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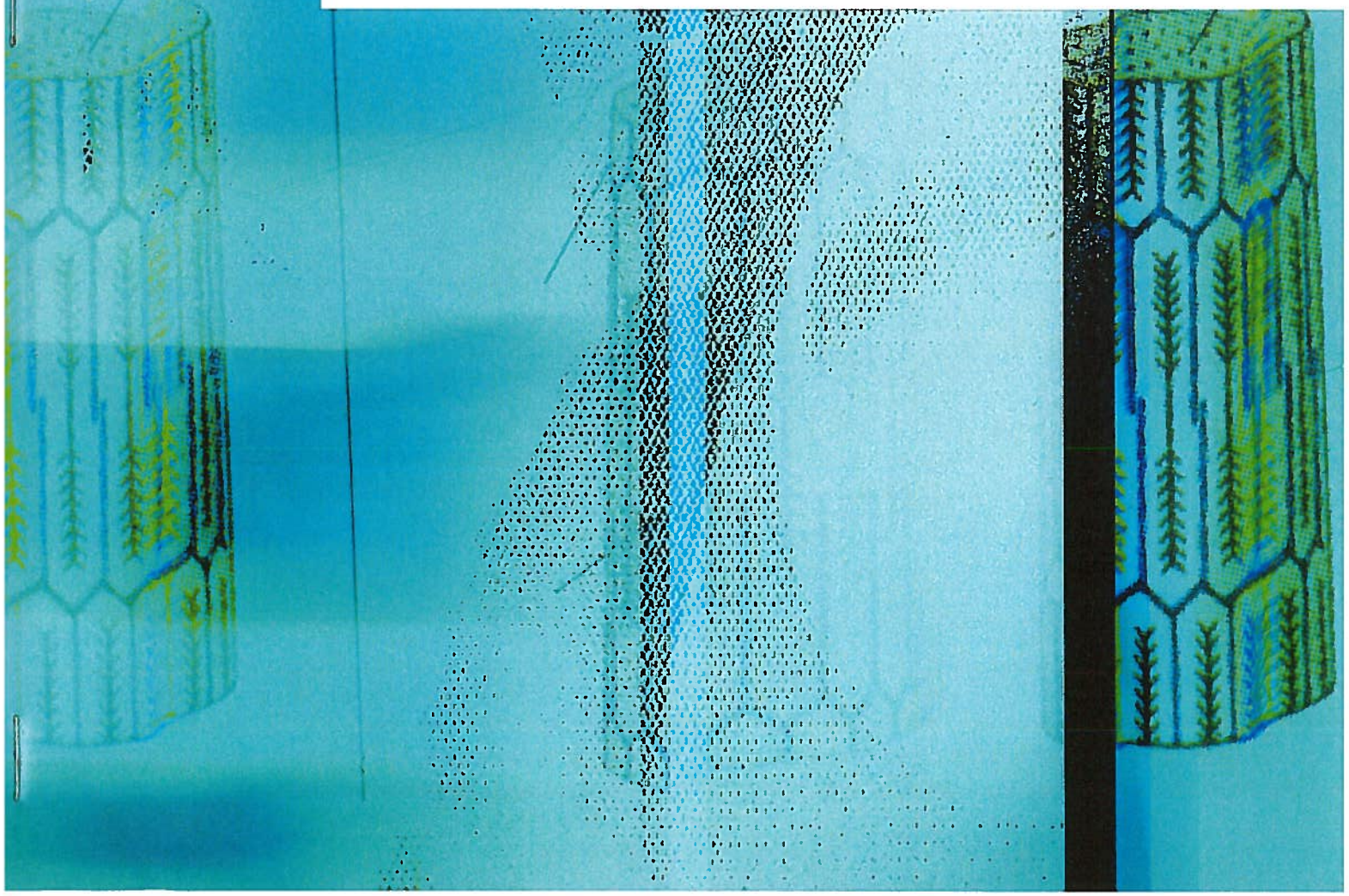
THE IMPACT OF DIABETES AND CO-MORBIDITY ON HEALTH-RELATED QUALITY OF LIFE: FINDINGS FROM THE 1996-97 NATIONAL POPULATION HEALTH SURVEY

Working Paper 04-01



THE IMPACT OF DIABETES AND CO-MORBIDITY ON HEALTH-RELATED QUALITY OF LIFE: FINDINGS FROM THE 1996-97 NATIONAL POPULATION HEALTH SURVEY

Working Paper 04-01

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Legal Deposit 2000
National Library Canada
ISSN 1481-3823

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ACKNOWLEDGEMENTS

Dr. Johnson is a Population Health Investigators with the Alberta Heritage Foundation for Medical Research (AHFMR). Dr. Johnson holds a Canada Research Chair in Diabetes Health Outcomes. Ms. Maddigan is a PhD Candidate and holds a full-time Studentship in Health Research with Alberta Heritage Foundation for Medical Research (AHFMR). Dr. Feeny holds a CIHR/Rx&D Chair in Pharmacoeconomics.

We would like to thank the Statistics Canada for allowing access to the data through the Research Data Center at the University of Alberta, the University of Alberta for providing facilities to access the data, and Irene Wong for her assistance with this project.

Funding for this project was provided through AHFMR.

The research and analysis are based on data from Statistics Canada. The opinions expressed do not represent the views of Statistics Canada.

ABSTRACT

Background

Health-related quality of life (HRQL) deficits associated with diabetes are likely not limited to the condition itself, but may be attributable to other factors including treatment, complications and comorbid medical conditions. Using generic measures to explore HRQL deficits in diabetes is appropriate, as diabetes specific measures may not capture the additional HRQL deficits associated with comorbidities.

Objectives

The purpose of this analysis was to assess the impact of comorbid heart disease, stroke and arthritis on HRQL in people with diabetes in the Canadian population using the Health Utilities Index Mark 3 (HUI3), a generic preference-based measure of HRQL.

Methods

Data used in this analysis were collected as part of the 1996-1997 National Population Health Survey (NPHS Cycle 2). The sample was restricted to respondents over the age of 18. HRQL was assessed using the HUI3, which provides an overall index score, as well as single attribute utility scores for vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain and discomfort. Respondents were classified into 1 of 16 groups based on the presence or absence of diabetes, heart disease, stroke, and arthritis in all possible combinations. Analysis of covariance was performed for each single attribute and the overall HUI3 score, with determinants of health and proxy status included as covariates. The abbreviated model (N=66093) included sentinel medical conditions, sex, age in a quadratic form, education and number of medical conditions as covariates. The full model (N=39772) included total annual household income, body mass index (BMI), marital status, smoking status and proxy response status as covariates, in addition to the covariates of the abbreviated model.

Results:

Missing data on the determinants of health created systematic bias in the full model, so we opted to rely on the abbreviated model to address our primary objective. Overall HUI3 scores for respondents with heart disease (0.89, 95% CI: 0.88-0.90, $p < 0.001$) and diabetes (0.88, 95% CI: 0.87-0.89, $p < 0.001$) alone were similar, and both were statistically significantly lower than controls (i.e. respondents who did not have diabetes, heart disease, arthritis, or stroke) (0.92: 95% CI: 0.92-0.92). Stroke alone was the single medical condition associated with the largest burden (0.74, 95% CI: 0.72-0.76, $p < 0.001$). Regardless of the specific comorbidity, there was a general trend such that pairwise combinations of the four conditions were associated with decrements of overall HRQL of approximately 0.13 to 0.15 and triplets were associated with decrements of approximately 0.26 to 0.30 compared to the control group. Overall HUI3 scores for diabetes in combination with heart disease (0.77), arthritis (0.78) or stroke (0.79) were considerably lower than diabetes alone (0.88). Of the single sentinel conditions, stroke was associated with the largest deficits on the cognition, ambulation and vision attributes. Arthritis was the single sentinel condition associated with the largest deficit on the pain attribute.

Conclusions

From this analysis, it was apparent that across the general population aged 18 and over, the illness burden experienced by individuals with diabetes was not only associated with diabetes itself, but also with comorbid medication conditions. The HUI3, appeared to be useful for assessing HRQL in the sentinel medication conditions explored in this analysis, and useful for assessing the additional decrements in HRQL that occur when these conditions exist as comorbidities.

BACKGROUND

Chronic medical conditions often impact multiple dimensions of health-related quality of life (HRQL). Overall health, physical health, mental well-being and ability to function independently may be affected by chronic conditions, although the consequences may vary considerably depending on the specific condition.[1-3] Older individuals with chronic medical conditions, such as diabetes, arthritis or cardiovascular disease, are more likely to have limitations in physical activities than individuals without.[1:3] Further, diabetes, heart disease, and arthritis have been associated with future declines in self-reported health status (from a rating of good health to a subsequent rating of poor health).[1] Given that chronic medical conditions such as arthritis, heart disease and diabetes increase with age [1], the impact of these conditions on HRQL is particularly important in the context of an aging population.

Diabetes, Comorbidity and Health Related Quality of Life

Diabetes affects approximately 5% of all Canadians aged 20 years or older, with the prevalence rising in older age categories. Approximately 13.5% of individuals over the age of 75 reported having a diagnosis of diabetes in the 1998/99 National Population Health Survey (NPHS), compared to 1.0% of individuals aged 20 to 39.[4] Type 2 diabetes accounts for 90% of the diagnosed cases of diabetes in Canada, with type 1 diabetes representing the majority of the remaining 10% of cases.

Individuals with diabetes experience a substantial illness burden due to the disease itself, its treatment, complications and the comorbid medical conditions that are prevalent in diabetes. Microvascular complications of diabetes include retinopathy and nephropathy, while macrovascular complications include cardiovascular disease (e.g. coronary artery disease) and cereobrovascular disease (i.e. stroke). Estimated rates of complications associated with diabetes vary between populations and with study design, but it has been estimated that approximately 60% of individuals have one or more complication, while almost one-quarter have two or more complications.[5] In a population-based study in Saskatchewan, nearly one-half of individuals in a cohort with type 1 or type 2 diabetes had cardiovascular comorbidity and approximately 20% had

ophthalmic comorbidity.[6] In the 1994/1995 NPHS, 10.6% of individuals over the age of 65 with diabetes reported having suffered the effects of stroke and 24.4% reported that they had heart disease.[7]

As type 2 diabetes is associated with obesity and is the more prevalent form of the disease, it is not unexpected that medical conditions associated with obesity occur as comorbidities in diabetes. Osteoarthritis is an example.[8] Osteoarthritis and diabetes may also exist as comorbidities because both conditions are associated with aging.[8] Regardless of the reason for the observed association, it is relatively common for people with diabetes to also have arthritis. In a US population-based study of cardiac risk factors in individuals with osteoarthritis, it was found that 11% had diabetes.[9]

Thus, it is likely that the HRQL deficits associated with diabetes are attributable to multiple factors, rather than limited to just the condition itself. Indeed, the presence and severity of complications have been associated with depression, anxiety and impairment on multiple dimensions of HRQL in type 1 and type 2 diabetes.[10-16] Comorbid heart disease in individuals with diabetes has been associated with decreased HRQL on physical functioning, role physical, bodily pain, general health, vitality, and social functioning on the Short Form 36 (SF-36)[15] and the physical functioning, vitality, general health perceptions, physical component, and mental component of the RAND-36.[17]

The prevalence of stroke as a comorbid condition in populations with diabetes may be substantially lower than heart disease, but the residual HRQL deficits associated with a major stroke can be considerable, making stroke an important comorbidity to account for when assessing HRQL in diabetes.[18;19] For those individuals with diabetes who have a major stroke, much of their self-reported HRQL deficits could arise from stroke, rather than directly from diabetes.

The burden attributable to comorbid arthritis should also be considered in populations with diabetes as dimensions of HRQL affected by diabetes and arthritis may be similar (e.g. physical functioning, pain, social functioning, etc). There is evidence to suggest that arthritis may be associated with deficits in many dimensions of health status [20;21] (e.g on the SF-36); thus, it is an important comorbidity to consider as well.

The Determinants of Health and Diabetes

Aside from comorbidities and complications, a number of social and demographic factors are recognized as key determinants of health in general populations, and would therefore be important to consider in assessing general health status in diabetes. Income and social status have been recognized as two of the most important determinants of health in the Canadian population.[22] Gradients in life expectancy have been associated with income, education and social class in many developed countries.[23] Self-reported ratings of general health are substantially lower in individuals in the lowest income brackets compared to those in the highest. After controlling for the effects of race, sex, age, and place of residence, individuals with low incomes have shorter life expectancies and have more chronic illnesses than individuals with higher incomes.[22] In a large US sample of individuals with type 1 and type 2 diabetes, income was an important predictor of social functioning and mental health, after controlling for a number of other clinical parameters and determinants of health.[24]

Education is an important determinant of health, not only through its relationship with income.[22] Higher levels of education are associated with healthier lifestyles, including refraining from smoking, participating in physical activity and better access to healthy foods. Low levels of literacy are associated with poor health and premature death. Socioeconomic status, regardless of whether it captures education, income or occupation, has been linked not only to diabetes, but also to other chronic medical conditions, such as hypertension, cardiovascular disease, cancer and arthritis.[25]

Lack of social support has been shown to be as important a risk factor for poor health as smoking, lack of physical activity, obesity and hypertension.[22] A number of hypotheses have been generated to explain the relationship between social support and quality of life. It has been proposed that social relationships may improve mood and create a sense of identity and companionship.[26] Further, social support may act as a buffer to stress, altering the response to a stressful event and enhancing ability to cope.[26] Marital status is considered a structural social support.[26] Research in diabetes has found that social support has a direct beneficial effects on depressive symptoms[27] and buffering

effects on stress.[28] Individuals with diabetes who are not married, separated or divorced have been found to have decrements in HRQL relative to married individuals.[12] Further, individuals with type 1 diabetes who live alone have lower levels of physical functioning and psychosocial well-being than those who live with others.[29]

Age and sex are two demographic characteristics that are associated with self-reported health status. While women have longer life expectancies than men, they are more likely to have depression, stress, chronic medical conditions, disability and report lower levels of HRQL.[22;30] The relationship between poor lower levels of HRQL and being female is in part attributable to the fact that older females tend to have lower levels of education and lower incomes.[30] As with the general population, in diabetes, HRQL in females is lower than males.[24;31] Specifically, females with diabetes report lower levels of treatment satisfaction, social, physical and role functioning, lower mental health and health perception scores, and higher levels of pain, diabetes burden, disease impact, anxiety and depression.[24] In diabetes, age is associated with physical functioning and some aspects of well-being.[14]

It has been suggested that age is an important variable to control for when assessing HRQL in diabetes.[14] The prevalence of morbid conditions increases exponentially over the age of 70.[32] It is possible that the relationship between age and HRQL is nonlinear (i.e. an accelerated rate of decline in HRQL in advanced ages to coincide with the exponential increase in morbid medical conditions). The compression of morbidity hypothesis[33] would also suggest a nonlinear relationship between age and HRQL. The majority of the morbidity that an individual experiences in developed countries arises from chronic diseases processes. With successful aging strategies, the age of onset of these illness and, hence, the age of onset of morbidity can be delayed to later years of life.[33] This effectively compresses or concentrates the morbidity burden into the latest years of life, which would suggest a nonlinear relationship between age and HRQL.

Personal health practices are also important determinants of health. Smoking is thought to be responsible for approximately 25% of deaths in Canadians aged 35 to 84 years old. Specifically in diabetes, smoking has been associated with lower scores on

multiple dimensions of HRQL.[34] Approximately, 34% of males and 23% of females in Canada are overweight.[22] Obesity, presumably related to inactivity and poor eating habits, has been associated with lower levels of HRQL in individuals with type 2 diabetes.[35;36]

Health Related Quality of Life Measurement in Diabetes

Although HRQL assessment in type 1 and 2 diabetes has been extensive, many questions about the most appropriate measures exist.[37] Many of the HRQL assessments have focused on the development and application of diabetes-specific instruments.[38,39] Specific HRQL measures bring into focus the impact on health and functioning arising directly from a condition or treatment. Specific measures have the advantage of focusing on the particular problems associated with the disease under study.[40] Such measures may be better able to identify functional impairments arising from a particular illness and may be more sensitive to small changes in health resulting from treatment than generic measures.[41] They are intended to provide greater detail concerning outcomes associated with a condition or treatment.

In contrast, generic HRQL measures are intended to provide information on the general function and well-being of individuals. Despite concerns of decreased sensitivity, generic measures of HRQL have an advantage over disease specific measures in that they permit comparisons of the impact of various diseases on multiple dimensions of HRQL, which may provide useful data for policy and resource allocation decisions.[41] Generic measures of HRQL are appropriate and desirable for particular applications in diabetes. For example, a diabetes specific measure may not capture the additional HRQL deficits associated with comorbidities. Generic measures can be classified into health status profiles and preference-based measures.[42] Profile measures provide an array of scores representing various dimensions of health status or HRQL. Examples of profile measures include the SF-36 and the Nottingham Health Profile. Such measures provide multiple outcome scores that may be useful to clinicians and researchers for monitoring or measuring differential effects of a condition or treatment.

There are two classes of preference-based measures: direct measures and multi-attribute preference-based index measures. Examples of direct measures include the standard gamble and the time trade off. Respondents are asked to assess the value they place on particular health states. Preference-based index measures are based upon decision theory and economics and reflect communities' preferences for alternative health outcomes.[42] They provide a single overall score for the HRQL associated with a health state. Scores reflect the preferences for that health state and are often referred to as utility scores. Index scores are presented on a scale of 0 to 1, conventionally anchored as 'dead' and 'full health' respectively. Multiattribute utility measures also provide information on specific attributes (dimensions) of health in addition to the overall index score. Depending on the attributes measured, these measures may be able to capture condition-specific information on health status if the dimensions captured in the measure are those likely to be affected by the disease.[42] Generic, preference-based index HRQL instruments have been largely ignored in the diabetes literature, although recently several studies have applied such measures and generated evidence to support their use in the condition.[35;43-50]

The majority of studies that have used preference-based measures have contributed evidence of their cross-sectional construct validity in type 2 diabetes. Cross-sectional assessments of individuals with type 2 diabetes in the United Kingdom have found the EQ-5D to be sensitive to the presence of macrovascular and microvascular complications in type 2 diabetes.[44-46] In a Dutch population with type 2 diabetes, the average EQ-5D utility score of individuals with diabetes (0.81 ± 0.23) who did not have complications was only slightly lower than values for general population of similar age.[35] Again, the EQ-5D was sensitive to complications and duration of diabetes. Other important predictors of overall HRQL on the EQ-5D included age, sex, treatment regimen, HbA1c and obesity. In a study of type 2 diabetes in five European countries, the EQ-5D was found to be sensitive to variations in HRQL by complications, treatment regimen, and glycemic control.[43] Other significant predictors of HRQL included age, sex and obesity.[43]

The remaining studies that have used preference-based measures in diabetes have used the Quality of Well-Being Index (QWB-SA), the 15-D and the Health Utilities

Indices Mark 2 and Mark 3 (HUI2 and HUI3). The 15-D was used in a sample with type 1 diabetes[47], the HUI2 and HUI3 were used in a sample with type 2 diabetes[48;49], and the QWB-SA was used in a sample with either type 1 or type 2 diabetes.[50] The 15-D and QWB-SA were sensitive to complications in both studies.

Preliminary research into the construct validity of the HUI2 and HUI3 generated initial evidence to support their use in type 2 diabetes. Both versions appeared to capture impairments in overall HRQL and on specific attributes of HRQL according to severity of diabetes and unstable glycemic control.[48;49] The HUI3 appeared to be more sensitive to the HRQL deficits associated with disease severity or advancement and unstable glycemic control and, thus, may be preferred over the HUI2.[49] The greater range of possible scores on the HUI3, its enhanced ability to assess the utility of states worse than dead and improved ability to discriminate moderate to severe impairment from mild or no impairment might favor the use of the HUI3 over the HUI2 in assessing HRQL in diabetes.[49] Using the HUI2 produced higher utility scores than the HUI3 for individuals with moderate to severe impairment and, therefore, may underestimate the true HRQL deficits associated with type 2 diabetes.[49]

In summary, there is initial evidence to support the use of preference-based multi-attribute utility measures in diabetes, including the HUI3. Additional evidence of the construct validity of the HUI3 has been generated at the population level for arthritis and stroke.[51] Given the body of evidence supporting the construct validity of the HUI3 in diabetes, stroke and arthritis, it would be a reasonable choice of generic preference-based measures of HRQL in the evaluation of comorbid medical conditions on HRQL deficits in diabetes, given that comorbidities likely make an important contribution to the overall disease burden.

Objectives

The purpose of this analysis was to assess the impact of comorbid heart disease, stroke and arthritis on HRQL in people with diabetes in the Canadian population. This study goal was accomplished through (1) comparing the overall HRQL deficits measured with the Health Utilities Index Mark 3 (HUI3) associated with various comorbidities and

(2) comparing the level of impairment on the attributes of the HUI3 associated with various comorbidities. We were interested in the burden of diabetes, heart disease, stroke and arthritis (and any possible combination of two or more of these conditions) relative to individuals without any of these sentinel conditions, after controlling for other relevant determinants of health.

RESEARCH DESIGN AND METHODS

Study Design

Data used in this analysis was collected as part of the 1996-1997 National Population Health Survey (NPHS Cycle 2). The NPHS collects data on health status, use of health services, risk factors, demographics and socioeconomic status on Canadian households (household component) and on long-term care residents (institutional component).[52] The institutional component includes individuals who are expected to stay in health care institutions (hospitals and residential care facilities) with four beds or more for six months or longer.[53] Data from all provinces are included in the institutional component; however, the territories are excluded. The target population of the household component of the NPHS is community dwelling individuals in all provinces, with the exclusion of individuals who live on Indian Reserves, Canadian Armed Forces Bases and some remote areas of Ontario and Quebec. For the NPHS Cycle 2, data were collected mainly through telephone survey (5% of respondents had in person interviews) of respondents from June 1996 to June 1997.

This analysis used data from the household component of the NPHS Cycle 2. Although the institutional component collected HUI3 data and allowed proxy reporting through family or staff members, we chose to use data from the community dwelling population. It was felt that there would be a more informative distribution of age and single and combinations of comorbidities in the community than in the institutionalized population. We felt that the institutional component may include mainly older, sicker individuals. Further, the institutional component would include respondents still in the process of recovering from major health events, such as myocardial infarction or stroke,

which may not provide accurate estimates of the utilities associated with stroke or heart disease as chronic conditions.

Ethical approval for this analysis was obtained through the University of Alberta Health Research Ethics Board. Approval to access the survey data through the Research Data Centre at the University of Alberta was obtained from Statistics Canada.

