

**HEALTH-ADJUSTED LIFE EXPECTANCY OF PEOPLE WITH DIABETES  
MELLITUS: CALCULATED USING LINKED DATA**

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## **HEALTH-ADJUSTED LIFE EXPECTANCY OF PEOPLE WITH DIABETES MELLITUS: CALCULATED USING LINKED DATA**

### **ABSTRACT**

*Objectives:* To estimate the health-adjusted life expectancy (HALE) from diabetes mellitus (DM) using a population health survey linked to a population-based DM registry.

*Methods:* The 1996/97 Ontario Health Survey (N=35,527) was linked to the Ontario Diabetes Database (N=487,576). HALE was estimated using an adapted Sullivan method.

*Results:* Life expectancy of people with DM was 64.7 and 77.5 years for men and women—12.8 and 12.3 years less than for men and women without DM. HALE was 58.3 and 63.8 years for men and women—11.7 and 9.7 years less than that of men and women without DM.

*Conclusions:* The linked data approach demonstrates that DM is an important burden of disease and reduces assumptions when estimating the prevalence and severity of disability from DM.

## **INTRODUCTION**

Summary measures of population health (SMPH)[1], which take into account both mortality and morbidity fall into two major classes: positive measures of health expectancy[2] such as health-adjusted life expectancy (HALE), and measures of health gaps such as loss of healthy life years[3] or disability-adjusted life years (DALYs).[4] Health expectancy, which is the focus of this study, estimates life expectancy adjusted according to the amount of time spent in less than perfect health or with disability.

Three components are needed to estimate all types of SMPH for specific conditions: mortality attributed to the condition; the prevalence or incidence and duration of the condition; and the degree to which health-related quality of life is affected. While all SMPH commonly use the same source of mortality information, namely vital statistics, there are differences in how other components are measured. Health expectancy measures typically estimate the impact of chronic conditions on health-related quality of life (HRQOL) through population-based health surveys. However, attributing HRQOL to different chronic diseases in population health surveys is difficult since self-reports of chronic disease status often underestimate the prevalence of many chronic conditions.[5-9] The best estimates of disease incidence/prevalence are achieved through population-based epidemiologic studies or disease registries. Typically, this method of estimating disease occurrence is used by health gap measures such as DALYs.[4] However, health gap measures typically use measures of HRQOL that have disability weights assigned by informed consumers, expert opinion or other epidemiologic sources that may not reflect the observed impact in specific populations.

In this study, we estimated HALE for people with DM in Ontario, Canada in 1996/97 using a population health survey that was directly linked to a DM registry. This linkage overcomes the limitations of previous estimations of both health gaps and health expectancy by directly measuring both disease prevalence and HRQOL impact without relying on self-reported disease status or case scenarios of HRQOL that may not reflect the actual HRQOL of people with DM in Ontario.

## **METHODS**

### *Data Sources*

Cross-sectional data on health status was derived from the 1996/97 Ontario Health Survey (OHS II).[10] The Ontario Ministry of Health sponsored Statistics Canada to augment the Ontario sample of the 1996/97 National Population Health Survey to be able to produce reliable local level estimates. Briefly, 48,770 households were selected through a stratified, multi-level cluster sampling method of all private dwellings in Ontario, with local planning regions as the primary sampling unit. Residents of Indian reserves, long-term care institutions, prisons, remote areas and Foreign Service personnel were excluded. There were two components to this telephone-based interview. The general component collected limited information on all members of the household; household response rate was 77.5%, or 37,796 households. The second component, which was the component used in this study, was administered to one randomly selected member from each survey household. The number of respondents who agreed to share their survey information with the provincial Ministry of Health was 37,247, a response rate of 98.5%.

Although the OHS II contained self-reported DM status, in this study the DM status of the survey respondents was established by directly and individually linking them to the Ontario Diabetes Database (ODD). The ODD is a population-based disease registry that was created through physician payment and hospital discharge data and a central health administrative database, the Registered Persons Database (RPDB). The ODD has been validated in previous studies.[11,12] The OHS II respondents and the ODD were linked through unique health card number, respondent name, address, sex and birthdate. 35,517 (96.3%) of respondents agreed to allow their survey responses to be linked to administrative data; however only 23,403 (65.6%) were actually linkable due to a technical difficulty resulting in missing OHS II demographic information. This technical problem did not bias the linkage process towards any particular group of respondents.[13]

In total 156,610 Ontario residents died during the study period; these deaths were used to estimate life and health expectancy for all Ontarians. Deaths for people with diabetes were estimated from vital statistics data that was linked to the ODD population. Approximately 93% of all deaths for people with diabetes were successfully linked in the ODD. Death rates based on ODD data were adjusted for incomplete linkage based on the observed age and sex-specific linkage difference. The linked ODD death data did not contain information on the cause of death as shown on the death registration. The death rate for people with DM in the ODD was compared to the underlying cause of death related to DM using age and sex-specific deaths in the ODD and Statistics Canada mortality data. The post-censal population estimates for 1996/97 for each age- and sex-group were from Statistics Canada.

