritis, amputations other than leg amputations and claudication. Statistically non-significant variables ($p > 0.05$) for the association with change in cognitive functioning were race, adequate income, marital status and education
[e] Statistically non-significant variables ($p > 0.05$) were race, high blood pressure and incident hospitalizations
[f] Statistically non-significant variables ($p > 0.05$) were ethnicity, education, sex, chronic obstructive pulmonary disease, heart attack, hip fracture, high blood pressure, diabetes, cancer, serious fall, hearing, vision, smoking and body weight.
[g] Statistically non-significant variables ($p > 0.05$) for the association with mean change in cognitive functioning score were age.

studies were conducted in European, American and Canadian populations and ten of these included individuals 65 years and older at baseline. Sample sizes ranged from 241 for the randomized controlled trial to 6247 for the cohort studies and follow-up periods ranged from 6 months to 16 years.

Health status was measured in a number of different ways such as the number of health problems (Shaprio & Roos, 1982), years of healthy life (Diehr & Beresford, 2003), aerobic fitness (Petrella, Koval, Cunningham et al., 2003), changes in physical or cognitive functioning (Kaplan, Strawbridge, Camacho et al., 1993; Jagger, Clarke & Cooke, 1989; Seeman, Chapentier, Berkman et al., 1994; Idler & Kasl, 1995) disability (Pennix, Leveille, Ferruci et al., 1999), mobility (Ostbye, Tayler, Krause et al., 2002) and depression (Morgan & Bath, 1998; Lampinen & Hikkinen, 2002). A large number of associations were studied in these 11 studies. Examples of variables whose relationship with health status was studied are healthy behaviours such as smoking and diet (Diehr & Beresford, 2003; Ostbye, Tayler, Krause et al., 2002); patient demographics such as age (Kaplan, Strawbridge, Camacho et al., 1993; Jagger, Clarke & Cooke, 1989), sex (Jagger, Clarke & Cooke, 1989) and marital status (Shapiro & Roos, 1985); the effects of a physician exercise counseling intervention (Petrella, Koval, Cunningham et al., 2003), hospitalizations (Seeman et al., 1994) and self-rated health (Kaplan, Strawbridge, Camacho et al., 1993).

Relationships were in the directions specified and were statistically significant at $p<0.05$ but the magnitude of estimates was not large in most studies. Many studies reported regression coefficients smaller than +/- 1 and relative risks or odds ratios smaller than 2.0 (Lampinen & Hikkinen, 2002; Ostbye, Tayler, Krause et al., 2002; Pennix, Leville, Ferrucci et al., 1999; Idler & Kasl, 1995; Seeman, Chapentier, Berkman et al., 1994). Relationships between healthy behaviour variables and health status were small but significant. For example, a healthy diet was reported to significantly add one year of healthy life compared to those with an unhealthy diet (Diehr & Beresford, 2003). The randomized controlled trial examining the impact of physician physical activity counseling found a 7% greater increase in aerobic fitness in the intervention group compared with the control group after six months (Petrella, Koval, Cunningham et al., 2003). Similarly, many studies reported small but significant relationships between heath status and age (Lampinen & Hikkinen, 2002; Ostbye, Tayler, Krause et al., 2002;

Morgan & Bath, 1998; Idler & Kasl, 1995; Seeman, Chapentier, Berkman et al., 1994; Kaplan, Strawbridge, Camacho et al., 1993; Jagger, Clarke & Cooke, 1989) or sex (Ostbye, Tayler, Krause et al., 2002; Seeman, Chapentier, Berkman et al., 1994; Jagger, Clarke & Cooke, 1989). The largest regression coefficients observed were in a study reporting on change in physical functioning (Kaplan, Strawbridge, Camacho et al., 1993). In this study, large associations, significant at $p<0.05$, were observed between change in physical functioning and income ($\beta=-4.45$), self-rated health ($\beta=-3.32$), number of chronic conditions ($\beta=-3.39$), stroke ($\beta=-5.93$), social network scores ($\beta=-5.48$), marital status ($\beta=-5.02$) and depression ($\beta=-2.98$). Another study (Morgan & Bath, 1998) reported a strong association between baseline depression and future depression (OR=7.37). In summary these studies demonstrate that the health status of older adults is strongly influenced by variables such as social support and health-related quality of life, as well as individual demographics such as age, sex, marital status and income.

2.3.6. Health Services Use

Of the eight studies described in Table 6 (A summary of evidence for variables related to health services use in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials), two were randomized controlled trials (Kerse, Elley, Robinson et al., 2005; Van Eijken, Wensing, De Konink et al., 2004) and six were population-based longitudinal studies (Ostbye, Taylor & Jung, 2002; Bath & Morgan, 1998; Shapiro & Roos, 1985; Coulton & Frost, 1982; Shapiro & Roos, 1982; Roos & Shapiro, 1981). The randomized controlled trials were based in primary care practices in New Zealand and the Netherlands. Of the six longitudinal studies, three reported on findings from the Manitoba Longitudinal Study on Aging, two were based on American populations and one was from the United Kingdom. The baseline age of subjects in six of the studies was 65 years and older. Sample sizes ranged from 270 to 5037, with five of the studies reporting a sample size over 1000. The follow-up period for the longitudinal studies ranged from one to eight years and for the randomized controlled trials was either three or 12 months.

Four studies measured health services use as visits to a family physician (Van Eijken, Wensing, De Konink et al., 2004; Shapiro & Roos, 1985; Coulton & Frost, 1982; Shapiro & Roos, 1982; Roos & Shapiro, 1981), four studies measured health services use as hospitalizations (Kerse, Elley, Robinson et al., 2005; Ostbye, Taylor & Jung, 2002;

Table 6. A summary of evidence for variables related to health services use in adults 65 years and older from prospective population-based cohort studies or randomized controlled trials.

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
Kerse, Elley, Robinson et al., 2005[a]										
Hospitalizations	Physician physical activity counseling intervention	34% vs. 28%	+	P < 0.03 (X^2 test)	42 primary care clinics in New Zealand	RCT	≥ 65 years	270	12 months	The physician lifestyle counseling intervention decreased hospitalizations
Van Eijken, Wensing, De Konink et al., 2004 [b]										
Attendance at General Practitioner	Mailed Health Education Booklet on 5 Common Treatable Health Problems	NS	NS	NS	Community-dwelling older adults from 34 general practices in The Netherlands	RCT	70-80 years	1018	3 months	Mailing health education booklets on 5 common treatable health problems does not increase general practice attendance for those problems.
Ostbye, Taylor & Jung, 2002[c]										
Hospitalized	Smoking			P < 0.05 (logistic regression)	Asset and Health Dynamics among the Oldest Old survey, 1993-1998	Population-Based Longitudinal Cohort	≥ 70 years	5037	5 years	Unhealthy lifestyle behaviours are associated with increase hospitalizations Demographic variables of age, sex, marital status, race and education are also important determinants of hospitalizations.
	Never	Reference								
	Current	OR=1.28	+							
	Former	OR=1.16	+							
	Body mass index	Reference		P < 0.05						
	18.5-30 kg/m^2	NS								
	< 18.5 kg.m^2	OR=1.27	+							
	≥ 30 kg/m^2									
	Alcohol Consumption			P < 0.05						
	Never	Reference								
	Light	OR=0.87	-							
	Heavy	NS								
	Past Drinking Problem	OR=1.38	+							

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
	Age			P < 0.05						
	< 75 years	Reference								
	75-84 years	OR=1.22	+							
	≥ 85 years	OR=1.49	+							
	Race (white)	OR=1.26	-	P < 0.05						
	Sex (Male)	OR=1.13	+	P < 0.05						
	Marital Status (Married)	OR=0.89	-	P < 0.05						
	Education	OR=0.98	-	P < 0.05						
Bath and Morgan, 1998[a]										
Men's use of home help	Low level of physical activity	OR=6.10	+	P < 0.05 (Multivariate Logistic regression)	All General Practices in Nottingham, UK	Longitudinal Cohort	≥ 65 years	410	8 years	Lower levels of physical activity were associated with increased used of home help for men and community nurses for women
Female's use of a community nurse	Low level of physical activity	OR=3.43	+	P < 0.01						
Shapiro & Roos, 1985[b]										
Non-use of physician vs. 1-3 visits in past two years	Marital Status (Married)	OR=2.05	+	P < 0.001 (Multivariate logistic regression)	Manitoba Longitudinal Study on Aging, 1971-76	Longitudinal, Population-Based Cohort	≥ 65 years	962	2 years	Non-use of ambulatory physician services is associated with marital status, mental status and education
	Mental status	OR=1.7	+	P <0.001 (Multivariate logistic regression)						
	Education	OR=1.4	+	P < 0.02 (Multivariate logistic regression)						
Coulton & Frost, 1982[c]										
Number of physician visits	Perceived Need of Health Services	β=0.1	+	P < 0.01 (linear regression)	Study of Older People in	Longitudinal, Population-Based Cohort	≥ 65 years	1834	1 year	Need, as measured by perceived and objective physical

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
	Level of physical impairment	β=0.24	+	P < 0.01	Cleveland, 1975-1976					health measures is the largest determinant of health services use
	Recipients of Case Management services	β=0.06	+	P < 0.05						
	Social Isolation	β=-0.06	-	P < 0.05						
Shaprio & Roos, 1982 [d]										
Hospital admissions	Diagnosed as having a serious condition	4-Fold increase in odds for 75+years 6-fold increase in odds for 65-74 years	+	P = 0.01 (Multivariate log linear analysis)	Manitoba Longitudinal Study on Aging	Longitudinal, Population-Based Cohort	≥ 65 years	2211	27 months	Hospital admissions are based on physical health and vary with age.
Roos & Shapiro, 1981 [e]										
Number of physician visits	Sex		+	P < 0.05 (t-test)	Manitoba Longitudinal Study on Aging, 1969-71	Longitudinal, Population-Based Cohort	≥ 65 years	4558	2 years	Being male, having low self-rated health and a greater number of health problems are associated with both number of physician visits and days in hospital Older age is associated with more days in hospital but not more physician visits.
	Male	5.2 visits								
	Female	5.8 visits								
	Self-rated health		-	P < 0.0001 (ANOVA, age and sex adjusted)						
	Excellent	4.4 visits								
	Good	5.0 visits								
	Fair	6.5 visits								
	Poor or Bad	7.5 visits								
	Number of health problems		+	P < 0.0001 (ANOVA, age and sex adjusted)						
	0	3.7 visits								
	1	4.7 visits								
	2	5.5 visits								
	3+	6.8 visits								

RELATIONSHIP STUDIED		STUDY RESULTS			STUDY CHARACTERISTICS					COMMENTS
Outcome	Independent Variable	Magnitude of Effect	Direction of Effect (+ or -)	Statistical Significance (p-value and type of analysis)	Setting	Study Design	Age of Population at Baseline	Sample Size	Follow-Up Period	
Number of hospital days	Age		+	P < 0.0001 (ANOVA)						
	65-69y	2.8 days								
	70-74y	5.1 days								
	75-79y	5.7 days								
	80-84y	5.7 days								
	85+y	9.2 days								
	Sex		-	P < 0.05 (t-test)						
	Male	5.5 days								
	Female	4.4 days								
	Self-rated health		-	P < 0.0001 (ANOVA)						
	Excellent	2.3 days								
	Good	3.4 days								
	Fair	6.2 days								
	Poor or Bad	10.5 days								
	Number of health problems		+	P < 0.0001 (ANOVA)						
	0	2.9 days								
	1	3.5 days								
	2	4.9 days								
	3+	6.8 days								

NS = Not statistically significant at p < 0.05; RCT = Randomized Controlled Trial; ANOVA = Analysis of Variance

[a] Levels of physical activity were not significantly associated (p > 0.05) with contact with a general practitioner for males or females.
[b] Variables adjusted for in the multivariate logistic regression model but not significant (p > 0.05) were: sex, age, income, adequacy, self-rated health, number of reported health conditions, one or more basic disabilities, index of living skills, needing help with interview, judged by interviewers to have weakened state of mind, location of nearest relative, no contact with neighbors in past month, ethnicity, urban residence
[c] Non-significant variables were income, education, medical insurance, sex, age, race and psychic distress.
[d] Multivariate analysis was adjusted for age, sex and urban-dwelling. Employment status was only related to hospital admissions when seriousness of diagnosis was not accounted for. Seriousness of diagnosis and employment status were not significantly related to number of physician visits. Self-rated health was not significantly (p > 0.05) related to either physician visits or hospital admissions.

[e] Monthly income was not significantly related to number of physician visits or days in the hospital when the number of health problems was controlled for. ANOVA's were adjusted for age and sex.

Shapiro & Roos, 1982; Roos & Shapiro, 1981) and one study reported on the use of home care services (Bath & Morgan, 1998). The association of a number of different variables with health services use was reported including: physician counseling, educational interventions, healthy behaviours, health status and patient demographics.

Odds ratios were not large, ranging from 0.87 to 2.0, with the exception of the relationship between men's use of home care and low levels of physical activity, OR=6.10 (Bath & Morgan, 1998). A number of studies reported on the relationship between health services use and health status. One study reported that individuals with a serious diagnosis were four to six times more likely to be hospitalized (Shapiro & Roos, 1982). Another study reported that as the number of health problems increased, the number of days spent in hospital also increased (Roos & Shapiro, 1981). This study also reported that individuals with poor or bad self-rated health had a greater number of physician visits than those with excellent self-rated health (7.5 visits compared with 4.4 visits over two years) (Roos & Shapiro, 1981). Also, individuals over 85 years and those with poor or bad self-rated health had the greatest number of days in the hospital (9.2 days and 10.5 days, respectively) (Roos & Shapiro, 1981). The direction of all relationships was as hypothesized. All reported relationships were statistically significant at $p < 0.05$ and associations between health status and health services use were highly significant at $p < 0.0001$ (Roos & Shapiro, 1981). The primary finding from these studies was that health services use is primarily determined by health status, both when it is measured objectively, for example, as the number of health problems, and when it is measured subjectively, for example, as self-rated health.

2.4. General Conclusions and Hypotheses to Guide Structural Equation Model Specification

Based on high-quality evidence from population-based prospective studies in adults 65 years and older, six relevant categories were identified that could be included in a model of healthy behaviours: health status, health-related quality of life, health services use, physician counseling, patient knowledge and healthy behaviours. All models are only simplified approximations to reality and, therefore, additional principles that guided hypothesis formulation were that:

- The model should remain simple enough that it can be evaluated through structural equation modeling. For example, there should be limited or no feedback loops in the model (Hoyle, 1995).
- The model should outline pathways in a coherent manner such that it can genuinely contribute to improving the understanding of healthy behaviours in older adults. For example, it is not required to specify all possible relationships between variables (Hoyle, 1995).

Therefore, based on the evidence from prospective population-based studies in adults 65 years and older, the following general hypotheses were formulated and are presented in a general model (See Figure 2, A general model of relationships among healthy behaviours and five relevant determinants (health status, health-related quality of life, health services use, physician counseling, patient knowledge) that were identified using high-quality evidence from prospective population-based studies in adults 65 years and older):

- Poor health status will increase health services use
- Increased health services use will increase physician counseling on healthy behaviours by providing more opportunities for physicians to provide counseling.
- One of the consequences of physician counseling on healthy behaviours is to increase a patient's knowledge of health and healthy behaviours.
- Increased patient knowledge will lead to an increase in healthy behaviours
- Poor health status will be related to poor health-related quality of life
- Poor health-related quality of life will increase health services use
- Self-care behaviours and healthy lifestyle behaviours are different types of healthy behaviours that will be correlated

To account for the influence of different demographic variables such as age, sex, marital status, education, employment and country of birth the model should be evaluated in different subpopulations.

2.5. Selection of the Data Set for Analysis

Once the determinants of healthy behaviours were identified and a potential model of healthy behaviours among older adults was specified, the feasibility of applying this model to data collected during the Community Hypertension Awareness Trial (CHAT) was considered. CHAT collected data on 980 older adults concerning healthy

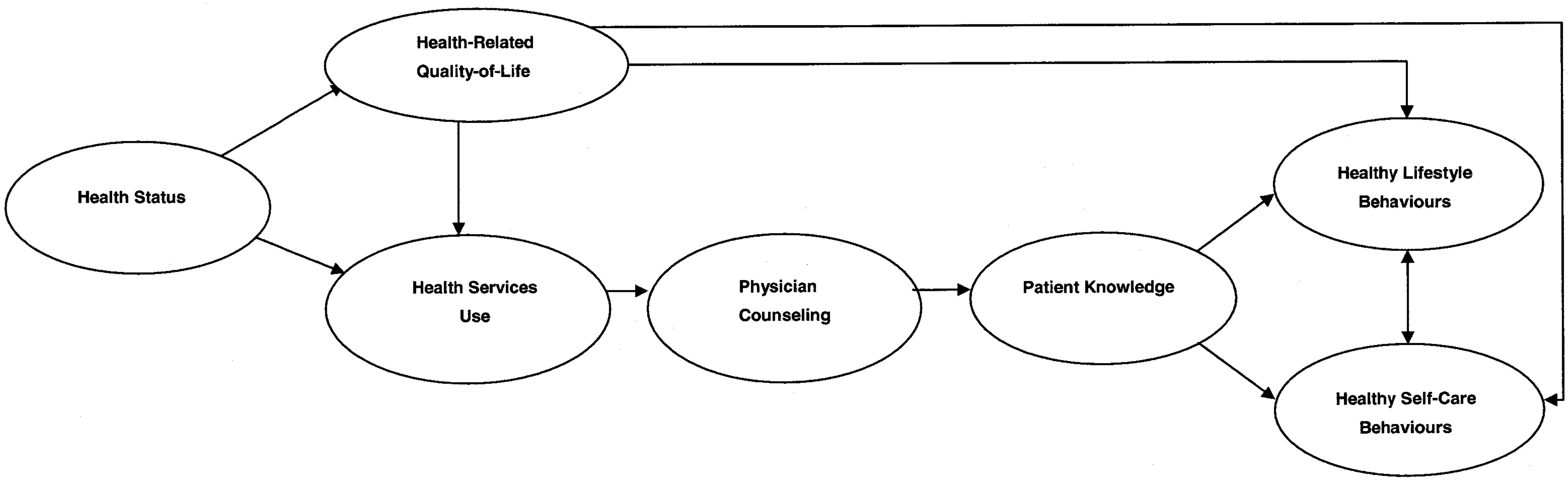


Figure 2. A general model of relationships among healthy behaviours and five relevant determinants (health status, health-related quality of life, health services use, physician counseling, patient knowledge) that were identified using high-quality evidence from prospective population-based studies in adults 65 years and older.

behaviours; health status; health-related quality-of-life; health services use; patient knowledge and beliefs related to high blood pressure; and the role of their family doctor in controlling and managing high blood pressure. Multiple data sources were available including two self-reported questionnaires and office health record reviews. Also, the agreement analysis found good agreement between self-report and health record review data, indicating the validity of this approach. Therefore, this was thought to be an appropriate data set for exploring a model of healthy behaviours in older adults. Although this is not a longitudinal dataset, it was decided that at this preliminary stage of model development, cross-sectional data would be appropriate for exploring a model of healthy behaviours in older adults. However, the evidence used to specify the model was based on prospective evidence from longitudinal studies and randomized controlled trials. The model of healthy behaviours in older adults was supported by the level of agreement between office health records and self-report data and by estimates population attributable fractions.

