Understanding the Determinants of Health for People With Type 2 Diabetes

Sheri L. Maddigan, PhD, David H. Feeny, PhD, Sumit R. Majumdar, MD, MPH, FRCP, Karen B. Farris, PhD, and Jeffrey A. Johnson, PhD

The health of a population is determined by a large number of factors. Specific medical conditions, such as diabetes, have a significant impact on health status. Diabetes affects approximately 5% of Canadians aged 20 years and older, and the prevalence increases with age. Individuals aged 65 years and older account for 50% of diabetes cases but represent only 15% of the population. Ninety percent of all diagnosed cases of diabetes are type 2 diabetes, which is associated with a substantial physical and emotional burden for individuals who have the disease and their families. However, HRQL deficits associated with type 2 diabetes may be better explained in the context of a more holistic determinants of health framework, because population health is not solely associated with disease and treatment.

The general approach to studying factors associated with HRQL and type 2 diabetes, however, has tended to focus on demographic and clinical factors. There has been less emphasis on individual lifestyle factors (e.g., stress), the social environment (e.g., social integration), and access to health care. Previous research has shown that demographic characteristics and clinical factors (e.g., complications and comorbidities, duration of diabetes, and insulin use) have an impact on HRQL associated with type 2 diabetes, and some heterogeneities of HRQL and the disease can be explained by these factors. This is not surprising because a number of these variables are determinants of population health.

There are many frameworks that conceptualize the determinants of health and their causal associations, but because of the complexity of the specified associations, it is often difficult to use such frameworks analytically. Hertzman et al. proposed a relatively simple conceptual scheme for organizing and analyzing the relative importance of individual-level determinants of health on the basis of a commonly used population health framework. They categorized the determinants of health into 3 domains for analysis: stage of life cycle, subpopulation partitions, and sources of heterogeneity. The objectives of our analysis were to (1) assess the magnitude of HRQL deficits associated with determinants of health and type 2 diabetes, and (2) assess the contribution of Hertzman et al.’s domains to explaining the variance in HRQL associated with type 2 diabetes.

METHODS

Survey Design

We used data from the Canadian Community Health Survey Cycle 1.1, which is a cross-sectional survey of the Canadian population aged 12 years and older. Data about use of health services, determinants of health, and health status are collected. The survey excludes individuals who live on crown and reserve land or in institutions, individuals who are members of the Canadian armed forces, and some remote areas of the country; however, it still represents approximately 98% of the Canadian population aged 12 years and older. We used a multistage stratified cluster design combined with random sampling methods to select the sample. Proxy reporting was permitted; however, certain components of the interview were only appropriate for self-response. Data for Cycle 1.1 were collected between September 2000 and November 2001; 131 535 respondents were surveyed, and the overall response rate was 84.7%.

Sample

Approximately 6361 respondents reported a diagnosis of diabetes, which represented a weighted percentage of 4.1% of the Canadian population. An algorithm was developed on the basis of age, treatment regimen, duration of time from initial diagnosis to initiation of insulin therapy, and age at diagnosis to categorize respondents as having type 1 (9.9%) or type 2 diabetes (90.1%). Fifty-four respondents could not be categorized because of missing data. The study was restricted to respondents aged 18 years and older who were...
categorized as having type 2 diabetes (n = 5497); 83.1% had complete data and were included in our analysis (n = 4678). The majority of excluded respondents were missing data on determinants of health.

**Health Utilities Index Mark 3**

HRQL was assessed with the HUI3, a preference-based measure of HRQL. The HUI3 was administered as a 31-item questionnaire that assessed usual health status. HUI3 health states are defined by a classification system that includes a set of HRQL attributes, with 5 to 6 levels of functioning for each attribute. Eight attributes are included in the Health Utilities Index Mark 3 (HUI3) system: vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain and discomfort. A utility function that ranges from −0.36 to 1.0 is used to obtain overall scores for health states (−0.36 = worst possible health, 0.0 = dead, and 1.0 = perfect health). Differences of greater than 0.03 for HUI3 overall scores are considered to be clinically important. This value was derived from a variety of types of evidence; in part, the clinically important difference is based on the premise that a change in 1 level of functioning for any of the 8 attributes is qualitatively important. As such, 0.03 represents the smallest change in an overall score that results from a 1-level change in functioning for 1 attribute (e.g., the difference in overall score between having level 1 and level 2 functioning for the vision attribute). Cross-sectional comparisons between groups of individuals who have diabetes and who are known to differ in their levels of HRQL also support this value as clinically important.