Sample

The NPHS Cycle 2 household sample consisted of a longitudinal core sample originating from the NPHS Cycle 1 (N=44,439) and supplemental samples (N=165,938), totaling 210,377 respondents.[54] Approximately 98.3% of the longitudinal core sample originating from Cycle 1 was available for follow-up in Cycle 2. The cross-sectional sample was selected through random digit dialing, with a stratified multistage design for the household component. From the households that were surveyed, 81,804 individuals were randomly selected (one individual from each household) and administered the health component.[52] The overall response rate for the NPHS Cycle 2 household component was 82.6% (94.3% in the core longitudinal sample and 80.0% for the supplemental samples). The sample for this analysis was restricted to respondents over the age of 18, which limited the maximum possible sample size for our analyses to 68, 282 respondents.

Measures

Health Utilities Index Mark 3 (HUI3)

HUI3 is a preference-based measure of HRQL that uses a multiplicative utility function to assign valuations to different health states.[55;56] Using the multi-attribute approach, health states are defined by a classification system that includes a set of dimensions or attributes of HRQL, with a number of different levels for each attribute. In the HUI3 system, eight attributes, including vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain, define health status. Each attribute has five or six levels, creating 972,000 unique HUI3 health states (Appendix 1).[55]

The overall utility function for the HUI3 was derived from visual analogue scale and standard gamble techniques and responses from random samples from the general population in Hamilton, Ontario, Canada.[55] Overall scores on the HUI3 range from -0.36 to 1.0, with -0.36 representing the utility of the worst possible HUI3 health state, 0.0 representing dead and 1.0 representing perfect health.[55] Differences of greater than 0.03 for HUI3 overall scores are considered to be clincally important.[57] Overall HUI3 scores had a test-retest reliability of 0.77 over one month in a population health survey, using the intra-class correlation coefficient.[55]

In addition to overall scores, single attribute utility (SAU) scores can be obtained for each attribute of the HUI3.[55;56] The availability of the SAU scores enables the HUI3 system to provide a generic health profile in addition to an overall preference-based index measure. For the single attribute utilities, scores range from 0.0 to 1.0, with a score of 0.0 representing the lowest level of functioning on an attribute and a score of 1.0 representing full functional capacity on an attribute. A difference of 0.05 on a single attribute is considered to be important and meaningful.[57] The morbidity burden on each single attribute can also be captured by the distribution of individuals at each level on the attribute.

The HUI3 may be particularly useful in studying HRQL in diabetes because several of the attributes would likely be affected by the severity of diabetes and diabetic complications. Amputation and peripheral neuropathy would presumably affect the ambulation and dexterity attributes. Similarly, neuropathy and myopathy would likely affect the pain and discomfort and the dexterity attributes. Diabetes itself would likely affect the emotion attribute. Finally, retinopathy would likely affect the vision attribute. Past cross-sectional research has shown that scores on the emotion, pain, ambulation, dexterity, and vision attributes were significantly lower in individuals with more advanced disease in a sample of rural Albertans with type 2 diabetes.[48]

Comorbidities could also be associated with additional HRQL decrements. Stroke, for example, could affect the speech, dexterity, ambulation, emotion, cognition and pain and discomfort attributes, while arthritis would be associated with HRQL deficits on the

dexterity, ambulation, pain and discomfort attributes.[51] Individuals with advanced heart disease would likely experience some burden on the ambulation, pain and emotion attributes. It was expected that those individuals who had various combinations of the sentinel medical conditions (i.e. diabetes, heart disease, arthritis, and stroke) would experience differing levels of impairments on a number of attributes, depending on the nature of the comorbidity. It should be noted, however, that these additional deficits may not be associated with just the diseases themselves. Additional drug therapies that are used in the management of comorbidities could also be associated with deficits in HRQL. Number of medications has been shown to be negatively correlated with HRQL[58] and functional status[59], perhaps because as the number of medications increases, the risk of drug-drug interactions and drug-disease interactions increases.[60] The diverse nature of the attributes captured by the HUI3 should permit us to capture the effects of the four sentinel conditions simultaneously with a single instrument, and make comparisons across these comorbid groups.

Determinants of Health

Sentinel Medical Conditions - Definitions of Diabetes, Stroke, Arthritis, and Heart Disease

The NPHS includes a direct question "We are interested in long term conditions that have lasted or are expected to last six months or more and that have been diagnosed by a health professional. Do you have…," followed by a list of common chronic conditions. Subjects were classified into the groups based on a positive response to the diabetes, stroke, arthritis or heart disease question. The type of diabetes, arthritis or heart disease was not differentiated in the survey. Respondents were classified into 1 of 16 groups based on the presence or absence of the sentinel chronic conditions: 1) Control Group – subjects having no sentinel medical condition 2) Diabetes – subjects having diabetes but not stroke, arthritis and heart disease 3) Stroke – subjects having stroke but not diabetes, arthritis or heart disease; 4) Arthritis – subjects having arthritis but not diabetes, stroke or heart disease; 5) Heart Disease – subjects having heart disease but not diabetes, stroke or arthritis; Groups 6 through 11) Pairs of comorbidities– subjects having two of diabetes, stroke, heart disease and arthritis; Groups 12 through 15) Triplets of comorbidities –

subjects having three of diabetes, stroke, arthritis, and heart disease and 16) All comorbidities- subjects having diabetes, stroke, heart disease and arthritis. In all groups, including the control group, respondents could have comorbidities other than the sentinel medical conditions.

Age

The age variable was operationalized using two different methods to consider the possibility of a nonlinear relationship between HRQL and age. In the first set of analyses, age was operationalized as a categorical variable, with five categories: 18 to 30 years, 31 to 39, 40 to 49, 50 to 59, and greater than 60. Age categories were selected to create approximately equal groupings. In the second set of models, a quadratic form was used (i.e. $b_1 \text{age} + b_2 \text{age}^2$).

Sex

Sex was included as a determinant of health in the model. Respondents were categorized as male or female.

Number of Medical Conditions

We included an overall measure of comorbidity, determined as the total number of self-reported medical conditions minus the number of reported sentinel medical conditions, so that these conditions were not accounted for twice in the analysis.

Education

Highest level of education of the respondent was assessed in four categories: less than secondary graduation, secondary graduation, other post-secondary education (e.g. diploma/certificate from a trade school, some community college), and college or university degree. These categories were provided as a derived variable in the NPHS data set. It was felt that four education categories were sufficient to provide discrimination between groups.

Income

Gross total annual household income from all sources was included as a determinant of health, with self-reported household income grouped in to four categories: less than $29,999; $30,000 to $49,999; $50,000 to $79,999 and $80,000 or more. These categories were provided as a derived variable in the NPHS data set. Again, it was felt that four education categories were sufficient to provide discrimination between groups.

Body Mass Index

Body mass index was a derived variable in the NPHS, calculated from self-reported height in meters (m) and weight in kilograms (kg). Specifically, BMI = kg/m^2. To create four groups of approximately equal cell size that were also biologically meaningful, respondents were categorized according to self-reported BMI as follows: less than 22.0, 22.1 to 25.0, 25.1 to 27.0, and 27.1 or greater.

Marital Status

For marital status, respondents were categorized as married/partnership or not married. The married category included respondents who reported being married, common-law or living with a partner, while not married included respondents who were single, widowed, separated or divorced. This categorization of marital status (married/partnership versus not) was chosen to reflect degree of social support or social interaction.

Smoking Status

For the variable smoking status, individuals were categorized as smokers (i.e. respondents who were categorized as current frequent smokers and current occasional smokers) and nonsmokers, which included individuals who never smoked, as well as former smokers. This categorization was chosen to reflect health risk.

Proxy Response Status

Proxy reporting was permitted on the health component of NPHS Cycle 2 for individuals over the age of 12 years only for reasons of illness or incapacity. Our analyses were restricted to individuals aged 18 years and older. Proxy status was controlled for as it was felt that proxy reporting could potentially affect the results. The direction of effect, however, was not clear, as two competing factors were considered. First, proxies tend to under-report HRQL deficits, particularly for attributes which are difficult to observe such as emotion or pain.[61] Second, the issue was further complicated by the fact that individuals who require a proxy to complete the survey on their behalf would likely be sicker. This was the explicit intent with the NPHS, i.e. proxies were only permitted for reasons of illness or incapacity. Thus, it was not clear what impact proxy reporting would have on results and it was decided to control for this factor in only the full model (as discussed below).

Data Analysis

To assess the impact of the sentinel medical conditions on overall HUI3 utility scores and the eight attributes of the HUI3, analysis of covariance (ANCOVA) models were used, with the determinants of health variables and proxy status entered into the model as covariates.

The survey design itself and selection probabilities can create problems with the estimation of variances using standard statistical programs.[62] To adjust for the unequal probability of being selected for inclusion into the survey due to the multi-stage sampling design, re-scaled (normalized) sampling weights were applied to the data for all descriptive and inferential statistical analyses. While this process does not adjust for the stratification and clustering in the survey design, it does give a more reasonable estimate of the sample variance by taking into account the unequal probability of selection.[62] Re-scaled weights are calculated dividing the original sampling weights by the average weight of respondents to be included in a particular analysis.[62] For example, for respondents included in the abbreviated model, the average sampling weight was 325.91. If a respondent's sampling weight was 15 (i.e. the respondent represented 15 people in

the general population), the re-scaled weight would be 15 / 328.10 = 0.046. A re-scaled weight was calculated for each respondent and this weight was applied before carrying out the analysis. Consistent with Statistics Canada's policies for disclosure, data pertaining to any cell with a weighted or unweighted frequency of less than five were suppressed.

In addressing the primary objective of this study, a number of versions of the basic ANCOVA model were assessed. Four sets of analyses were performed to address two methodological issues. The first methodological issue stemmed from relatively large amounts of missing data on a number of the determinants of health. The large amount of missing data appeared to result in censoring of cases in a nonrandom manner. To explore more fully the effects of missing data, two sets of analyses were performed using different sets of covariates. The first model (the full model) included the sentinel medical conditions, and sex, age, education, number of medical conditions other than sentinel, total annual household income, body mass index (BMI), marital status, smoking status and proxy response status as covariates. As well, BMI was only included in the first model as it was felt that it could be a potential source of measurement error in that respondents may inaccurately report their height and weight. The second model (the abbreviated model) included sentinel medical conditions, sex, age, education and number of medical conditions other than sentinel as covariates, variables for which there were relatively little missing data. We opted not to include number of medications as a covariate due to potential collinearity with number of medical conditions (r=0.48 and due to a large amount of missing data for number of medications, i.e. over 8000 cases). It was felt that similar information could be obtained using number of medical conditions in the analysis, without eliminating respondents missing information on medication use.

Descriptive statistics were used to characterize the study samples in the full and abbreviated models; t-tests and χ^2 tests were used to determine if statistically significant differences existed between respondents who were censored from the full model due to missing data. Nonparametric tests (Mann-Whitney) were used to verify results from the t-tests for the overall and single attribute utility scores as these data were not normally distributed. We also assessed the appropriateness of the various models through the

interpretation of the coefficients of the covariates in the model, in terms of known associations with determinants of health (e.g. age).

The second methodological issue was the handling of the hypothesized nonlinear relationship between age and HRQL. To address this, we used a quadratic equation (i.e. an age squared term in addition to the main age variable) compared with a categorical grouping of age. We compared the two different approaches to the age variable for both the full and abbreviated models. Plots of the relationship between age, overall and single attribute utility scores for the quadratic form were examined. The regression coefficients and proportion of explained variance of each model (i.e. age in the quadratic form compared to age in categories) for the overall and single attribute utility scores were examined to determine the preferred manner in which to operationalize the age variable in the analyses.

To aid in the interpretation of the ANCOVA, details of the coding of variables has been provided in Appendix 2.

RESULTS

Survey Sample

As stated previously, 68,282 of the 81,804 NPHS Cycle 2 respondents selected for the health component were over the age of 18. For those individuals, single attribute and overall HUI3 scores were available for 67, 192 respondents. No respondent was missing data on age or sex, but 723 were missing data on education, 468 were missing data on number medical conditions other than sentinel, and 123 were missing data on disease grouping variable. This reduced the overall sample size to 66,093 for the abbreviated model. For the full model, the sample size was further reduced from 66,093 to 39,772, as 33.4% of the remaining respondents did not report marital status or smoking status, 22.2% did not report body mass index and 15.7% did not report income (Table 1).

Full Model

Sample Characteristics

The average age of survey respondents included in the full model was approximately 40.0 years ± 11.63, with just over one-half of respondents in the analysis being male (Table 1). The prevalence of smoking in the sub-sample was relatively high (31.8% of respondents smoked). The majority of the respondents in the full model had no sentinel medical conditions (85.9% of the sample), but on average, respondents had approximately one other medical condition. Arthritis was the most prevalent sentinel medical condition (10.9%).

Respondents included in the full model had an average overall HUI3 score of 0.92 ± 0.16, implying on average very few impairments on the eight attributes. The largest deficit for the single attribute utility scores was observed for the pain and discomfort attribute (mean = 0.95 ±0.17) (Table 2). Across the eight attributes, the majority of the sample was at Level 1 (no impairment) or Level 2 (mild impairment) (Tables 3a and 3b). Weighted sample sizes of less than five in the triplet with diabetes, stroke and heart disease and the group with all four sentinel medical conditions prohibited reporting descriptive or inferential statistics for these groups.

HRQL Deficits

Overall HUI3

After controlling for age, sex, education, number of medical conditions, body mass index, marital status, smoking status and proxy completion, on average respondents having stroke, diabetes or arthritis had clinically important overall HRQL deficits (Table 4). Overall HRQL deficits associated with heart disease alone were small and nonsignificant, relative to the control group (overall HUI3 score = 0.91 for both, p=0.545). Stroke as a single sentinel condition was associated with the lowest overall HUI3 scores (0.80, 95% CI: 0.77-0.83, $p < 0.001$) compared to the control group).

Pairs of comorbidities had inconsistent associations with overall HRQL deficits. Some pairs, such as stroke and arthritis (overall HUI3 score = 0.63, 95% CI: 0.57-0.69, $p < 0.001$) and diabetes and arthritis (overall HUI3 score = 0.77, 95% CI: 0.75-0.79, $p < 0.001$) were associated with deficits of considerable magnitude relative to the control group. Other pairs, including diabetes and stroke (overall HUI3 score = 0.97, 95% CI: 0.89-1.05, p=0.165) and stroke and heart disease (overall HUI3 score = 0.90, 95% CI: 0.84-0.95, p=0.507) had scores that were similar or higher than the control group. Triplets of comorbidities that contained arthritis and stroke (in addition to heart disease or diabetes) were associated with the largest deficits in overall HRQL (Table 4).

Sensory Deficits

Clinically important vision or hearing deficits did not appear to be associated with any of the single sentinel medical conditions (Table 4). Vision deficits were more pronounced in groups with two or three comorbidities, although no pattern of association with a particular sentinel condition appeared to emerge. Hearing deficits were not observed in the sample, while some speech deficits were apparent in the stroke group. The magnitude of this deficit, although statistically significant, would not necessarily be sufficient to be considered clinically important, relative to the control group (difference = 0.03, $p < 0.001$). Minor speech deficits were also seen in pairs of comorbidities that

contained stroke (i.e. stroke and arthritis, stroke and heart disease), but again, these differences were not necessarily clinically important.

Ambulation

The sentinel medical conditions alone were not associated with deficits in ambulation, with the exception of stroke, where clinically important and statistically significant deficits were observed relative to the control group (0.87, 95% CI: 0.85-0.88 versus 0.99, 95% CI: 0.99-0.99, $p < 0.001$). The association between stroke and impaired ambulation was not consistent in the pairs of sentinel conditions. In the diabetes and stroke group, the average score on the ambulation attribute was 1.00 (0.97-1.05), which was similar to the control group (0.99, 95% CI: 0.99-0.99, $p=0.502$). The combination of stroke and arthritis with or without heart disease was associated with large deficits in ambulation, larger than those associated with stroke alone (Table 4).

Dexterity

Minimal impairment was seen on the dexterity attribute across conditions; where impairment existed, it was associated mainly with stroke and arthritis. The largest magnitude of dexterity problems were found in individuals with stroke and arthritis (a difference of 0.11 compared to the control group, $p < 0.001$).

Emotion

Clinically important emotional deficits were not found in any of the single sentinel medical condition groups, but were pronounced in individuals with comorbidities (Table 4). Scores on the emotion attribute were of similar magnitude in individuals with diabetes and heart disease (0.88, 95% CI: 0.86-0.89) and stroke and arthritis (0.90, 95% CI: 0.87-0.93, $p < 0.001$ compared to control group for both) (Table 4). Similar emotional deficits were observed in individuals with diabetes, stroke and arthritis (0.89, 95% CI: 0.83-0.95, $p < 0.001$ compared to the control group) (Table 4).

Cognition

Cognitive deficits associated the single sentinel medical conditions were not necessarily clinically important, with the deficit in the stroke group being the largest (0.03, $p < 0.001$) (Table 4). While some comorbid groups that included stroke had considerable cognitive deficits, others did not follow this trend. Of the triplets for which data were available, stroke containing triplets had considerably higher levels of cognitive impairment than the diabetes, heart disease, arthritis triplet.

Pain and Discomfort

Arthritis was associated with clinically important deficits on the pain and discomfort attribute relative to the control group (0.86, 95% CI: 0.85-0.86 versus 0.96, 95% CI: 0.96-096, $p < 0.001$) and the other sentinel medical conditions (Table 4). Some impairment on the pain attribute was also associated with diabetes, but not sufficient in magnitude to be considered clinically important. Pairs of comorbidities were generally associated with substantial deficits on the pain attribute, with the exception of the diabetes and stroke group and the stroke and heart disease groups. Triplets of comorbidities were associated with the largest burden on the pain attribute.

Determinants of Health

Approximately 17% of the variance in overall HUI3 score in the full model was accounted for by the determinants of health included in the model, proxy reporting status, and sentinel medical conditions. In this sample of respondents, females had slightly lower overall self-reported HRQL, although the absolute magnitude of the difference (0.006) would not be considered clinically important (Appendix 3, Table 8A). Having less than a secondary education relative to a college or university degree and an income of less than $29,999 per year compared to greater than $80,000 were associated with clinically important and statistically significant overall HRQL deficits (Table 8A). Each additional medical condition other than the sentinel conditions was associated with a clinically important decrement (0.031) in overall HUI3 score (Appendix 3, Table 8A). Body mass index was the only determinant of overall health that was not associated with overall

HRQL. Education, income, number of chronic medical conditions, sex, smoking status, age and marital status were associated with level of function on a number of HUI3 attributes (Appendix 3, Tables 8B through 8I). The emotion ($R^2 = 0.06$) and pain and discomfort ($R^2 = 0.14$) attributes were best explained attributes by the full model (Appendix 3, Tables 8B through 8J).

Limitations with Full Model

Several issues arose with the interpretation of the results from the full model. First, the censoring of respondents due to missing data decreased the number of respondents in two of the 16 disease groups below the threshold of release of data from Statistics Canada (i.e. cell sizes were too small and we were required by Statistics Canada to suppress output). When comparing the full and abbreviated model, 85.9% of respondents versus 80.4% of respondents were in the control group, suggesting that we had indeed censored individuals with sentinel medical conditions (Table 1). Further, the percentage of subjects with arthritis, for example, dropped from 15.1% in the abbreviated model to 10.9% in the full model, while stroke decreased from 0.9% to 0.5%, and heart disease from 4.2% to 2.2% (Table 1). Thus, the censoring of respondents due to missing data systematically excluded respondents with the sentinel conditions of interest in our research.

Comparisons of respondents who were included in the abbreviated model, but missing from the full model (i.e. missing data on a covariate) showed that they were older (52.50 ± 22.03 versus 40.03 ± 11.63 years of age, $p < 0.001$) and more likely to be female (56.3% versus 48.5%, $p < 0.001$), have less than a secondary education (34.8% versus 17.7%, $p<0.001$), and have incomes less than $29,999 (53.2% versus 27.8%, $p < 0.001$) (Table 5). Small, but statistically significant differences were also seen according to BMI, number of medical conditions, and proxy completions (Table 5). As well, prevalence of all sentinel medical conditions was considerably lower in the full model (Table 5). Further, there was a clinically important difference in overall HUI3 scores between respondents who were included in and missing from the full model (0.92 ± 0.16 vs 0.87 ± 0.22, $p < 0.001$) (Table 5). Small differences were also seen on the single attributes (Table 5).

The bias created by nonrandom censoring of respondents (i.e. the older, sicker individuals) was seen in reduced explained variance in the full model relative to the abbreviated model (Table 6) for the overall HUI3 scores and most attributes (except emotion and dexterity). This bias could also explain the counter-intuitive results of the diabetes and stroke group, who had higher overall HUI3 scores and single attribute utility scores than the control group (Table 4).

The systematic exclusion of older individuals from the full model could also explain, in part, unexpected patterns in the data. For example, overall HUI3 scores for the age categories in the full model followed a 'U'-shaped pattern (Appendix 4, Tables 9C-9K), suggesting better HRQL in the older categories. This pattern may have occurred because sicker individuals were excluded from the older categories due to missing data, leaving the more healthy individuals in these older age categories. The quadratic form for the relationship between age and overall HUI3 score in the full model (Figure 1) was 'U'-shaped as well. In the full model, after overall HUI3 scores decrease in older adults, they begin to increase again in respondents over the age of 75, which is basically the inverse of the quadratic form estimated in the abbreviated model (Figure 2). This functional form, where deficits or impairment decrease in the much advanced age groups, was observed in the full models for the emotion, cognition and pain and discomfort attributes (Figures 4-6). Further problems with the estimates in the full model were evidenced by findings of lowest levels of impairment on the cognition and pain and discomfort attributes in the over 60 age category. This was contrary to what we had expected.

A general lack of burden across a number of comorbidities and attributes suggested that respondents with larger HRQL deficits had been excluded from the full model due to missing data on the determinants of health. This was particularly evident in sentinel medical condition groups containing stroke, where large deficits in HRQL were anticipated.[51]

Further difficulties with the full model were seen with the adjusted means and confidence intervals of the single attribute utility scores, particularly in groups with small cell sizes. The estimated adjusted mean of the emotion attribute exceeded the maximum

value of 1.00 for the stroke, arthritis and heart disease group, as did the adjusted mean of the hearing attribute for the diabetes, heart disease arthritis group. The upper limit of the 95% confidence interval for a number of attributes exceeded 1.00 in many cases for the full model. This also happened in the abbreviated model, but less frequently and, in most instances, the amount by which the upper limit was exceeded was small.