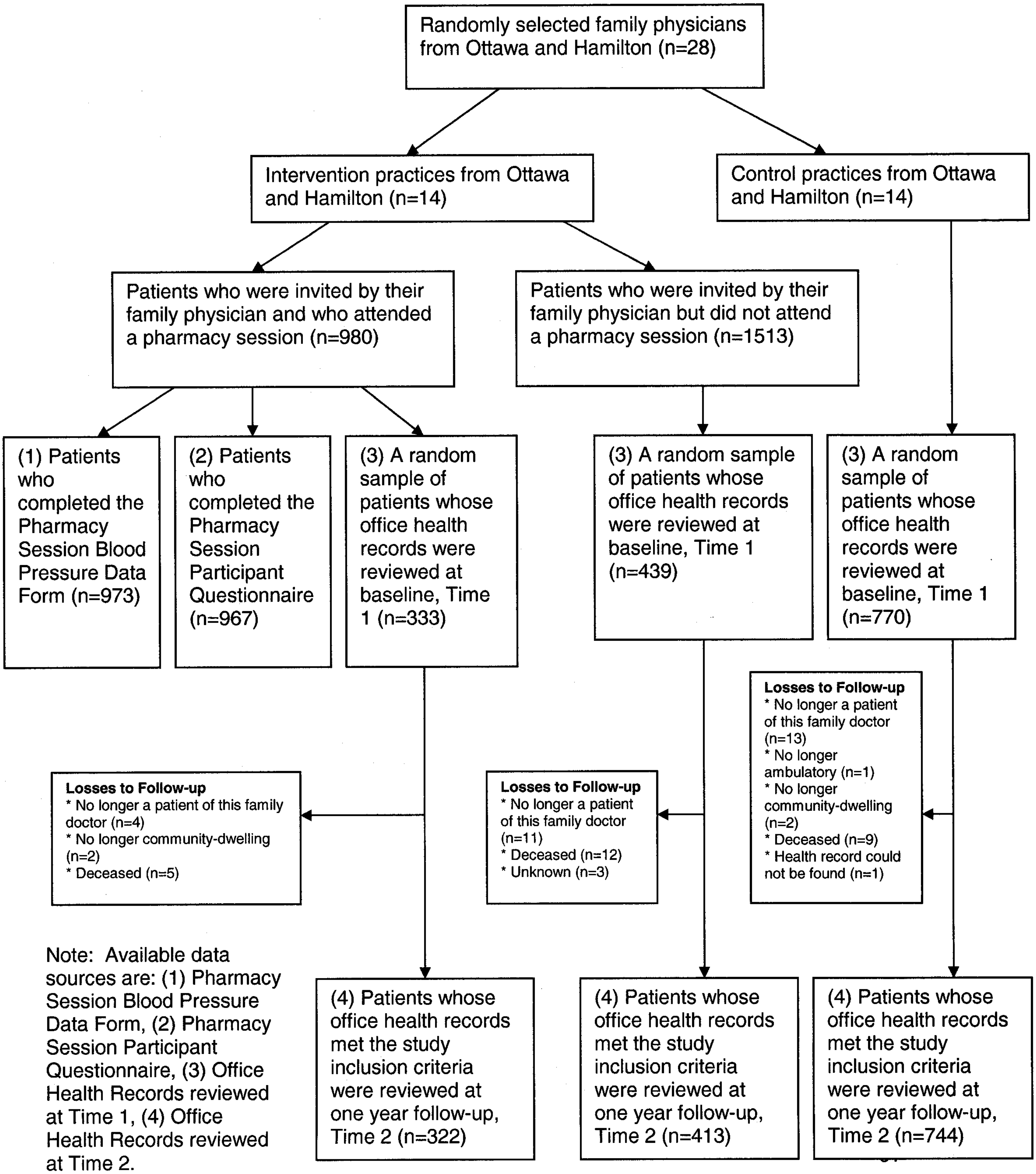
3. METHODS

3.1. Data Sources

Data were collected between May and December 2003 as part of the Community Hypertension Awareness Trial (CHAT) (Chambers, Kaczorowski, Levitt et al., 2002; Chambers, Kaczorowski, Hendriks et al., 2005). CHAT was a paired cluster randomized controlled trial that evaluated the effectiveness of an invitational cardiovascular health promotion program. Twenty-eight family practices from Hamilton and Ottawa, 47% of eligible family physicians contacted, were randomly recruited and assigned to the control or intervention arm. A family physician was eligible if practicing full-time in a regular size and case-mix practice. In the 14 intervention practices, all mobile, community-dwelling individuals over the age of 65 who had visited their family physician in the previous year were sent a letter from their physician and invited to attend a cardiovascular health awareness session at a community pharmacy. At the pharmacy session, volunteers assisted patients in taking and recording their blood pressure as well as in completing questionnaires collecting information on cardiovascular disease risk factors. With the patient's permission, this information was then faxed to the patient's family physician. Ethics approval for the original study and for subsequent analyses, including this thesis, was obtained from the SCO Health Service Research Ethics Board.

Four separate sources of data were collected on patients whose family physicians agreed to participate in CHAT (See Figure 3, Selection of patients and number who completed the Pharmacy Session Blood Pressure Data Form (1), the Pharmacy Session Participant Questionnaire (2) and who had their office health records reviewed at Time 1 (3) and Time 2 (4)). Two patient self-report questionnaires were completed at the pharmacy sessions: the Blood Pressure Data Form (n=973) and the Participant Questionnaire (n=967). The Blood Pressure Data Form collected patient demographics as well as information on cardiovascular disease risk factors, including unhealthy behaviours and self-reported cardiovascular comorbidities. The Participant Questionnaire also collected patient demographics as well as asking specific questions

Figure 3. Selection of patients and number who completed the Pharmacy Session Blood Pressure Data Form (1), the Pharmacy Session Participant Questionnaire (2) and who had their office health records reviewed at Time 1 (3) and Time 2 (4).



about blood pressure management, health-related-quality-of-life and health services use. Also, office health records were reviewed for a random sample of 55 patients in each of the 28 participating family practices (n=1540) at baseline, Time 1, and one-year following the pharmacy sessions, Time 2. Among attendees of the CHAT pharmacy sessions, 322 had their health records reviewed at both Time 1 and Time 2. Information collected from office health records at Times 1 and 2 included data on cardiovascular comorbidities, health services use and blood pressure management.

In addition, two questionnaires were completed by participating physicians at Time 1 that provided information on physician demographics, practice characteristics and their approaches to blood pressure control and management.

3.1.1. Eligible Variables

The collected variables from office health records and from pharmacy session questionnaires that measured healthy behaviours, health status, health-related quality of life, health services use, physician counseling, patient knowledge and patient demographics are listed below. The exact questions asked and the data source for each of the questionnaire variables are listed in Appendix A, Variables From Questionnaires That Were Included In The Thesis Analysis.

Measures from the office health record reviews were only used to assess agreement between self-report and office health record measures and to assess the generalizability of CHAT attendees to the general population. The office health record variables that were used for these analyses were as follows: number of family physician visits; number of emergency room visits; number of day surgeries; number of hospital admissions; hypertension diagnosis; diabetes diagnosis; retinopathy diagnosis; nephropathy diagnosis; heart disease diagnosis; stroke, transient ischemic attack or cerebral vascular accident diagnosis; peripheral vascular disease diagnosis; aortic aneurysm diagnosis; current smoker; and medications being prescribed for high blood pressure.

Self-reported measures of healthy behaviours were: not smoking, moderate alcohol use, low fat diet, moderate physical activity, low stress and blood pressure self-monitoring. The variable "total number of healthy lifestyle behaviours" was also created. This was the sum of five self-reported healthy lifestyle behaviours (being physically active, moderate alcohol use, never smoking, low fat diet and low stress). For each behaviour, the data were collapsed into two categories with the lowest risk behaviour classified as healthy and all other categories classified as unhealthy behaviour. For example, a low fat diet was considered a healthy behaviour while moderate and high fat diets were considered an unhealthy behaviour.

Self-reported measures of heath status were: stroke or transient ischemic attack, heart attack, high cholesterol, diabetes, high blood pressure and depression. Also, obesity was determined using self-reported height and weight from the Blood Pressure Data Form to calculate body mass index (Body Mass Index = Weight in Kilograms / (Height in Meters Squared)). A body mass index ≥ 30 kg/m^2 was considered obese as per national guidelines (National Heart, Lung and Blood Institute, 1998). The variable "number of cardiovascular comorbidities" was created by summing the presence of six self-reported cardiovascular comorbidities (stroke, heart attack, diabetes, obesity, high blood pressure and high cholesterol).

Self-reported measures of health-related quality-of-life were: self-rated general health; the number of physically unhealthy days in the past 30 days; the number of mentally unhealthy days in the past 30 days; and the number of limited activity days in the past 30 days.

Self-reported measures of health services use were: admitted to hospital in the past year; the last time blood pressure was checked by a health professional, and if your family doctor measured your blood pressure in the past year. The variable "attended more than one pharmacy session" was also created because it was possible to determine how many pharmacy sessions each individual attended.

Self-reported measures of physician counseling were: family doctor discussed the health risks of high blood pressure; and your physician uses information handouts for lifestyle counseling.

Self-reported measures of patient knowledge were: knowing your most recent blood pressure reading.

Self-reported measures of patient demographics were: sex, marital status, age, education, employment status and country of birth.

Variables were excluded from the analysis if the questions were only answered by a subset of participants due to built-in skip patterns in the questionnaire (See Appendix B for list of excluded variables). When variables were selected for structural equation modeling, the excluded variables were those not identified as relevant to healthy behaviours based on relationships reported in prospective population-based studies of adults 65 years and older (See Appendix B for list of excluded variables). Additionally, variables from the office health record reviews were excluded from the structural equation model due to the small sample size (n=321).

3.1.2. Missing Data

Most variables had no more than five to ten percent missing data. For some variables, when data were missing it was reasonable to substitute "no" for the missing value. For example, if an individual did not answer the question "do you know your most recent blood pressure reading", it was assumed that this individual did not know their most recent blood pressure reading. Similarly, for diagnosis-type variables, for example, having had a heart attack, individuals with missing data were classified as not having the disease. For variables that asked the number of days of ill or good health, missing data values were substituted with a value of zero days because patterns in the data indicated that many individuals may have left the question blank as an indicator of zero unhealthy days. For all other categorical and continuous variables, median and mean substitution was used respectively (Allison, 2001). For example, for the smoking variable, the median value was "previous smoker"; therefore, missing values were substituted with the value "previous smoker". (See Appendix C, Table C1, for further detail on missing data and strategies for handling missing data)

3.2. Analysis Strategy

There were four components to this analysis.

1. Comparing the level of agreement between patient self-report data and office health record review data.
2. Examining the representativeness of older adults attending the pharmacy sessions
3. Estimating of the fraction of cardiovascular comorbidities and depression in the population that can be attributed to behavioural and physiological risk factors.
4. Specifying and evaluating a unified model of healthy behaviours among older adults through structural equation modeling.

3.2.1. Comparison of Office Health Record Data with Patient-Reported Questionnaire Data

The quality of self-report data in this population was assessed by estimating the level of agreement between patient questionnaires and health record review data. Likelihood ratios, as well as the sensitivity, specificity and positive predictive values were calculated using the office health records as the gold standard. Sensitivity is calculated as the number of individuals with disease who are correctly identified by the measure as having the disease divided by the number of individuals with the disease and expressed as a percentage (Aschengrau & Seage, 2004). Specificity is calculated as the number of individuals without disease who are correctly identified by the measure as not having the disease divided by the number of individuals without the disease and expressed as a percentage (Aschengrau & Seage, 2004). Positive predictive value (PPV+) is calculated as the number of individuals who the measure identifies as having the disease and who truly do have the disease/ number of individuals the measure identifies as having the disease and expressed as a percentage (Guyatt & Rennie, 2002). The likelihood ratio (LLR) is calculated as sensitivity/(1-specificity). Likelihood ratios have a lower threshold of 0 and no upper limit. Likelihood ratios greater than 10 are considered evidence that the disease is truly present when using self-report data (Guyatt & Rennie, 2002).

3.2.2. Representativeness of Attendees of CHAT Pharmacy Sessions

3.2.2.1 Comparison of those who attended CHAT pharmacy sessions and those who did not

Baseline and one year follow-up office health record reviews were available on 772 family practice patients who were invited to the CHAT pharmacy sessions, 322 of who attended the pharmacy sessions. A comparison of relevant variables of those who attended the pharmacy sessions versus those who did not attend the pharmacy sessions was conducted using the chi-square test of independence and independent t-tests, for categorical and continuous variables, respectively. The Bonferroni correction for multiple testing was calculated using the formula, $\alpha^* = 0.05/(k \text{ choose } 2)$, where k is the number of independent tests to perform (Pagano & Gavereau, 2004). Attendees were compared with non-attendees on 16 measures, therefore, a p-value less than 0.0004 was considered a statistically significant difference between the two groups of individuals.

3.2.2.2. Characteristics of Attendees of the Pharmacy Sessions

Demographic characteristics of the pharmacy session attendees were reported. Frequency distributions of healthy behaviours, cardiovascular comorbidities and other variables relevant to healthy behaviours in older adults were also estimated. For the two composite variables of total number of cardiovascular comorbidities and total number of healthy behaviours the relationships among cardiovascular comorbidities and the relationships among healthy behaviours were examined to determine if diseases and behaviours were independent. Correlation matrices examining relationships among cardiovascular comorbidities and among healthy behaviours were produced. Correlations were calculated as phi, which is a measure of the Pearson correlation coefficient that is weighted by sample size and appropriate for analyzing dichotomous variables; it ranges from –1 to 1 with values close to +/-1 indicating a strong association (Pagano & Gavereau, 2004).

3.2.3. Population Attributable Fractions

The amount of self-reported cardiovascular comorbidities and self-reported depression attributable to unhealthy behaviours was estimated by the population attributable fraction (AF_P), using the formula,

$$AF_P = [P_e(RR-1)]/[1+P_e(RR-1)]$$

Where P_e is the prevalence of risk exposure in the population and RR is the relative risk of the outcome for those exposed (Murray & Lopez, 1996).

Population attributable fractions were calculated for six cardiovascular comorbidities (heart attack, stroke, diabetes, high blood pressure, high cholesterol and obesity) and depression. Eight risk factors were examined: five behavioural risk factors (physical inactivity, immoderate alcohol use, ever having smoked, high fat diet and high stress) and three physiological risk factors (high blood pressure, high cholesterol and obesity). There was some overlap between cardiovascular comorbidities and physiological risk factors because some cardiovascular comorbidities are considered risk factors for other diseases, for example, high blood pressure.

3.2.4. Structural Equation Modeling

Structural equation modeling is a method of evaluating a conceptual theory against empirical data (Hoyle, 1995). It allows the simultaneous assessment of direct and indirect pathways among variables and permits latent variables to be reflected by multiple observed measures. Based on relationships reported in prospective studies of older adults, a unified model of healthy behaviours in older adults was specified and evaluated. Following model specification, there are three steps to structural equation modeling: (1) estimation of model parameters such as correlations and regression coefficients, (2) evaluation of model fit and (3) potential modifications to the hypothesized model in order to improve the model fit.

3.2.4.1. Model Specification

Variables to be included in the model of healthy behaviours and pathways among the variables were identified based on conclusions drawn from prospective population-based studies of healthy behaviours among adults 65 years and older, input from the thesis committee and variables available in the CHAT data sources. Due to the large sample size requirements of structural equation modeling with categorical variables (n = 1000) (Hoyle, 1995), the office health record review data (n=321) were excluded from the structural equation model. The selected variables were grouped according to the identified determinants of healthy behaviours (health status, health-related quality of life, health services use, physician counseling, patient knowledge and healthy behaviours) that they reflected (See Table 7, Observed variables included in the hypothesized structural equation model of healthy behaviours in older adults).

Table 7. Observed variables included in the hypothesized structural equation model of healthy behaviours in older adults.