**Determinants of Health**

Determinants of health were selected in accordance with the 3 domains of the conceptual scheme. The stage of life cycle domain reflects the fact that age, in part, determines vulnerabilities or susceptibility to disease. For example, individuals are most susceptible to chronic disease between the ages of 45 to 75 years. With type 2 diabetes, however, the lower age boundary for the chronic disease stage becomes less relevant. All individuals with type 2 diabetes have already developed a chronic disease, and they frequently have additional comorbidities and complications.

For our analysis, stage of life cycle was represented by age, chronic medical conditions, and duration of diabetes. Of the 25 chronic conditions included in the CCHS, stroke, heart disease, and osteoarthritis were of particular interest because they are consistent with the chronic disease stage. Moreover, heart disease and stroke are common macrovascular comorbidities associated with diabetes that also are associated with large HRQL deficits. Furthermore, it is relatively common for individuals with type 2 diabetes to also have osteoarthritis, because both conditions are associated with aging and obesity. Depression is a relevant comorbidity because depression has been associated with additional HRQL deficits that are associated with diabetes. Diagnoses of heart disease, stroke, and osteoarthritis were self-reported. Respondents whose predicted probability for major depression exceeded 0.90 on the Composite International Diagnostic Interview Short Form for Major Depression were considered to have depression.

Subpopulation partitions are segments of the population across which heterogeneities in health status are observed, including gender, socioeconomic status, geographic location, race/ethnicity, and special populations (groups not defined by 1 of the other subpopulation partitions but who share a particular characteristic that is associated with patterns in health status). Individuals with type 2 diabetes who use insulin can be considered a special population because they generally have HRQL deficits compared with those who do not use insulin. The CCHS provided data on socioeconomic status, gender, race (Aboriginal or non-Aboriginal), geographic location (rural or urban), and insulin use (users or nonusers). Because data on income was missing, we used other markers of socioeconomic status: education, social assistance, and food insecurity. Food insecurity was determined by 3 questions about financial access to a sufficient quantity and quality of food; respondents were considered to have food insecurity if, for financial reasons, they did not have enough food to eat or did not eat the quality or variety of foods desired.

Sources of heterogeneity are mechanisms that operate across subpopulation partitions and stage of life cycle. Sources of heterogeneity include individual lifestyle factors, physical and social environment, genetic endowment, and differential access to health care. Individual lifestyle factors include body mass index (BMI), smoking status, alcohol consumption, physical activity, and ability to cope. Level of physical activity was determined by energy expenditure, a variable derived from 47 questions about participation in activities. Energy expenditure was derived from metabolic equivalent level, frequency, and time per session of each physical activity. Life stress was used to determine ability to cope and was measured with a 5-point Likert scale. Exposure to environmental tobacco smoke by a family member who smoked inside the home was used to assess the physical environment, and sense of belonging to the community (measured with a 4-point Likert scale) and marital status were used to assess the social environment. Access to medical care was determined by self-perceived unmet healthcare needs and whether respondents had a regular medical doctor.

**Analysis**

We used multiple regression analysis to assess the clinical importance (i.e., magnitude of the unstandardized regression coefficients) and the statistical significance of each determinant of health in a single overall model. Normalized sampling weights and bootstrap variance estimates were used to account for the multistage stratified cluster design. The statistical significance of each determinant of health was derived from the 95% confidence intervals (on the basis of the bootstrap variance estimate) of the regression coefficients. Collinearity in the regression model was assessed from the tolerance of each independent variable and was not problematic.

All analyses were conducted with SPSS Version 12.0 software (SPSS Inc, Chicago, Ill) and with a bootstrap algorithm designed by Statistics Canada.