Primarily due to the systematic bias created as a result of missing data on the determinants of health, which systematically excluded older and less healthy respondents, we opted to rely on the abbreviated model to address our primary objective of comparing the HRQL burden between the sentinel medical conditions.

Abbreviated Model

Sample Characteristics

The average age of respondents included in the abbreviated model was 44.20 ±16.94, with 51.1% of respondents being female (Table 1). Over one-half of respondents had a college or university degree or another form of post-secondary education. Of the respondents with data available, almost one-third smoked and almost one-half were consider overweight (BMI greater than 25.0). Approximately 80% of respondents were in the control group, with arthritis being by far the most prevalent of the sentinel medical conditions (15.1%), followed by diabetes (3.5%). On average, respondents had 1.00 ± 1.25 medical conditions in addition to the sentinel conditions. Respondents included in the abbreviated model had an average overall HUI3 score of 0.90 ± 0.18, with the largest burden on the single attributes being seen on the pain and discomfort attribute (0.95 ± 0.18) (Table 2). Deficits on the remaining attributes were small. As with the full model, the majority of respondents were at Level 1 or Level 2 of functioning for each attribute (Table 3a and 3b).

HRQL Deficits

Overall Deficits

The overall HUI3 scores for the heart disease (0.89, 95% CI: 0.88-0.90, $p < 0.001$) and diabetes (0.88, 95% CI: 0.87-0.89, $p < 0.001$) alone groups were similar and were clinically important relative to the control group (Table 7). Stroke was the single sentinel medical condition associated with the largest burden (0.74, 95% CI: 0.72-0.76, $p < 0.001$), while the combination of stroke and arthritis was the pair of comorbidities associated with the largest burden (0.58, 95% CI: 0.55-0.61, $p < 0.001$) (Table 7). A gradient in overall HRQL deficits was clearly evident, with increasing number of sentinel medical conditions being associated with larger overall HRQL deficits. Regardless of the specific comorbidity, there was a general trend such that pairwise combinations of arthritis, stroke, diabetes and heart disease were associated with decrements of overall HRQL of approximately 0.13 to 0.15 compared to the control group with the exception of

the stroke and arthritis group, which had an extremely large overall HRQL deficit (0.34). Triplets of the sentinel medical conditions also followed a similar pattern in that overall HRQL deficits were of similar magnitude regardless of which conditions comprised the triplet, ranging in magnitude from approximately 0.26 to 0.30 (Table 7). The average overall HRQL deficit in the group with all of the four sentinel medical conditions was 0.46 (Table 7).

Sensory Deficits

Sensory deficits for the sentinel medical conditions alone were not necessarily clinically important relative to the control group, although the stroke group did have some impairment on the vision (a difference of 0.04, $p < 0.001$) and speech (a difference of 0.02, $p < 0.001$) attributes (Table 7). Small speech deficits were also observed in the stroke and heart disease group. Statistically significant vision deficits were apparent in many of the pairs of comorbid medical conditions, but were not clinically important in magnitude (Table 7). Hearing deficits varied, but were considerable in the diabetes, stroke and heart disease group (0.87, 95% CI: 0.83-0.99) relative to the control group (0.99, 95% CI: 0.99-0.99) (Table 7).

Ambulation

Functioning on the ambulation attribute for the sentinel medical conditions was similar to the control group with the exception of the stroke group, where significant deficits were observed (0.85, 95% CI: 0.83-0.86 versus 0.99, 95% CI: 0.99-0.99, $p < 0.001$). Stroke containing pairs of sentinel medical conditions had considerably larger deficits on the ambulation attribute compared to pairs without. Stroke and arthritis (as a pair or in triplets with heart disease or diabetes) was associated with relatively large deficits as well (Table 7). Significant burden on the ambulation attribute was found in the group with all four sentinel medical conditions (0.67, 95% CI: 0.63-0.67) (Table 7).

Dexterity

No clinically important deficits on the dexterity attribute were seen in the disease groups. A difference of 0.04 ($p < 0.001$), relative to the control group, was found in the

triplets that had either diabetes, stroke and heart disease or diabetes, heart disease and arthritis.

Emotion

No clinically important impairments on the emotion attribute were found in any of the single sentinel medical condition groups, or in individuals with pair of comorbidities (Table 7). Triplets of comorbidities were associated with clinically important deficits on the emotion attribute. The largest emotional deficits were observed in individuals with diabetes, stroke and heart disease (0.84, 95% CI: 0.79-0.88, $p < 0.001$ compared to the control group), followed by diabetes, stroke and arthritis (0.89, 95% CI: 0.87-0.92, $p < 0.001$) (Table 7).

Cognition

Stroke was associated with clinically important and statistically significant cognitive deficits, relative to the control group (0.91, 95% CI: 0.89-0.92 versus 0.97, 0.97-0.98, $p < 0.001$) (Table 7). Any stroke containing group had cognitive deficits, with the exception of the diabetes and stroke group (0.97, 95% CI: 0.94 -1.00, p=0.684) (Table 7). Important impairment on the cognition attribute was also seen in a number of the diabetes containing comorbid groups (diabetes and arthritis; diabetes, heart disease, arthritis).

Pain and Discomfort

Arthritis was associated with the largest burden on the pain and discomfort attribute relative to the control group (0.87, 95% CI: 0.86-0.87 versus 0.97, 95% CI: 0.96-0.97, $p < 0.001$) (Table 7). Stroke was also associated with clinically important deficits on the pain and discomfort attribute (0.91, 95% CI: 0.89-0.94, $p < 0.001$) (Table 7). Some impairment on the pain attribute was also associated with diabetes and heart disease but not sufficient in magnitude to be considered clinically important. Pairs of comorbidities were generally associated with substantial deficits on the pain attribute, with the exception of the diabetes and stroke group and the stroke and heart disease groups. Triplets of comorbidities were associated with the considerable burden on the pain attribute.

Abbreviated Model Determinants of Health

The sentinel medical conditions, age in the quadratic form, sex, education and number of other chronic medical conditions accounted for 21% of the variance in overall HUI3 score (Appendix 3, Table 8A). The proportions of explained variance in the single attributes were highest for the pain and discomfort attribute ($R^2 = 0.15$) and the ambulation attribute ($R^2 = 0.13$), but quite low for the dexterity and speech attributes ($R^2 = 0.01$ for both) (Appendix 3, Table 8A). Age and sex were associated with overall HUI3 score and the vision, hearing, speech, emotion, cognition and pain attributes (Appendix 3, Tables 8A through 8I). Age was also associated with the dexterity attribute. Each additional chronic medical condition was associated with a clinically important deficit in overall HUI3 score (-0.033) (Appendix 3, Table 8A), but was associated with only small impairments on the single attributes with exception of pain and discomfort, which had a beta coefficient of -0.031 ($p < 0.001$) (Appendix 3, Table 8I). Similar to the coefficient observed in the full model, not having secondary education was associated with relatively large deficits in overall HRQL (-0.039) (Appendix 3, Table 8A) and impairment on the pain and discomfort attribute (-0.029) compared to individuals with a college or university degree (Appendix 3, Table 8I).

Age – Quadratic Form Versus Categorical

A slightly larger proportion of variance in the single attribute utility scores was explained in the abbreviated models for vision, hearing, ambulation, cognition and overall HUI3 scores when age was entered into the model in the quadratic form compared to in categories (Table 6). In all models, the beta coefficients for the age squared term were statistically significant, indicating a nonlinear relationship between overall HUI3 scores and age (Appendix 3, Table 8A), and the single attribute utility scores and age (Appendix 3, Table 8B-Table 8I).

Using the beta coefficients for males, with a secondary education, stroke and arthritis, and one other medical condition (from the abbreviated model) for a reference case, it was apparent that the deviation from linearity, although statistically significant, was not considerable (Figures 2-6).

The age categories performed reasonably well in the abbreviated model with overall HRQL declining and level of impairment increasing on vision, hearing and ambulation attributes with increasing age (Appendix 4 - Tables 9C-9K). The association between age category and cognition (Appendix 4, Table 9J), however, was relatively weak, with the largest absolute difference between the reference category (greater than 60 years old) and other categories being 0.013. Further, the age categories did not seem to capture the 'concave down' nature of the relationship that was captured by the quadratic. With the quadratic, overall HUI3 scores and scores on a number of the single attributes were slightly lower before the age of 25, were highest approximately between ages 25 to 45, and declined after approximately 45 years of age (Figures 2-6). Possibly due to the break points used to create age categories, the categories did not capture this curvilinear relationship. Because the quadratic appeared to be a better fit with the data than age categories, we chose to focus on the quadratic form in the full and abbreviated models, rather than the categorical data. For complete information, however, the results with age in categories can be found in Appendix 4, Tables 9A-9K.

DISCUSSION

Diabetes is a chronic medical condition associated with a substantial illness burden. This burden has generally been attributed to three factors: the disease itself, its treatment and complications, and comorbidities associated with the disease. In this population-based study of individuals residing in the community with type 1 and type 2 diabetes, overall HRQL deficits associated with diabetes alone were clinically important relative to a group of respondents without diabetes, arthritis, heart disease or stroke. HRQL deficits associated with diabetes alone were somewhat lower than deficits found in the groups with stroke or arthritis alone. When comorbid medical conditions accompanied diabetes, the associated decrements in overall HRQL were substantial, emphasizing the contribution of comorbidities or complications to the illness burden in diabetes. Overall HRQL deficits associated with diabetes in combination with heart disease (deficit = 0.15), arthritis (deficit = 0.14) or stroke (deficit = 0.13) were approximately three times the magnitude of the HRQL deficit associated with diabetes alone (deficit = 0.04), and

considerably larger with triplets of comorbidities. The decrement in overall HUI3 score associated with having any two or three of the sentinel medical conditions was strikingly similar, despite the fact that the deficits arose from impairment on different attributes of HRQL. For all sentinel conditions, there was an association between comorbidity and additional HRQL deficits.

Based on the literature and our past work with the HUI3, we had anticipated that diabetes would affect the vision, dexterity, ambulation, emotion and pain and discomfort attributes.[15;16;48;49] At the population level, however, respondents included in the abbreviated model with diabetes but not stroke, arthritis or heart disease did not have substantial impairment on these attributes. Across the eight attributes, in the diabetes group, the lowest single attribute utility scores were observed on the pain attribute but the magnitude of the difference from the control group was insufficient to be considered clearly clinically important, after controlling for age, sex, education and number of medical conditions. The average utility score on the pain attribute of respondents in the diabetes group was 0.94, which was higher than the score for level two on the pain attribute (0.92), i.e. 'mild to moderate pain that prevents no activities'.

The lack of burden associated with diabetes alone (i.e. without the other sentinel medical conditions) on the single attributes was surprising. Small impairments, however, across multiple attributes produced clinically important overall HQRL deficits relative to the control group. One possible explanation for the lack of burden on the diabetes relevant HUI3 attributes in the diabetes group was that by definition, this group could not have two of the macrovascular complications (i.e. stroke or heart disease). Thus, we may have selected a group of respondents that did not have severe or advanced disease or had diabetes of relatively short duration and would, therefore, have fewer HRQL deficits.[48] While glycemic control is not directly linked to macrovascular complications, these subjects might also have had more adequate glycemic control.

In groups with combinations of comorbid sentinel medical conditions and diabetes, impairments on the anticipated diabetes relevant attributes were more prominent than in the diabetes alone group. Comorbid heart disease (utility = 0.90) and stroke (utility =

0.81) were associated with relatively large deficits in ambulation, while comorbid arthritis (utility = 0.82) and heart disease (utility = 0.81) were associated with significant amounts of pain. While the type of heart disease was not specified in the NPHS, ischemic heart disease, angina, and congestive heart failure are all associated with pain.[63-65] The amount of pain reported in the diabetes and heart disease group far exceeded that associated with either condition alone. It is possible that some of the pain and discomfort found in the diabetes and heart disease group was attributable to neither condition, but rather to another painful comorbid condition associated with the two conditions, such as peripheral vascular disease.[66;67]

No clear pattern of emotional burden associated with comorbidities could be observed. Clinically important impairment on the emotion attribute was observed in only two groups of three comorbidities (diabetes, stroke and heart disease; diabetes, stroke and arthritis). Interestingly, of the comorbidities paired with diabetes, heart disease had the largest emotional burden as well as the largest deficits on the pain and discomfort attribute. Pain and depression are often associated; there appears to be a relationship between severity of pain and depression.[68] Thus, the large impairment on the pain and discomfort attribute in the diabetes and heart disease group may also have been associated with altered perception of pain by increased emotional burden. Conversely, the observed emotional burden may have been attributable to pain. Emotional burden became much more prominent in triplets of the sentinel medical conditions that included stroke; thus, it is possible that comorbidity, in particular stroke, moderates the observed relationship between diabetes and depression.[19;69-72]

The relationship between comorbidity and poor HRQL is complex and may be difficult to interpret in that stroke and some forms of heart disease are macrovascular complications. Respondents with these comorbidities may also have poorer glycemic control, more severe or advanced disease or disease of longer duration than respondents without these comorbidities. Thus, when comparisons were made between diabetes alone versus diabetes and stroke or diabetes and heart disease, differences in overall and single attribute utility scores could be associated with the comorbidity itself or differences in severity of diabetes or duration of diabetes and, therefore, other complications associated

with diabetes. While we did control for age, we were not able to control for duration of diabetes as it was not collected as part of the NPHS. This is not likely an issue with arthritis, as it is pathophysiologically distinct, making the additive decrements associated with arthritis and diabetes more easily interpretable.

The substantial burden found in the comorbid groups containing diabetes was perhaps more consistent with the burden that would be anticipated in a population with diabetes than the burden observed in the group with diabetes alone. The relative lack of burden in the diabetes alone group suggests perhaps that much of the burden that is generally attributed to diabetes may be attributable to the combination of diabetes and other comorbid medical conditions. This suggests that comorbidities must be controlled for when assessing HRQL in diabetes so that the burden is not misattributed to diabetes. In a sample of rural Albertans with type 2 diabetes, the average HUI3 score was 0.64 ± 0.30,[48] which was similar to the average overall HUI3 score for respondents with diabetes with two other sentinel medical conditions in the abbreviated model. This lends evidence to the notion that comorbidities and complications are involved in determining the health states associated with diabetes. That said, it is diabetes may be an indirect contributing factor to the observed decrements in HRQL when complications are involved.

Stroke alone was the sentinel medical condition associated with the largest overall HRQL deficit while heart disease alone was associated with the least. Generally speaking, any comorbid group that contained stroke had a substantial overall burden. Across the single sentinel medical conditions, overall HUI3 scores were lowest in the stroke group (0.74). Average overall HUI3 scores remained approximately similar or were lower in stroke groups with comorbidities, ranging from a low of 0.46 in the all sentinel medical condition group to a high of 0.79 in the diabetes and stroke group. Combinations of comorbidities that included stroke and arthritis had the largest deficits in overall HRQL, relative to the control group.

While the recovery from a stroke can be quite variable, the question pertaining to stroke was worded in the 1996 NPHS as "Do you have effects of a stroke?" Interpretation of this question could be such that respondents with a history of a milder stroke, with

minor or no residual deficits may answer the question as "no". Thus, the question may have captured only individuals who had stroke with residual effects which could, in part, explain why the illness burden in stroke was so pronounced. Questions pertaining to the other sentinel medical conditions were not linked to symptoms or effects and, thus, would capture symptomatic and asymptomatic respondents. This could result in the conditions being associated with less pronounced HRQL deficits.

Impairment with ambulation was associated with stroke alone, while impairment on the emotion and pain and discomfort attributes became evident when stroke occurred with comorbidities. The association between stroke and impairment on the ambulation attribute was markedly consistent: the difference between the control group and stroke alone on the ambulation attribute was 0.14, with the smallest difference on the ambulation attribute between the control group and any comorbid group containing stroke being 0.09. Patterns of pain and discomfort across stroke groups were somewhat difficult to interpret. Stroke alone was associated with a clinically important impairment on the pain and discomfort attribute compared to the control group (difference = 0.051, $p < 0.001$). The diabetes and stroke group and diabetes, stroke, and heart disease group, however, had less pain than the control group.

In contrast to findings of Grootendorst et al. (2000), who assessed the construct validity of the HUI3 in stroke and arthritis in the Ontario Health Survey (OHS),[51] speech and dexterity deficits were not prevalent in any of the stroke groups. The pain and emotional burden with stroke alone was smaller than what was observed in the OHS. Differences in pain from those observed from Grootendorst et. al. (2000) could be due to differences in the populations, but could also be related to the cleaner categorization of disease groups in this study. We removed comorbid heart disease, diabetes and, hence, their associated burden from the stroke group, whereas in Grootendorst et. al. (2000), part of the burden of stroke could actually be attributed to diabetes and heart disease, since they are associated with stroke as well as pain and emotional deficits.

Individuals with arthritis experienced greater overall HRQL deficits (overall HUI3 score = 0.84) than individuals with diabetes or heart disease, but smaller deficits than

those associated with stroke. The combination of arthritis and stroke was particularly burdensome (overall HUI3 score = 0.58). Pain and discomfort was the only single attribute for which clinically important differences were observed between the arthritis only group and the control group (0.87 versus 0.97). All arthritis containing comorbid groups had considerable deficits relative to the control group on the pain and discomfort attribute, the deficit ranging in magnitude from 0.14 in the diabetes and arthritis group to 0.38 in the all sentinel medical condition group. Marked differences on the pain attribute were observed between the comorbid groups that did and did not involve arthritis. Results for the dexterity, emotion and ambulation attributes were similar to those found in the OHS for arthritis alone[51] in that neither population had much burden. The specific type of arthritis, as well as treatment, would be expected to have some bearing on the overall HRQL deficit associated with the illness but was not differentiated in the survey.

Heart disease by itself was the sentinel medical condition associated with the smallest overall HRQL deficit, with the difference being the heart disease and the control group being 0.03, which was still considered clinically important. The overall burden of heart disease alone was relatively small and mainly associated with pain, although the difference between the heart disease alone and the control group on the pain attribute was not necessarily clinically important (0.93 versus 0.97). The nature of the heart disease was not distinguished on the survey. Different types of heart disease (e.g. congestive heart failure versus a well controlled arrhythmia versus a history of myocardial infarction) would be expected to be associated with different levels of disease burden. Combining of all types of heart disease could have diluted the burden associated with the more debilitating conditions. The overall HRQL deficits associated with heart disease and comorbidities were pronounced. Heart disease in combination with diabetes (overall utility = 0.81) or arthritis (overall utility = 0.78) was associated with larger burden than heart disease alone, primarily due to pain. In the stroke and heart disease group (0.85) and the diabetes and heart disease (0.90) group, ambulation problems were apparent. In the heart disease containing triplets, emotion, ambulation, cognition and pain and discomfort attributes were also affected.

Across the four sentinel medical conditions, the HUI3 performed reasonably well, as small differences were seen on attributes relevant to particular medical conditions. Interpretation of minimally clinically important differences on disease relevant attributes was somewhat difficult, however, in that comparisons were made to a control group that had other medical conditions, apart from the sentinel conditions. It is not clear if a lower threshold for clinically important differences would be more useful, as the true difference between conditions may have been understated. Many of differences between groups approached clinical importance. Our findings do not necessarily indicate that the HUI3 lacks sensitivity to the burden associated with the sentinel medical conditions. Rather, it could be a reflection on the overall good health and lack of burden of the respondents included in the analysis. Using diabetes alone as an example, by definition respondents could not have had macrovascular complications. Further, the average age of the respondents included in the abbreviated model was 44; thus, the diabetes alone group may have had type 2 diabetes (90% of cases) of relatively short duration, without macrovascular complications and, therefore, had little illness burden to be detected.

The ability of the HUI3 to detect consistently the increased illness burden associated with having two, three or four comorbid medical conditions was clear. The utilities of the pairs of comorbidities and of the triplets of comorbidities were within 0.02 to 0.04 units, after controlling for the covariates in the model. Regardless of the specific comorbidity, there was a general trend such that pairwise combinations of arthritis, stroke, diabetes and heart disease were associated with decrements of overall HRQL of approximately 0.13 to 0.15 compared to the control group with the exception of the stroke and arthritis group, which had an extremely large overall HRQL deficit (0.42). Triplets of the sentinel medical conditions also followed a similar pattern in that overall HRQL deficits were of similar magnitude regardless of which conditions comprised the triplet, ranging in magnitude from approximately 0.26 to 0.30. The average overall HRQL deficit associated with having the four sentinel medical conditions was 0.46. The gradient of HRQL deficits across one, two, three and four sentinel medical conditions adds evidence of construct validity of this measure. It seems that in medical conditions whose burden arises in part from comorbidities, generic measures such as the HUI3 are one means by which the entire burden of the health state can be captured.

There is evidence of the construct validity of the HUI3, QWB-SA, and EQ-5D in diabetes, but no comparisons of these measures in a single population with diabetes has been carried out to date. We feel that the HUI3 may be the preferred instrument for a number of reasons. The larger number of dimensions and levels of the HUI3 create a larger number of health states (972,000) compared to the EQ-5D (243) or the QWB-SA (945). Further, the larger number of levels per attribute of the HUI3 (5 or 6) allows for better discrimination of level of functioning relative to the EQ-5D and QWB-SA which have three levels of functioning per attribute. Another advantage of the HUI3 is that single attribute scores can be calculated, whereas this is not possible with the EQ-5D or QWB-SA. One possible limitation of the HUI3 is that it does not include social interaction as a domain or attribute, i.e. it is restricted to 'within the skin' in its attributes. While this is a limitation, it should be noted that general recommendations for measuring HRQL suggest using a preference-based measure, a generic health profile and a disease specific measure. Thus, information on social interaction could be captured using an additional instrument that provides complimentary information.

In carrying out the analyses, a number of limitations became apparent. In particular, the relatively large amounts of missing data on a number of important determinants of health precluded us from including them in the analysis. The full model produced obviously biased results; systematic differences in patterns of missing data resulted in a sample that included more males, individuals that were younger, healthier, with higher incomes, higher educations and fewer of the sentinel medical conditions. Interpretation problems were apparent in the full model, leaving us with the abbreviated model, which controlled for fewer determinants of health, but did not exclude one-third of the sample and did not exclude respondents in a systematic manner. The performance of the abbreviated model seemed to be more appropriate in terms of known relationships, for example age. We were, therefore, more confident in interpreting the HRQL deficits estimated by the abbreviated model than from the full model.