Variables Measuring Healthy Behaviours
Sum of five possible healthy lifestyle behaviours (being physically active, moderate alcohol use, not smoking, low fat diet and low stress)
Blood pressure self-monitoring
Variables Measuring Health Status
Sum of six possible cardiovascular comorbidities (stroke, heart attack, diabetes, obesity, high blood pressure and high cholesterol)
Depressed in the past year
Variables Measuring Health-Related Quality of Life
General self-rated health
Number of physically unhealthy days in the past 30 days
Number of mentally unhealthy days in the past 30 days
Number of limited activity days in the past 30 days
Variables Measuring Health Services Use
Admitted to hospital in the last year
Attended more than one CHAT pharmacy session
Last time your blood pressure was checked by a health professional
Family doctor measured your blood pressure in the past year
Variables Measuring Physician Counseling
Family doctor discussed the health risks of high blood pressure
Family physician uses patient handouts for lifestyle counseling
Variables Measuring Patient Knowledge
Know your most recent blood pressure reading

3.2.4.1.1. Measurement Model

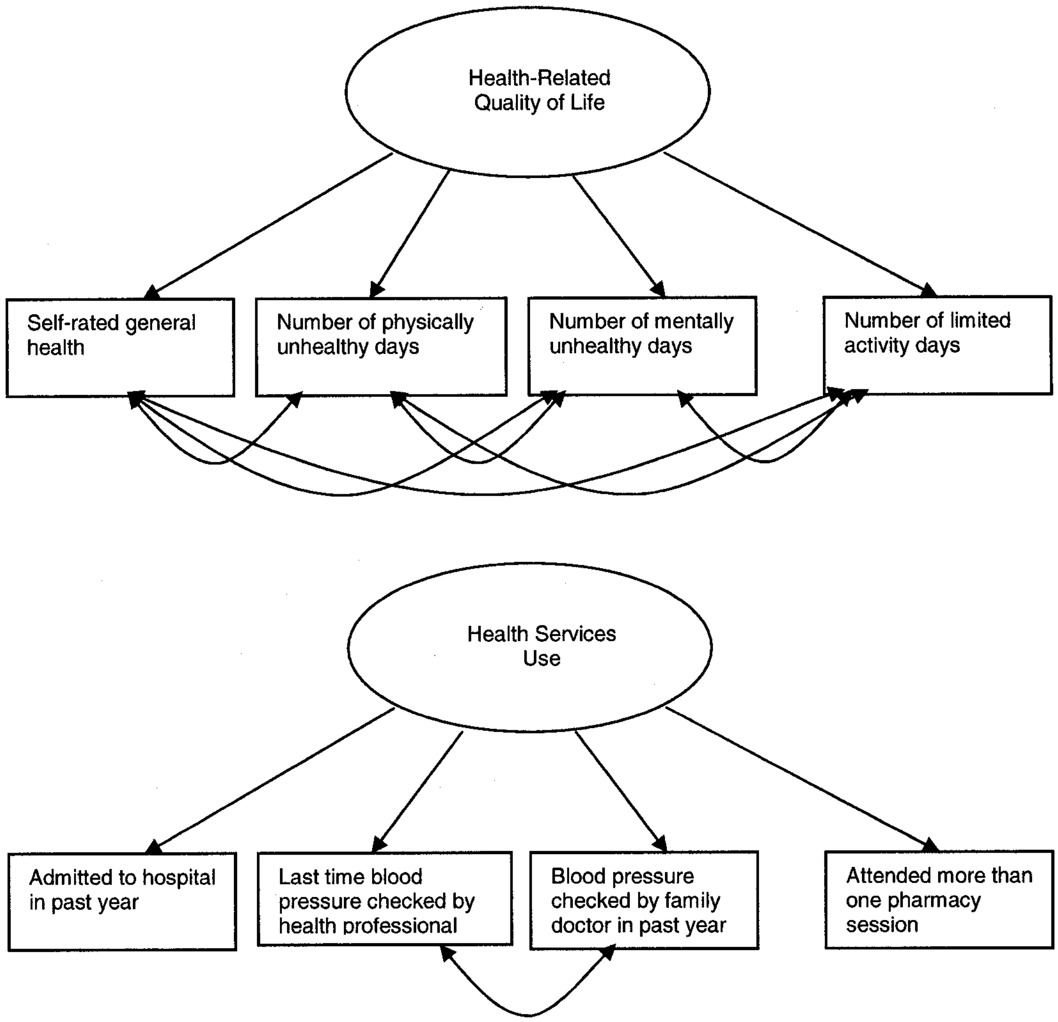
Measurement models were defined for latent constructs where possible. In a measurement model, a latent, or underlying, construct is represented by multiple observed variables that reflect the same concept (Hoyle, 1995). For example, four different questions reflecting health-related quality of life (self-rated general health, the number of physical unhealthy days, the number of mental unhealthy days and the number of limited activity days) are variables measuring the latent construct health-related quality-of-life.

One of the advantages of structural equation modeling is that some of the error associated with each observed variable is thought to be a result of systematic measurement error. When the systematic measurement error of two observed variables is related, then the error terms of the two variables will be correlated with each other (Hoyle, 1995). For example, measurement error terms may be related because the variables are jointly influenced by an additional construct or because variables are influenced by similar methodological factors. While correlating measurement error terms can incorporate systematic error into the measurement model, it will still not eliminate the random error that is associated with the variables (Hoyle, 1995).

In this hypothesized model of healthy behaviours, two latent constructs were specified and are shown in Figure 4 (Measurement models for the latent constructs health-related quality of life and health services use):

1. The latent construct of health-related quality of life was reflected by four observed variables: self-rated general health, the number of physical unhealthy days, the number of mental unhealthy days and the number of limited activity days. The error terms were hypothesized to be correlated among the four observed variables due to difficulties individuals may have in quantifying their overall impression of their health according to required response categories (Centers for Disease Control and Prevention, 2000).
2. The latent construct of health services use was reflected by four observed variables: admitted to hospital in the previous year, blood pressure checked by family physician in the previous year, last time blood pressure checked by a health professional and attended more than one CHAT pharmacy session. The error terms between blood pressure checked by family physician in the past year and last time blood pressure checked by a health professional were hypothesized to be correlated because both variables are subject to a similar recall bias.

Although two variables measuring physician counseling were available, the variables were included in this model as two separate observed variables (and not a latent construct) because they reflected two different types of physician counseling: one focused on healthy lifestyle behaviours and the other focused on high blood pressure risks. Also, although six variables measuring healthy behaviours were available (being physically active, moderate alcohol consumption, not smoking, low stress, low fat diet and blood pressure self-monitoring) a latent construct for healthy behaviours was not



Note: In a model diagram, latent constructs are drawn as ellipses and observed variables are drawn as rectangles. Straight arrows represent paths from the latent construct to observed variables. Curved arrows represent correlations between the error terms of observed variables.

Figure 4. Measurement models for the latent constructs health-related quality of life and health services use.

considered appropriate as these are unique behaviours that may not all reflect the same underlying concept (MacKenzie, Podsakoff & Jarvis, 2005; Fayers & Hand, 1997). Therefore, instead of a latent construct, two observed healthy behaviour variables were included in the structural equation model: one reflected healthy lifestyle behaviours and was measured by the sum of five healthy lifestyle behaviours, and one reflected healthy self-care behaviours and was measured by blood pressure self-monitoring. Similarly, health status was reflected by two observed variables, mental health and physical health, as these are two distinct aspects of health. Physical health was measured as the number of cardiovascular comorbidities. Mental health was measured by the presence or absence of depression. All other variables in the model were included as single observed variables.

3.2.4.1.2. Structural Model

Based on both the variables available for analysis from the CHAT data sources and the relationships identified in prospective population-based studies of adults 65 years and older, specific hypotheses were formulated and pathways in the structural model were specified (See Figure 5, Hypothesized structural equation model of relationships among healthy behaviours, physician influence, patient knowledge, health-related quality of life, health services use, mental health and physical health in older adults):

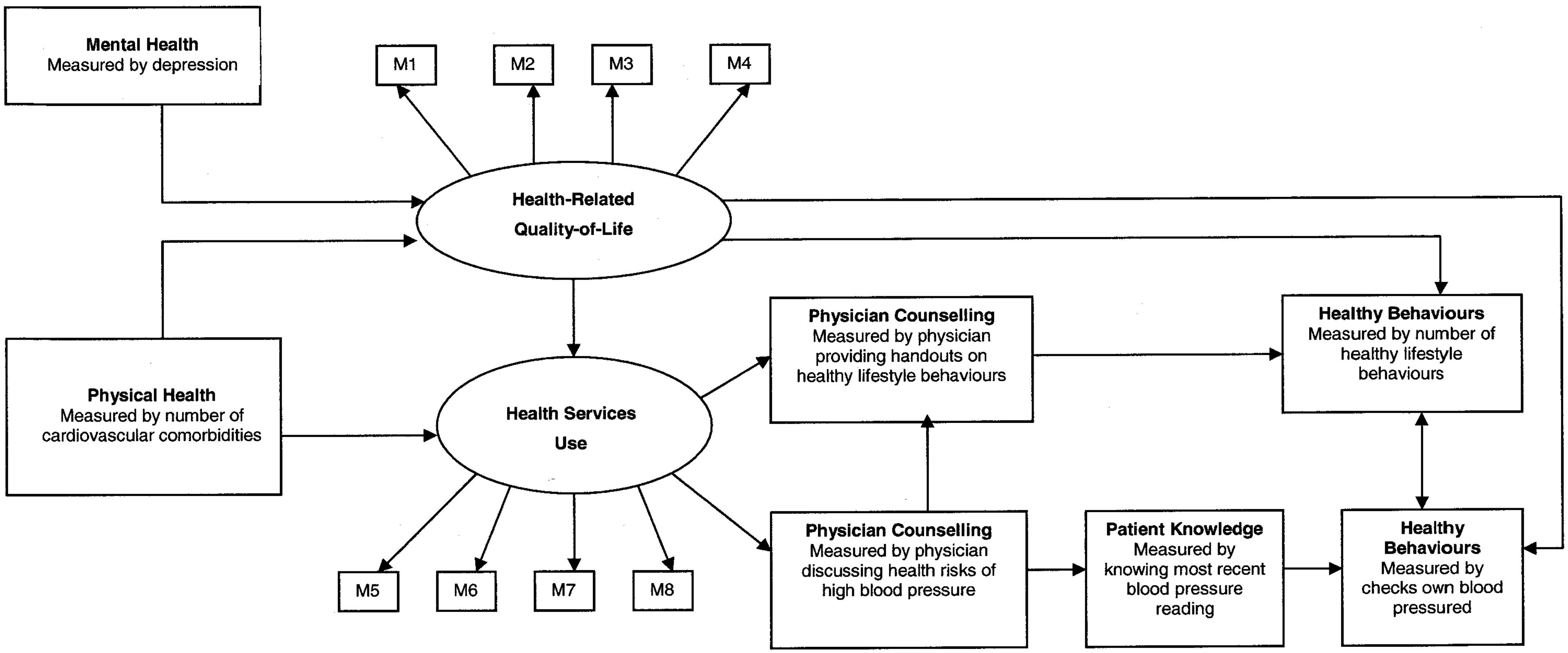
- Poor physical health, as measured by a greater number of cardiovascular comorbidities, will increase health services use.
- Increased use of health services (a latent construct) will provide more opportunities for physician counseling, both lifestyle counseling and counseling specifically related to high blood pressure risks.
- Physician counseling on high blood pressure risks, as measured by a family physician discussing the health risks associated with high blood pressure, will increase a patient's knowledge, as measured by knowing their most recent blood pressure reading.
- Physician counseling on lifestyle behaviours, as measured by whether or not physicians use information handouts for lifestyle counseling, will increase healthy lifestyle behaviours, as measured by the total number of lifestyle behaviours one engages in.
- Physician counseling on high blood pressure risks will increase physician counseling on lifestyle behaviours because improving lifestyle behaviours is a prescribed treatment for high blood pressure control and management.

- Increased patient knowledge, as measured by knowing your most recent blood pressure reading, will increase blood pressure self-monitoring, which is a healthy self-care behaviour.
- Poor physical health, as measured by a higher number of cardiovascular comorbidities, will decrease health-related quality of life (a latent construct).
- Poor mental health, as measured by depression in the past year, will directly decrease health-related quality of life.
- Poor health-related quality of life will increase health services use
- Good health-related quality of life will increase healthy behaviours as measured by both the number of healthy lifestyle behaviours one engages in and blood pressure self-monitoring.
- Healthy self care behaviours, as measured by blood pressure self-monitoring, will be correlated with healthy lifestyle behaviours as measured by the total number of healthy lifestyle behaviours.

Therefore, in this model only health-related quality of life, patient knowledge and physician influence are hypothesized to directly influence healthy behaviours. The effects of mental health, physical health and health services use on healthy behaviours will be indirectly modelled through pathways from other variables.

3.2.4.1.3. Subgroup Analysis

Additionally, it was hypothesized that these relationships might differ based on the socio-demographic characteristics of the population such as age, sex, marital status, education level, employment status and country of birth. An attempt was made to study these characteristics by evaluating the model in different population subgroups but due to the small subgroup sample sizes, this was not possible. Therefore, univariate regressions were reported for the relationships between each of these six demographic characteristics and the two healthy behaviour outcomes: number of healthy behaviours and blood pressure self-monitoring.



Note:

- Measures of health-related quality of life are: self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- Measures of health services use are: number of hospital admissions in the last year (M5), the last time blood pressure was checked by a health professional (M6), whether or not family doctor checked blood pressure in past year (M7) and if more than one cardiovascular health awareness pharmacy session was attended (M8).

Figure 5. Hypothesized structural equation model of relationships among healthy behaviours, physician influence, patient knowledge, health-related quality of life, health services use, mental health and physical health in older adults.

3.2.4.2. *Model Estimation*

Because both continuous and categorical variables were part of the model, the continuous/categorical variable estimation method (CVM) was used to estimate the model parameters (Skrondel & Rabe-Hesketh, 2005; Hoyle, 1995). The continuous/categorical variable estimation method is based on the assumption that latent variables have an underlying continuous distribution; therefore, there must be a large sample size (n= 500 to 1000) and a relatively simple model (approximately 20 to 25 measured variables) (Hoyle, 1995). Mplus, version 3.0 was the software used to evaluate the structural equation model (Muthen & Muthen, 2005). Within the Mplus modeling framework, the specific estimator used for continuous/categorical variable estimation is the Weighted Least Squares Mean Variance estimator (WLSMV) (Muthen & Muthen, 2005). Estimation of the model begins with pairwise correlations between the observed variables. Different correlations are estimated depending on the nature of the variables: Pearson correlations are estimated between two continuous variables; tetrachoric correlations are estimated between two dichotomous variables; polycohric correlations are estimated between two ordinal variables or between an ordinal variable and a dichotomous variable; and polyserial correlations are estimated when one variable is continuous and one variable is either ordinal or dichotomous. Then, an asymptotic covariance matrix of these correlations is estimated (Skrondel & Rabe-Hesketh, 2005). The parameters of the model, such as regression coefficients, can then be estimated using WLSMV where the diagonal of the asymptotic covariance matrix is used as the weight matrix (Skrondel & Rabe-Hesketh, 2005). An iterative procedure is used to estimate the model parameters. The one-step model estimation method was used where the fit of both the latent constructs and the pathways among variables were assessed simultaneously (Hayduk & Glaser, 2000).

Estimated regression coefficients for continuous observed variables, such as number of healthy behaviours, and continuous latent constructs, such as health-related quality of life and health services use, are simple linear regression coefficients. For dichotomous and ordinal dependent variables, parameter estimates are probit regression coefficients. Additionally, an R^2 value is calculated for each dependent variable, which is an estimate of the variance explained by variables that are directly regressed on the dependent variable in question. These estimates are comparable to those obtained from a regression model for continuous variables and for continuous latent constructs (Muthen & Muthen, 2005).

3.2.4.3. Model Evaluation

A model fits the observed data based on the extent to which the hypothesized correlation matrix is equivalent to the observed sample correlation matrix (Hoyle, 1995). The chi square test for model fit tests the null hypothesis that there is no difference between the hypothesized correlation matrix and the observed correlation matrix. Therefore, a non-significant chi-square indicates a good fit of the model. The chi-square test of model fit is extremely sensitive to sample size, though. If the sample size is greater than 200, the chi-square will most likely be significant due to small differences between the observed and hypothesized models (Hoyle, 1995). The chi-square test of model fit must still always be reported, though, in order to provide a reference that can be used for comparisons with other reported models, as well as to evaluate the effects of potential post-hoc model modifications. In response to this limitation of the chi-square test, alternative indices that adjust for sample size have been developed to evaluate model fit. The indices used to evaluate model fit in this thesis are the comparative fit index (CFI) and the root mean square error of approximation (RMSEA), both of which adjust for large sample sizes (Rigdon, 1996).

1. The comparative fit index compares the observed sample correlation matrix to a null correlation matrix, where all variables are assumed to be uncorrelated with each other. The comparative fit index ranges from 0 (no fit) to 1 (perfect fit) and a value greater than 0.95 is considered a good model fit (Rigdon, 1996).
2. The root mean square error of approximation estimates the amount of model misfit per degree of freedom (Rigdon, 1996). Like the chi-square test statistic, it compares the hypothesized correlation matrix with the observed sample correlation matrix but It is calculated independently of sample size. In addition, the root mean square error of approximation adjusts for degrees of freedom and, therefore, model complexity. It has a lower bound of 0, which indicates perfect model fit and no upper bound. Based on model simulation studies, it has been determined that a value ≤ 0.06 indicates a good model fit, between 0.06 and 0.08 indicates adequate fit, between 0.08 and 0.1 indicates mediocre fit and greater than 0.1 indicates unacceptable fit (Rigdon, 1996; Hu & Bentler, 1999). The root mean square error of approximation is

considered the best measure of model fit when there is a large sample size and when the model is complex (Rigdon, 1996).

3.2.4.3. Model Modification

Two approaches were used to evaluate potential modifications that would improve the fit of the model.

1. The effect of adding pathways to the hypothesized model was evaluated by calculating the Lagrange multiplier modification index (Hoyle, 1995). The Lagrange multiplier modification index estimates the impact on model fit that would occur if a path were added to the model. It measures the change in the chi-square test statistic that would exist between the model with the path and the model without the path (Hoyle, 1995). While the significance of the chi-square test statistic is not always a good measure of model fit in large sample sizes, the change in the chi-square test statistic is still important for evaluating the impact of model modifications. Modification index values have a minimum threshold of 0 with no maximum. Standard cut points for evaluating modification index values have not been established (Hoyle, 1995). In a sample size of approximately 1000, though, if the modification index value is greater than 100 and if there is a theoretical justification for making the change, the impact of the modification on model fit should be evaluated. (D Baer, personal communication, May 2006). Nonetheless, if theoretically justifiable, pathways with smaller modification indexes can still be added in an attempt to improve model fit (C McIntosh, personal communication, May 2006).
2. The effect of removing pathways from the model was evaluated by examining the statistical significance of regression path coefficients at $p < 0.05$. If a pathway was non-significant and, if there was a theoretical justification for removing the path, the effect on model fit was examined by comparing the change in the chi-square test of model fit between the model with the path and the model without the path (Hoyle, 1995).

It should be noted that, if variables are removed from the model during post-hoc modifications, comparing the differences in fit between the models should be interpreted with caution.

In order to evaluate whether the magnitude of selected pathway regression coefficients within the model were significantly different from each other, the regression coefficients were assumed to be equal and the fit of the model was estimated when this constraint was imposed. Model fit was compared between the free model and the constrained model by calculating the difference in chi-square test statistics. If this difference was statistically significant at $p<0.05$, the two pathway regression coefficients were considered to be significantly different in magnitude (Hoyle, 1995).