Previous research that used the HUI3 detected a nonlinear association between age
and HRQL among the Canadian population; thus, age was modeled in a mean-centered quadratic form (i.e., age was analyzed as a deviation from its mean and the square of this variable), which reduced collinearity between age and its square. The total number of self-reported medical conditions other than heart disease, stroke, depression, and osteoarthritis also were included. Duration of diabetes was analyzed in quartiles. For life stress, response options were collapsed to create 3 categories: not at all stressful, not very stressful/a bit stressful, and quite a bit stressful/extremely stressful. For BMI, respondents were categorized as obese (BMI ≥ 30) or not obese (BMI < 30). For marital status, respondents were categorized as married/partnership or not married. Alcohol consumption was analyzed as a dichotomous variable (heavy drinker vs not). Respondents who consumed 5 or more drinks during 1 occasion more than once a month were considered heavy drinkers. Respondents’ physical activity level was categorized as inactive, moderately active, or active in accordance with guidelines used in previous health surveys.

The proportion of explained HRQL variance ($R^2$) within each domain was then assessed with 3 regression models that each contained the determinants for their respective domains (stage of life cycle, subpopulation partitions, and Sources of Heterogeneity). To determine the unique contribution to the explained variance of a particular domain, the $R^2$ change was calculated between models that had the 2 domains and models that had all 3 domains.

We performed analyses of the cases with complete data; however, some of this data had been imputed by Statistics Canada during data processing. The demographic characteristics of respondents who were excluded from the analysis because of missing HUI3 scores (n = 76) were compared with respondents included in the analysis sample (n = 4678). The overall HUI3 scores of the analysis sample (n = 4678) were compared with those of respondents who were excluded from the analysis because of missing data on determinants of health (n = 819). Chi-square and t tests were used, when appropriate, for these analyses.

### RESULTS

The average age of respondents included in our analysis was 61.6 years (SD = 13.3), and the average duration of diabetes was 9.3 years (SD = 9.8) (Table 1). Attaining less than high-school education was relatively common (42.4%), and physical inactivity (64.6%) and obesity (36.4%) were prevalent among this sample. The HUI3 scores of respondents who were excluded from the analyses because of missing data on determinants of health (n = 819) were significantly lower than the overall HUI3 scores of respondents who had complete data (n = 4678) (mean difference = 0.14; 95% confidence interval [CI] = −0.17, 0.09).

#### TABLE 1—Demographic Characteristics of Sample, by Domain (N = 4678)

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Stage of life cycle</th>
<th>Subpopulation partitions</th>
<th>Sources of heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD)</td>
<td>61.6 (13.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of diabetes, m (SD)</td>
<td>9.3 (9.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>6.0 (2.0, 13.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of medical conditions, mean (SD)</td>
<td>2.7 (1.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has osteoarthritis, % yes</td>
<td>19.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suffers the effects of stroke, % yes</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has heart disease, % yes</td>
<td>20.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted probability of depression &gt; 0.90, %</td>
<td>7.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender, % male</td>
<td>51.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of education, %</td>
<td>42.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than secondary</td>
<td>16.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary graduation</td>
<td>29.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some postsecondary, college, trade school</td>
<td>12.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University degree</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal status, % yes</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some food insecurity, % yes</td>
<td>7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social assistance, % yes</td>
<td>19.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural geographic location, % rural</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulin use, % yes</td>
<td>19.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoking status, % current smoker</td>
<td>6.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy drinkers, % yes</td>
<td>36.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index &gt; 30.0, % yes</td>
<td>14.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical activity index</td>
<td>20.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>64.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately active</td>
<td>21.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all stressful</td>
<td>55.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not very stressful/a bit stressful</td>
<td>23.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quite a bit/extremely stressful</td>
<td>24.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family member smokes inside house, % yes</td>
<td>67.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital status, % married</td>
<td>22.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense of belonging to the community, %</td>
<td>38.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong</td>
<td>24.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak</td>
<td>15.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular medical doctor, % yes</td>
<td>96.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-perceived unmet healthcare needs, % yes</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Utilities Index Mark 3, mean (SD)</td>
<td>0.78 (0.26)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Domains refer to the categories of determinants of health proposed by Hertzman et al. Other than stroke, heart disease, osteoarthritis, or depression.
TABLE 2—Unstandardized Regression Coefficients for Each Domain Alone and Overall Model (N = 4678)