Another potential limitation in the analysis was related to the accuracy of self-reported medical conditions. Although the questions regarding medical conditions specified that the condition have been diagnosed by a health professional, there remained

potential for individuals to over-report or under-report any medical condition. Further, as previously described, the nature of the stroke question in particular may have lead to under-reporting. As well, there was a lack of detail on the nature of diabetes, arthritis or heart disease that would preclude us from differentiating the type of disease and the anticipated HRQL deficits associated with each. Further, in the analysis, we were unable to account for treatment effects in the relationships between the sentinel conditions and HRQL. Treatment effects could be an additional source of heterogeneity between individuals within a disease group. Individuals whose conditions were appropriately managed through therapeutic interventions could have higher HRQL compared to poorly managed individuals. Conversely, individuals who experience adverse reactions to medications or inappropriate treatment would likely have relatively larger HRQL deficits.

The nature of the data collection (i.e. mainly via telephone survey) could have potentially created systematic bias in that individuals with impairment on the hearing and/or speech attributes may not have been selected for in the survey. This bias may have been overcome, in part, by allowing for proxy reporting, but it is not clear if that was the case, as we observed that the overwhelming majority of respondents were at level one functioning (normal) on these attributes. Thus, functioning of the general population on the hearing and speech attributes may have been overstated in these analyses.

Despite having a large sample size, some of the 16 groups in the full and abbreviated models had relatively small cell sizes (e.g. a weighted N of less than 15). This resulted in relatively large standard errors and imprecise estimates of the adjusted means. In some cases, the adjusted means and upper limit of the 95% confidence intervals exceed the upper limit of the single attribute utility scores. This happened more frequently in the full model, where biased estimates and wider confidence intervals were observed. As we relied on the abbreviated model for our primary objective of comparing HRQL deficits in the sentinel medical conditions, this was less of a problem.

One final limitation was that, although we controlled for the number of medical conditions other than the sentinel conditions, the disease groups could still contain other medical conditions. Thus, HRQL deficits that were observed could also be attributed to

these conditions or complications and symptoms not otherwise identified. It should be noted, however, that the average number of other medical conditions was approximately 1.00 in the abbreviated model and that a considerable proportion of subjects had no other medical conditions.

Despite these limitations, these data have captured the utility of health states and HRQL deficits associated with common chronic medical conditions in a large sample, representative of 95% of the community dwelling Canadian population. Unfortunately, the results are not generalizable to individuals living on reserves, crown lands or in institutions as they were not included in this component of the NPHS. Further, as the analysis was restricted to the household component, these results are not generalizable to individuals who reside in institutions, who would be expected to have considerably larger HRQL deficits.

CONCLUSION

Diabetes is part of a metabolic syndrome that increases the risk of developing vascular diseases, such as stroke and heart disease.[73] Thus, diabetes is often accompanied by comorbidities and complications, particularly in individuals with advanced or poorly controlled disease. It is essential to treat all components of metabolic syndrome to avoid the complications of the disease and limit their impact on HRQL.

From this analysis, it was apparent that across the general population of adults aged 18 and over, the illness burden experienced by individuals with diabetes was not only associated with diabetes itself, but also with comorbid medication conditions. The illness burden associated with comorbidity of two, three and four of the sentinel medical conditions together was greater than the deficits associated with diabetes alone. Stroke was important to consider, alone or as a comorbid medical condition, because of the magnitude of the deficits associated with it. Arthritis and heart disease are important comorbidities to assess because of their prevalence in individuals with diabetes. The HUI3 appeared to be useful for assessing HRQL in the sentinel medication conditions explored in this analysis and, as a generic measure of HRQL, is useful for assessing the

additional decrements in HRQL that occur when they exist as comorbid medical conditions.

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TABLES

Table 1: Demographic Characteristics of Respondents in Full and Abbreviated Models

	Abbreviated Model (N=66093)	Full Model (N=39772)
Age – Mean (SD)	44.20 (16.94)	40.03 (11.63)
Median (Interquartile Range)	42.00 (31.00-56.00)	39.00 (31.00-49.00)
Age Categories - %		
18 - 30	23.6	23.9
31 - 39	21.6	27.1
40 - 49	20.6	25.5
50 - 59	14.0	17.4
60 or older	20.2	6.1
Sex -%		
Male	48.9	51.5
Female	51.1	48.5
Level of Education[2] - %		
Less than secondary	23.4	17.7
Secondary graduation	17.6	17.0
Other post-secondary	24.3	25.8
College/university degree	34.7	39.6
Marital Status[2] - %		
Married	32.6	32.6
Not Married	67.4	67.4
Income[2] - %		
Less than $29,999	33.1	27.8
$30,000 - 49,999	30.1	31.1
$50,000 - 79,999	24.8	27.5
$80,000 or greater	12.0	13.6
Proxy Completion - %		
Proxy	23.3	22.7
Nonproxy	76.7	77.3
Smoking Status[2] - %		
Current Smoker	31.8	31.8
Nonsmoker	68.2	68.2
Number of Medical Conditions[1]		
Mean (SD)	1.00 (1.25)	0.97 (1.22)
Median (Interquartile Range)	1.00 (0.0, 2.0)	1.0 (0.0, 1.0)
Body Mass Index[2] - %		
Less than 22.0	23.4	23.3
22.1 - 25.0	30.4	30.2
25.1 - 27.0	17.3	17.3
Greater than 27.0	28.8	29.2
Has Arthritis[2] (% Yes)	15.1	10.9
Has Diabetes[2] (% Yes)	3.5	2.3
Suffers the Effects of Stroke[2] (% Yes)	0.9	0.5
Has Heart Disease[2] (Yes)	4.2	2.2
Sentinel Medical Conditions[2] - %		
Control Group	80.4	85.9
Diabetes	1.8	1.4
Stroke	0.3	0.2
Arthritis	12.1	9.6
Heart disease	1.9	1.3
Diabetes and stroke	0.1	<0.1
Diabetes and arthritis	0.9	0.6
Diabetes and heart disease	0.3	0.2
Stroke and arthritis	0.2	0.1
Stroke and heart disease	0.1	0.1
Arthritis and heart disease	1.3	0.5
Stroke, arthritis, heart disease	0.1	<0.1
Diabetes, heart disease, arthritis	0.3	0.1
Diabetes, stroke, heart disease	<0.1	Suppressed
Diabetes, arthritis, stroke	0.1	<0.1
Diabetes, stroke, heart disease, arthritis	0.1	Suppressed

1 Number of medical conditions other than sentinel
2 Percentages based on number of cases with complete data

Table 2: Descriptive Statistics for Overall and Single Attribute Utility Scores for Individuals in Full and Abbreviated Models

	Abbreviated Model (N=66093)		Full Model (N=39772)	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Overall HUI3 Score	0.90 (0.18)	0.97 (0.91 - 1.00)	0.92 (0.16)	0.97 (0.91 - 1.00)
Vision	0.97 (0.07)	1.00 (0.95 – 1.00)	0.97 (0.06)	1.00 (0.95 – 1.00)
Hearing	0.99 (0.08)	1.00 (1.00 – 1.00)	0.99 (0.05)	1.00 (1.00 – 1.00)
Speech	1.00 (0.03)	1.00 (1.00 – 1.00)	1.00 (0.03)	1.00 (1.00 – 1.00)
Ambulation	0.98 (0.10)	1.00 (1.00 – 1.00)	0.99 (0.07)	1.00 (1.00 – 1.00)
Dexterity	1.00 (0.04)	1.00 (1.00 – 1.00)	1.00 (0.03)	1.00 (1.00 – 1.00)
Emotion	0.98 (0.08)	1.00 (1.00 – 1.00)	0.98 (0.07)	1.00 (1.00 – 1.00)
Cognition	0.97 (0.09)	1.00 (1.00 – 1.00)	0.98 (0.08)	1.00 (1.00 – 1.00)
Pain and Discomfort	0.95 (0.18)	1.00 (1.00 – 1.00)	0.95 (0.17)	1.00 (1.00 – 1.00)

Table 3a: Distribution of Respondents in Full and Abbreviated Models on Attributes of the HUI3

	Vision		Hearing		Speech	
	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)
Level 1	49.0	53.0	96.4	98.0	99.4	99.6
Level 2	49.1	45.6	1.8	1.2	0.4	0.3
Level 3	0.5	0.4	0.6	0.2	0.1	0.1
Level 4	0.8	0.6	0.7	0.5	0.1	<0.1
Level 5	0.5	0.2	0.2	0.1	<0.1	<0.1
Level 6	0.1	0.1	0.2	0.1	-	-

Table 3b: Distribution of Respondents in Full and Abbreviated Models on Attributes of the HUI3

	Ambulation		Dexterity		Emotion		Cognition		Pain	
	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)	Abbreviated (%)	Full Model (%)
Level 1	96.5	98.2	99.1	99.3	81.8	81.8	82.9	84.8	86.1	87.5
Level 2	0.7	0.5	0.5	0.4	15.4	15.7	11.0	10.2	3.5	3.6
Level 3	1.6	0.7	0.1	<0.1	2.1	1.9	1.8	1.8	4.8	4.2
Level 4	0.2	0.1	0.2	0.2	0.5	0.5	3.0	2.3	3.2	2.7
Level 5	0.7	0.3	0.1	0.1	0.1	0.1	1.1	0.9	2.3	2.1
Level 6	0.3	0.2	<0.1	<0.1	-	-	0.1	<0.1	-	-

Table 4: Full Model Adjusted[a] Mean (95% CI) Overall and Single Attribute Utility Scores According to Sentinel Medical Conditions[b] (n=39,772)

	Overall	Vision	Hearing	Speech	Ambulation	Dexterity	Emotion	Cognition	Pain & Discomfort
Control Group	0.91 (0.91 -0.92)	0.97 (0.97-0.97)	0.99 (0.99-1.00)	1.00 (1.00-1.00)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.98 (0.97-0.98)	0.97 (0.97-0.98)	0.96 (0.96-0.96)
Heart Disease	0.91 (0.90-0.92)	**0.96** (0.96-0.97)	0.99 (0.99-1.00)	1.00 (0.99-1.00)	0.99 (0.99-1.00)	**1.00** (1.00-1.00)	0.98 (0.97-0.99)	0.98 (0.97-0.98)	0.95 (0.94-0.97)
Diabetes	**0.86** (0.85-0.88)	0.97 (0.96-0.97)	1.00 (0.99-1.00)	1.00 (1.00-1.00)	**0.99** (0.98-0.99)	**1.00** (1.00-1.00)	**0.96** (0.95-0.96)	**0.95** (0.94-0.96)	**0.92** (0.91-0.93)
Arthritis	**0.84** (0.83-0.84)	**0.97** (0.96-0.97)	0.99 (0.99-0.99)	**1.00** (0.99-1.00)	**0.98** (0.98-0.98)	**0.99** (0.99-1.00)	**0.97** (0.97-0.97)	**0.96** (0.96-0.97)	**0.86** (0.85-0.86)
Stroke	**0.80** (0.77-0.83)	0.97 (0.95-0.98)	1.00 (0.98-1.00)	**0.97** (0.97-0.98)	**0.87** (0.85-0.88)	**0.97** (0.97-0.98)	0.97 (0.95-0.98)	**0.94** (0.92-0.96)	0.96 (0.92-0.99)
Diabetes, Stroke	0.97 (0.89-1.05)	0.98 (0.95-1.02)	1.00 (0.98-1.04)	1.00 (0.98-1.01)	1.00 (0.97-1.05)	1.00 (0.98-1.00)	0.98 (0.94-1.02)	0.98 (0.93-1.03)	1.00 (0.91-1.10)
Diabetes, Arthritis	**0.77** (0.75-0.79)	**0.95** (0.94-0.96)	0.99 (0.99-1.00)	1.00 (0.99-1.00)	**0.97** (0.96-0.98)	1.00 (0.99-1.00)	0.97 (0.96-0.98)	**0.92** (0.91-0.93)	**0.80** (0.78-0.83)
Diabetes, Heart Disease	**0.81** (0.77-0.84)	0.97 (0.95-0.99)	1.00 (0.99-1.02)	1.00 (0.99-1.00)	**0.94** (0.93-0.96)	**0.99** (0.98-1.00)	**0.88** (0.86-0.89)	0.98 (0.96-1.00)	**0.85** (0.82-0.89)
Arthritis, Heart Disease	**0.81** (0.79-0.83)	0.98 (0.97-0.99)	1.00 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)	0.99 (1.00-1.00)	**0.96** (0.95-0.97)	**0.99** (0.98-1.00)	**0.78** (0.76-0.80)
Stroke, Arthritis	**0.63** (0.57-0.69)	**0.94** (0.92-0.97)	1.00 (0.98-1.02)	**0.98** (0.97-0.99)	**0.83** (0.80-0.86)	**0.89** (0.87-0.90)	**0.90** (0.87-0.93)	**0.88** (0.84-0.91)	**0.69** (0.63-0.76)
Stroke, Heart Disease	0.90 (0.84-0.95)	0.98 (0.96-1.00)	1.00 (0.99-1.03)	**0.98** (0.97-0.99)	**0.94** (0.92-0.97)	1.00 (0.99-1.02)	0.99 (0.96-1.02)	0.97 (0.94-1.00)	0.95 (0.89-1.01)
Diabetes, Stroke, Heart Disease	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed
Diabetes, Heart Disease, Arthritis	**0.78** (0.73-0.83)	0.96 (0.94-0.98)	1.01 (0.99-1.03)	1.00 (0.99-1.01)	**0.94** (0.92-0.97)	**0.95** (0.94-0.96)	0.98 (0.95-1.00)	0.95 (0.92-0.98)	**0.80** (0.75-0.85)
Diabetes, Stroke, Arthritis	**0.47** (0.34-0.58)	0.93 (0.88 -0.98)	**0.90** (0.86-0.94)	1.00 (0.98-1.02)	**0.97** (0.91-1.02)	0.99 (0.96-1.01)	**0.89** (0.83-0.95)	**0.69** (0.63-0.76)	**0.65** (0.52-0.77)
Stroke, Arthritis, Heart Disease	**0.44** (0.33-0.54)	**0.86** (0.82-0.90)	**0.64** (0.60-0.68)	1.00 (0.98-1.02)	**0.55** (0.50-0.60)	1.00 (0.98-1.03)	1.04 (0.98-1.09)	**0.63** (0.57-0.69)	**0.58** (0.47-0.69)
Diabetes, Stroke, Heart Disease, Arthritis	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed

a Adjusted for Age as a Quadratic, Sex, Education, Number of Medical Conditions, Body Mass Index, Marital Status, Smoking Status and Proxy Completion
b Bold entries are statistically different from control group ($p < 0.05$)

Table 5: Comparison of Demographics between Individuals Full Model and Missing from Full Model

	In Full Model (N=39772)	Missing From Full Model (N=26321)	P-Value
Age – Mean (SD)	40.03 (11.63)	52.50 (22.03)	<0.001
Sex[2] - %			
Male	51.5	43.6	
Female	48.5	56.3	
Level of Education[2] - %			
Less than secondary	17.7	34.8	<0.001
Secondary graduation	17.0	18.8	
Other post-secondary	25.8	21.4	
College/university degree	39.6	25.0	
Marital Status[2] - %			
Married	32.6	-	-
Not Married	67.4		
Income[2]- %			
Less than $29,999	27.8	53.2	<0.001
$30,000 - 49,999	31.1	26.3	
$50,000 - 79,999	27.5	14.4	
$80,000 or greater	13.6	0.06	
Proxy Completion - %			
Proxy	22.7	24.5	<0.001
Nonproxy	77.3	75.5	
Smoking Status[2] - %			
Current Smoker	31.8	-	-
Nonsmoker	68.2	-	
Number of Medical Conditions[1]	0.97 (1.22)	1.11 (1.33)	<0.001
Body Mass Index[2] - %			
Less than 22.0	23.3	24.4	<0.001
22.1 - 25.0	30.2	32.0	
25.1 - 27.0	17.3	17.3	
Greater than 27.0	29.2	26.3	
Has arthritis	10.9	23.4	<0.001
Has diabetes	2.3	5.7	<0.001
Suffers the effects of stroke	0.5	1.9	<0.001
Has heart disease	2.2	8.0	<0.001
Overall HUI3 – Mean (SD)	0.92 (0.16)	0.87 (0.22)	<0.001
Vision – Mean (SD)	0.97 (0.06)	0.96 (0.09)	<0.001
Hearing – Mean (SD)	0.99 (0.99)	0.98 (0.11)	<0.001
Speech – Mean (SD)	1.00 (0.03)	1.00 (0.03)	<0.001
Ambulation – Mean (SD)	0.99 (0.07)	0.97 (0.15)	<0.001
Dexterity – Mean (SD)	1.00 (0.03)	1.00 (0.05)	<0.001
Emotion – Mean (SD)	0.98 (0.07)	0.97 (0.08)	<0.001*
Cognition – Mean (SD)	0.98 (0.08)	0.96 (0.11)	<0.001
Pain and Discomfort – Mean (SD)	0.95 (0.17)	0.93 (0.20)	<0.001

1 Number of medical conditions other than sentinel
2 Percentages based on respondents with complete data
* p-value = 0.226 using Mann Whitney Test

Table 6: Proportion of Variance Explained in Full and Abbreviated Models with Age in the Quadratic Form Compared to Age in Categories

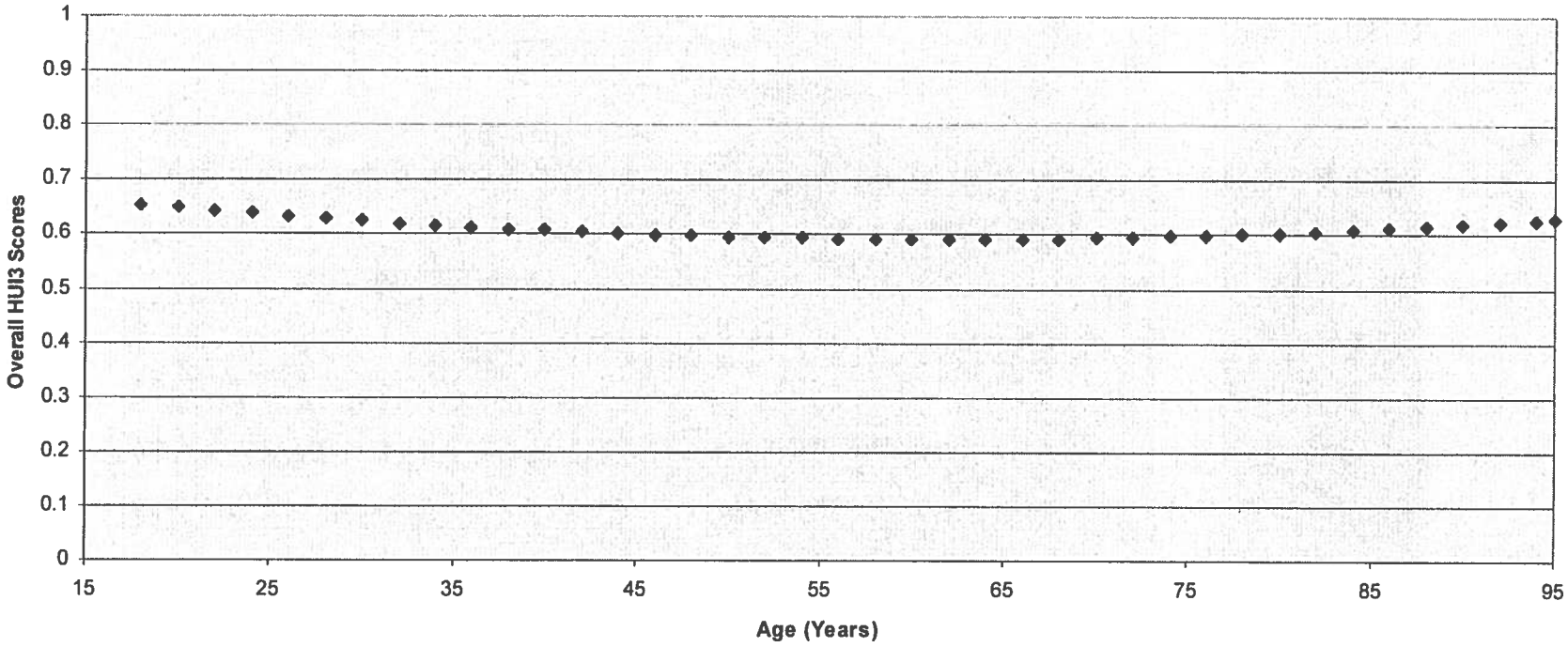
	Abbreviated Model R-Squared		Full Model R-Squared	
	Quadratic	Categories	Quadratic	Categories
Overall HUI3	0.21	0.20	0.17	0.17
Vision	0.08	0.07	0.05	0.05
Hearing	0.06	0.04	0.02	0.02
Speech	0.01	0.01	0.01	0.01
Ambulation	0.13	0.10	0.04	0.04
Dexterity	0.01	0.01	0.02	0.02
Emotion	0.04	0.04	0.06	0.06
Cognition	0.06	0.05	0.05	0.05
Pain and Discomfort	0.15	0.15	0.14	0.14

Table 7: Adjusted[a] Mean (95% CI) Overall and Single Attribute Utility Scores According to Sentinel Medical Conditions[b] (N=66,093)