4. RESULTS

4.1. Comparison of Self-Reported Questionnaire Data and Office Health Record Data

The level of agreement between the self-report and health record review data was good for measures of diabetes (LLR=56.5), smoking (LLR=27.9), stroke (LLR=16.6) and heart attack (LLR=12.4) as assessed by a likelihood ratio greater than 10 (See Table 8, Level of agreement between office health record review data and self report questionnaire data from pharmacy sessions as measured using likelihood ratios, sensitivity, specificity and positive predictive values). The two measures that had likelihood ratios smaller than 10 were both related to high blood pressure: hypertension diagnosis (LLR=3.6) and taking hypertension medication (LLR=8.6). In both instances, the prevalence was lower as measured by self-report variables than as measured by office health records. For hypertension diagnosis, the sensitivity was 79.6% and the specificity was 78.2%. For taking hypertension medication, the sensitivity was 83.0% and the specificity was 90.3%. Although the likelihood ratio was greater than 10 for heart attack, the sensitivity was low at 36.6% and the prevalence was underestimated by self-report (11.6%) as compared with the office health record (25.6%).

4.2. Representativeness of the Population

4.2.1. Comparison of those who attended the pharmacy sessions and those who did not

A comparison of a sample of 16 variables that were collected during the review of office health records revealed no statistically significant differences ($p > 0.0004$, as determined by the Bonferroni correction for multiple testing) between individuals who attended the pharmacy sessions versus those who did not attend the sessions (See Table 9, Comparison of attendees of (n=333) pharmacy sessions vs. non-attendees (n=439) of pharmacy sessions based on relevant variables available in health record reviews).

Table 8. Level of agreement between office health record review data and self report questionnaire data from pharmacy sessions as measured using measures of performance (sensitivity, specificity, positive predictive values and positive likelihood ratios).

Gold Standard		Comparative Source						
Office Health Records		Self-Report Questionnaires		Measures of Performance				
Question asked	Prevalence	Question asked	Prevalence	Sensitivity	Specificity	Positive Predictive Value	95% CI (Positive Predictive Value)	Positive Likelihood Ratio
Stroke in health record	6.6%	Ever had a stroke or transient ischemic attack (TIA)	8.1%	66.7%	96.0%	53.8%	35.5, 71.2	16.6
Heart disease in health record[1]	25.6%	Ever had a heart attack	11.6%	36.6%	97.1%	81.1%	65.8, 90.5	12.4
Diabetes in health record	17.8%	Ever had diabetes	16.6%	86.0%	98.5%	92.5%	82.1, 97.0	56.5
Hypertension diagnosis in past two years from health records	61.3%	Ever been told by a doctor that you have high blood pressure	57.2%	79.6%	78.2%	85.2%	79.4, 89.7	3.6
No medication for high blood pressure in last 12 months from health record	64.4%	Currently taking prescription pills for high blood pressure	56.9%	83.0%	90.3%	94.0%	89.5, 96.6	8.6
Currently a smoker from health record	6.3%	Current smoking status	6.3%	65.0%	97.7%	65.0%	43.3, 81.9	27.9

CI: Confidence Interval

[1] Heart disease may include left ventricular hypertrophy (LVH); angina, atrial fibrillation; prior myocardial infarction (MI); prior coronary revascularization, which includes coronary bypass graft surgery (CABG)/ percutaneous coronary intervention (PCI)/percutaneous transluminal coronary angioplasty (PTCA); coronary artery disease (CAD); ischemic/arteriosclerotic heart disease (IHD/ASHD); congestive heart failure (CHF); acute coronary syndrome (ACS); coronary artery bypass surgery; or arteriosclerosis.

Table 9. Comparison of attendees of (n=333) pharmacy sessions vs. non-attendees (n=439) of pharmacy sessions based on relevant variables available in health record reviews.

Health Record Review Variables	**Attendees N (% Yes)**	**Non-Attendees N (% Yes)**	**p-value**
Does the health record state that the patient has hypertension	197 (61.1)	206 (49.9)	0.002
Does the health record state that the patient has diabetes	59 (17.7)	77 (17.5)	0.9
Does the health record state that the patient has retinopathy	2 (0.6)	3 (0.7)	0.9
Does the health record state that the patient has nephropathy? [1]	15 (4.5)	16 (3.6)	0.6
Does the health record state that the patient has heart disease? [2]	86 (25.8)	111 (25.3)	0.9
Does the health record state that the patient has had a stroke or transient ischemic attack (TIA)/cerebral vascular accident (CVA)?	23 (6.9)	37 (8.4)	0.4
Does the health record state that the patient has peripheral vascular disease (PVD)?	14 (4.2)	11 (2.5)	0.2
Does the health record state that the patient has aortic aneurysm?	10 (3.0)	8 (1.8)	0.3

Health Record Review Variables	Attendees N (% Yes)	Non-Attendees N (% Yes)	p-value
Is there a family history of cardiovascular disease?	219 (62.6)	125 (53.2)	0.09
Is lifestyle counseling noted in the 12 months prior to the pharmacy clinics?	203 (60.9)	237 (54.0)	0.05
Anti-hypertensive medications prescribed in the 12 months prior to the pharmacy clinics?	215 (64.6)	266 (60.6)	0.3
Does the patient currently smoke?	21 (6.3)	41 (9.3)	0.3
Mean # family physician visits in the 12 months prior to the pharmacy clinics	7.3 (0.3)	6.0 (0.2)	0.001
Mean # emergency room visits in review period	0.4 (0.05)	0.3 (0.05)	0.7
Mean # day surgeries in review period	0.4 (0.04)	0.4 (0.04)	0.7
Mean # hospital admissions in review period	0.2 (0.03)	0.2 (0.03)	0.6

[1] Nephropathy may include chronic renal insufficiency, chronic renal/kidney failure, chronic renal/kidney disease, end-stage renal disease (ERSD) or nephrosclerosis.
[2] Heart disease may include left ventricular hypertrophy (LVH); angina, atrial fibrillation; prior myocardial infarction (MI); prior coronary revascularization, which includes coronary bypass graft surgery (CABG)/ percutaneous coronary intervention (PCI)/percutaneous transluminal coronary angioplasty (PTCA); coronary artery disease (CAD); ischemic/arteriosclerotic heart disease (IHD/ASHD); congestive heart failure (CHF); acute coronary syndrome (ACS); coronary artery bypass surgery; or arteriosclerosis.
[3] The review period includes the 12 months prior to the pharmacy clinics and the 12 months following the pharmacy clinics.

4.2.2. Demographic Characteristics of Individuals who Attended Pharmacy Sessions

Thirty-nine percent (983 of 2493) of individuals over the age of 65, who were invited by their family physician, attended a cardiovascular health awareness pharmacy session. The average age of attendees was 74.8 years. Fifty-three percent (521 of 983) were female, 39% (384 of 983) had completed post-secondary education and 5.9% (57 of 983) were employed. Approximately 70% (688 of 983) of attendees were born in Canada.

4.2.3. Prevalence of Healthy Behaviours for Individuals Who Attended Pharmacy Sessions

The prevalence of healthy behaviors in this population (See Table 10, Healthy behaviours of older adults who attended a cardiovascular health awareness pharmacy session) was high, with only 5-10% of the population reporting themselves in the unhealthiest risk category for lifestyle behaviours such as physical inactivity, immoderate alcohol consumption, smoking, high fat diet and high stress. On average, study participants were engaged in 3.5 (range=0 to 5) of these healthy lifestyle behaviours (physical activity, moderate alcohol consumption, not smoking, low fat diet and low stress). The distribution for monitoring one's own blood pressure in the previous year, a self-care behavior, was very different from the distribution for engaging in healthy lifestyle behaviours with approximately half of the population monitoring their own blood pressure. Correlations among healthy behaviours were examined (See Table 11, Correlations among healthy behaviours of older adults who attended a cardiovascular health awareness pharmacy session) and showed that moderate alcohol use and never smoking were highly correlated (phi=0.15, $p < 0.0001$), as were low stress and a low fat diet (phi=0.10, $p = 0.004$) but the magnitude of these correlations was not large.

Table 10. Healthy behaviours of older adults who attended a cardiovascular health awareness pharmacy session.

Healthy Behaviours	**%**
Typically, do you drink 2 or more alcoholic drinks per day? (No)	89.1
Are you moderately physically active for 30 to 60 minutes, most days of the week (e.g. brisk walking, active gardening, swimming, dancing or biking)? (Yes)	83.6
Do you smoke?	
Never	46.4
Not now, but previously	46.5
Yes	6.1
How much high fat or fast foods do you consume in your diet?	
Low	71.1
Moderate	27.6
High	1.0
In a typical week, how frequently do you feel overwhelmed or stressed by the demands on you?	
Seldom or never	68.3
Few times	26.7
Often or a lot of the time	4.9
In the last year have you measured your blood pressure yourself? (Yes)	47.4

Table 11. Correlations among healthy behaviours of older adults who attended a cardiovascular health awareness pharmacy session.

		1	2	3	4	5	6
1	Being physically active	-	0.01	0.05	-0.02	0.05	-0.04
2	Moderate alcohol use	-	-	0.16*	0.02	-0.008	-0.02
3	Never smoked	-	-	-	-0.02	-0.046	-0.04
4	Low fat diet	-	-	-	-	0.10*	0.01
5	Low stress	-	-	-	-	-	0.02
6	Blood pressure self-monitoring	-	-	-	-	-	-

Note: Correlations are reported as phi, the Pearson correlation coefficient adjusted for sample size.
*Statistically significant correlation, $p < 0.001$

4.2.4. Prevalence of Cardiovascular Comorbidities for Individuals Who Attended Pharmacy Sessions

The most prevalent cardiovascular comorbidities among individuals who attended the pharmacy sessions were high blood pressure (56.3%), high cholesterol (38.1%) and obesity (15.5%) (See Table 12, Prevalence of cardiovascular comorbidities among older adults who attended a cardiovascular health awareness pharmacy session).

Table 12. Prevalence of cardiovascular comorbidities among older adults who attended a cardiovascular health awareness pharmacy session.

Cardiovascular Comorbidities	**% Yes**
Stroke or TIA	8.6
Heart attack	12.3
Diabetes	13.9
Obesity	15.5
High blood pressure	56.3
High cholesterol	38.1

TIA=transient ischemic attack

The mean number of six possible cardiovascular comorbidities (heart attack, stroke, diabetes, obesity, high blood pressure and high cholesterol) in this population was 1.4 (range=0 to 6). Correlations among most pairs of cardiovascular diseases were significant (See Table 13, Correlations among cardiovascular comorbidities of older adults who attended a cardiovascular health awareness pharmacy session), as would be expected for conditions that are considered comorbid.

Table 13. Correlations among cardiovascular comorbidities of older adults who attended a cardiovascular health awareness pharmacy session (Reported as phi, the Pearson correlation coefficient adjusted for sample size).

		1	2	3	4	5	6
1	Heart Attack	-	0.06*	0.08**	0.11***	0.10***	0.15***
2	Stroke or TIA	-	-	0.11***	-0.03	0.06*	0.12***
3	Diabetes	-	-	-	0.10***	0.08**	0.09***
4	Obesity	-	-	-	-	0.11***	-0.03
5	High Blood Pressure	-	-	-	-	-	0.15***
6	High Cholesterol	-	-	-	-	-	-

Note: Correlations are reported as phi, the Pearson correlation coefficient adjusted for sample size; TIA=transient ischemic attack.

*Statistically significant correlation, $p < 0.05$; **Statistically significant correlation, $p < 0.01$; ***Statistically significant correlation, $p < 0.001$

The only associations that were not statistically significant at $p<0.05$ were between obesity and stroke or transient ischemic attack (phi=-0.03) and between obesity and high cholesterol (phi=-0.03). Correlation coefficients ranged from –0.03 to a maximum of 0.15. The correlations of 0.15 were observed for both the association between high blood pressure and high cholesterol and the association between high blood pressure and heart attack.

4.2.5. Other Variables Relevant to Healthy Behaviours in Older Adults

Frequency distributions of other variables that were relevant to an exploration of healthy behaviours in older adults were reported (See Table 14, Frequency distributions of variables relevant to healthy behaviours in older adults: health-related quality of life, health status, health services use, physician counseling and patient knowledge).

Table 14. Frequency distributions of variables relevant to healthy behaviours in older adults: health-related quality of life, health status, health services use, physician counseling and patient knowledge.

Variables Measuring Health-Related Quality of Life	
General self-rated health:	
Excellent	6.8%
Very Good	36.8%
Good	41.2%
Fair	12.0%
Poor	1.0%
Mean number limited activity days in the past 30 days	1.8 days
Mean number of physically unhealthy days in the past 30 days	1.4 days
Mean number of mentally unhealthy days in the past 30 days	1.0 days
Variables Measuring Health Status	
Depression in the past year (Yes)	13.2%
Variables Measuring Health Services Use	
Admitted to hospital in the past year (Yes)	14.7%
Attended more than one CHAT pharmacy session (Yes)	60.6 %
When was the last time your blood pressure was checked by a health professional?	
In the past month	38.4%
In the past 3 months	28.6%
In the past 6 months	13.5%
In the past 12 months	9.0%
More than 12 months ago	7.4%
In the last year has your family doctor measured your blood pressure? (Yes)	70.0%
Variables Measuring Physician Counseling	
Family doctor discussed the health risks of high blood pressure (Yes)	62.4 %
Family doctor uses patient handouts for lifestyle counseling? (Yes)	34.3 %
Variables Measuring Patient Knowledge	
Know your most recent blood pressure reading? (Yes)	40.5 %

Variables measuring health-related quality of life found that 43.6% individuals rated their health as either excellent or very good. The mean number of unhealthy days in the past 30 days was less than two days for variables measuring mental health, physical health and activity limitations. Approximately, 13% of individuals had been depressed in the previous year. Only 14.7% of individuals had been admitted to the hospital in the previous year. Variables related to blood pressure control and management indicated that 38.4% of individuals had their blood pressure checked by a health professional in the previous month and that 40.5% knew their most recent blood pressure reading. Approximately 60% reported that their family doctor had discussed the risks of high blood pressure with them and 34% had a family doctor who routinely used patient handouts for lifestyle counseling.

4.3. Population Attributable Fractions

4.3.1. Physiological Risk Factors

Three physiological conditions, high blood pressure, high cholesterol and obesity, were studied as risk factors for cardiovascular diseases and depression. High blood pressure was related to all five cardiovascular diseases studied (heart attack, stroke, diabetes, obesity and high cholesterol) with population attributable fractions ranging from 0.22 for heart attack to 0.43 for stroke (See Table 15, Relative risks and population attributable fractions calculated using prevalence and risk estimates from the study population). In other words, approximately one in five people can attribute their heart attacks to high blood pressure and two in five people can attribute their stroke to high blood pressure. Three cardiovascular comorbidites were also associated with high cholesterol: heart attack (AF_p=0.32), diabetes (AF_p=0.22) and high blood pressure (AF_p=0.12). The only condition that could be attributed to obesity was diabetes (AF_p=0.15).

None of the physiological risk factors (high blood pressure, high cholesterol and obesity) were considered responsible for depression, as population attributable fractions ranged from 0.00 to 0.06.

Table 15. Relative risks and population attributable fractions of physiological and behavioural risk factors for cardiovascular comorbidities and depression

Exposure	Disease	Relative Risk	Population Attributable Fraction (AF_p)
PHYSIOLOGICAL RISK FACTORS			
High Blood Pressure	Heart Attack	1.43	0.22
	Stroke	2.03	0.43
	Diabetes	1.54	0.26
	High Blood Pressure	-	-
	High Cholesterol	1.48	0.24
	Obesity	1.81	0.36
	Depression	0.97	0.00
High Cholesterol	Heart Attack	1.89	0.32
	Stroke	1.19	0.07
	Diabetes	1.58	0.22
	High Blood Pressure	1.29	0.12
	High Cholesterol	-	-
	Obesity	0.88	-0.05
	Depression	1.11	0.04
Obesity	Heart Attack	0.79	-0.03
	Stroke	0.63	-0.04
	Diabetes	1.78	0.15
	High Blood Pressure	1.30	0.05
	High Cholesterol	0.91	-0.01
	Obesity	-	-
	Depression	1.36	0.06
BEHAVIOURAL RISK FACTORS			
Physical Inactivity	Heart Attack	1.45	0.09
	Stroke	2.11	0.24
	Diabetes	1.63	0.13
	High Blood Pressure	0.96	-0.02
	High Cholesterol	0.99	0.00
	Obesity	1.73	0.15
	Depression	1.81	0.17
Immoderate Alcohol Use	Heart Attack	0.92	-0.01
	Stroke	0.76	-0.02
	Diabetes	0.59	-0.03
	High Blood Pressure	0.85	-0.01
	High Cholesterol	0.73	-0.02
	Obesity	1.53	0.08
	Depression	1.34	0.05
Ever Smoked	Heart Attack	1.48	0.23
	Stroke	1.31	0.16
	Diabetes	1.01	0.00
	High Blood Pressure	1.01	0.01
	High Cholesterol	0.98	-0.01
	Obesity	1.19	0.10
	Depression	1.08	0.04
High Fat Diet	Heart Attack	0.95	-0.02
	Stroke	0.84	-0.04
	Diabetes	1.17	0.05
	High Blood Pressure	1.01	0.00
	High Cholesterol	0.93	-0.02
	Obesity	1.80	0.25
	Depression	1.08	0.02
High Stress	Heart Attack	0.87	-0.04
	Stroke	0.99	0.00
	Diabetes	1.29	0.10
	High Blood Pressure	1.05	0.02
	High Cholesterol	1.16	0.05
	Obesity	1.06	0.02
	Depression	3.62	0.62

4.3.2. Behavioural Risk Factors

Physical inactivity was the unhealthy behaviour that had an impact on the largest number of cardiovascular comorbidities. For example, a proportion of stroke (AF_p=0.24), diabetes (AF_p=0.13) and obesity (AF_p=0.15) were attributable to physical inactivity. Ever having smoked was also an important behavioural risk factor for heart attack (AF_p=0.23) and for stroke (AF_p=0.16). None of the cardiovascular comorbidites could be attributed to immoderate alcohol use as population attributable fractions ranged from –0.02 to 0.08. A high fat diet was not considered responsible for any of the conditions except obesity (AF_p=0.15). Diabetes was attributed to high stress for approximately one in ten people (AF_p=0.10).

Population attributable fractions estimated for depression indicated that eliminating high stress among older adults levels would have the greatest impact on depression (AF_p=0.62). Also, a proportion of depression was attributed to physical inactivity (AF_p=0.17).