<table>
<thead>
<tr>
<th>Model 1: Stage of Life Cycle</th>
<th>Model 2: Subpopulation Partitions</th>
<th>Model 3: Sources of Heterogeneity</th>
<th>Model 4: Overall Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agea</td>
<td>Age</td>
<td>-0.001*</td>
<td>-0.003*</td>
</tr>
<tr>
<td>Age2</td>
<td>Age2</td>
<td>-0.0001*</td>
<td>-0.0001*</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>-0.08*</td>
<td>-0.06*</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>-0.14*</td>
<td>-0.11*</td>
<td></td>
</tr>
<tr>
<td>Heart disease</td>
<td>-0.07*</td>
<td>-0.05*</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>-0.16*</td>
<td>-0.11*</td>
<td></td>
</tr>
<tr>
<td>Number of medical conditionsb</td>
<td>-0.05*</td>
<td>-0.04*</td>
<td></td>
</tr>
<tr>
<td>Duration of diabetes</td>
<td>&lt;2 y</td>
<td>0.05*</td>
<td>0.03*</td>
</tr>
<tr>
<td>2 y–5.9 y</td>
<td>0.07*</td>
<td>0.04*</td>
<td></td>
</tr>
<tr>
<td>6 y–13 y</td>
<td>0.02*</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>&gt;13 y</td>
<td>Reference</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Level of education</td>
<td>Less than secondary</td>
<td>-0.09*</td>
<td>-0.04*</td>
</tr>
<tr>
<td>Secondary graduation</td>
<td>-0.03</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Some postsecondary, college,</td>
<td>University degree</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>trade school</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food insecurity</td>
<td>-0.13*</td>
<td>-0.08*</td>
<td></td>
</tr>
<tr>
<td>Social assistance</td>
<td>-0.12*</td>
<td>-0.07*</td>
<td></td>
</tr>
<tr>
<td>Aboriginal status</td>
<td>0.02</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>Rural geographic location</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.03*</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>Insulin use</td>
<td>-0.08*</td>
<td>-0.04*</td>
<td></td>
</tr>
<tr>
<td>Sources of heterogeneity</td>
<td>Current smoker</td>
<td>-0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td>Heavy drinker</td>
<td>0.04*</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>Body mass index &gt; 30</td>
<td>-0.04*</td>
<td>-0.03*</td>
<td></td>
</tr>
<tr>
<td>Physical activity index</td>
<td>Active</td>
<td>0.08*</td>
<td>0.06*</td>
</tr>
<tr>
<td>Moderately active</td>
<td>0.09*</td>
<td>0.06*</td>
<td></td>
</tr>
<tr>
<td>Inactive</td>
<td>Reference</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Life stress</td>
<td>Not at all stressful</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>Not very stressful/a bit</td>
<td>-0.02</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>extremely stressful</td>
<td>Quite a bit/extremely stressful</td>
<td>-0.11*</td>
<td>-0.08*</td>
</tr>
<tr>
<td>Family member smokes inside</td>
<td>-0.01</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>house</td>
<td>Marital status</td>
<td>0.06*</td>
<td>0.00</td>
</tr>
<tr>
<td>Sense of belonging to the</td>
<td>Strong</td>
<td>0.11*</td>
<td>0.09*</td>
</tr>
<tr>
<td>community</td>
<td>Somewhat strong</td>
<td>0.11*</td>
<td>0.08*</td>
</tr>
<tr>
<td>Somewhat weak</td>
<td>Weak</td>
<td>0.07*</td>
<td>0.05*</td>
</tr>
<tr>
<td>Weak</td>
<td>Reference</td>
<td>Reference</td>
<td></td>
</tr>
</tbody>
</table>

Continued
be vital to preserving or improving HRQL among people with type 2 diabetes. From both the clinical and broader health policy perspectives, efforts at primary and secondary prevention of heart disease and stroke could have a significant impact on HRQL among people with type 2 diabetes. Identifying individuals with depression and providing appropriate treatment is important because of the magnitude of the deficit associated with this comorbidity and diabetes.