	Overall	Vision	Hearing	Speech	Ambulation	Dexterity	Emotion	Cognition	Pain & Discomfort
Control Group	0.92 (0.92 -0.92)	0.97 (0.97-0.97)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.98 (0.98-0.98)	0.97 (0.97-0.98)	0.97 (0.96-0.97)
Heart Disease	**0.89** (0.88-0.90)	0.97 (0.96-0.97)	**0.99** (0.98-0.99)	1.00 (1.00-1.00)	1.00 (0.99-1.00)	**1.00** (1.00-1.00)	**0.97** (0.97-0.98)	**0.97** (0.96-0.97)	**0.93** (0.92-0.94)
Diabetes	**0.88** (0.87-0.89)	0.97 (0.96-0.97)	1.00 (0.99-1.00)	1.00 (1.00-1.00)	**0.98** (0.97-0.98)	1.00 (1.00-1.00)	**0.96** (0.96-0.97)	**0.96** (0.95-0.97)	**0.94** (0.93-0.95)
Arthritis	**0.84** (0.84-0.85)	**0.96** (0.96-0.96)	**0.99** (0.98-0.99)	1.00 (1.00-1.00)	**0.98** (0.98-0.98)	**0.99** (0.99-0.99)	**0.97** (0.97-0.97)	**0.97** (0.96-0.97)	**0.87** (0.86-0.87)
Stroke	**0.74** (0.72-0.76)	**0.93** (0.92-0.94)	**0.98** (0.97-0.98)	**0.98** (0.97-0.98)	**0.85** (0.83-0.86)	**0.98** (0.98-0.99)	**0.96** (0.95-0.97)	**0.91** (0.89-0.92)	**0.91** (0.89-0.94)
Diabetes, Stroke	**0.79** (0.74-0.85)	**0.95** (0.92-0.97)	**0.95** (0.93-0.98)	1.00 (1.00-1.00)	**0.81** (0.79-0.85)	**0.98** (0.96-0.99)	0.98 (0.96-1.01)	0.97 (0.94-1.00)	0.98 (0.92-1.04)
Diabetes, Arthritis	**0.78** (0.77-0.80)	**0.95** (0.95-0.96)	0.99 (0.99-1.00)	1.00 (1.00-1.00)	**0.95** (0.94-0.96)	**0.99** (0.99-0.99)	**0.96** (0.95-0.96)	**0.93** (0.92-0.94)	**0.82** (0.81-0.83)
Arthritis, Heart Disease	**0.78** (0.77-0.79)	0.97 (0.97-0.98)	**0.98** (0.98-0.99)	1.00 (1.00-1.00)	**0.95** (0.94-0.96)	**0.98** (0.98-0.99)	**0.97** (0.96-0.97)	0.96 (0.96-0.98)	**0.78** (0.77-0.79)
Diabetes, Heart Disease	**0.77** (0.74-0.79)	**0.93** (0.92-0.94)	0.99 (0.98-1.00)	1.00 (1.00-1.00)	**0.90** (0.89-0.921)	1.00 (0.99-1.00)	**0.94** (0.93-0.95)	0.98 (0.96-0.99)	**0.81** (0.78-0.83)
Stroke, Heart Disease	**0.76** (0.73-0.80)	**0.94** (0.93-0.96)	**0.97** (0.96-0.99)	**0.98** (0.98-.099)	**0.85** (0.83-0.87)	**0.98** (0.97-0.99)	**0.95** (0.93-0.97)	**0.87** (0.85-0.90)	0.95 (0.91-0.98)
Stroke, Arthritis	**0.58** (0.55-0.61)	**0.94** (0.93-0.96)	**0.96** (0.95-0.98)	**0.99** (0.99-1.00)	**0.74** (0.72-0.76)	**0.98** (0.97-0.99)	**0.94** (0.92-0.95)	**0.87** (0.86-0.89)	**0.72** (0.68-0.76)
Diabetes, Stroke, Heart Disease	**0.66** (0.57-0.74)	1.00 (0.96-1.03)	**0.87** (0.83-0.90)	1.00 (0.99-1.00)	**0.90** (0.85-0.95)	**0.96** (0.94-0.98	**0.84** (0.79-0.88)	**0.78** (0.73-0.83)	1.03 (0.94-1.12)
Diabetes, Heart Disease, Arthritis	**0.65** (0.62-0.68)	**0.91** (0.90-0.92)	**0.99** (0.98-1.00)	**0.96** (0.96-0.97)	**0.87** (0.85-0.88)	**0.96** (0.95-0.97)	0.98 (0.97-0.99)	**0.90** (0.88-0.91)	**0.78** (0.67-0.72)
Diabetes, Stroke, Arthritis	**0.64** (0.58-0.69)	0.97 (0.95 -1.00)	**0.98** (0.96-1.00)	1.00 (0.99-1.00)	**0.78** (0.75-0.82)	**0.99** (0.98-1.00)	**0.89** (0.87-0.92)	**0.88** (0.85-0.91)	**0.84** (0.78-0.90)
Stroke, Arthritis, Heart Disease	**0.62** (0.59-0.66)	**0.95** (0.93-0.97)	**0.96** (0.95-0.98)	**0.99** (0.98-0.99)	**0.78** (0.75-0.80)	**0.99** (0.98-1.00)	**0.92** (0.91-0.94)	**0.81** (0.79-0.83)	**0.79** (0.75-0.82)
Diabetes, Stroke, Heart Disease, Arthritis	**0.46** (0.41-0.51)	**0.86** (0.83-0.88)	**0.88** (0.86-0.91)	1.00 (0.99-1.00)	**0.67** (0.63-0.70)	1.00 (0.99-1.02)	**0.92** (0.89-0.95)	**0.87** (0.84-0.90)	**0.59** (0.53-0.64)

a Adjusted for Age as a Quadratic, Sex, Education and Number of Medical Conditions
b Bold entries are statistically different from control group ($p < 0.05$)

Figure 1: Overall HUI3 Scores for Males with Stroke and Arthritis, Secondary Education, One Other Medical Condition in Full Model*



* Scores estimated for cases with BMI's between 22.1 to 25.0, who were not married, did not have proxies, were nonsmokers and had incomes between $30,000 and 49,999

Figure 2: Overall HUI3 Score for Males with Stroke and Arthritis, Secondary Education,and One Other Medical Condition in Abbreviated Model

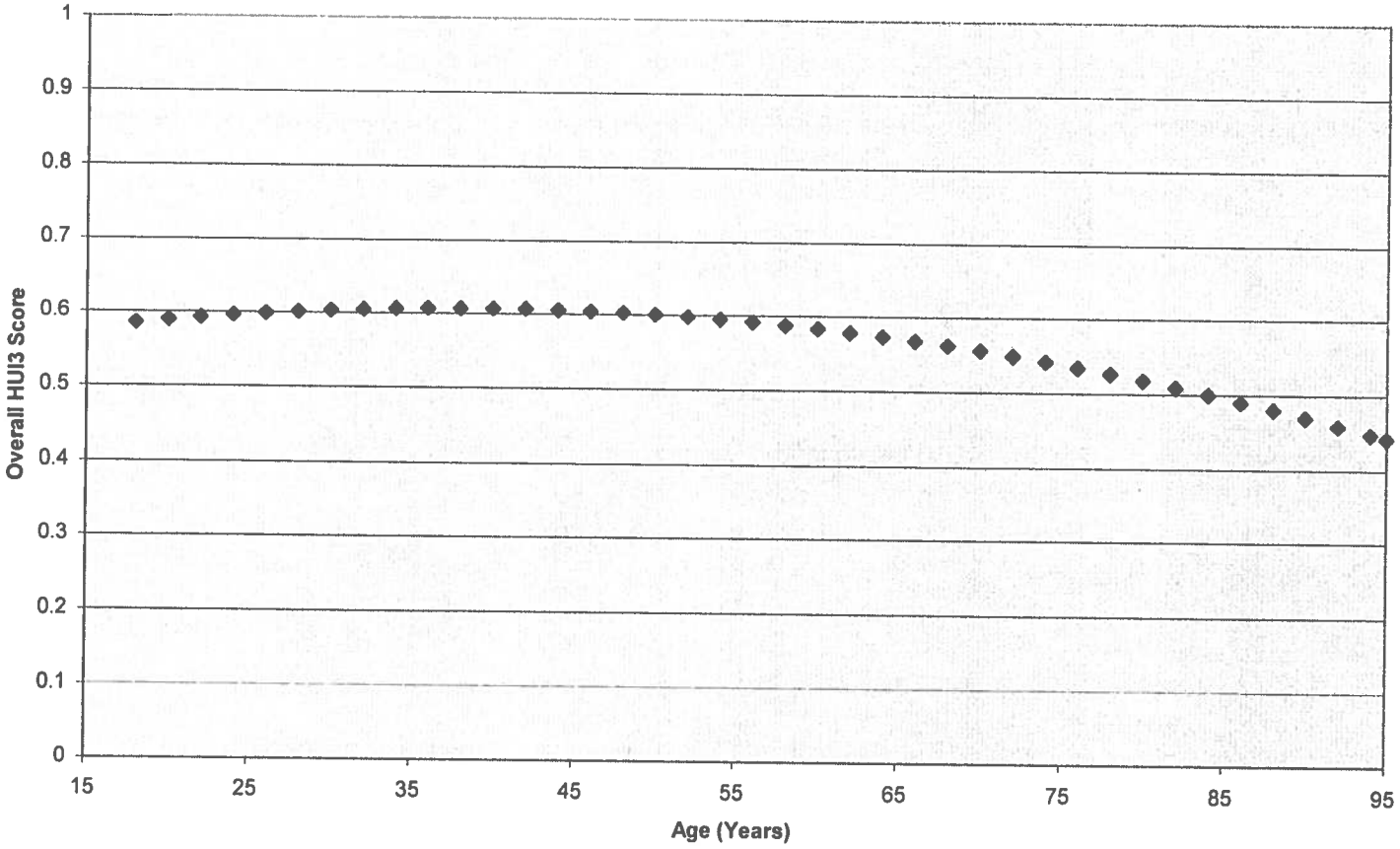


Figure 3: Ambulation Attribute Scores for Males with Stroke and Arthritis, Secondary Education and One Other Medical Condition in Abbreviated Model

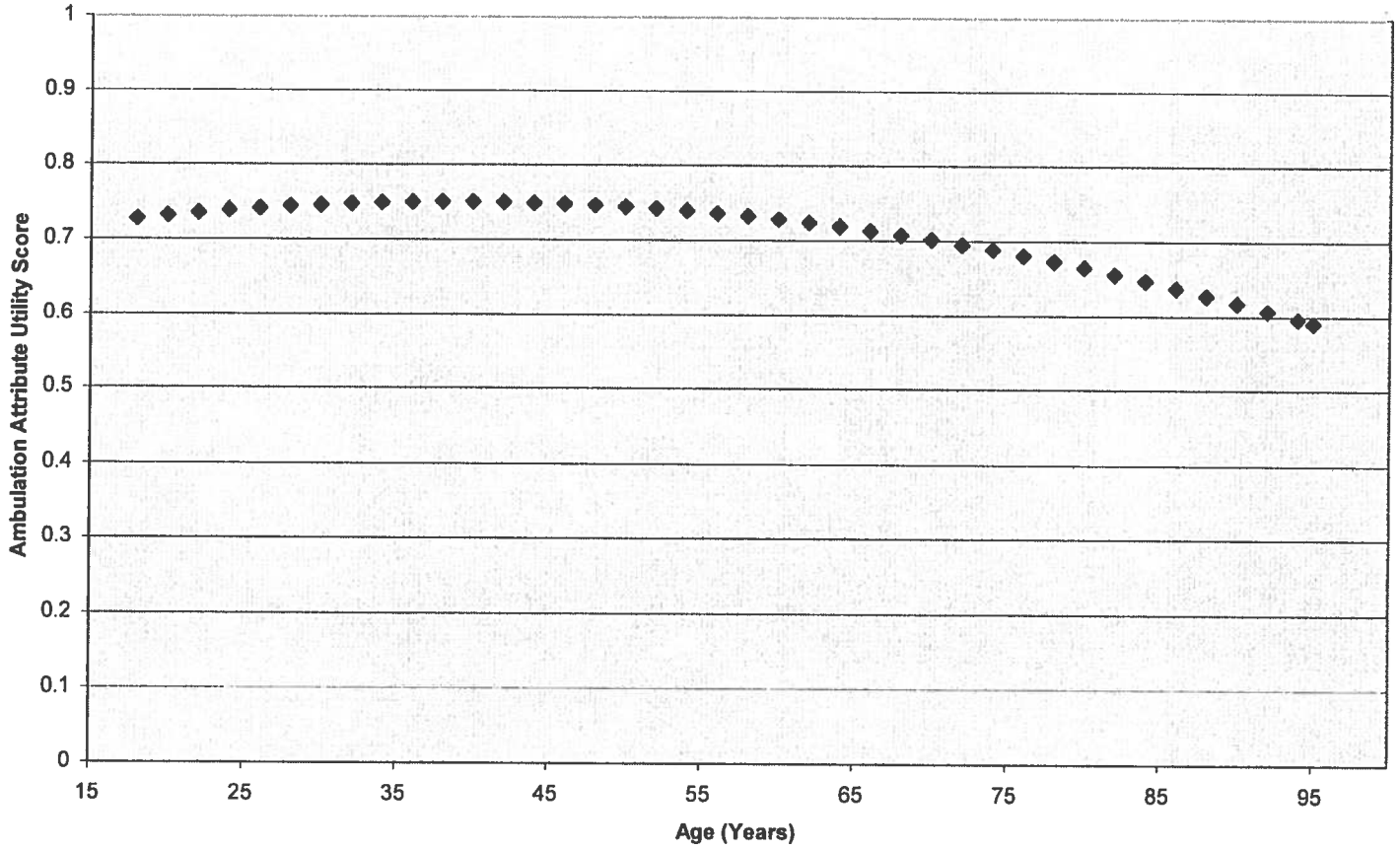


Figure 4: Emotion Attribute Scores for Males with Stroke and Arthritis, Secondary Education, and One Other Medical Condition in Abbreviated Model

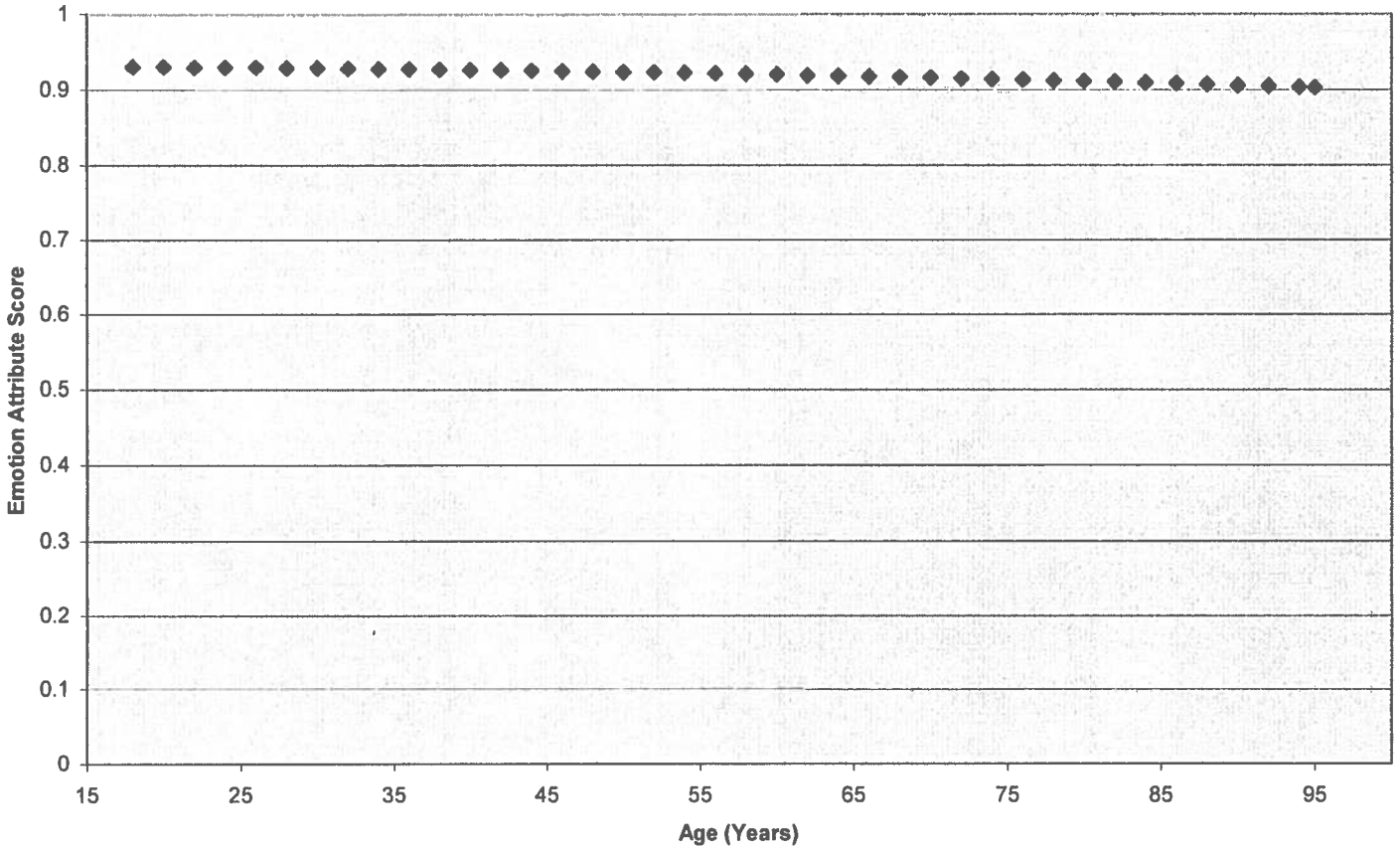


Figure 5: Cogntion Attribute Scores for Males with Stroke and Arthritis, Secondary Education and One Other Medical Condition in Abbreviated Model

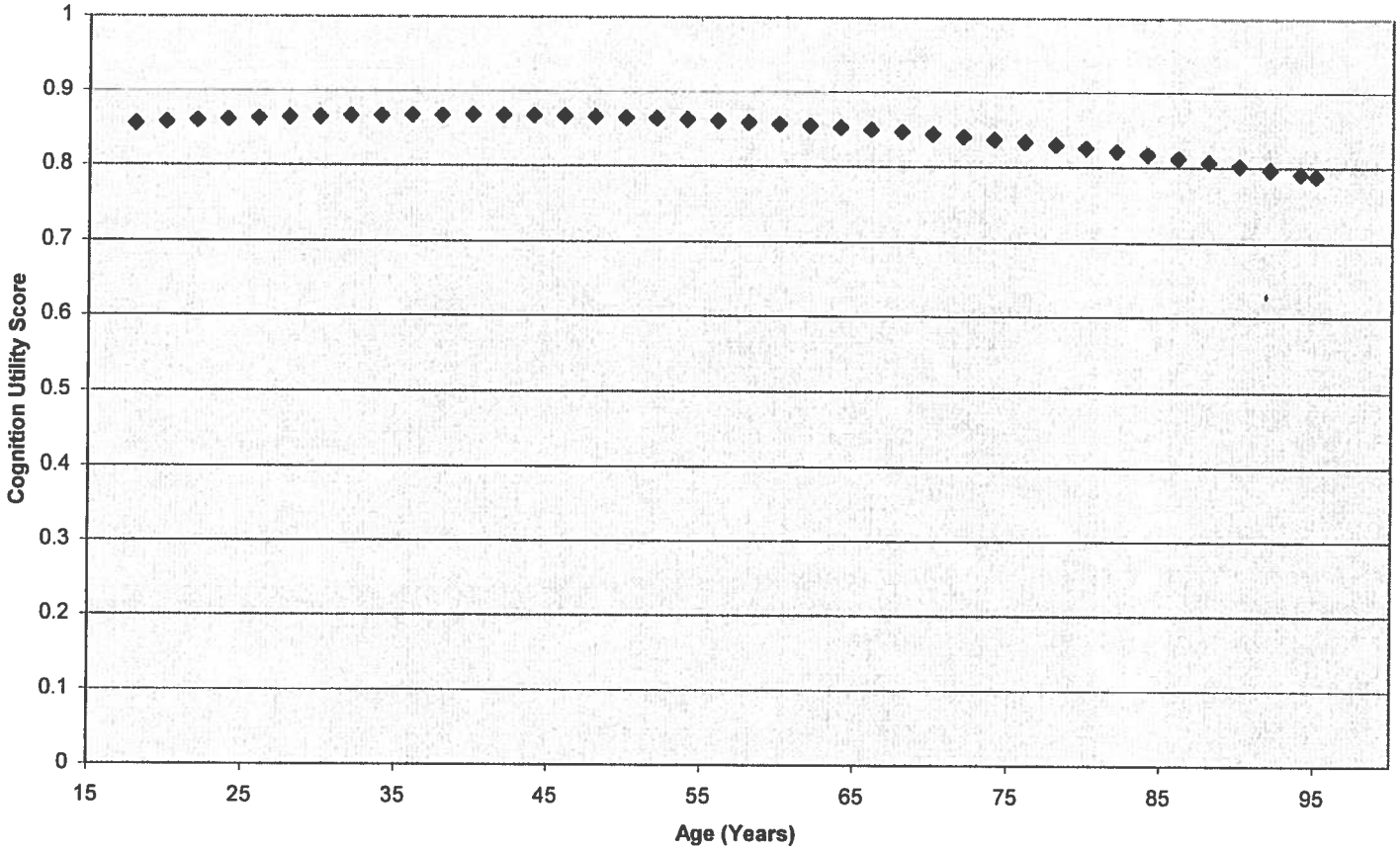
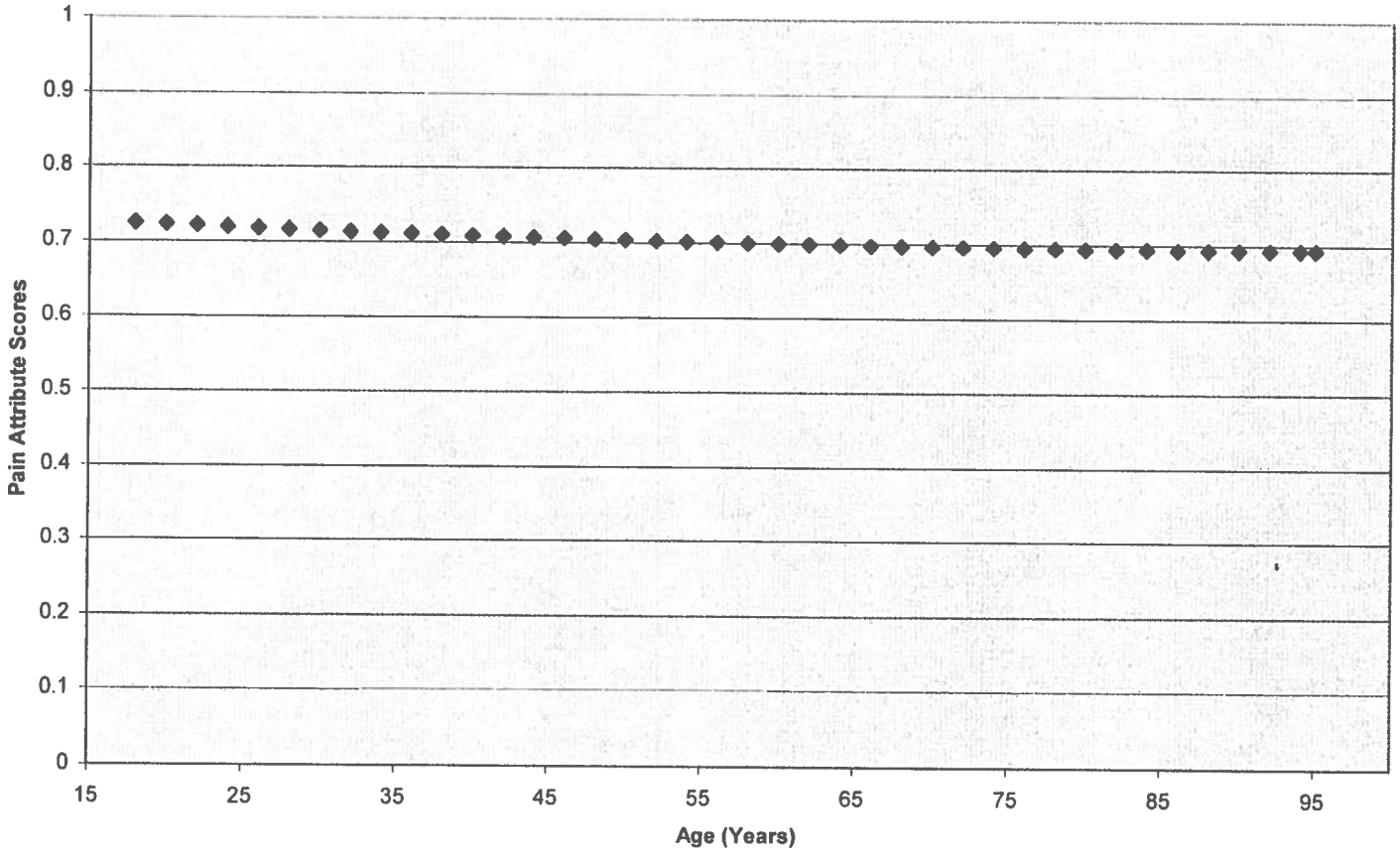