4.4. Structural Equation Modeling

4.4.1. Model Estimation and Evaluation

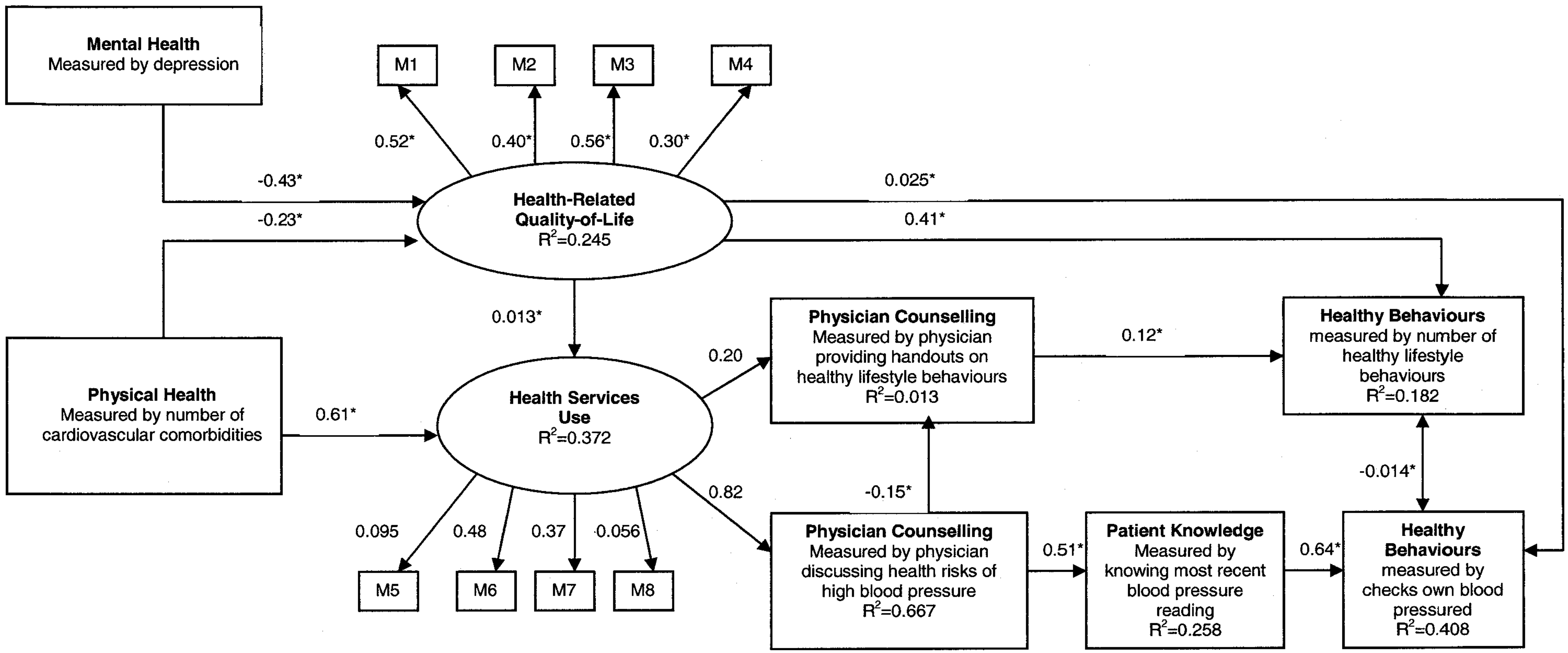
The specified model was estimated in one-step and measures of model fit were calculated. Model fit is evaluated based on the extent to which the hypothesized correlation matrix is equivalent to the observed sample correlation matrix (Hoyle, 1995). The observed sample correlation matrix is provided in Table 16 (Sample correlation matrix for observed variables used to estimate a structural equation model of healthy behaviours among older adults). As expected due to the large sample size (n=967), the chi-square for model fit indicated significant differences between the observed and hypothesized correlation matrices (X^2=152.8, degrees of freedom=47 $p < 0.00001$). The comparative fit index (0.87) was less than the desired 0.95 but the root mean square error of approximation was 0.048, which is below 0.06 and considered good fit (Rigdon, 1996; Hu & Bentler, 1999). Figure 6 (Originally hypothesized structural equation model of healthy behaviours among older adults with standardized coefficient estimates) shows the path diagram for the originally hypothesized model and reports the path regression coefficients and the corresponding R^2 statistics for each dependent variable.

Table 16. Sample correlation matrix for variables used to estimate a structural equation model of healthy behaviours among older adults.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Depression	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Number of Cardiovascular Comorbidities	0.036	**1.21**	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Self-Rated Health	0.26	0.24	**0.62**	-	-	-	-	-	-	-	-	-	-	-	-
4	Physical Unhealthy Days	0.21	0.13	0.29	**57.8**	-	-	-	-	-	-	-	-	-	-	-
5	Mental Unhealthy Days	0.31	0.026	0.23	0.38	**36.5**	-	-	-	-	-	-	-	-	-	-
6	Limited Activity Days	0.14	0.082	0.23	0.60	0.33	**33.2**	-	-	-	-	-	-	-	-	-
7	Admitted to Hospital	0.17	0.078	0.14	0.12	-0.24	0.11	-	-	-	-	-	-	-	-	-
8	Last Time Health Professional Checked BP	-0.011	0.29	0.081	0.10	0.043	0.081	0.14	-	-	-	-	-	-	-	-
9	Family Doctor Checked BP	0.048	0.21	-0.024	0.019	-0.013	0.045	0.10	0.29	-	-	-	-	-	-	-
10	Attended More than One Pharmacy Session	-0.17	-0.080	-0.067	0.027	-0.041	-0.039	-0.11	-0.024	0.023	-	-	-	-	-	-
11	Physician Handouts for Lifestyle Counseling	-0.18	0.098	-0.035	-0.058	-0.023	-0.085	0.092	-0.12	0.072	0.13	-	-	-	-	-
12	Physician Discusses Risks of High BP	-0.098	0.52	-0.14	0.014	0.005	0.007	-0.095	0.24	0.22	0.049	-0.053	-	-	-	-
13	Know Most Recent BP	-0.12	0.17	-0.12	-0.020	0.006	-0.001	0.035	0.25	0.18	-0.035	0.054	0.46	-	-	-
14	Number of Healthy Behaviours	-0.27	-0.082	-0.17	-0.114	-0.18	-0.125	-0.053	-0.071	0.005	-0.052	0.13	-0.050	0.072	**0.98**	-
15	BP Self-Monitoring	-0.081	0.21	-0.030	-0.002	-0.012	0.005	-0.11	0.095	0.15	-0.027	0.023	0.31	0.51	-0.006	-

BP=Blood Pressure

Note: Variances for continuous variables are bolded and run on the diagonal.



NOTE:

- Measures of health-related quality of life are: self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- Measures of health services use are: admitted to hospital in the last year (M5), the last time blood pressure was checked by a health professional (M6), whether or not family doctor checked blood pressure in past year (M7) and if attended more than one pharmacy session (M8).
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were $X^2=152.8$ (degrees of freedom=47, $p<0.00001$), Comparative fit index=0.87, Root mean square error of approximation=0.048

Figure 6. Originally hypothesized structural equation model of healthy behaviours among older adults with standardized coefficient estimates.

Due to the poor model fit as measured by the comparative fit index, post-hoc model modifications were considered. Two other reasons for evaluating a number of post-hoc model modifications were that, one, this is only a preliminary model of healthy behaviours in older adults, and, two, not all desired variables were available due to the nature of using secondary data for structural equation modeling.

4.4.2. Model Modification

The Lagrange multiplier modification indices were examined to determine if adding any pathways to the model would improve the model fit. No modification index value was greater than 100 and the largest observed value was 16.0, therefore, no paths were added to the model during post-hoc modifications. The statistical significance of the regression path coefficients was examined to determine if removing paths would improve model fit. This resulted in some modifications (See Appendix D, Figures D1 to D4, for path diagrams for intermediate models examined during post-hoc modifications).

1. In the originally hypothesized model, the latent construct health services use was not significantly reflected by the four observed variables: admitted to hospital, last time blood pressure checked by a health professional, blood pressure checked by family doctor in the past year and attended more than one pharmacy session. As well, paths between health services use and both measures of physician counseling (physician provides handouts on healthy lifestyle behaviours and physician discussed health risks of high blood pressure) were not statistically significant. Therefore, the construct health services use was removed from the model. Prior to removing the latent construct health services use modifications to the measurement model for health services use were evaluated but an optimal model could not be identified (See Figures D1 and D2, Appendix D). The theoretical rationale for justifying the removal of the latent construct health services use is that physician counseling may require a greater stimulus than contact with a patient (Ashden, Silagy & Weller, 1997; Hudon, Beaulieu & Roberge, 2004; Sims, Kerse, Naccarella et al., 2000). The model that excluded the latent construct health services use, had significantly better fit as measured by X^2= 66 (degrees of freedom=20, $p<0.00001$), a comparative fit index of 0.93 and a root mean square error of approximation of 0.049 (See Figure D3, Appendix D).

2. When the latent construct, health services use was excluded from the model, the observed variable, admitted to the hospital in the past year, was also excluded from the model. Because of the strong relationship between health services use and physical health needs (Coulton & Frost, 1982; Roos & Shaprio, 1981), being admitted to the hospital could also be considered a reflection of physical health status. Therefore, it was hypothesized that this variable might be included in the model as a variable measuring physical health. This would also have the advantage of having a measure of physical health that accounted for more conditions than simply cardiovascular comorbidities. Because of the disparities between the two measures of physical health, number of cardiovascular comorbidities and admitted to hospital in the past year, a latent construct for physical health was not considered appropriate. Therefore, the two variables measuring physical health were included in the model as two separately observed variables. This model had slightly worse fit than the model with only cardiovascular comorbidities as evaluated by a X^2=78.6 (degrees of freedom=24, p <0.00001), a comparative fit index of 0.92 and a root mean squared error of approximation of 0.049 (See Figure D4, Appendix D for modified model).
3. Because including two measures of physical health as separately observed variables increased the complexity of the model, a decrease in model fit was observed. Therefore, an additional model was hypothesized where physical health was reflected by only one observed variable, admitted to hospital in the past year. This was chosen as the more comprehensive measure of physical health because it incorporated more conditions than simply cardiovascular comorbidities. This model had a X^2=26 (degrees of freedom=14, p=0.02), a comparative fit index of 0.97 and a root mean square error approximation of 0.030. Because all measures of model fit indicated good model fit, no further modifications were made and this is presented as the final model (See Figure 7, Final structural equation model of healthy behaviours among older adults with standardized coefficient estimates).

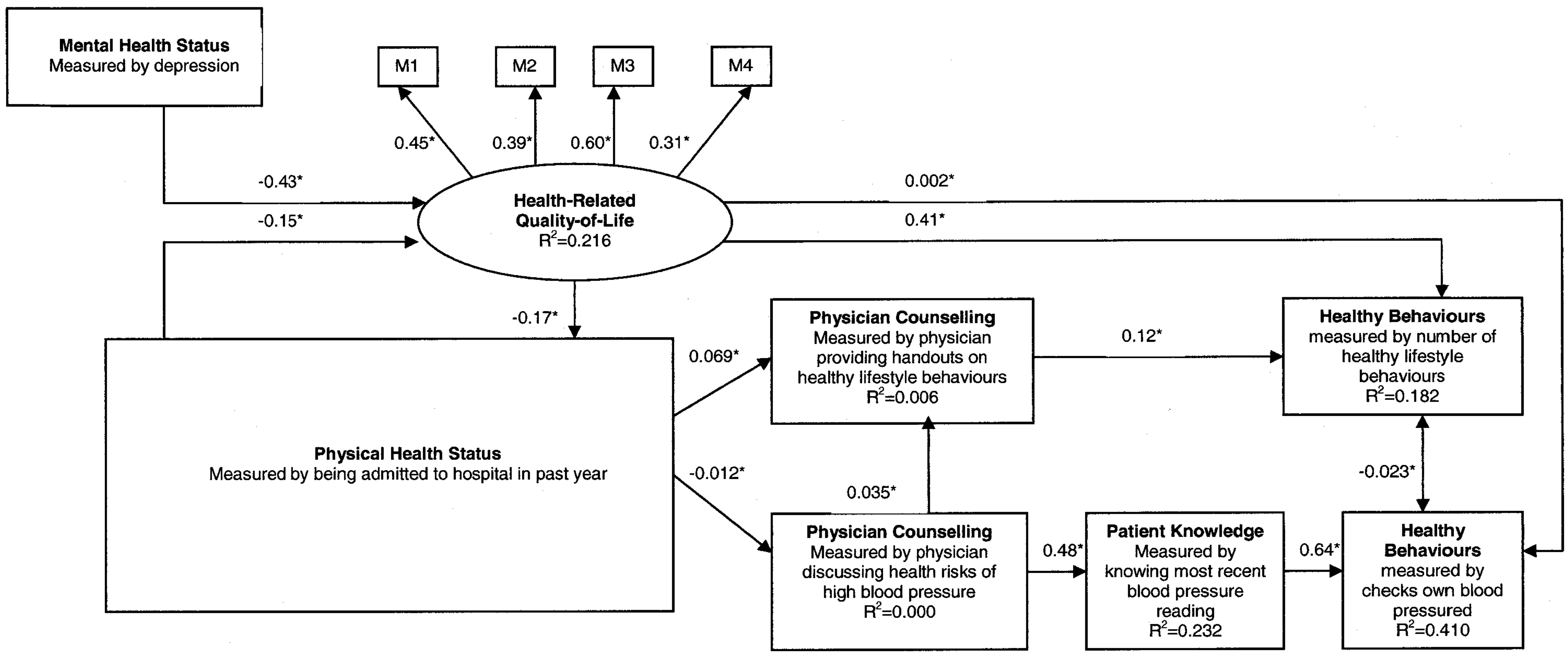
4.4.3. Evaluation of Model Pathways
All pathways in the final model were statistically significant at p<0.05. Additionally, all path regression coefficients in the fitted model were in the hypothesized directions

except for the small negative correlation between healthy lifestyle behaviours, as measured by the sum of five healthy behaviours engaged in, and healthy self-care behaviours, as measured by blood pressure-self monitoring (-0.023). The largest coefficients in the model were observed along the pathway from physicians discussing health risks of high blood pressure to knowing your most recent blood pressure reading to blood pressure self-monitoring (β = 0.48 and 0.64, respectively). Physical health status, as measured by being admitted to the hospital in the past year, did little to explain the variance in physician counseling, as measured by physicians providing information handouts during lifestyle counseling (R^2=0.006) and in discussing health risks of high blood pressure (R^2=0.000).

When constraints were imposed on the model to test the equivalence of selected model pathways, the path from health-related quality of life to number of healthy lifestyle behaviours (β=0.41) was significantly different ($p<0.00001$) from the path from health-related quality of life to blood pressure self-monitoring (β=0.002). In contrast, the path from patient knowledge to blood pressure self-monitoring (β=0.64) was not significantly different (p=0.29) from the path between physician counseling and number of healthy lifestyle behaviours (β=0.12). When the pathway from health-related quality of life to number of healthy lifestyle behaviours (β=0.41) was compared with the pathway from physician counseling to number of healthy lifestyle behaviours (β=0.12), a model could not be estimated when the two paths were estimated to be equivalent, indicating a significant difference between the fit of the constrained and unconstrained model (C McIntosh, personal communication, April 2006). When the pathway from health-related quality of life to blood pressure self-monitoring (β=0.002) was compared with the pathway from patient knowledge to blood pressure self-monitoring (β=0.64), the two paths were significantly different ($p<0.00001$).

4.4.4. Subgroup Analysis

Univariate regressions found that being female, being currently married, being older and being more educated were significantly related to checking one's blood pressure. Employment status and country of birth were not associated blood pressure self-monitoring. The only demographic variable significantly related to a greater number of healthy lifestyle behaviours was being currently married ($p < 0.0001$) (See Table 17, Results



NOTE:

- Measures of health-related quality of life are: self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were $X^2=26$ (degrees of freedom=14, p=0.02), Comparative fit index=0.97, Root mean square error of approximation=0.039

Figure 7. Final structural equation model of healthy behaviours among older adults with standardized coefficient estimates.

of univariate regressions examining the association of demographic variables (sex, age, marital status, education, employment status and country of birth) with healthy behaviours (number of healthy lifestyle behaviours and blood pressure self-monitoring).

Table 17. Results of univariate regressions examining the association of demographic variables (sex, age, marital status, education, employment status and country of birth) with healthy behaviours (number of healthy lifestyle behaviours and blood pressure self-monitoring).

	Healthy Behaviours			
	Blood pressure self-monitoring		Total number of healthy lifestyle behaviours	
Demographic Characteristics	β	p-value	β	p-value
Age	-0.052	< 0.001	0.001	0.87
Female	0.74	< 0.001	- 0.087	0.20
Currently married	-0.52	< 0.001	0.33	<0.001
Higher Education	0.16	< 0.001	0.046	0.06
Employed	0.00	1.00	- 0.124	0.37
Canadian-born	-0.14	0.32	- 0.071	0.32

5. DISCUSSION

5.1. Data Sources

Understanding healthy behaviours among older adults is important because this is a growing population who bear a significant proportion of the burden of chronic disease. Policy initiatives to encourage healthy behaviours among older adults should be guided by high-quality evidence. One of the first steps in providing high-quality evidence to policymakers is being able to accurately assess the burden of disease in populations. The availability of different data sources on approximately 1,000 community-dwelling older adults in Ontario offered an opportunity to estimate the level of agreement between self-reported cardiovascular diseases and office health record diagnoses. This is important, as there are concerns that recall bias may be of considerable importance among older adults whose cognitive functioning may be declining (Simpson, Boyd, Carlson et al., 2004).