Across the subpopulation partitions domain, the largest deficits were associated with the 2 markers of income: social assistance (−0.07) and food insecurity (−0.08). Income and social status have been recognized as 2 of the most important determinants of health for the Canadian population. It was interesting to note, however, that the 2 markers appeared to capture somewhat different phenomena, because they were both independently associated with clinically important deficits that reached statistical significance. Although social assistance may have captured respondents with low income, as intended, it was possible that food insecurity reflected, in part attributable to the association between respondents were observed. Residents who felt their lives were not at all stressful. Stress is recognized as a determinant of health for the general population, but high levels of stress may be particularly problematic for individuals with diabetes because stress is associated with poor glycemic control. This might explain the magnitude of the deficit associated with high stress levels that we observed.

Of the 3 domains in the conceptual scheme, stage of life cycle variables accounted for the largest proportion of the variance in HRQL. We represented this domain in a manner somewhat specific to diabetes, because we included the comorbidities that are more frequently associated with diabetes and the duration of diabetes. Thus, it is not clear if stage of life cycle would be the dominant domain for the general population or for other chronic diseases. Furthermore, the use of cross-sectional data precluded us from definitively stating that stage of life cycle variables were the most important determinants of health associated with diabetes, because we were unable to assess causal associations among variables. For example, we could not capture the fact that Aboriginals, individuals who smoke, and individuals who are sedentary may be more likely to develop comorbidities, such as heart disease. Thus, the full explanatory power of the subpopulation partitions and sources of heterogeneity domains may not have been captured in our analysis.

A number of limitations should be noted in this analysis. The algorithm used to distinguish between respondents with type 1 and type 2 diabetes has not been previously validated. A number of the criteria in the algorithm have been used and validated previously, but the algorithm as a whole has not. Misclassification of individuals’ type of diabetes could affect both the internal and external validity of the results if determinants of health differ between the 2 diseases. However, we are reasonably confident that the algorithm accurately classified respondents, because categorization of type 1 and type 2 diabetes produced by the algorithm was 10% and 90%, which is generally recognized as the distribution of type 1 and type 2 diabetes in Canada.
important for type 2 diabetes. Clinically important heterogeneities in HRQL were associated with stroke and depression, which emphasizes the importance of preventing and managing comorbidities and complications associated with type 2 diabetes. Social and behavioral determinants of health (socioeconomic status, life stress, and sense of belonging) also were important and showed that factors other than medical factors have an impact on the health of individuals with type 2 diabetes. A better understanding of the broader determinants of health is the necessary first step that will permit the development of interventions and policies for improving HRQL among this vulnerable population.

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Contributors
All authors originated the study, interpreted findings, and reviewed drafts of the article. S.L. Maddigan completed the analyses and led the writing.

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Note. The opinions expressed here do not necessarily represent the views of Statistics Canada.

Human Participant Protection
This study was approved by the health research ethics board of the University of Alberta.

References

**Fighting Global Blindness**

**Improving World Vision Through Cataract Elimination**

*By Sanduk Ruit, MD, Charles C. Wykoff, MD, D.Phil., MD, Geoffrey C. Tabin, MD*

Unoperated cataract is the cause of millions of cases of visual impairment and blindness in poor populations throughout both the developing and the developed world. This wonderfully written volume shares the experiences of a team of surgeons who have demonstrated how the surgical procedures can be simplified and made more efficient, accessible, and far less expensive. It is a step–by–step manual to solving the problem where adequate surgeons can be trained to follow suit. Subject matter ranges from ways to increase demand among those who need surgery to the organization of surgical services, responsibilities among different personnel, efficient layout of clinical facilities, and how to sustain services at the least cost to those who need it most.

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