Figure 6: Pain Attribute Scores for Males with Stroke and Arthritis, Secondary Education and One Medical Condition in Abbreviated Model



APPENDIX 1
HEALTH UTILITIES INDEX MARK 3 CLASSIFICATION SYSTEM

HUI3 Health Status Classification System

Attribute	Level	Level Description
Vision	1	Able to see well enough to read ordinary newsprint and recognize a friend on the other side of the street, without glasses or contact lenses
	2	Able to see well enough to read ordinary newsprint and recognize a friend on the other side of the street, but with glasses
	3	Able to read ordinary newsprint with or without glasses but unable to recognize a friend on the other side of the street, even with glasses
	4	Able to recognize a friend on the other side of the street with or without glasses but unable to read ordinary newsprint even with glasses
	5	Unable to read ordinary newsprint and unable to recognize a friend on the other side of the street, even with glasses
	6	Unable to see at all
Hearing	1	Able to hear what is said in a group conversation with at least three other people, without a hearing aid
	2	Able to hear what is said in a conversation with one other person in a quiet room without a hearing aid, but requires a hearing aid to hear what is said in a group conversation with at least three other people
	3	Able to hear what is said in a conversation with one other person in a quiet room with a hearing aid and able to hear what is said in a group conversation with at least three other people with a hearing aid
	4	Able to hear what is said in a conversation with one other person in a quiet room without a hearing aid, but unable to hear what is said in a group conversation with at least three other people even with a hearing aid
	5	Able to hear what is said in a conversation with one other person in a quiet room with a hearing aid, but unable to hear what is said in a group conversation with at least three other people even with a hearing aid
	6	Unable to hear at all
Speech	1	Able to be understood completely when speaking with strangers or friends
	2	Able to be understood partially when speaking with strangers but able to be understood completely when speaking with people who know the respondent well
	3	Able to be understood partially when speaking with strangers or people who know the respondent well
	4	Unable to be understood when speaking with strangers but able to be understood partially by people who know the respondent well
	5	Unable to be understood when speaking to other people (or unable to speak at all)
Ambulation	1	Able to walk around the neighborhood without difficulty and without walking equipment
	2	Able to walk around the neighborhood with difficulty, but does not require walking equipment or the help of another person
	3	Able to walk around the neighborhood with walking equipment, but without the help of another person
	4	Able to walk only short distances with walking equipment and requires a wheelchair to get around the neighborhood
	5	Unable to walk alone, even with walking equipment; able to walk short distances with the help of another person, and requires a wheelchair to get around the neighborhood
	6	Cannot walk at all
Dexterity	1	Full use of two hands and ten fingers
	2	Limitations in the use of hands or fingers, but does not require special tools or help of another person
	3	Limitations in the use of hands or fingers, is independent with use of special tools (does not require the help of another person)
	4	Limitations in the use of hands or fingers, requires the help of another person for some tasks (not independent even with the use of special tools)
	5	Limitations in the use of hands or fingers, requires the help of another person for most tasks (not independent even with the use of special tools)
	6	Limitations in the use of hands or fingers, requires the help of another person for all tasks (not independent even with the use of special tools)
Emotion	1	Happy and interested in life
	2	Somewhat happy
	3	Somewhat unhappy
	4	Very unhappy
	5	So unhappy that life is not worthwhile
Cognition	1	Able to remember most things, think clearly and solve day to day problems
	2	Able to remember most things, but have a little difficulty when trying to think and solve day to day problems
	3	Somewhat forgetful, but able to think clearly and solve day to day problems
	4	Somewhat forgetful, and have a little difficulty when trying to think or solve day to day problems
	5	Very forgetful, and have great difficulty when trying to think and or solve day to day problems
	6	Unable to remember anything at all, and unable to think or solve day to day problems
Pain	1	Free of pain and discomfort
	2	Mild to moderate pain that prevents no activities
	3	Moderate pain that prevents a few activities
	4	Moderate to severe pain that prevents some activities
	5	Severe pain that prevents most activities

Source: http://www.fcs.mcmaster.ca/hug/index.htm

APPENDIX 2
INDEPENDENT VARIABLE CODING OF CATEGORICAL VARIABLES

Variable Name	Variable Coding	Reference Category
Sentinel Medical Conditions	DM - S - HD – A = 1 DM - S – A = 2 DM - S – HD = 3 D - HD – A = 4 S - A – HD = 5 A – HD = 6 S – HD = 7 S – A = 8 DM – HD = 9 DM – A = 10 DM – S = 11 Heart Disease (HD) = 12 Arthritis (A) = 13 Stroke (S) = 14 Diabetes (DM) =15 Control =16	Control
Sex	Male =1 Female = 2	Female
Age	18 to 30 = 1 31 to 39 = 2 40 to 49 = 3 50 to 59 = 4 Greater than 60 = 5	Greater than 60
Education	Less Than Secondary = 1 Secondary Graduation = 2 Other Post-Secondary = 3 College/University Degree = 4	College/University Degree
Income	Less than $29,999 = 1 $30,000 to $49,999 = 2 $50,000 to $79,999 = 3 $80,000 or greater = 4	$80,000 or greater
Body Mass Index	Less than 22.0 = 1 22.1 to 25.0 = 2 25.1 to 27.0 = 3 27.1 or greater = 4	27.1 or greater
Marital Status	Yes = 1 No = 0	Married
Smoking Status	Yes = 1 No = 0	Current Smoker
Proxy Response	Yes = 1 No = 2	Completed by proxy

A – Arthritis S – Stroke DM – Diabetes HD – Heart Disease

APPENDIX 3
RESULTS WITH AGE AS A QUADRATIC

Table 8A: Overall HUI3 Score with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.050 (0.006)	<0.001	-0.037 (0.005)	<0.001
Stroke (S)	-0.114 (0.016)	<0.001	-0.178 (0.011)	<0.001
Arthritis (A)	-0.078 (0.003)	<0.001	-0.075 (0.002)	<0.001
Heart Disease (HD)	-0.004 (0.007)	0.545	-0.028 (0.005)	<0.001
DM - S	0.059 (0.043)	0.165	-0.126 (0.028)	<0.001
DM - A	-0.145 (0.010)	<0.001	-0.134 (0.007)	<0.001
DM - HD	-0.107 (0.018)	<0.001	-0.149 (0.012	<0.001
S - A	-0.285 (0.032)	<0.001	-0.335 (0.016)	<0.001
S - HD	-0.018 (0.026)	0.507	-0.151 (0.019)	<0.001
A - HD	-0.104 (0.011)	<0.001	-0.138 (0.006)	<0.001
S - A - HD	-0.476 (0.054)	<0.001	-0.295 (0.018)	<0.001
D - HD - A	-0.132 (0.024)	<0.001	-0.263 (0.013)	<0.001
DM - S - HD	Suppressed		-0.258 (0.044)	<0.001
DM - S - A	-0.444 (0.058)	<0.001	-0.280 (0.028)	<0.001
DM - S - HD - A	Suppressed		-0.456 (0.027)	<0.001
Sex (1=male, 2=female)	-0.006 (0.002)	<0.001	-0.010 (0.001)	<0.001
Age	-0.004 (0.000)	<0.001	0.004 (0.000)	<0.001
Age^2	3.2E-05 (0.000)	<0.001	-5.2E-05 (0.000)	<0.001
Education				
Less Than Secondary	-0.031 (0.002)	<0.001	-0.039 (0.002)	<0.001
Secondary Graduation	-0.003 (0.002)	0.216	-0.006 (0.002)	0.001
Other Post-Secondary	-0.002 (0.002)	0.187	-0.005 (0.002)	0.005
College/University Degree	0	0	0	-
Number of Medical Conditions	-0.031 (0.001)	<0.001	-0.033 (0.001)	<0.001
Income				
Less than $29,999	-0.041 (0.003)	<0.001	-	-
$30,000 to $49,999	-0.012 (0.002)	<0.001	-	-
$50,000 to $79,999	-0.003 (0.002)	0.270	-	-
$80,000 or greater	0		-	-
BMI				
Less than 22.0	-0.003 (0.002)	0.241	-	-
22.1 to 25.0	-0.003 (0.002)	0.109	-	-
25.1 to 27.0	-0.003 (0.002)	0.138	-	-
27.1 or greater	0		-	-
Marital Status (Yes =1, No=0)	-0.017 (0.002)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.018 (0.002)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.024 (0.002)	<0.001	-	-
	R^2=0.17 Adjusted R^2=0.17		R^2=0.21 Adjusted R^2=0.21	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8B: Vision Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.002 (0.003)	0.247	-0.002 (0.002)	0.0.350
Stroke (S)	-0.005 (0.007)	0.358	-0.039 (0.005)	<0.001
Arthritis (A)	-0.004 (0.001)	<0.001	-0.006 (0.001)	<0.001
Heart Disease (HD)	-0.009 (0.003)	0.001	-0.004 (0.002)	0.083
DM - S	0.010 (0.018)	0.730	-0.023 (0.012)	0.058
DM - A	-0.020 (0.004)	<0.001	-0.015 (0.003)	<0.001
DM - HD	-0.000 (0.008)	0.892	-0.043 (0.005)	<0.001
S - A	-0.026 (0.013)	0.028	-0.026 (0.007)	<0.001
S - HD	0.006 (0.011)	0.525	-0.026 (0.008)	0.001
A - HD	0.006 (0.005)	0.301	0.001 (0.003)	0.646
S - A - HD	-0.110 (0.022)	<0.001	-0.019 (0.008)	0.015
D - HD - A	-0.012 (0.010)	0.125	-0.056 (0.005)	<0.001
DM - S - HD	Suppressed	Suppressed	0.028 (0.019)	0.139
DM - S - A	-0.041 (0.024)	0.068	0.003 (0.012)	0.772
DM - S - HD - A	Suppressed	Suppressed	-0.112 (0.012)	<0.001
Sex (1=male, 2=female)	0.003 (0.001)	<0.001	0.005 (0.001)	<0.001
Age	0.001 (0.000)	0.003	0.000 (0.000)	<0.001
Age^2	-1.93E-05 (0.000)	<0.001	-1.27E-05 (0.000)	<0.001
Education				
Less Than Secondary	-0.003 (0.001)	<0.001	-0.002 (0.001)	<0.041
Secondary Graduation	0.001 (0.001)	0.192	0.001 (0.001)	0.269
Other Post-Secondary	0.002 (0.001)	0.025	0.001 (0.001)	0.219
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.002 (0.000)	<0.001	-0.003 (0.001)	<0.001
Income				
Less than $29,999	-0.001 (0.001)	0.299	-	-
$30,000 to $49,999	0.000 (0.001)	0.655	-	-
$50,000 to $79,999	$6.3x10^{-7}$ (0.001)	1.000	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.001)	0.846	-	-
22.1 to 25.0	-0.001 (0.001)	0.359	-	-
25.1 to 27.0	-0.001 (0.001)	0.152	-	-
27.1 or greater	0		-	-
Marital Status (Yes =1, No=0)	-0.005 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	-0.001 (0.001)	0.189	-	-
Proxy Response (Yes=1, No=2)	-0.002 (0.001)	0.036	-	-
	R^2=0.053 Adjusted R^2=0.052		R^2=0.079 Adjusted R^2=0.078	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8C: Hearing Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	0.001 (0.002)	0.626	0.005 (0.002)	0.216
Stroke (S)	0.002 (0.006)	0.792	-0.018 (0.005)	<0.001
Arthritis (A)	-0.002 (0.001)	0.068	-0.006 (0.001)	<0.001
Heart Disease (HD)	-8.09×10^{-5} (0.002)	0.974	-0.009 (0.002)	<0.001
DM - S	0.015 (0.016)	0.348	-0.042 (0.013)	0.001
DM - A	0.004 (0.004)	0.315	-0.007 (0.003)	0.038
DM - HD	0.012 (0.007)	0.067	-0.007 (0.006)	0.233
S - A	0.006 (0.012)	0.577	-0.039 (0.007)	<0.001
S - HD	0.012 (0.010)	0.209	-0.029 (0.009)	0.001
A - HD	0.005 (0.004)	0.154	-0.017 (0.003)	<0.001
S - A - HD	-0.355 (0.020)	<0.001	-0.050 (0.008)	<0.001
D - HD - A	0.017 (0.009)	0.053	-0.015 (0.006)	0.014
DM - S - HD	Suppressed	Suppressed	-0.134 (0.020)	<0.001
DM - S - A	-0.096 (0.021)	<0.001	-0.018 (0.013)	0.171
DM - S - HD - A	Suppressed	Suppressed	-0.118 (0.012)	<0.001
Sex (1=male, 2=female)	-0.004 (0.001)	<0.001	-0.006 (0.001)	<0.001
Age	0.001 (0.000)	<0.001	0.002 (0.000)	
Age^2	-1.34×10^{-5} (0.000)	<0.001	-3.20×10^{-5} (0.000)	
Education				
Less Than Secondary	0.001 (0.001)	0.440	-0.004 (0.001)	<0.001
Secondary Graduation	-4.84×10^{-5} (0.001)	0.955	0.001 (0.001)	0.307
Other Post-Secondary	0.000 (0.001)	0.684	0.000 (0.001)	0.794
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.001 (0.000)	0.016	-0.001 (0.001)	<0.001
Income				
Less than $29,999	-0.006 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.004 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.003 (0.001)	0.001	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.001)	0.639	-	-
22.1 to 25.0	-0.001 (0.001)	0.191	-	-
25.1 to 27.0	0.000 (0.001)	0.781	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	0.000 (0.001)	0.322	-	-
Smoking Status (Yes=1, No=0)	0.000 (0.001)	0.595	-	-
Proxy Response (Yes=1, No=2)	-0.004 (0.001)	<0.001	-	-
	R^2=0.017 Adjusted R^2=0.018		R^2=0.056 Adjusted R^2=0.056	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8D: Speech Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	0.000 (0.001)	0.864	0.001 (0.001)	0.164
Stroke (S)	-0.023 (0.003)	<0.001	-0.023 (0.002)	<0.001
Arthritis (A)	-0.003 (0.000)	<0.001	-0.001(0.000)	0.033
Heart Disease (HD)	-0.002 (0.001)	0.104	0.000 (0.001)	0.759
DM - S	0.002 (0.008)	0.837	0.004 (0.005)	0.483
DM - A	0.001 (0.002)	0.460	0.001 (0.001)	0.340
DM - HD	0.002 (0.003)	0.564	0.003 (0.002)	0.156
S - A	-0.015 (0.006)	0.009	-0.007 (0.003)	0.032
S - HD	-0.018 (0.005)	<0.001	-0.014 (0.004)	<0.001
A - HD	-0.001 (0.002)	0.727	0.001 (0.001)	0.255
S - A - HD	0.004 (0.010)	0.723	-0.011 (0.003)	0.001
D - HD - A	0.002 (0.005)	0.584	-0.037 (0.002)	<0.001
DM - S - HD	Suppressed	-	0.004 (0.008)	0.636
DM - S - A	0.004 (0.011)	0.713	0.004 (0.005)	0.446
DM - S - HD - A	Suppressed	-	-0.002 (0.005)	0.984
Sex (1=male, 2=female)	0.000 (0.000)	0.505	-9.96×10^{-6} (0.000)	0.008
Age	0.001 (0.000)	<0.001	0.000 (0.000)	<0.001
Age^2	-1.93×10^{-5} (0.000)	<0.001	-3.36×10^{-6} (0.000)	<0.001
Education				
Less Than Secondary	-0.001(0.000)	0.033	-0.002(0.000)	<0.001
Secondary Graduation	-0.001 (0.000)	0.038	0.000 (0.000	0.198
Other Post-Secondary	0.000 (0.000)	0.666	0.000 (0.000)	0.312
College/University Degree	0	-	0	-
Number of Medical Conditions	0.000 (0.000)	<0.001	0.000 (0.000)	<0.001
Income				
Less than $29,999	-0.002 (0.000)	0.000	-	-
$30,000 to $49,999	-0.001 (0.000)	0.073	-	-
$50,000 to $79,999	0.000 (0.000)	0.374	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.000)	0.219	-	-
22.1 to 25.0	0.000 (0.000)	0.390	-	-
25.1 to 27.0	-0.001 (0.000)	0.144	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.002 (0.000)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.000 (0.000)	0.184	-	-
Proxy Response (Yes=1, No=2)	-0.003 (0.000)	<0.001	-	-
	R^2=0.009 Adjusted R^2=0.008		R^2=0.011 Adjusted R^2=0.011	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8E: Ambulation Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.007 (0.003)	0.020	-0.010 (0.003)	<0.001
Stroke (S)	-0.125 (0.008)	<0.001	-0.141 (0.007)	<0.001
Arthritis (A)	-0.014 (0.001)	<0.001	-0.009 (0.001)	<0.001
Heart Disease (HD)	0.001 (0.003)	0.847	0.009 (0.003)	0.929
DM - S	0.014 (0.021)	0.502	-0.177 (0.017)	<0.001
DM - A	-0.027 (0.005)	<0.001	-0.040 (0.004)	<0.001
DM - HD	-0.049 (0.009)	<0.001	-0.086 (0.007)	<0.001
S - A	-0.162 (0.016)	<0.001	-0.250 (0.010)	<0.001
S - HD	-0.048 (0.013)	<0.001	-0.137 (0.011)	<0.001
A - HD	0.004 (0.005)	0.421	-0.039 (0.004)	<0.001
S - A - HD	-0.445 (0.026)	<0.001	-0.213 (0.011)	<0.001
D - HD - A	-0.049 (0.012)	<0.001	-0.120 (0.008)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.090 (0.026)	<0.001
DM - S - A	-0.028 (0.028)	0.332	-0.206 (0.017)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.323 (0.016)	<0.001
Sex (1=male, 2=female)	-0.003 (0.001)	0.001	0.000 (0.001)	0.828
Age	0.000 (0.000)	0.054	0.004 (0.00)	<0.001
Age^2	$3.74x10^{-6}$ (0.000)	0.169	$-5.10x10^{-5}$ (0.000)	<0.001
Education				
Less Than Secondary	-0.004 (0.001)	<0.001	-0.001 (0.001)	0.167
Secondary Graduation	-0.001 (0.001)	0.345	0.002 (0.001)	0.057
Other Post-Secondary	0.000 (0.001)	0.608	0.003 (0.001)	0.011
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.006 (0.000)	<0.001	-0.008 (0.000)	< 0.001
Income				
Less than $29,999	-0.004 (0.001)	0.001	-	-
$30,000 to $49,999	-0.002 (0.001)	0.169	-	-
$50,000 to $79,999	0.002 (0.001)	0.080	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	-0.003 (0.001)	0.002	-	-
22.1 to 25.0	-0.002 (0.001)	0.087	-	-
25.1 to 27.0	-0.002 (0.001)	0.053	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.003 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	-8.1x10-5 (0.001)	0.920	-	-
Proxy Response (Yes=1, No=2)	-0.004 (0.001)	<0.001	-	-
	R^2=0.041 Adjusted R^2=0.041		R^2=0.130 Adjusted R^2=0.129	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8F: Dexterity Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.003 (0.001)	0.048	-0.001 (0.001)	0.573
Stroke (S)	-0.026 (0.004)	<0.001	-0.014 (0.003)	<0.001
Arthritis (A)	-0.005 (0.001)	<0.001	-0.005 (0.001)	<0.001
Heart Disease (HD)	0.004 (0.002)	0.018	0.003 (0.001)	0.046
DM - S	0.004 (0.010)	0.651	-0.021 (0.007)	0.001
DM - A	-0.003 (0.002)	0.181	-0.007 (0.002)	<0.001
DM - HD	-0.008 (0.004)	0.040	-0.001 (0.003)	0.726
S - A	-0.11 (0.007)	<0.001	-0.019 (0.004)	<0.001
S - HD	0.006 (0.006)	0.327	-0.017 (0.005)	<0.001
A - HD	-0.004 (0.002)	0.135	-0.015 (0.001)	<0.001
S - A - HD	0.008 (0.0012)	0.491	-0.012 (0.004)	0.001
D - HD - A	-0.046 (0.006)	<0.001	-0.038 (0.003)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.037 (0.011)	<0.001
DM - S - A	-0.013 (0.013)	0.325	-0.006 (0.007)	0.282
DM - S - HD - A	Suppressed	Suppressed	0.006 (0.007)	0.454
Sex (1=male, 2=female)	0.001 (0.000)	0.070	$3.55x10^{-5}$ (0.000)	0.910
Age	0.000 (0.000)	0.155	0.000 (0.000)	0.007
Age^2	-2.59x10-6 (0.000)	0.039	-1.94x10-6 (0.000)	<0.001
Education				
Less Than Secondary	0.000 (0.001)	0.622	-0.002 (0.000)	<0.001
Secondary Graduation	0.000 (0.000)	0.820	0.000 (0.000)	0.590
Other Post-Secondary	$7.59x10^{-5}$ (0.000)	0.859	$5.74x10^{-5}$ (0.000)	0.688
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.001 (0.000)	<0.001	-0.001 (0.000)	<0.001
Income				
Less than $29,999	-0.001 (0.001)	0.140	-	-
$30,000 to $49,999	-0.002 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.001 (0.001)	0.118	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.000)	0.491	-	-
22.1 to 25.0	-0.001 (0.000)	0.247	-	-
25.1 to 27.0	0.000 (0.001)	0.388	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-2.39x10-5 (0.000)	0.953	-	-
Smoking Status (Yes=1, No=0)	0.000 (0.000)	0.295	-	-
Proxy Response (Yes=1, No=2)	-0.002 (0.000)	<0.001	-	-
	R^2=0.019 Adjusted R^2=0.018		R^2=0.014 Adjusted R^2=0.014	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8G: Emotion Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.016 (0.003)	<0.001	-0.014 (0.002)	<0.001
Stroke (S)	-0.005 (0.008)	0.507	-0.013 (0.005)	0.015
Arthritis (A)	-0.007 (0.001)	<0.001	-0.005 (0.001)	<0.001
Heart Disease (HD)	0.005 (0.003)	0.154	-0.005 (0.002)	0.016
DM - S	0.005 (0.021)	0.797	0.007 (0.013)	0.582
DM - A	-0.006 (0.005)	0.241	-0.021 (0.003)	<0.001
DM - HD	-0.097 (0.009)	<0.001	-0.037 (0.006)	<0.001
S - A	-0.069 (0.016)	<0.001	-0.039 (0.008)	<0.001
S - HD	0.016 (0.013)	0.227	-0.028 (0.009)	0.002
A - HD	-0.016 (0.005)	0.002	-0.011 (0.003)	<0.001
S - A - HD	0.061 (0.027)	0.022	-0.053 (0.006)	<0.001
D - HD - A	0.004 (0.012)	0.744	0.001 (0.009)	0.819
DM - S - HD	Suppressed	Suppressed	-0.142 (0.021)	<0.001
DM - S - A	-0.085 (0.029)	0.003	-0.083 (0.013)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.055 (0.013)	<0.001
Sex (1=male, 2=female)	-0.004 (0.001)	<0.001	-0.004 (0.001)	<0.001
Age	-0.003 (0.000)	0.002	0.000 (0.000)	0.002
Age^2	$2.70x10^{-5}$ (0.000)	<0.001	$-3.13x10^{-6}$ (0.000)	0.001
Education				
Less Than Secondary	-0.003 (0.001)	0.007	-0.013 (0.001)	<0.001
Secondary Graduation	0.002 (0.001)	0.039	-0.002 (0.001)	0.041
Other Post-Secondary	0.004 (0.001)	<0.001	0.001 (0.001)	0.316
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.008 (0.000)	<0.001	-0.008 (0.000)	<0.001
Income				
Less than $29,999	-0.020 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.007 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.005 (0.001)	<0.001	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	-0.005 (0.001)	<0.001	-	-
22.1 to 25.0	-0.001 (0.001)	0.496	-	-
25.1 to 27.0	-8.40x10-5 (0.001)	0.940	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.013 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.013 (0.001)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.001 (0.001)	0.208	-	-
	R^2=0.063 Adjusted R^2=0.062		R^2=0.036 Adjusted R^2=0.036	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8H: Cognition Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.024 (0.004)	<0.001	-0.015 (0.003)	<0.001
Stroke (S)	-0.032 (0.009)	<0.001	-0.068 (0.006)	<0.001
Arthritis (A)	-0.012 (0.002)	<0.001	-0.008 (0.001)	<0.001
Heart Disease (HD)	0.001 (0.004)	0.731	-0.009 (0.003)	0.001
DM - S	0.003 (0.025)	0.912	-0.007 (0.016)	0.684
DM - A	-0.055 (0.006)	<0.001	-0.043 (0.004)	<0.001
DM - HD	0.005 (0.010)	0.614	0.002 (0.007)	0.753
S - A	-0.099 (0.018)	<0.001	-0.100 (0.009)	<0.001
S - HD	-0.001 (0.015)	0.953	-0.100 (0.011)	<0.001
A - HD	0.019 (0.006)	0.002	-0.005 (0.003)	0.119
S - A - HD	-0.341 (0.031)	<0.001	-0.167 (0.010)	<0.001
D - HD - A	-0.023 (0.014)	0.100	-0.077 (0.007)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.194 (0.025)	<0.001
DM - S - A	-0.283 (0.033)	<0.001	-0.092 (0.016)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.107 (0.015)	<0.001
Sex (1=male, 2=female)	0.002 (0.001)	0.011	-0.002 (0.001)	0.006
Age	-0.001 (0.000)	0.007	0.002 (0.000)	<0.001
Age^2	1.07x10-5 (0.000)	0.001	$-2.54x10^{-5}$ (0.000)	<0.001
Education				
Less Than Secondary	-0.015 (0.001)	<0.001	-0.018 (0.001)	<0.001
Secondary Graduation	-0.005 (0.001)	<0.001	-0.007 (0.001)	<0.001
Other Post-Secondary	-0.004 (0.001)	<0.001	-0.004 (0.001)	<0.001
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.008 (0.000)	<0.001	-0.009 (0.000)	<0.001
Income				
Less than $29,999	-0.016 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.001 (0.001)	0.431	-	-
$50,000 to $79,999	-0.002 (0.001)	0.098	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.001 (0.001)	0.571	-	-
22.1 to 25.0	0.000 (0.001)	0.664	-	-
25.1 to 27.0	0.002 (0.001)	0.217	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.005 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.005 (0.001)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.011 (0.001)	<0.001	-	-
	R^2=0.048 Adjusted R^2=0.047		R^2=0.059 Adjusted R^2=0.058	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 8I: Pain and Discomfort Attribute Scores with Age in the Quadratic Form