Results indicated that of the diseases studied, self-reported diabetes most closely agreed with disease status as reported in the heath record in the family physician's office (LLR=56.5, Sensitivity=86%, Specificity=98%). This is consistent with other studies such as Bayliss, Ellis, Steiner et al. (2005) who reported sensitivity of 88% and specificity of 98% for diabetes reporting among older adults as well as Kreigsman, Penninx, Van Eijk et al. (1996) who reported a kappa of 0.85 for diabetes reporting. Good agreement has also previously been reported for stroke and heart disease (Simpson, Boyd, Carlson et al., 2004; Klungel, De Boer, Paes et al., 1999). Although for heart attack, good agreement was indicated by a likelihood ratio greater than 10 (LLR=12.4), sensitivity was low (36.6%), indicating a large number of false negatives. This is not surprising, given that the office health record estimated the presence of heart disease and the questionnaire only asked if the individual ever had a heart attack, which is a subset of heart disease. Measures of hypertension only showed moderate agreement between self-report and health records, which is similar to other studies. For example, one study reported a kappa value of 0.43 for hypertension diagnosis (Klungel, De Boer, Paes et al., 1999) while another reported a kappa value of 0.71 for hypertension diagnosis (Bush, Miller, Golden et al., 1989). Sensitivity (79.6%) and specificity (78.2%) in this analysis were similar for hypertension diagnosis, indicating that misclassification was a result of both false positives and false negatives. The false negatives may be explained by the asymptomatic nature of hypertension, which would lead individuals to underreport high blood pressure because of the lack of observed symptoms (Hajjar & Kotchen, 2003). For measures of hypertension medication adherence, sensitivity (83.0%) was lower than specificity (90.3%), indicating more false negatives than false positives. Misclassification in both directions may have been due to individuals who did not know the purpose of medications they were prescribed. The positive predictive value was higher for taking hypertension medication (94.0%) than for hypertension diagnosis (85.2%), indicating a greater proportion of correct positive classifications when hypertension is assessed through self-report of medication use rather than by diagnosis. In the future, therefore, self-reported use of hypertension medication may be a better measure than self-reported hypertension diagnosis to estimate hypertensive status. This adds support to prior research indicating that medication reviews are an appropriate method of assessing disease status (for example MacKnight & Rockwood, 2001; Malone, Billups, Valuck et al., 1999). The only healthy behaviour in this study that was measured by both self-report and health record reviews was current smoking status. A high likelihood ratio was observed, indicating good agreement (LLR=27.9). A similar study comparing smoking data on individuals 15-74 years also found good agreement between self-reported and health record information on smoking status (kappa=0.83) (Wilson, Manku-Scott & Jones, 2000). Overall, these estimates found that self-reporting by older adults had good agreement with information found in office health records.

A number of studies evaluating the level of agreement between self-report and health record reviews reported kappa values (for example, Simpson, Boyd, Carlson et al., 2004; Klungel, De Boer, Paes et al., 1999; Bush, Miller, Golden et al., 1989). Calculating measures such as specificity, sensitivity and positive predictive values to assess agreement between data sources, should be encouraged over kappa values because they allow one to estimate the direction of misclassification (Guyatt & Rennie, 2002). The likelihood ratio also has the advantage of being a global measure that incorporates both specificity and sensitivity into its estimates of the level of agreement between sources.

5.2. Representativeness of the Population

Study participants were a group of older adults invited by their family physician to attend a cardiovascular health awareness pharmacy session. Although this is a practice-based sample, an analysis of the National Population Health Survey reported that 90% of individuals over 65 years of age have a regular family physician (Rosenberg & Moore, 1997) and that 92% of individuals in Canada aged 40 to 78 years visit their family physician at least once a year (Finkelstein, 2001). Thus, practice-based samples of older adults should be representative of over 90% of older community-dwelling adults.

Comparisons of health records between attendees and non-attendees found no differences between the two groups, indicating that attendees are no healthier than typical patients in a general practice (See Table 9, Comparison of attendees of (n=333) pharmacy sessions vs. non-attendees (n=439) of pharmacy sessions based on relevant variables available in health record reviews). While this provides evidence of the comparability of pharmacy session attendees with respect to disease status and health services use, the office health record data did not permit comparisons of variables related to healthy behaviours and demographic factors.

When healthy behaviours of study participants were compared with a representative sample of older Canadians from the National Population Health Survey (Newsom, Kaplan & Huguet et al, 2004) it was observed that fewer older Canadians were current smokers than the sample in this thesis (6% compared with 17%), and that older Canadians were more physically active than the sample in this thesis (84% compared with 55%). Therefore, this sample appears to be healthier than average Canadians with respect to behaviours such as smoking and physical activity. This may be due to a healthy volunteer effect, whereby those who participate in health promotion programs are healthier than the general population (Aschengrau & Seage, 2003). In contrast, 10% of older Canadians drank more than 2 alcoholic drinks per day compared with only 1.5% of the study participants. The lower alcohol consumption among pharmacy session attendees may be due, in part, to the higher educational attainment of this sample: 39% completed post-secondary education compared with the national average of 17% for individuals 65 years and older as reported in the 2001 Canadian census (www.statcan.ca, Cat No. 97F0017SCB2001001). There is evidence that lower alcohol consumption is associated with higher socio-economic status, which can be reflected by educational attainment (For example: Van Oers, Bongers, Van de Goor et al., 1999; Fillmore, Golding, Graves et al, 1998). It should be noted that in both the National Population Health Survey and in this study, data on healthy behaviours were collected through self-report measures, which may overestimate the prevalence. Social desirability biases individuals towards reporting more correct behaviours such as a healthier diet and increased physical activity (Motl, McAuley & DiStefano, 2005; Hebert, Clemow, Pbert et al., 1995)

There is debate in the literature as to whether or not healthy behaviours are correlated with each other. Previous research has postulated that clustering of healthy behaviours is common and occurs when an attitude of health consciousness exists (Ma, Betts & Hampl, 2000). Despite this theory, a recent analysis of smoking, diet and exercise in four large population health surveys (The National Population Health Survey, The National Health Interview Survey, The Behavioral Risk Factor Surveillance System and the National Health and Nutrition Examination Survey) could not find large correlations among healthy behaviours (Newsom, McFarland, Kaplan et al., 2005). Newsom, McFarland, Kaplan et al. (2005) reported that the largest correlation found between healthy behaviours was for smoking and diet, $r = -0.224$. In this thesis, only two statistically significant healthy behaviour correlations were observed: between moderate alcohol use and never smoking (phi=0.15) and between low stress and a low fat diet (phi=0.10) and the magnitude of these correlations was small. The lack of correlation between different healthy behaviours provided further support for not including a latent construct reflecting a uni-dimensional concept of healthy behaviours in the structural equation modeling analysis (Fayers & Hand, 1997).

Study participants reported an average of 1.4 cardiovascular comorbidities. Wolff, Starfield & Anderson (2002) found that 65% of aged Medicare recipients have multiple chronic conditions, with the mean number of chronic conditions being 2.3. This appears to be a comparable estimate of disease burden in light of the fact that the number of cardiovascular comorbidities would underestimate the burden of disease in this population, as it does not account for other chronic conditions. Most correlations among different cardiovascular diseases (heart attack, stroke, diabetes, obesity, high blood pressure and high cholesterol) were statistically significant as would be expected since many of these conditions are comorbidities (See Table 13, Correlations among cardiovascular comorbidities of older adults who attended a cardiovascular health awareness pharmacy session). The magnitude of correlations was not large, though, which is expected due to the dichotomous nature of the variables being correlated (MacCallum, Zhang, Preacher et al., 2002).

5.3. The Attributable Fraction in the Population

In addition to having accurate estimates of the burden of disease, priority setting by policymakers requires accurate estimates of the relative contributions of risk factors to the burden of disease. Population attributable risk fractions are one method of estimating this. The limited data set with dichotomous categorical outcomes measuring healthy behaviours and morbidity limited the ability to calculate estimates of the population attributable fraction based on CHAT data using the same methodology as the Global Burden of Disease Study (Murray & Lopez, 1996). Additionally, only a small subset of diseases were measured in the CHAT study while the Global Burden of Disease Study estimated the effect of risk factors on all-cause mortality and all-cause disability-adjusted life years (Murray & Lopez, 1996). Therefore, in this thesis, the relationships between five behavioural risk factors (physical inactivity, alcohol use, smoking, high fat diet, high stress), three physiological risk factors (high blood pressure, high cholesterol and obesity), six cardiovascular comorbidities (heart attack, stroke, diabetes, high blood pressure, high cholesterol and obesity) and depression were estimated.

When comparisons were made between population attributable risk estimates from the CHAT study and from the Global Burden of Disease Study, similar trends were observed. The Global Burden of Disease Study found that 12.9% of mortality and 4.7% of disability-adjusted life years were attributable to hypertension, ranking it number two of the 10 risk factors that were studied (Murray & Lopez, 1996). In this thesis, hypertension, or high blood pressure, consistently emerged as a risk factor that, if targeted, would reduce the burden of cardiovascular diseases. It was responsible for a large proportion of heart attack (22%), stroke (43%), diabetes (26%), obesity (36%) and high cholesterol (24%), confirming its importance as a risk factor for cardiovascular disease. In the Global Burden of Disease Study, the risk factor responsible for the largest burden of mortality (14.5%) and disability-adjusted life years (12.1%) was tobacco use (Murray & Lopez, 1996). In this thesis, a proportion of heart attack (23%), stroke (16%) and obesity (10%) were related to ever having smoked. Because diseases such as cancer, which have a strong causal relationship with tobacco use, were not included in the CHAT study, much of the burden of mortality and morbidity assessed in The Global Burden of Disease Study is not captured by these estimates. In the CHAT study, being physically inactive had the most widespread impact of the behavioural risk factors. It substantially affected the incidence of depression (AF_p=0.17), stroke (AF_p=0.24), diabetes (AF_p=0.13), and obesity (AF_p=0.15) in this population. Again, this is consistent with trends from the Global Burden of Disease Study, which ranked it as the third most important risk factor. Population attributable fractions from the Global Burden of Disease Study estimate that eliminating physical inactivity would reduce mortality by approximately 10% and disability-adjusted life years by 4% (Murray & Lopez, 1996). The final risk factor that was evaluated in both the Global Burden of Disease Study and this thesis was alcohol use. In the Global Burden of Disease Study, 1.9% of mortality and 9.6% of disability-adjusted life years were associated with immoderate alcohol use (Murray & Lopez, 1996). Of the diseases studied in this thesis, none displayed strong relationships with immoderate alcohol use. This is not surprising as the burden of alcohol use is more often related to liver diseases and accidents or injuries (Murray & Lopez, 1996). As well, alcohol use may be protective for cardiovascular diseases in some cases (Murray & Lopez, 1996). The Global Burden of Disease Study identified hypertension, tobacco use, alcohol use and physical inactivity as important risk factors for all-cause mortality and disability-adjusted life years. This thesis provides support that three of these risk factors, hypertension, tobacco use and physical inactivity are also important risk factors contributing to cardiovascular diseases and, in the case of physical inactivity, to depression, as well.

In addition to the four risk factors estimated in the Global Burden of Disease Study (hypertension, tobacco use and alcohol use and physical inactivity), the CHAT study collected data on additional risk factors including high cholesterol, obesity, high stress and a high fat diet. A report issued by the WHO in 2002, which was based, in part, on the methodology developed by Murray & Lopez in the Global Burden of Disease Study (WHO, 2002), studied the population attributable fractions for mortality of a number of risk factors including high cholesterol, being overweight and low fruit and vegetable intake. The WHO report (2002) found that 7.6% of all-cause mortality was related to high cholesterol levels. This thesis confirmed that high cholesterol is an important disease risk factor since a large proportion of heart attack (32%), diabetes (22%) and high blood pressure (12%) were associated with high cholesterol. Additionally, the WHO report (2002) found that 7.4% of all-cause mortality was related to being overweight. Estimates from this thesis found that only diabetes was related to obesity (AF_p=0.15). This was surprising as obesity is often reported as a risk factor for a number of cardiovascular diseases; further work should be done in additional populations to verify these findings. While a high fat diet was not one of the risk factors evaluated in the WHO report (2002), one of its potential corollaries, a diet low in fruit and vegetables was explored and it was found that 3.9% of mortality was related to this poor diet. In this sample, the only condition that was associated with a high fat diet was obesity (AF_p=0.25). No studies were found that estimated the attributable fraction of stress on morality or morbidity. Nonetheless, the association between cardiovascular comorbidities and high stress levels or between depression and high stress levels has previously been established (Blazer & Hybels, 2005; Levenstein, Smith & Kaplan, 2001; Seeman, 2000). This thesis found that stress was responsible for a large proportion of depression (62%). The elderly years can be a period of major transitions with stressful life events such as the death of a spouse, declines in physical functioning and changes in employment status (Blazer & Hybels, 2005). Interventions to alleviate stress in older adults, such as increasing social support may, therefore, improve health outcomes (Kaplan, Strawbridge, Camacho et al., 1993), and should be considered by population health policymakers. It was surprising that a meaningful proportion of conditions such as high blood pressure and heart attacks was not associated with high stress levels as these relationships have been previously reported (for example, Levenstein, Smith & Kaplan, 2001).

When the contributions of the five behavioural risk factors and three physiological risk factors to disease burden were studied in this thesis, it was determined that high blood pressure and physical inactivity, which were ranked second and third by the Global Burden of Disease as risk factors for all-cause mortality, were the two exposures that, if eliminated would eliminate the largest burden of cardiovascular disease and depression in this population. Additionally, eliminating stress among older adults would eliminate a large portion of depression.

While, the population attributable fractions are comparable to those observed in other studies including the Global Burden of Disease Study (Murray & Lopez, 1996) and the WHO Report (WHO, 2002), they should be considered preliminary estimates due to methodological concerns that were encountered during the analysis. First, Murary & Lopez (1996) recommend using relative risks from an external source to estimate the population attributable fraction. Because comparable relative risk estimates from an external source could not be identified, relative risks from the CHAT study population were used to calculate the population attributable fraction. One of the consequences of calculating the population attributable risk using incorrect relative risk estimates is that population attributable fractions may be overestimated (Tanuseputro, Manuel, Schultz et al., 2005; Flegal, Graubard & Williamson, 2004). This may be one of the reasons that high population attributable fractions were observed in this thesis. Additionally, due to the nature of the questions asked in the surveys, a zero exposure level could not be set for many of the unhealthy behaviours as recommended by Murray & Lopez (1996). These concerns are in addition to common issues that must be considered with population attributable risk estimates such as potential misclassification due to a lag-time bias when the consequences of changes in exposure are not immediately observed (Tanuseputro, Manuel, Schultz et al., 2005). Furthermore, the population attributable risk is an estimate that only has full value when a causal relationship between the exposure and the outcome has been firmly established (Aschengrau & Seage, 2003). For these reasons, the magnitude of the population attributable fractions in this analysis should be treated with caution and should be verified in other regional-level datasets before being used to guide policy.

5.4. Structural Equation Modeling

After establishing the importance of healthy behaviours among older adults, it is also important that the determinants of whether older adults engage in healthy behaviours are identified. Using high-quality evidence from prospective, population-based studies in this thesis to guide the specification of a unified model of healthy behaviours among older adults was essential so that this model can eventually be a useful tool for policymakers when setting priorities. Prospective studies identified six important variables that were included in the model of healthy behaviours in older adults: health status, health-related quality-of-life, health services use, physician counseling, patient knowledge and healthy behaviours. The specified model, therefore, presented a unified exploration of healthy behaviours in older adults, by reflecting the influences of biological (health status) psychosocial (health-related quality of life) behavioural (healthy behaviours) and environmental (health services use, physician counseling) variables.

5.4.1. A Structural Equation Model of Healthy Behaviours Among Older Adults

The originally hypothesized model had only moderate fit as evaluated by the comparative fit index (0.87) (See Figure 6, Originally hypothesized structural equation model of healthy behaviours among older adults with standardized coefficient estimates). Because this was a preliminary analysis of a model of healthy behaviours in older adults, some post-hoc modifications to the model were explored. The final model was based on two major modifications: one, removing the construct of health services use from the model and, two, substituting the original measure of physical health status, number of cardiovascular comorbidities, with being admitted to the hospital in the past year. This resulted in a well-fitting model of healthy behaviours in older adults (comparative fit index=0.97, root mean square error of approximation=0.031). By having a well-fitting model, this thesis analysis confirmed the importance of the variables reported in population-based prospective studies (health status, health-related quality of life, physician counseling and patient knowledge) to a model of healthy behaviours among older adults (See Figure 7, Final structural equation model of healthy behaviours among older adults with standardized coefficient estimates).

The one variable that was not included in the final model of healthy behaviours among older adults was that of health services use. In the originally hypothesized model, health services use was not significantly related to increased physician counseling. This may be due to the fact that engaging in physician lifestyle counseling requires a greater stimulus than contact with a patient (Ashden, Silagy & Weller, 1997; Hudon, Beaulieu & Roberge, 2004; Sims, Kerse, Naccarella et al., 2000). A number of barriers to physician counseling have been identified in cross-sectional studies such as insufficient time, lack of financial incentives for the physician and lack of physician training in behaviour modification strategies (Hudon, Beaulieu & Roberge, 2004). Similarly, the one prospective population-based study that examined determinants of physician counseling reported that physicians who received a multi-faceted educational intervention regarding the importance of healthy lifestyle behaviours in older adults, improved the health of their older patients, presumably by engaging in more healthy behaviour lifestyle counseling with them (Kerse, Flicker, Jolley et al., 1999).

Physician demographics, patient demographics and practice characteristics may also be important determinants of whether or not a physician engages in behaviour counseling (Goldstein, DePue, Kazure et al., 1998). For example, one survey found that lifestyle counseling on smoking is more often provided to men than women and to younger patients than older patients (Arber, McKinlay, Adams et al., 2004). Also, it has been observed that patients with important cardiovascular risk factors are more often given lifestyle advice than those without these risk factors (Little, Slocock, Griffin et al., 1999). This most likely reflects an approach to lifestyle counseling that targets high-risk populations rather than a population-based approach. Another survey of 430 British family physicians reported that physicians in solo practices spent more time on counseling than physicians from group practices (McAvoy, Kaner, Lock et al., 1999). Thus, the relationships of these patient characteristics, physician characteristics, and practice characteristics to physician counseling behaviour should be studied in high-quality prospectively designed studies and potentially included in future developments of an evidence-guided model of healthy behaviours among older adults.