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.039 (0.007)	<0.001	-0.027 (0.005)	<0.001
Stroke (S)	-0.003 (0.017)	0.876	-0.051 (0.011)	<0.001
Arthritis (A)	-0.101 (0.003)	<0.001	-0.098 (0.002)	<0.001
Heart Disease (HD)	-0.009 (0.007)	0.229	-0.031 (0.005)	<0.001
DM - S	0.056 (0.046)	0.223	0.016 (0.029)	0.868
DM - A	-0.156 (0.011)	<0.001	-0.144 (0.007)	<0.001
DM - HD	-0.104 (0.019)	<0.001	-0.158 (0.013)	<0.001
S - A	-0.259 (0.034)	<0.001	-0.241 (0.017)	<0.001
S - HD	-0.014 (0.028)	0.663	-0.020 (0.019)	0.230
A - HD	-0.181 (0.012)	<0.001	-0.184 (0.006)	<0.001
S - A - HD	-0.386 (0.058)	<0.001	-0.179 (0.019)	<0.001
D - HD - A	-0.157 (0.026)	<0.001	-0.269 (0.013)	<0.001
DM - S - HD	Suppressed	Suppressed	0.065 (0.045)	0.207
DM - S - A	-0.314 (0.062)	<0.001	-0.125 (0.029)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.377 (0.028)	<0.001
Sex (1=male, 2=female)	-0.008 (0.002)	<0.001	-0.010 (0.001)	<0.001
Age	-0.004 (0.000)	<0.001	-0.001 (0.000)	0.003
Age^2	4.64x10-5 (0.000)	<0.001	$5.28x10^{-6}$ (0.000)	0.013
Education				
Less Than Secondary	-0.029 (0.002)	<0.001	-0.029 (0.002)	<0.001
Secondary Graduation	0.000 (0.002)	0.845	-0.003 (0.002)	0.091
Other Post-Secondary	-0.006 (0.002)	0.003	-0.007 (0.002)	<0.001
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.031 (0.001)	<0.001	-0.031 (0.001)	<0.001
Income				
Less than $29,999	-0.020 (0.003)	<0.001	-	-
$30,000 to $49,999	-0.005 (0.003)	0.049	-	-
$50,000 to $79,999	0.006 (0.003)	0.013	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.002 (0.002)	0.419	-	-
22.1 to 25.0	-0.002 (0.002)	0.382	-	-
25.1 to 27.0	-0.005 (0.002)	0.030	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.005 (0.002)	0.015	-	-
Smoking Status (Yes=1, No=0)	0.012 (0.002)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.019 (0.002)	<0.001	-	-
	R^2=0.143 Adjusted R^2=0.143		R^2=0.153 Adjusted R^2=0.152	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Appendix 4
Results with Age in Categories

Table 9A: Abbreviated Model Adjusted[a] Mean (95% CI) Overall and Single Attribute Utility Scores According to Sentinel Medical Conditions[b] (n=66,093)

	Overall	Vision	Hearing	Speech	Ambulation	Dexterity	Emotion	Cognition	Pain & Discomfort
Control Group	0.92 (0.92 -0.92)	0.97 (0.97-0.97)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.98 (0.98-0.98)	0.98 (0.97-0.98)	0.97 (0.96-0.97)
Diabetes	**0.88** (0.87-0.88)	0.96 (0.94-97)	0.99 (0.99-1.00)	1.00 (1.00-1.00)	**0.98** (0.97-0.98)	1.00 (1.00-1.00)	**0.96** (0.96-0.97)	**0.96** (0.95-0.96)	**0.93** (0.93-0.94)
Stroke	**0.72** (0.70-0.74)	**0.92** (0.91-0.93)	**0.97** (0.96-0.98)	**0.98** (0.97-0.98)	**0.83** (0.82-0.85)	**0.98** (0.98-0.99)	**0.96** (0.95-0.97)	**0.90** (0.89-0.91)	**0.91** (0.89-0.93)
Arthritis	**0.84** (0.83-0.84)	**0.96** (0.96-0.96)	**0.98** (0.98-0.99)	**1.00** (1.00-1.00)	**0.97** (0.97-0.98)	**0.99** (0.99-0.99)	**0.97** (0.97-0.97)	**0.97** (0.96-0.97)	**0.86** (0.86-0.87)
Heart Disease	**0.88** (0.87-0.88)	**0.96** (0.96-0.97)	**0.98** (0.98-0.99)	1.00 (1.00-1.00)	0.99 (0.98-1.00)	**1.00** (1.00-1.00)	**0.97** (0.97-0.97)	**0.96** (0.96-0.97)	**0.93** (0.92-0.94)
Diabetes, Stroke	**0.78** (0.72-0.83)	**0.94** (0.92-0.97)	**0.95** (0.92-0.97)	1.00 (1.00-1.00)	**0.80** (0.77-0.84)	**0.98** (0.96-0.99)	0.98 (0.96-1.00)	0.97 (0.93-1.00)	0.97 (0.91-1.03)
Diabetes, Arthritis	**0.77** (0.75-0.78)	**0.95** (0.94-0.95)	**0.98** (0.98-0.99)	1.00 (1.00-1.00)	**0.93** (0.93-0.94)	**0.99** (0.99-0.99)	**0.95** (0.95-0.96)	**0.93** (0.92-0.93)	**0.82** (0.80-0.83)
Diabetes, Heart Disease	**0.76** (0.73-0.78)	**0.92** (0.91-0.93)	0.98 (0.97-0.99)	1.00 (1.00-1.00)	**0.90** (0.88-0.91)	1.00 (0.99-1.00)	**0.94** (0.93-0.95)	0.98 (0.96-0.99)	**0.80** (0.78-0.83)
Stroke, Arthritis	**0.55** (0.52-0.59)	**0.93** (0.92-0.95)	**0.95** (0.94-0.97)	**0.99** (0.98-1.00)	**0.72** (0.70-0.74)	**0.98** (0.97-0.99)	**0.94** (0.92-0.95)	**0.87** (0.85-0.89)	**0.72** (0.68-0.75)
Stroke, Heart Disease	**0.75** (0.71-0.78)	**0.94** (0.92-0.95)	**0.96** (0.94-0.98)	**0.98** (0.98-.099)	**0.83** (0.81-0.86)	**0.98** (0.97-0.99)	**0.95** (0.93-0.97)	**0.87** (0.85-0.89)	0.94 (0.90-0.98)
Arthritis, Heart Disease	**0.76** (0.74-0.77)	**0.96** (0.96-0.97)	**0.97** (0.97-0.98)	1.00 (1.00-1.00)	**0.93** (0.92-0.94)	**0.98** (0.98-0.99)	**0.96** (0.96-0.97)	**0.96** (0.96-0.97)	**0.77** (0.76-0.79)
Stroke, Arthritis, Heart Disease	**0.58** (054-0.61)	**0.93** (0.92-95)	**0.94** (0.92-0.96)	**0.98** (0.98-0.99)	**0.74** (0.72-0.76)	**0.98** (0.98-0.99)	**0.92** (0.90-0.94)	**0.79** (0.77-0.81)	**0.78** (0.74-0.81)
Diabetes, Heart Disease, Arthritis	**0.62** (0.60-0.65)	**0.90** (0.89-0.91)	**0.98** (0.96-0.99)	**0.96** (0.96-0.96)	**0.84** (0.83-0.86)	**0.96** (0.95-0.97)	0.98 (0.96-0.99)	**0.89** (0.87-0.90)	**0.68** (0.66-0.71)
Diabetes, Stroke, Heart Disease	**0.64** (0.55-0.72)	0.99 (0.95-1.00)	**0.86** (0.82-0.90)	1.00 (0.99-1.00)	**0.88** (0.83-0.93)	**0.96** (0.94-0.98	**0.83** (0.79-0.87)	**0.78** (0.73-0.82)	1.02 (0.93-1.11)
Diabetes, Stroke, Arthritis	**0.61** (0.56-0.67)	0.96 (0.0.94-0.99)	0.97 (0.95-1.00)	1.00 (0.99-1.00)	**0.76** (0.73-0.80)	0.99 (0.98-1.00)	**0.89** (0.87-0.92)	**0.88** (0.85-0.91)	**0.83** (0.77-0.89)
Diabetes, Stroke, Heart Disease, Arthritis	**0.44** (0.38-0.49)	**0.85** (0.83-0.87)	**0.87** (0.85-0.90)	1.00 (0.99-1.00)	**0.65** (0.62-0.68)	1.00 (0.99-1.01)	**0.92** (0.89-0.94)	**0.86** (0.83-0.89)	**0.58** (0.52-0.63)

a Adjusted for Age Category, Sex, Education and Number of Medical Conditions
b Bold entries are statistically different from control group ($p < 0.05$)

Table 9B: Full Model Adjusted[a] Mean (95% CI) Overall and Single Attribute Utility Scores According to Sentinel Medical Conditions (n=39,772)

	Overall	Vision	Hearing	Speech	Ambulation	Dexterity	Emotion	Cognition	Pain & Discomfort
Control Group	0.91 (0.91 -0.92)	0.97 (0.97-0.97)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.99 (0.99-0.99)	1.00 (1.00-1.00)	0.97 (0.97-0.98)	0.97 (0.97-0.97)	0.96 (0.96-0.96)
Diabetes	**0.86** (0.85-0.88)	0.96 (0.96-0.97)	0.99 (0.99-1.00)	1.00 (1.00-1.00)	**0.98** (0.98-0.99)	**1.00** (1.00-1.00)	**0.96** (0.95-0.96)	**0.95** (0.94-0.96)	**0.92** (0.91-0.93)
Stroke	**0.80** (0.77-0.73)	**0.96** (0.95-0.97)	0.99 (0.98-1.00)	**0.98** (0.97-0.98)	**0.87** (0.85-0.88)	**0.97** (0.97-0.98)	0.97 (0.95-0.98)	**0.94** (0.92-0.96)	0.95 (0.92-0.99)
Arthritis	**0.83** (0.83-0.84)	**0.96** (0.96-0.96)	**0.99** (0.98-0.99)	**1.00** (0.99-1.00)	**0.98** (0.98-0.98)	**0.99** (0.99-0.99)	**0.97** (0.96-0.97)	**0.96** (0.96-0.96)	**0.86** (0.85-0.86)
Heart Disease	0.91 (0.89-0.92)	0.96 (0.95-0.96)	0.99 (0.99-1.00)	1.00 (0.99-1.00)	0.99 (0.99-1.00)	**1.00** (1.00-1.00)	0.98 (0.97-0.99)	0.97 (0.97-0.98)	0.95 (0.93-0.96)
Diabetes, Stroke	0.96 (0.88-1.05)	0.97 (0.94-1.00)	1.00 (0.98-1.04)	1.00 (0.98-1.01)	1.00 (0.97-1.05)	1.00 (0.98-1.02)	0.98 (0.94-1.02)	0.98 (0.93-1.02)	1.01 (0.92-1.10)
Diabetes, Arthritis	**0.76** (0.75-0.79)	**0.95** (0.94-0.95)	0.99 (0.99-1.00)	1.00 (1.00-1.00)	**0.97** (0.96-0.97)	1.00 (0.99-1.00)	0.97 (0.96-0.98)	**0.92** (0.91-0.93)	**0.80** (0.78-0.82)
Diabetes, Heart Disease	**0.80** (0.77-0.84)	0.97 (0.95-0.98)	1.00 (0.99-1.02)	1.00 (0.99-1.00)	**0.94** (0.93-0.96)	**0.99** (0.98-1.00)	**0.88** (0.86-0.89)	0.98 (0.96-1.00)	**0.85** (0.82-0.89)
Stroke, Arthritis	**0.62** (0.56-0.68)	**0.94** (0.91-0.96)	0.99 (0.98-1.02)	**0.98** (0.97-0.99)	**0.83** (0.80-0.86)	**0.89** (0.87-0.90)	**0.91** (0.87-0.93)	**0.87** (0.84-0.91)	**0.70** (0.63-0.77)
Stroke, Heart Disease	**0.90** (0.85-0.95)	0.97 (0.95-1.00)	1.00 (0.99-1.02)	**0.98** (0.97-0.99)	**0.94** (0.92-0.97)	1.00 (0.99-1.02)	0.99 (0.96-1.02)	0.97 (0.94-1.00)	0.94 (0.89-1.00)
Arthritis, Heart Disease	**0.81** (0.79-0.83)	0.97 (0.96-0.98)	0.99 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)	0.99 (0.99-1.00)	**0.96** (0.95-0.97)	**0.99** (0.98-1.00)	**0.78** (0.75-0.80)
Stroke, Arthritis, Heart Disease	**0.44** (0.33-0.54)	**0.85** (0..81-0.90)	**0.64** (0.60-0.67)	1.00 (0.98-1.02)	**0.55** (0.49-0.60)	1.00 (0.98-1.03)	1.03 (0.98-1.09)	**0.63** (0.57-0.69)	**0.57** (0.46-0.68)
Diabetes, Heart Disease, Arthritis	**0.78** (0.73-0.83)	0.95 (0.93-0.97)	1.00 (0.99-1.03)	1.00 (0.99-1.01)	**0.94** (0.92-0.97)	**0.95** (0.94-0.96)	0.98 (0.95-1.00)	0.95 (0.92-0.98)	**0.80** (0.75-0.85)
Diabetes, Stroke, Heart Disease	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed
Diabetes, Stroke, Arthritis	**0.46** (0.35-0.58)	0.92 (0.88 -0.97)	0.90 (0.85-0.94)	1.00 (0.98-1.02)	**0.96** (0.91-1.02)	0.99 (0.96-1.01)	**0.89** (0.83-0.94)	**0.69** (0.63-0.76)	**0.64** (0.52-0.77)
Diabetes, Stroke, Heart Disease, Arthritis	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed	Suppressed

a Adjusted for Age in Categories, Sex, Education, Number of Medical Conditions, Body Mass Index, Marital Status, Smoking Status and Proxy Completion
b Bold entries are statistically different from control group ($p < 0.05$)