The other reason that the construct of health services use was removed from the model during post-hoc modifications was because difficulties were encountered in developing a measurement model for health services use. This may have been due to the disparities among the observed variables reflecting health services use. For example, being admitted to the hospital and having blood pressure monitored by your family doctor in the previous year might be more accurately said to measure two different aspects of health services use, than to reflect the same aspect of health services use. Traditionally, structural equation modeling has only been applied to reflective latent constructs, that is, those in which the observed variables all reflect the same latent construct (MacKenzie, Podsakoff & Jarvis, 2005). Recently, exploratory simulation analyses have been conducted to apply structural equation modeling to composite latent constructs, that is, those in which the observed variables combine to form a construct as appears to be the case with health services use (MacKenzie, Podsakoff & Jarvis, 2005). This research is still in exploratory phases but when further developed, would be useful in datasets such as were evaluated in this thesis. For example, a simpler model, as outlined in Figure 2

(A general model of relationships among healthy behaviours and five relevant determinants (health status, health-related quality of life, health services use, physician counseling, patient knowledge) that were identified using high-quality evidence from prospective population-based studies in adults 65 years and older), might be developed that includes composite latent constructs for health services use, physical health, physician counseling and healthy behaviours instead of including many single observed variables as was done in this thesis.

The second major modification to the model was to replace the number of cardiovascular comorbidities with being admitted to the hospital in the past year as a measure of physical health status. This change was proposed once the latent construct of health services use was removed because of the strong relationship between physical health and being hospitalized (Shaprio & Roos, 1982; Roos & Shapiro, 1981; Coulton & Frost, 1982). Additionally, it was felt that this was a more global measure of physical health status that would reflect a greater range of conditions than simply cardiovascular comorbidities.

All pathways in the final model were statistically significant and the direction of all path regression coefficients was in the hypothesized direction (See Figure 7, Final structural equation model of healthy behaviours among older adults with standardized coefficient estimates). The one exception was that a positive correlation was hypothesized between blood pressure self-monitoring and number of healthy lifestyle behaviours. A small negative correlation (-0.023) was observed. Due to the small magnitude of this correlation, the direction was not considered an important finding. The small magnitude of the correlation also provided support for modeling healthy self-care behaviours and healthy lifestyle behaviours as separate types of health behaviours.

For each of the two healthy behaviour outcomes, two main pathways were modeled: one from health-related quality of life and the other from physician counseling. For blood pressure self-monitoring, the path from patient knowledge was greater than that from health-related quality-of-life ($\beta=0.64$ compared with $\beta=0.002$). This may be because self-care behaviours such as blood pressure monitoring are often a response to existing disease, therefore, physician influence through diagnosis and counseling may increase patient knowledge and, therefore, be more important than perceived health (Harris, Petrella, Lambert-Lanning et al., 2004; Little, Slocock, Griffin et al., 1999; Haug, Wykle & Namazi, 1989).

The path from physician counseling to healthy lifestyle behaviours was not as large as the path from health-related quality of life (β=0.12 compared with β=0.41). This is consistent with a systematic review of family physicians' effectiveness in changing patients' lifestyle behaviours, which concluded that that the physician's impact on changing behaviours, although significant, was small (Ashden, Silagy & Weller, 1997). Similarly, Resnick (2003) reported that when older adults were surveyed, one of the reasons they reported not engaging in health promotion activities was because their health care provider had never told them to do so. These reports support an important role for physician counseling in a model of healthy behaviours among older adults. The magnitude of the effect may be small, though, due to physicians' inability to provide effective behaviour modification strategies (Hudon, Beaulieu & Roberge, 2004). The large magnitude of the path regression coefficient from health-related quality-of-life to healthy lifestyle behaviours (β=0.41) indicates the importance of the individual's own perceptions of health in relation to engaging in healthy behaviours. This provides support for many of the existing social-cognitive frameworks related to healthy behaviours (for example, The Health Beliefs Model or Bandura's Self-Efficacy Model).

The largest parameter estimate was for the relationship between patient knowledge and blood pressure self-monitoring (β=0.64), supporting the important role educational interventions can play in increasing knowledge and changing behaviours. Many health interventions are aimed at teaching individuals to change behaviours. Education alone is often not enough to change behaviours, thus it is important that multiple influences on healthy behaviours are identified, as was done in this model of healthy behaviours among older adults. Multi-level, multi-strategy interventions are often necessary to effect behaviour change (Edwards, Mill & Kothari, 2004). Unified, quantitative models such as the one developed in this thesis can contribute to identifying different pathways to healthy behaviours that can be targeted with interventions and the relative importance of different pathways such as health-related quality of life and physician counseling.

While other attempts have been made to use structural equation modeling to understand healthy behaviours and quantitatively evaluate the relative contributions of variables to healthy behaviours, it is often difficult to compare models. A different set of variables was used in each of three structural equation models that were identified as modeling healthy behaviours (Resnick, 2003; Kostner, 1996; Barkley, 2005). For example, a model of healthy behaviours among army personnel identified stress and socio-demographic characteristics as important variables related to healthy behaviours (Kostner, 1996). A similar attempt to model healthy behaviors in older adults used the National Health and Nutrition Examination Survey population-based survey but was unsuccessful due to difficulties in specifying appropriate relationships among the determinants of healthy behaviours (Barkley, 2005). The importance of model specification in structural equation modeling cannot be emphasized enough. It is also important to remember that although in this current analysis the hypothesized relationships were found to be a well-fitting model for healthy behaviours in older adults, structural equation modeling does not offer proof that this model is the only correct model; rather, it should be considered one of many possible models that may fit the observed data (McDonald & Ho, 2002).

5.4.2. The Influence of Demographic Characteristics on Healthy Behaviours in Older Adults

Because differences in pathways to healthy behaviours among different subpopulations could not be estimated in a multi-group analysis due to sample size limitations, univariate regressions were conducted as an exploratory analysis of the influence of demographic characteristics on healthy behaviours (See Table 17, Results of univariate regressions examining the association of demographic variables (sex, age, marital status, education, employment status and country of birth) with healthy behaviours (number of healthy lifestyle behaviours and blood pressure self-monitoring).

The only demographic characteristic that was significantly related to both healthy lifestyle behaviours and healthy self-care behaviours was marital status. This replicates the findings in the literature in which married individuals are more likely to engage in healthy behaviours, possibly due to increased social support provided by a spouse. Country of birth was not associated with either blood pressure self-monitoring or healthy lifestyle behaviours. This was unexpected as a healthy immigrant effect, whereby immigrants to Canada are healthier than the general population, may contribute to increases in healthy behaviours. It may be that the healthy immigrant effect is not as strong in older populations such as were studied in this thesis but might only be reflective of younger immigrant populations (Gee, Kobayashi & Prus, 2004; Ali, McDermott & Gravel, 2004)

Two variables reflecting socioeconomic status were studied: education level and employment status. Education showed a significant association with blood pressure self-monitoring ($p < 0.001$) and a marginally non-significant relationship with increased healthy lifestyle behaviours ($p=0.06$). The relationship between higher education and increased healthy behaviours has been consistently reported in literature (for example, Newsom, Kaplan, Huguet et al., 2004; Kubzansky, Berkman, Glass et al., 1998). This relationship may be due a greater understanding of the benefits of healthy behaviours on health status among more highly educated individuals. As well, conditions associated with higher socio-economic status such as increased financial resources, a healthier environment and increased leisure time may facilitate engaging in healthy behaviours. Being employed was not significantly associated with either healthy self-care behaviours or healthy lifestyle behaviours in this thesis, reflecting the fact that in a Canadian population 65 years and older, this may not be a good indicator of socioeconomic status.

In this population, being female was related to increased healthy self-care behaviours, as measured by blood pressure self-monitoring. This confirms findings from the literature review of healthy behaviours in older adults (See Table 3, A summary of evidence for variables related to healthy behaviours in adults 65 years and older from population-based longitudinal cohort studies and randomized controlled trials) where being female was associated with increased self care behaviours (Haveman-Nies, De Groot & Van Staveren, 2003) but not with increased healthy lifestyle behaviours (Armstrong & Morgan, 1998). Similarly, other reports of healthy behaviours in older adults have found that sex differences vary with respect to the health behaviour under consideration (Newsom, Kaplan, Huguet et al., 2004).

Due to the exploratory nature of the influence of demographic characteristics on healthy behaviours in older adults, the presence of confounding relationships with other variables such as health status was not taken into consideration. Future analyses with larger sample sizes that permit comparisons of model fit between important subpopulations, such as males and females, will also control for potential confounders.

5.4.3. Limitations of the Structural Equation Model of Healthy Behaviours in Older Adults

Because this thesis only included high-quality evidence on healthy behaviours among older adults, only five prospective population-based studies in adults over 65 years were identified that reported on healthy behaviour outcomes. Also, among these five studies, many parameters differed such as follow-up periods and the age of populations, so the results may not be strictly comparable across studies. Additionally, longitudinal studies among older adults are susceptible to survivor bias, where healthy individuals are more likely to be alive at follow-up and so conclusions may be based on an elite healthy subgroup of the general population (Szklo & Nieto, 2004). Finally, measures that were reported on in literature were not always available in the selected data set. Because one of the advantages of structural equation modeling is the ability to model latent constructs, other measures were identified in the data set that would reflect the same latent construct. For example, the number of cardiovascular comorbidities instead of a change in physical function was originally selected to reflect the latent variable physical health.

The low explanatory value of some of the variables, as measured by the R^2 values, indicates that variables are missing from the model. Additional measures of patient knowledge, physician counseling and health status may improve the explanatory value of some of the model variables. Also, due to the many variables specifically related to high blood pressure, such as knowing your most recent blood pressure reading and blood pressure self-monitoring, the generalizability of this model to all healthy behaviours may be low.

Also, data was sometimes aggregated, and information was lost in the process that could have contributed to model estimation. For example, five different healthy behaviours were reflected in the one observed variable total number of healthy behaviours. This may not be an appropriate way to represent healthy behaviours but investigating the properties of the summed healthy behaviour score was beyond the scope of this thesis due to the limited nature of the data collected on healthy behaviours.

5.4.4. Implications of Model Results

All models are simplified approximations to reality, regardless of the analytical technique used or the efforts to correctly specify the model. Nonetheless, these findings confirm the importance of variables that were identified in prospective population-based longitudinal studies and randomized controlled trials (health status, health-related quality-of-life, physician counseling and patient knowledge) and their relevance in a population of older adults in Ontario. These results also underscore the importance of physician health behavior counseling for older adults. Evidence exists that changing health behaviors even at a later age in life can have a positive influence on health outcomes and quality-of-life (Peel, McClure & Bartlett, 2005). It is important that physicians recognize this and encourage healthy behaviors during visits with older adults. The inability of this model to provide a better understanding of determinants of physician behaviour counseling is an indication that future research is required in this area. Additionally, health-related quality-of-life appears to have an important role in influencing whether or not older adults engage in healthy behaviors. Therefore, modifying perceptions of health status may potentially increase participation in healthy behaviours.

5.4.5. Future Directions in Structural Equation Modeling

This is a preliminary model and further development is necessary before it can be a useful tool for policymakers. First, researchers should be encouraged to analyze data from existing longitudinal studies in aging in order to provide a stronger evidence-base for understanding healthy behaviours in older adults. Second, future work on this model should include a larger sample size to permit subgroup analysis as well as more measures that are relevant to healthy behaviours in older adults. Two options exist for conducting future analyses. One option is to identify an alternative dataset that contains more measures related to healthy behaviours, a larger sample size and is population-based, for example, the National Population Health Survey (http://www.statcan.ca/english/concepts/nphs/index.htm). The other option is to collect data for the primary purpose of specifying and developing a structural equation model of healthy behaviours among older adults. Limitations of conducting structural equation modeling as secondary data analysis were encountered in this study as well as being identified elsewhere (Barkely, 2005; Kostner, 1996; Raina, McIntyre, Zhu et al., 2004), thus, from an analytical viewpoint, collecting primary data would be optimal.

Nonetheless, practical considerations such as the availability of existing on-going surveys in a large Canadian population must be considered. The proposed Canadian Longitudinal Study on Aging will provide large numbers of subjects and prospective data.

5.5. Conclusions

1) An analysis of agreement between self-report and health record review data using likelihood ratios found good agreement between the two methods for all variables except those related to hypertension. Misclassification, as evaluated using specificity and sensitivity found that lack of agreement was the result of both false negatives and false positives.

2) Despite the fact that study participants were not selected using population-based methods a comparison of health record reviews on pharmacy session attendees and non-attendees revealed no significant differences with respect to health status and health services use. Nonetheless, comparisons of attendees' healthy behaviours with estimates from population health surveys of healthy behaviours suggest that attendees of the pharmacy sessions were more likely to engage in healthy behaviours than the general population.

3) Although estimates of the attributable fractions in the population were exploratory, trends were similar to findings from the Global Burden of Disease Study. This thesis found that high blood pressure and physical inactivity, ranked second and third by the Global Burden of Disease as risk factors for all-cause mortality (Murray & Lopez, 1996), were the two exposures that, if eliminated would eliminate the largest burden of disease in this population. Additionally, eliminating stress among older adults would eliminate a large portion of depression.

4) A preliminary evidence-guided model of healthy behaviours among older adults was specified and evaluated that included the effects of health status, health-related quality of life, physician counseling and patient knowledge on healthy behaviours. Evaluation of the model found that health services use was not a key component in a model of healthy behaviours in older adults. Additionally,

physical health status did not explain a lot of the variability in physician counseling. Health-related quality of life had a stronger relationship with healthy lifestyle behaviours than did physician lifestyle counseling. The path from physician counseling and patient knowledge was more important than health-related quality of life for blood pressure self-monitoring.

The importance of healthy behaviours in successful aging is slowly being recognized (Peel, McClure & Bartlett, 2005). Policies to promote healthy aging must be based on the best available evidence. This analysis presented evidence on the reliability of data sources for older adults, the representativeness of a general practice population of older adults, possible risk factors to be targeted among older people and a preliminary model exploring determinants of healthy behaviours in older adults. Further work must be done using additional data from larger population-based studies of older adults but the findings reported in this thesis can contribute to this building an evidence base for health policy makers trying to improve population health by encouraging healthy behaviours and successful aging.

6. REFERENCES

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Table B2. Excluded variables that were deemed irrelevant to healthy behaviours because relationships with healthy behaviours were not reported in prospective population-based studies in adults 65 years and older.

VARIABLES FROM THE BLOOD PRESSURE DATA FORM
Are you South Asian, First Nations, Inuit or Black? (Yes, No)
VARIABLES FROM THE PARTICIPANT QUESTIONNAIRE
How many people live with you?
VARIABLES FROM THE BASELINE PHYSICIAN NEEDS ASSESSMENT
Physician sex (Male, Female)
Physician age calculated from date of birth
Physician age at graduation from medical school
Physician certification with Canadian College (Yes, No)
Practice location (Ottawa, Hamilton)
Practice type (solo, shared office space, shared patients)
Practice Type (Fee for service, Health service organization, Community health centre, Primary care reform)
Physician academic appointment (Yes, No)
Number of years in practice.
Number of patients seen per day.
Number of patients in practice.
Number of patients 65 years and older in practice.

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APPENDIX A.

VARIABLES FROM QUESTIONNAIRES THAT WERE INCLUDED IN THE THESIS ANALYSIS.

Table A1. Questionnaire data sources used to measure variables included in the analysis.

VARIABLES MEASURING HEALTHY BEHAVIOURS	
Variables from the Blood Pressure Data Form	
	Do you smoke? (Never, Not now but previously, Yes) Typically, do you drink 2 or more alcoholic drinks per day? (Yes, No) How much high fat or fast foods do you consume in your diet? (Low, Moderate, High) Are you moderately physically active for 30 to 60 minutes, most days of the week (for example brisk walking, active gardening, swimming, dancing or biking)? (Yes, No) In a typical week, how frequently do you feel overwhelmed or stressed by the demands on you? (Seldom or never, Few times, Often or a lot of the time)
Variables from the Participant Questionnaire	
	In the last year, have you measured your blood pressure yourself, either at home or somewhere else? (Yes, No)
VARIABLES MEASURING HEALTH STATUS	
Variables from the Blood Pressure Data Form	
	Have you ever had stroke or TIA (transient ischemic attack)? (Yes, No) Have you ever had heart attack? (Yes, No) Has your doctor told you that your cholesterol is high? (Yes, No) Has your doctor told you that you have diabetes? (Yes, No) In the last year, have you felt sad, blue, or depressed for more than 2 weeks in a row? (Yes, No)
Variables from the Participant Questionnaire	
	Have you ever been told by a doctor that you have high blood pressure? (Yes, No);
VARIABLES MEASURING PATIENT DEMOGRAPHICS	
Variables from the Blood Pressure Data Form	
	Sex (Male, Female)
Variables from the Participant Questionnaire	
	Do you know your most recent blood pressure reading or roughly what it was? (Yes, No) What is the highest level of education that you have completed? (Elementary School Grades 1-8, Secondary School to Grades 12 or 13, Trade Technical Vocational School or Apprenticeship Program, Community College Nursing School Or Business College, University, Other) What is your current marital status? (Married, Living with a Partner, Single – Never Married, Widowed Separated or Divorced) Are you currently working for pay or profit? (Yes, No)
	What is your country of birth? (Canada, Other)
VARIABLES MEASURING HEALTH-RELATED QUALITY OF LIFE	
Variables from the Participant Questionnaire	
	Would you say that in general your health is: excellent, very good, good, fair, or poor Thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good? Thinking about your mental health, which includes stress, depression and emotional problems, for how many days during the past 30 days was your mental health not good? During the past 30 days, how many days did poor physical or mental health keep you from doing your usual activities such as self-care, work or recreation?

VARIABLES MEASURING HEALTH SERVICES USE	
Variables from the Participant Questionnaire	
	Have you been admitted to a hospital in the last year? When was the last time your blood pressure was checked by a health professional? (In the past month, In the past 3 months, In the past 6 months, In the past 12 months, More than 12 months ago) In the last year, has your family doctor measured your blood pressure? (Yes, No)
VARIABLES MEASURING PHYSICIAN COUNSELING	
Variables from the Participant Questionnaire	
	Has your family doctor ever discussed the health risks associated with high blood pressure risks with you? (Yes, No)
Variables from the Physician Baseline Needs Assessment	
	Do you routinely use patient handouts as part of your approach to lifestyle counseling to improve cardiovascular health? (Yes, No)

APPENDIX B.

VARIABLES EXCLUDED FROM THE THESIS ANALYSIS

Table B1. Excluded variables answered by a subset of the population due to built-in skip patterns in the participant questionnaire.

VARIABLES FROM THE PARTICIPANT QUESTIONNAIRE
Does your doctor answer your questions about your blood pressure, treatment, and side effects to your satisfaction? (Always, Most of the Time, Some of the Time, Rarely, Never)
Has your family doctor told you your target blood pressure (what it should be)? (Yes, No)
How often do you think your blood pressure is in the target range (controlled)? (Always, Most of the Time, Some of the time, Rarely, Never)
Has your doctor ever discussed with you why it is important to keep your blood pressure under control? (Yes, No)
In the last year, has your family doctor recommended a change in lifestyle to treat your high blood pressure (for example change in diet, quitting smoking, etc.) (Yes, No)
Are you currently taking prescription medication for high blood pressure (Yes, No)
In the last month have you had side effects from your blood pressure medication? (Yes, No)
In a typical week, how often do you miss a dose of your blood pressure medication? (Never, Once or Twice, Two or more times)
I need to take my medication to prevent complications of high blood pressure (Agree, Disagree)
I need to take my medication because to help me live longer (Agree, Disagree)
I need to take my medication every day for it to be effective (Agree, Disagree)
I can stop my medication from time to time without any negative effects (Agree, Disagree)
I believe that my blood pressure medication is working for me (Agree, Disagree)

APPENDIX C

MISSING DATA AND STRATEGIES FOR HANDLING MISSING DATA

Table C1. Missing data of self-report variables collected in the Blood Pressure Data Form, Participant Questionnaire and physician questionnaires and the selected strategy for handling missing data.

Variable	Percent Missing (%)	Missing Value	Strategy for Handling Missing Data
Healthy Behaviours			
Smoking	0.9	Previous	Median Substitution
Alcohol	0.3	No	Median Substitution
Low Fat Diet	0.2	Moderate	Median Substitution
Physical Activity	0.3	Yes	Median Substitution
Low Stress	0.2	Seldom/Never	Median Substitution
BP Self-Monitoring	5.1	No	Conservative Estimate [a]
Health Status			
Stroke or TIA	2.3	No	Conservative Estimate
Heart Attack	2.1	No	Conservative Estimate
High Cholesterol	6.8	No	Conservative Estimate
Diabetes	1.7	No	Conservative Estimate
High BP	5.1	No	Conservative Estimate
Depression	0.1	No	Conservative Estimate
Body Mass Index	1.2	26.0	Mean Substitution
Health-Related Quality of Life			
Self-rated Health	2.2	Good	Median Substitution
Physically Unhealthy Days	15.0	0	Conservative Estimate
Mentally Unhealthy Days	15.0	0	Conservative Estimate
Limited Activity Days	15.0	0	Conservative Estimate
Health Services Use			
Admitted to hospital	2.3	No	Conservative Estimate
Last time BP checked by health professional	3.0	More than 12 months ago	Conservative Estimate
Family doctor measured BP	21.3	No	Conservative Estimate
Attended more than one pharmacy session	0	N/A	N/A

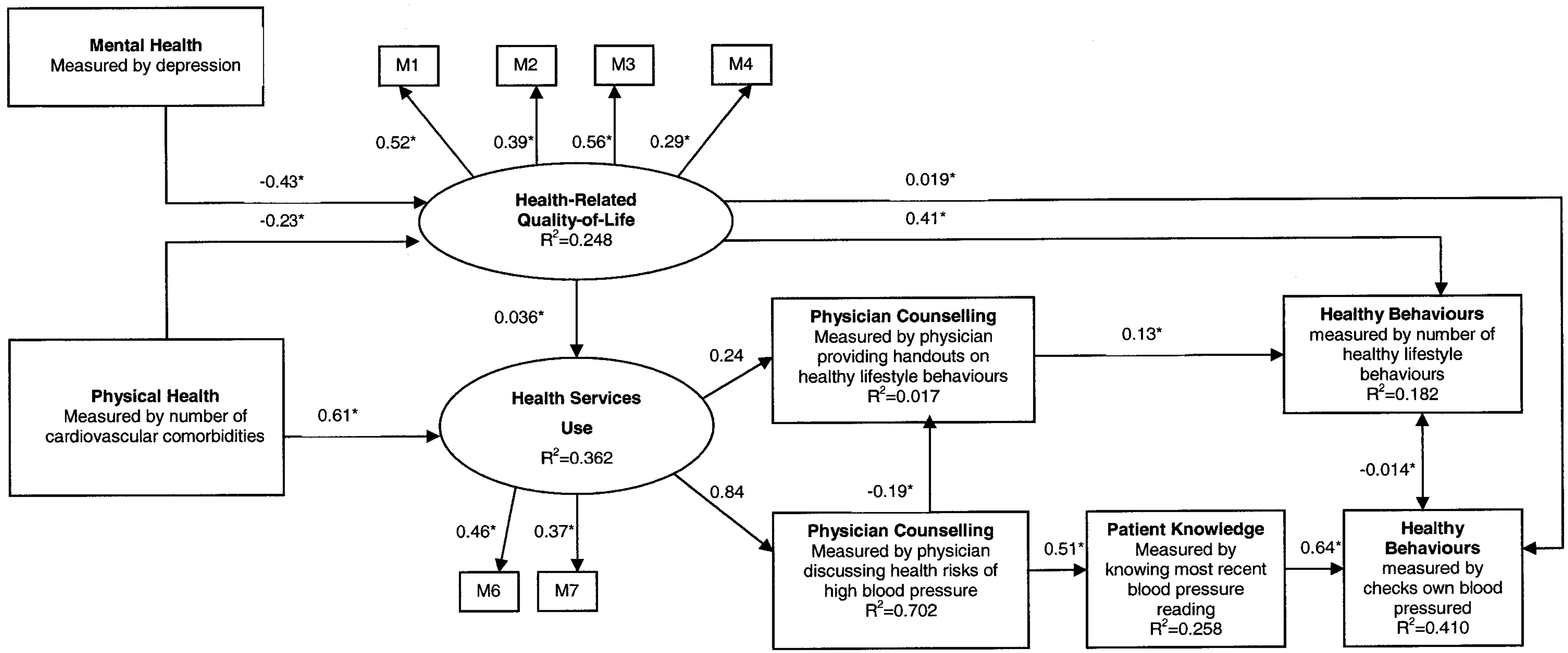
Variable	Percent Missing (%)	Missing Value	Strategy for Handling Missing Data
Physician Counseling			
Family doctor discussed high BP risks	7.2	No	Conservative Estimate
Physician uses handouts for lifestyle counseling	6.1	No	Median Substitution
Patient Knowledge			
Know most recent BP	14.5	No	Conservative Estimate
Demographics			
Sex	0.4	Female	Median Substitution
Marital Status	5.3	Married	Median Substitution
Age	0.2	75	Mean Substitution
Education	10.3	Secondary	Median Substitution
Employment Status	6.5	No	Median Substitution
Canadian-Born	5.2	Yes	Median Substitution

BP=Blood pressure; N/A= Not applicable

[a] Conservative estimates were made for questions where a if an individual did not know or left the response blank response, "no" or "zero" could be reasonably assumed.

APPENDIX D.

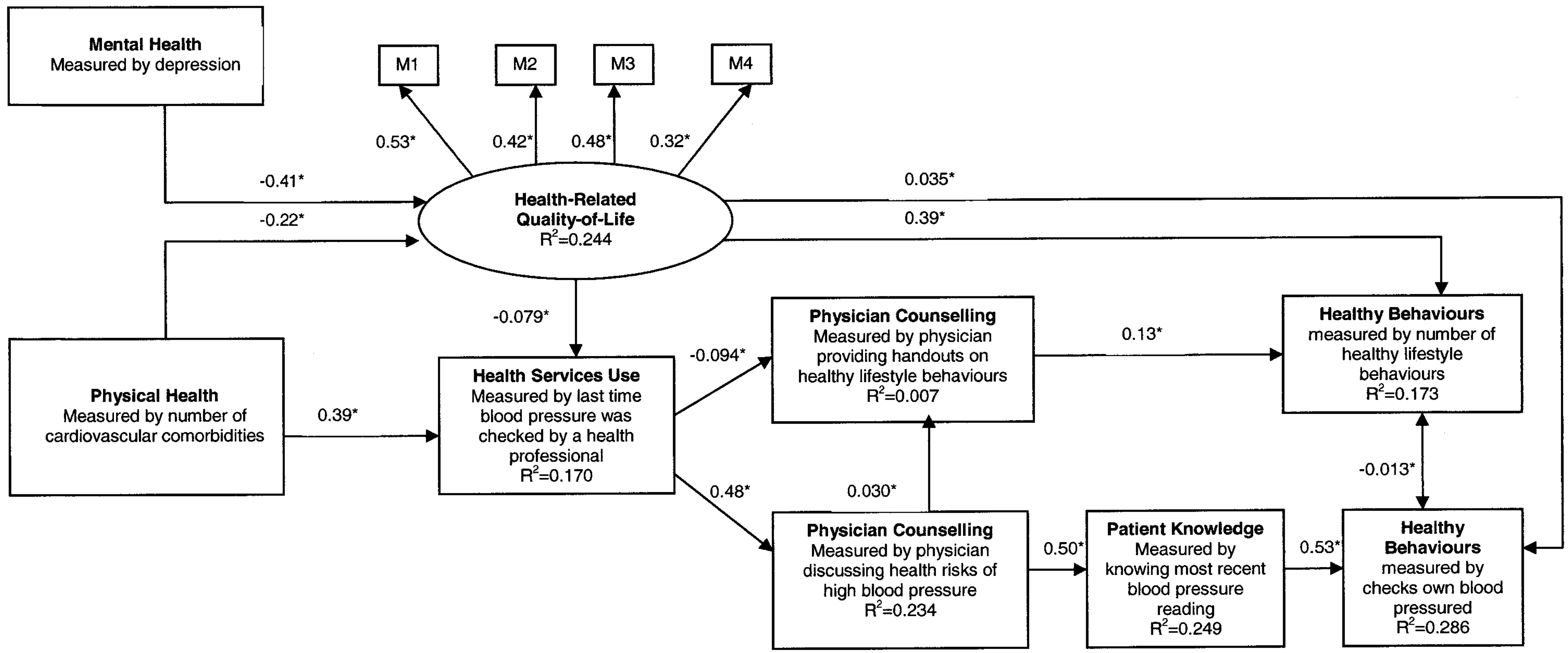
PATH DIAGRAMS FOR INTERMEDIATE MODELS EXAMINED DURING POST-HOC MODEL MODIFICATION.



NOTES:

- Measures of health-related quality of life are: Self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- Measures of health services use are: the last time blood pressure was checked by a health professional (M6) and whether or not family doctor checked blood pressure in past year (M7)
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were X^2=109.7 (degrees of freedom=32, $p<0.00001$), Comparative fit index=0.90, Root mean square error of approximation=0.050

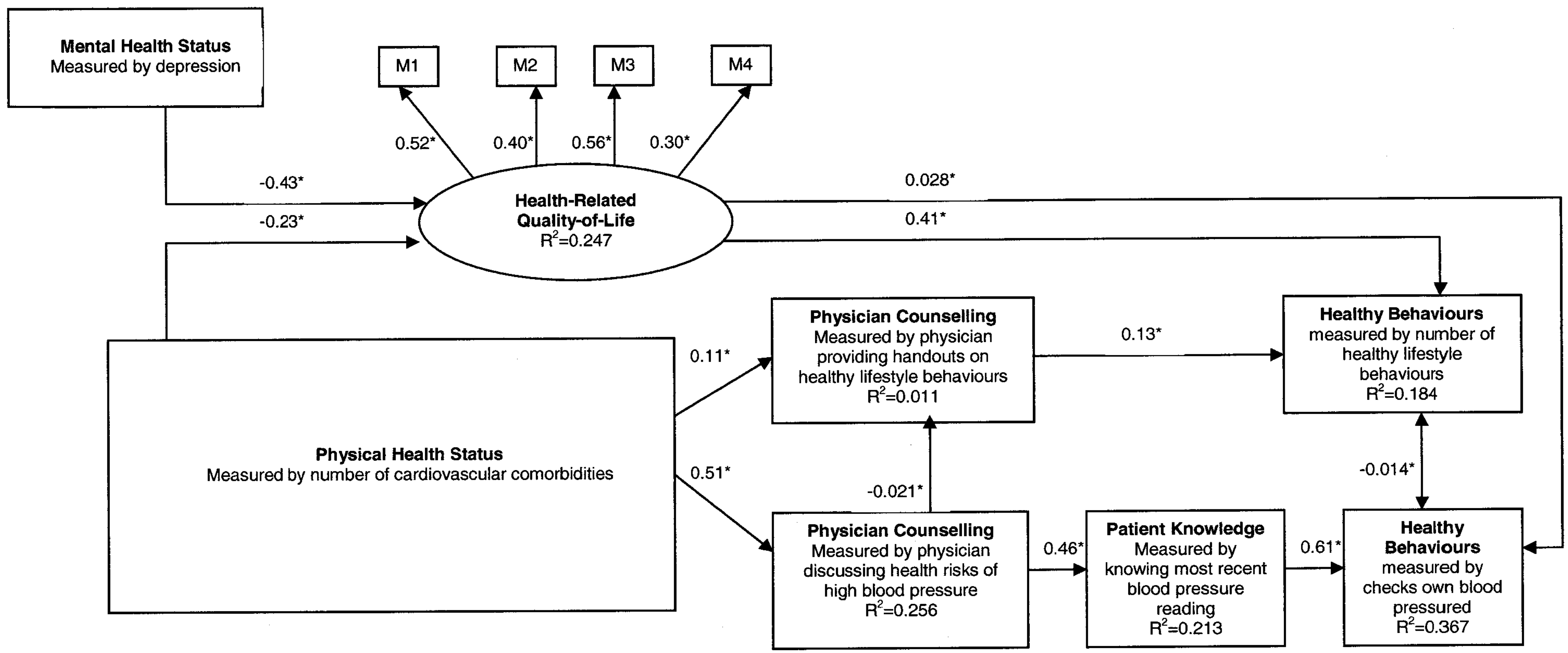
Figure D1. Modified structural equation model of healthy behaviours in older adults with two observed variables originally hypothesized to reflect health services use removed: Admitted to hospital in past year and Attended more than one pharmacy session.



NOTES:

- Measures of health-related quality of life are: Self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were $X^2=187.1$ (degrees of freedom=26, $p<0.00001$), Comparative fit index=0.79, Root mean square error of approximation=0.080

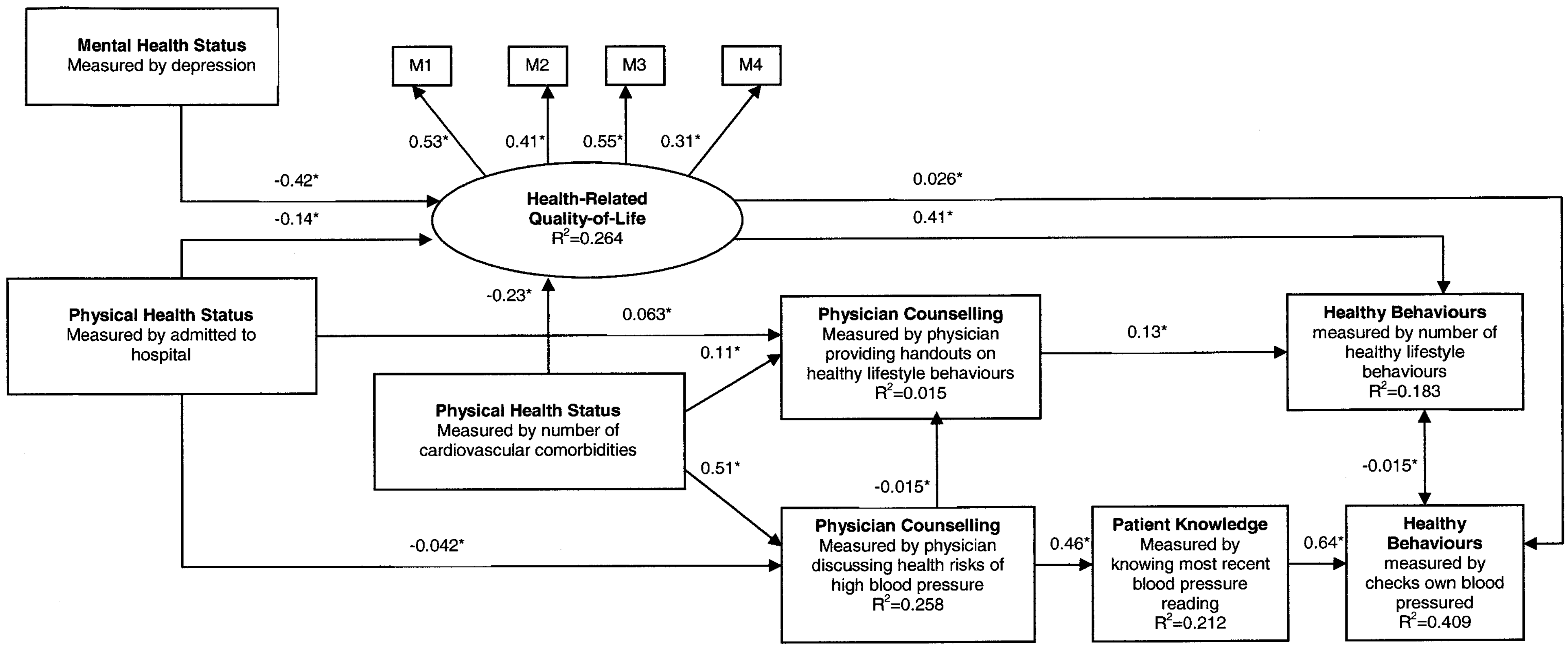
Figure D2. Modified structural equation model of healthy behaviours in older adults with health services use measured using only the observed variable last time blood pressure was checked by a health professional.



NOTE:

- Measures of health-related quality of life are: self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were $X^2=66$ (degrees of freedom=20, $p<0.00001$), Comparative fit index=0.93, Root mean square error of approximation=0.049

Figure D3. Modified structural equation model of healthy behaviours in older adults with the variable health services use removed from the model.



NOTE:

- Measures of health-related quality of life are: self-rated general health (M1), number of physically unhealthy days in the last 30 days (M2), number of mentally unhealthy days in the last 30 days (M3) and number of limited activity days in the last 30 days (M4).
- R^2 represents the amount of variance explained by the direct effects of independent variables
- * Indicates path regression coefficients significant at $p<0.05$
- Tests for model fit were $X^2=78.6$ (degrees of freedom=24, $p<0.00001$), Comparative fit index=0.92, Root mean square error of approximation=0.049

Figure D4. Modified structural equation model of healthy behaviours in older adults with two observed variables reflecting physical health: admitted to hospital in past year and number of cardiovascular comorbidities.