Table 9C: Overall HUI3 Score with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.051 (0.006)	<0.001	-0.042 (0.005)	<0.001
Stroke (S)	-0.116 (0.016)	<0.001	-0.196 (0.011)	<0.001
Arthritis (A)	-0.079 (0.003)	<0.001	-0.082 (0.002)	<0.001
Heart Disease (HD)	-0.004 (0.007)	0.505	-0.040 (0.005)	<0.001
DM - S	0.050 (0.043)	0.248	-0.142 (0.028)	<0.001
DM - A	-0.146 (0.010)	<0.001	-0.151 (0.007)	<0.001
DM - HD	-0.110 (0.018)	<0.001	-0.159 (0.013)	<0.001
S - A	-0.292 (0.032)	<0.001	-0363 (0.016)	<0.001
S - HD	-0.017 (0.026)	0.527	-0.172 (0.019)	<0.001
A - HD	-0.105 (0.011)	<0.001	-0.162 (0.006)	<0.001
S - A - HD	-0.475 (0.054)	<0.001	-0.341 (0.018)	<0.001
D - HD - A	-0.136 (0.024)	<0.001	-0.293 (0.013)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.281 (0.044)	<0.001
DM - S - A	-0.447 (0.058)	<0.001	-0.306 (0.028)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.480 (0.027)	<0.001
Sex (1=male, 2=female)	-0.006 (0.002)	<0.001	-0.009 (0.001)	<0.001
Age				
18 to 30	0.018 (0.004)	<0.001	0.037 (0.002)	<0.001
31 to 39	0.003 (0.003)	0.447	0.032 (0.002)	<0.001
40 to 49	-0.007 (0.003)	0.031	0.025 (0.002)	<0.001
50 to 59	-0.018 (0.004)	<0.001	0.019 (0.002)	<0.001
Greater than 60	0	-		<0.001
Education				
Less Than Secondary	-0.031 (0.002)	<0.001	-0.049 (0.002)	<0.001
Secondary Graduation	-0.002 (0.002)	0.303	-0.009 (0.002)	<0.001
Other Post-Secondary	-0.001 (0.002)	0.442	-0.008 (0.002)	<0.001
College/University Degree	0	-	0	<0.001
Number of Medical Conditions	-0.031 (0.001)	<0.001	-0.033 (0.001)	<0.001
Income				
Less than $29,999	-0.042 (0.003)	<0.001	-	-
$30,000 to $49,999	-0.012 (0.002)	<0.001	-	-
$50,000 to $79,999	-0.003 (0.002)	0.218	-	-
$80,000 or greater	0	-		
BMI				
Less than 22.0	-0.002 (0.002)	0.319	-	-
22.1 to 25.0	-0.003 (0.002)	0.137	-	-
25.1 to 27.0	-0.003 (0.002)	0.14	-	-
27.1 or greater	0	-		
Marital Status (Yes =1, No=0)	-0.015 (0.002)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.018 (0.002)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.023 (0.002)	<0.001	-	-
	R^2=0.17 Adjusted R^2=0.17		R^2=0.20 Adjusted R^2=0.20	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9D: Vision Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.003 (0.003)	0.247	-0.003 (0.002)	0.195
Stroke (S)	-0.006 (0.006)	0.358	-0.045 (0.005)	<0.001
Arthritis (A)	-0.005 (0.001)	<0.001	-0.007 (0.001)	<0.001
Heart Disease (HD)	-0.010 (0.003)	0.001	-0.006 (0.002)	0.002
DM - S	0.006 (0.018)	0.730	-0.026 (0.012)	0.032
DM - A	-0.021 (0.004)	<0.001	-0.020 (0.003)	<0.001
DM - HD	-0.001 (0.008)	0.892	-0.045 (0.005)	<0.001
S - A	-0.029 (0.013)	0.028	-0.034 (0.007)	<0.001
S - HD	0.007 (0.011)	0.525	-0.031 (0.008)	<0.001
A - HD	0.005 (0.005)	0.301	-0.005 (0.003)	0.034
S - A - HD	-0.114 (0.022)	<0.001	-0.034 (0.008)	<0.001
D - HD - A	-0.016 (0.010)	0.125	-0.065 (0.005)	<0.001
DM - S - HD	Suppressed	Suppressed	0.022 (0.019)	0.241
DM - S - A	-0.044 (0.024)	0.068	-0.004 (0.012)	0.721
DM - S - HD - A	Suppressed	Suppressed	-0.119 (0.012)	0.000
Sex (1=male, 2=female)	0.003 (0.001)	<0.001	0.006 (0.001)	<0.001
Age				
18 to 30	0.031 (0.002)	<0.001	0.035 (0.001)	<0.001
31 to 39	0.028 (0.001)	<0.001	0.034 (0.001)	<0.001
40 to 49	0.018 (0.001)	<0.001	0.025 (0.001)	<0.001
50 to 59	0.000 (0.001)	0.945	0.007 (0.001)	<0.001
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.003 (0.001)	<0.001	-0.003 (0.001)	<0.001
Secondary Graduation	0.001 (0.001)	0.176	0.001 (0.001)	0.721
Other Post-Secondary	0.002 (0.001)	0.005	0.001 (0.001)	0.241
College/University Degree	0	-	0	
Number of Medical Conditions	-0.002 (0.000)	<0.001	-0.003 (0.001)	<0.001
Total Annual Household Income				
Less than $29,999	-0.002 (0.001)	0.032	-	-
$30,000 to $49,999	0.000 (0.001)	0.819	-	-
$50,000 to $79,999	0.000 (0.001)	0.670	-	-
$80,000 or greater	0	-		
BMI				
Less than 22.0	0.000 (0.001)	0.907	-	-
22.1 to 25.0	-0.001 (0.001)	0.298	-	-
25.1 to 27.0	-0.001 (0.001)	0.119	-	-
27.1 or greater	0	-		
Marital Status (Yes =1, No=0)	-0.004 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	-0.001 (0.001)	0.099	-	-
Proxy Response (Yes=1, No=2)	-0.002 (0.001)	0.044	-	-
	R^2=0.053 Adjusted R^2=0.052		R^2=0.073 Adjusted R^2=0.072	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9E: Hearing Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	0.001 (0.002)	0.767	0.003 (0.002)	0.216
Stroke (S)	0.001 (0.006)	0.825	-0.018 (0.005)	<0.001
Arthritis (A)	-0.002 (0.001)	0.035	-0.006 (0.001)	<0.001
Heart Disease (HD)	-3.13×10^{-5} (0.002)	0.990	-0.009 (0.002)	<0.001
DM - S	0.015 (0.016)	0.342	-0.042 (0.013)	0.001
DM - A	0.003 (0.004)	0.445	-0.007 (0.003)	0.038
DM - HD	0.012 (0.007)	0.072	-0.007 (0.006)	0.233
S - A	0.006 (0.012)	0.589	-0.039 (0.008)	<0.001
S - HD	0.012 (0.010)	0.229	-0.029 (0.009)	0.001
A - HD	0.005 (0.004)	0.208	-0.017 (0.003)	<0.001
S - A - HD	-0.358 (0.020)	<0.001	-0.050 (0.008)	<0.001
D - HD - A	0.016 (0.009)	0.067	-0.015 (0.006)	0.014
DM - S - HD	Suppressed	Suppressed	-0.134 (0.020)	<0.001
DM - S - A	-0.097 (0.021)	<0.001	-0.018 (0.013)	0.171
DM - S - HD - A	Suppressed	Suppressed	-0.118 (0.013)	<0.001
Sex (1=male, 2=female)	-0.002 (0.001)	<0.001	-0.006 (0.001)	<0.001
Age				
18 to 30	0.012 (0.001)	<0.001	0.027 (0.001)	<0.001
31 to 39	0.010 (0.001)	<0.001	0.025 (0.001)	<0.001
40 to 49	0.010 (0.001)	<0.001	0.026 (0.001)	<0.001
50 to 59	0.005 (0.001)	<0.001	0.022 (0.001)	<0.001
Greater than 60	0	-	0	-
Education				
Less Than Secondary	0.000 (0.001)	0.666	-0.004 (0.001)	<0.001
Secondary Graduation	-9.32×10^{-5} (0.001)	0.907	0.001 (0.001)	0.307
Other Post-Secondary	0.000 (0.001)	0.883	0.000 (0.001)	0.794
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.001 (0.001)	0.016	-0.001 (0.001)	<0.001
Total Annual Household Income				
Less than $29,999	-0.006 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.004 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.003 (0.001)	0.001	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.001)	0.642	-	-
22.1 to 25.0	-0.001 (0.001)	0184	-	-
25.1 to 27.0	0.000 (0.001)	0.762	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	0.000 (0.001)	0.688	-	-
Smoking Status (Yes=1, No=0)	-0.001 (0.001)	0.398	-	-
Proxy Response (Yes=1, No=2)	-0.005 (0.001)	<0.001	-	-
	R^2=0.017 Adjusted R^2=0.018		R^2=0.036 Adjusted R^2=0.035	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9F: Speech Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	0.000 (0.001)	0.858	0.001 (0.001)	0.328
Stroke (S)	-0.023 (0.003)	<0.001	-0.024 (0.002)	<0.001
Arthritis (A)	-0.003 (0.000)	<0.001	-0.001(0.000)	0.002
Heart Disease (HD)	-0.002 (0.001)	0.126	0.000 (0.001)	0.623
DM - S	0.002 (0.008)	0.806	0.003 (0.005)	0.628
DM - A	0.002 (0.002)	0.385	0.000 (0.001)	0.891
DM - HD	0.002 (0.003)	0.557	0.003 (0.002)	0.255
S - A	-0.015 (0.006)	0.010	-0.008 (0.003)	0.007
S - HD	-0.018 (0.005)	<0.001	-0.015 (0.004)	<0.001
A - HD	-0.001 (0.002)	0.799	0.000 (0.001)	0.929
S - A - HD	0.004 (0.010)	0.677	-0.014 (0.003)	<0.001
D - HD - A	0.003 (0.005)	0.514	-0.039 (0.002)	<0.001
DM - S - HD	Suppressed	-	0.003 (0.008)	0.758
DM - S - A	0.004 (0.011)	0.688	0.003 (0.005)	0.632
DM - S - HD - A	Suppressed	-	-0.002 (0.005)	0.761
Sex (1=male, 2=female)	0.000 (0.000)	0.701	-0.001 (0.000)	0.012
Age				
18 to 30	0.001(0.001)	0.427	0.000 (0.000)	0.329
31 to 39	-0.001(0.001)	0.031	-0.001(0.000)	0.055
40 to 49	0.000 (0.001)	0.630	0.001 (0.000)	0.155
50 to 59	-0.001(0.001)	0.437	0.000 (0.000)	0.640
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.001(0.000)	0.059	-0.003(0.000)	0.059
Secondary Graduation	-0.001 (0.000)	0.053	-0.001 (0.000)	0.053
Other Post-Secondary	0.000 (0.000)	0.647	-6.78×10^{-5} (0.000)	0.830
College/University Degree	0	-	0	-
Number of Medical Conditions	0.000 (0.000)	<0.001	0.000 (0.000)	<0.001
Total Annual Household Income				
Less than $29,999	-0.002 (0.000)	0.000	-	-
$30,000 to $49,999	-0.001 (0.000)	0.108	-	-
$50,000 to $79,999	0.000 (0.000)	0.424	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.001 (0.000)	0.188	-	-
22.1 to 25.0	0.000 (0.000)	0.317	-	-
25.1 to 27.0	-0.001 (0.000)	0.158	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.002 (0.000)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.000 (0.000)	0.247	-	-
Proxy Response (Yes=1, No=2)	-0.003 (0.000)	<0.001	-	-
	R^2=0.009 Adjusted R^2=0.008		R^2=0.010 Adjusted R^2=0.010	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9G: Ambulation Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.007 (0.003)	0.020	-0.014 (0.003)	<0.001
Stroke (S)	-0.125 (0.008)	<0.001	-0.156 (0.007)	<0.001
Arthritis (A)	-0.014 (0.001)	<0.001	-0.015 (0.001)	<0.001
Heart Disease (HD)	0.001 (0.003)	0.832	0.000 (0.003)	0.929
DM - S	0.016 (0.021)	0.443	-0.188 (0.017)	<0.001
DM - A	-0.027 (0.005)	<0.001	-0.055 (0.004)	<0.001
DM - HD	-0.048 (0.009)	<0.001	-0.094 (0.008)	<0.001
S - A	-0.160 (0.016)	<0.001	-0.272 (0.010)	<0.001
S - HD	-0.049 (0.013)	<0.001	-0.156 (0.011)	<0.001
A - HD	0.004 (0.005)	0.421	-0.058 (0.004)	<0.001
S - A - HD	-0.446 (0.026)	<0.001	-0.251 (0.011)	<0.001
D - HD - A	-0.048 (0.012)	<0.001	-0.145 (0.008)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.108 (0.027)	<0.001
DM - S - A	-0.027 (0.028)	0.339	-0.225 (0.017)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.340 (0.017)	<0.001
Sex (1=male, 2=female)	-0.003 (0.001)	0.001	0.001 (0.001)	<0.001
Age				
18 to 30	0.007 (0.002)	<0.001	0.025 (0.001)	<0.001
31 to 39	0.004 (0.002)	0.014	0.023 (0.001)	<0.001
40 to 49	0.003 (0.002)	0.095	0.023 (0.001)	<0.001
50 to 59	0.004 (0.002)	0.012	0.025 (0.001)	<0.001
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.004 (0.001)	0.002	-0.009 (0.001)	<0.001
Secondary Graduation	-0.002 (0.001)	0.103	0.000 (0.001)	0.755
Other Post-Secondary	0.002 (0.001)	0.061	-0.001 (0.001)	0.346
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.006 (0.000)	<0.001	-0.008 (0.001)	< 0.001
Total Annual Household Income				
Less than $29,999	-0.004 (0.001)	0.002	-	-
$30,000 to $49,999	-0.002 (0.001)	0.205	-	-
$50,000 to $79,999	0.002 (0.001)	0.064	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	-0.003 (0.001)	0.002	-	-
22.1 to 25.0	-0.002 (0.001)	0.103	-	-
25.1 to 27.0	-0.002 (0.001)	0.061	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.003 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	-5.8x10-5 (0.001)	0.942	-	-
Proxy Response (Yes=1, No=2)	-0.004 (0.001)	<0.001	-	-
	R^2=0.041 Adjusted R^2=0.041		R^2=0.101 Adjusted R^2=0.101	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9H: Dexterity Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.003 (0.001)	0.038	-0.001 (0.001)	0.573
Stroke (S)	-0.027 (0.004)	<0.001	-0.015 (0.003)	<0.001
Arthritis (A)	-0.005 (0.001)	<0.001	-0.005 (0.001)	<0.001
Heart Disease (HD)	0.004 (0.002)	0.021	0.002 (0.001)	0.046
DM - S	0.002 (0.010)	0.799	-0.022 (0.007)	0.001
DM - A	-0.003 (0.002)	0.157	-0.008 (0.002)	<0.001
DM - HD	-0.009 (0.004)	0.029	-0.001 (0.003)	0.726
S - A	-0.111 (0.007)	<0.001	-0.021 (0.004)	<0.001
S - HD	0.006 (0.006)	0.306	-0.018 (0.005)	<0.001
A - HD	-0.004 (0.002)	0.114	-0.016 (0.001)	<0.001
S - A - HD	0.008 (0.0012)	0.499	-0.014 (0.004)	0.001
D - HD - A	-0.047 (0.006)	<0.001	-0.039 (0.003)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.039 (0.011)	<0.001
DM - S - A	-0.014 (0.013)	0.301	-0.007 (0.007)	0.282
DM - S - HD - A	Suppressed	Suppressed	0.005 (0.007)	0.454
Sex (1=male, 2=female)	0.001 (0.000)	0.086	6.42×10^{-5} (0.000)	0.205
Age				
18 to 30	0.000	0.809	0.001 (0.001)	0.016
31 to 39	9.43x10-5 (0.001)	0.905	0.001 (0.001)	0.041
40 to 49	-1.52x10-5 (0.001)	0.984	0.002 (0.001)	0.004
50 to 59	-0.003 (0.001)	<0.001	-0.001 (0.001)	0.022
Greater than 60	0	-	0	-
Education				
Less Than Secondary	0.000 (0.001)	0.614	-0.002 (0.000)	<0.001
Secondary Graduation	0.000 (0.000)	0.830	0.000 (0.000)	0.420
Other Post-Secondary	9.60x10-5 (0.000)	0.822	5.74×10^{-5} (0.000)	0.888
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.001 (0.000)	<0.001	-0.001 (0.000)	<0.001
Total Annual Household Income				
Less than $29,999	-0.001 (0.001)	0.052	-	-
$30,000 to $49,999	-0.002 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.001 (0.001)	0.082	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.000 (0.000)	0.448	-	-
22.1 to 25.0	-0.001 (0.000)	0.212	-	-
25.1 to 27.0	0.000 (0.001)	0.341	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-3.24x10-5 (0.000)	0.936	-	-
Smoking Status (Yes=1, No=0)	0.000 (0.000)	0.378	-	-
Proxy Response (Yes=1, No=2)	-0.002 (0.000)	<0.001	-	-
	R^2=0.019 Adjusted R^2=0.019		R^2=0.014 Adjusted R^2=0.014	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9I: Emotion Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.016 (0.003)	<0.001	-0.015 (0.002)	<0.001
Stroke (S)	-0.006 (0.008)	0.450	-0.015 (0.005)	0.005
Arthritis (A)	-0.007 (0.001)	<0.001	-0.006 (0.001)	<0.001
Heart Disease (HD)	0.004 (0.003)	0.200	-0.007 (0.002)	0.001
DM - S	0.002 (0.021)	0.916	0.004 (0.013)	0.750
DM - A	-0.006 (0.005)	0.216	-0.023 (0.003)	<0.001
DM - HD	-0.098 (0.009)	<0.001	-0.038 (0.006)	<0.001
S - A	-0.071 (0.016)	<0.001	-0.042 (0.008)	<0.001
S - HD	0.015 (0.013)	0.247	-0.030 (0.009)	0.001
A - HD	-0.017 (0.005)	0.002	-0.014 (0.003)	<0.001
S - A - HD	0.061 (0.027)	0.021	-0.058 (0.006)	<0.001
D - HD - A	0.002 (0.012)	0.838	-0.002 (0.009)	0.727
DM - S - HD	Suppressed	Suppressed	-0.146 (0.021)	<0.001
DM - S - A	-0.086 (0.029)	0.003	-0.086 (0.013)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.058 (0.013)	<0.001
Sex (1=male, 2=female)	-0.004 (0.001)	<0.001	-0.004 (0.001)	<0.001
Age				
18 to 30	0.003 (0.002)	0.119	-0.002 (0.001)	0.021
31 to 39	-0.004 (0.002)	0.011	-0.003 (0.001)	0.006
40 to 49	-0.010 (0.002)	<0.001	-0.006 (0.001)	<0.001
50 to 59	-0.006 (0.002)	<0.001	0.000 (0.001)	0.864
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.003 (0.001)	0.009	-0.015 (0.001)	<0.001
Secondary Graduation	0.002 (0.001)	0.023	-0.002 (0.001)	0.011
Other Post-Secondary	0.005 (0.001)	<0.001	0.000 (0.001)	0.739
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.008 (0.000)	<0.001	-0.008 (0.000)	<0.001
Total Annual Household Income				
Less than $29,999	-0.020 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.007 (0.001)	<0.001	-	-
$50,000 to $79,999	-0.005 (0.001)	<0.001	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	-0.004 (0.001)	<0.001	-	-
22.1 to 25.0	-0.001 (0.001)	0.496	-	-
25.1 to 27.0	3.13x10-5 (0.001)	0.977	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.012 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.013 (0.001)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.001 (0.001)	0.385	-	-
	R^2=0.063 Adjusted R^2=0.062		R^2=0.036 Adjusted R^2=0.036	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9J: Cognition Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.024 (0.004)	<0.001	-0.016 (0.003)	<0.001
Stroke (S)	-0.032 (0.009)	<0.001	-0.074 (0.006)	<0.001
Arthritis (A)	-0.012 (0.002)	<0.001	-0.010 (0.001)	<0.001
Heart Disease (HD)	0.001 (0.004)	0.783	-0.013 (0.003)	<0.001
DM - S	0.003 (0.025)	0.909	-0.010 (0.016)	0.526
DM - A	-0.055 (0.006)	<0.001	-0.048 (0.004)	<0.001
DM - HD	0.005 (0.010)	0.624	-0.001 (0.007)	0.926
S - A	-0.099 (0.018)	<0.001	-0.108 (0.009)	<0.001
S - HD	-0.002 (0.015)	0.918	-0.107 (0.011)	<0.001
A - HD	0.019 (0.006)	0.002	-0.012 (0.003)	<0.001
S - A - HD	-0.341 (0.031)	<0.001	-0.182 (0.010)	<0.001
D - HD - A	-0.023 (0.014)	0.102	-0.087 (0.007)	<0.001
DM - S - HD	Suppressed	Suppressed	-0.201 (0.025)	<0.001
DM - S - A	-0.282 (0.033)	<0.001	-0.099 (0.016)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.113 (0.015)	<0.001
Sex (1=male, 2=female)	0.002 (0.001)	0.011	-0.002 (0.001)	0.013
Age				
18 to 30	-0.007 (0.002)	0.001	0.001 (0.001)	0.401
31 to 39	-0.007 (0.002)	<0.001	0.005 (0.001)	<0.001
40 to 49	-0.007 (0.002)	<0.001	0.006 (0.001)	<0.001
50 to 59	-0.001 (0.002)	0.745	0.013 (0.001)	<0.001
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.015 (0.001)	<0.001	-0.021 (0.001)	<0.001
Secondary Graduation	-0.005 (0.001)	<0.001	-0.008 (0.001)	<0.001
Other Post-Secondary	-0.004 (0.001)	<0.001	-0.005 (0.001)	<0.001
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.008 (0.000)	<0.001	-0.009 (0.000)	<0.001
Total Annual Household Income				
Less than $29,999	-0.015 (0.001)	<0.001	-	-
$30,000 to $49,999	-0.001 (0.001)	0.494	-	-
$50,000 to $79,999	-0.002 (0.001)	0.123	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.001 (0.001)	0.502	-	-
22.1 to 25.0	0.000 (0.001)	0.726	-	-
25.1 to 27.0	0.002 (0.001)	0.197	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.004 (0.001)	<0.001	-	-
Smoking Status (Yes=1, No=0)	0.005 (0.001)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.011 (0.001)	<0.001	-	-
	R^2=0.048 Adjusted R^2=0.047		R^2=0.053 Adjusted R^2=0.053	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

Table 9K: Pain and Discomfort Attribute Scores with Age in Categories

	Full Model (N=39772)		Abbreviated Model (N=66093)	
	β (S.E.)	P-Value	β (S.E.)	P-Value
Sentinel Medical Conditions				
Control Group	0	-	0	-
Diabetes (DM)	-0.039 (0.007)	<0.001	-0.030 (0.005)	<0.001
Stroke (S)	-0.003 (0.017)	0.850	-0.055 (0.011)	<0.001
Arthritis (A)	-0.101 (0.003)	<0.001	-0.100 (0.002)	<0.001
Heart Disease (HD)	-0.008 (0.007)	0.246	-0.036 (0.005)	<0.001
DM - S	0.045 (0.046)	0.327	0.005 (0.029)	0.868
DM - A	-0.154 (0.011)	<0.001	-0.149 (0.007)	<0.001
DM - HD	-0.106 (0.019)	<0.001	-0.163 (0.013)	<0.001
S - A	-0.266 (0.034)	<0.001	-0.250 (0.017)	<0.001
S - HD	-0.011 (0.028)	0.710	-0.023 (0.019)	0.230
A - HD	-0.180 (0.012)	<0.001	-0.191 (0.006)	<0.001
S - A - HD	-0.379 (0.058)	<0.001	-0.188 (0.019)	<0.001
D - HD - A	-0.160 (0.026)	<0.001	-0.277 (0.013)	<0.001
DM - S - HD	Suppressed	Suppressed	0.056 (0.045)	0.207
DM - S - A	-0.314 (0.062)	<0.001	-0.134 (0.029)	<0.001
DM - S - HD - A	Suppressed	Suppressed	-0.387 (0.028)	<0.001
Sex (1=male, 2=female)	-0.008 (0.002)	<0.001	-0.010 (0.001)	<0.001
Age				
18 to 30	-0.008 (0.004)	0.049	-0.004 (0.002)	0.114
31 to 39	-0.022 (0.004)	<0.001	-0.015 (0.002)	<0.001
40 to 49	-0.022 (0.004)	<0.001	-0.017 (0.002)	<0.001
50 to 59	-0.030 (0.004)	<0.001	-0.021 (0.002)	<0.001
Greater than 60	0	-	0	-
Education				
Less Than Secondary	-0.027 (0.002)	<0.001	-0.032 (0.002)	<0.001
Secondary Graduation	0.001 (0.002)	0.674	-0.004 (0.002)	0.030
Other Post-Secondary	-0.005 (0.002)	0.012	-0.008 (0.002)	<0.001
College/University Degree	0	-	0	-
Number of Medical Conditions	-0.031 (0.001)	<0.001	-0.031 (0.001)	<0.001
Total Annual Household Income				
Less than $29,999	-0.021 (0.003)	<0.001	-	-
$30,000 to $49,999	-0.006 (0.003)	0.028	-	-
$50,000 to $79,999	0.006 (0.003)	0.020	-	-
$80,000 or greater	0	-	-	-
BMI				
Less than 22.0	0.002 (0.002)	0.396	-	-
22.1 to 25.0	-0.002 (0.002)	0.424	-	-
25.1 to 27.0	-0.005 (0.002)	0.029	-	-
27.1 or greater	0	-	-	-
Marital Status (Yes =1, No=0)	-0.003 (0.002)	0.085	-	-
Smoking Status (Yes=1, No=0)	0.012 (0.002)	<0.001	-	-
Proxy Response (Yes=1, No=2)	-0.018 (0.002)	<0.001	-	-
	R^2=0.144 Adjusted R^2=0.144		R^2=0.154 Adjusted R^2=0.154	

A – Arthritis
S – Stroke
DM – Diabetes
HD – Heart Disease

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