## *Variable Definition and Classification*

### **The Health Utilities Index**

The HRQOL measure used to calculate HALE in this study was the Health Utilities Index (HUI3).[14] The HUI3 is a utility-based, multi-attribute health classification system that estimates a summary value of individual health where 0.0=“dead” and 1.0=“perfect health”, (states worse than death are also possible), based on preference scores for different health states.[15] Each respondent answered questions pertaining to eight attributes of functional health: vision, hearing, speech, mobility, dexterity, emotional state, cognition and level of pain and discomfort. Each attribute has from 5 to 6 possible levels ranging from unrestricted to a highly disabled state (see Torrance et al.[16] for a description of health states). The eight attributes were then combined using preference scores from the HUI mark III version using the following multi-attribute utility function[17]:

$$u = 1.371 (u_1 * u_2 * u_3 * u_4 * u_5 * u_6 * u_7 * u_8) - 0.371$$

## *Analysis Methods*

### **Diabetes-deleted Mortality Rate and HUI3 Estimates**

DM-deleted mortality rates were calculated by subtracting the mortality rate for people with DM from the overall mortality rate for each age-sex group. DM-deleted HUI3 was calculated in a similar manner by removing all people with DM from the OHS II sample and recalculating the mean HUI3 for each age-sex group.

## **Life Table Analysis**

Period life tables for 1996/97 for men and women were calculated using an adaptation of Chiang's method[18] and 20 standard age-groups (<1,1-4,5-9,..., 90+ years), except for an adaptation for the final age-group.[19] DM-deleted life expectancy was calculated by substituting the DM-deleted mortality rates for the overall mortality rates in the life table.[20]

HALE was calculated using a modified Sullivan method.[21] Sullivan used a period life table and the prevalence of disability to estimate the number of life years lived free of disability. After calculating life tables for each group, we estimated HALE by weighting the years of life lived according to the mean HUI3 values by age and sex for each population. The DM-deleted mean HUI3 values were used to calculate DM-deleted HALE.

## **RESULTS**

Table 1 shows that DM was not self-reported by 50.3% of people who have the disease, as defined in the ODD. Since DM status in the ODD has been comprehensively validated, this low self-reported DM represented true underreporting.[12]

Table 2 shows the mean HUI3 score for people with and without DM; these weights were compared to the World Health Organization Global Burden of Disease (GBD) disability weights.[4] The GBD disability weights are reported on a similar scale as the HUI3 with 0 corresponding to a utility weight of death and 1 being perfect health. Similar to other diseases, the GBD project assigns different weights for DM severity. While this would have been possible in our study, we instead estimated the mean HUI3 score for men and women at different ages,

while the GBD study uses a single value for the impact of the disease regardless of age or sex.

We then assumed that the impact of DM on HRQOL was the difference between the mean HUI3 score for people with and without DM.

Table 3 shows mortality and HALE estimates for people with and without DM. Almost one quarter of all people who died in Ontario in 1996/97 had DM (18,320 people per year). However, only 12.5% of the people who died in Ontario had DM identified as the underlying cause of death. The age-standardized death rate for people with DM was over twice that of people without DM (1,370 per 100,000 for men with DM versus 590 for men without DM; 1,320 per 100,000 for women with DM versus 530 for women without DM). This increased death rate translates into a life expectancy 12.8 years less than men without DM and 12.3 years less than women without DM (64.7 years for men with DM compared with 77.5 years for those without the disease; for women, 70.6 years for those with DM, compared with 82.9 years for those without the disease).

HALE was 58.3 years for men with DM, compared to 70.0 years for those without; and 63.8 years for women with DM compared to 73.5 years for those without DM. The ratio of HALE to life expectancy can be interpreted as the proportion of life spent in equivalent years of good health. For men and women with DM, these proportions were 90 and 89% respectively. Men and women without DM could also expect to spend a similar amount of their lives in good health (91 and 89%). The observation that the ratio of HALE to life expectancy is very similar for people with and without DM suggests that the impact of DM on length of life is similar to or slightly larger than its impact on years of healthy life. Given the present burden of disease,

eliminating DM will extend overall life expectancy in Ontario by 2.7 years, but would only extend HALE by 1.0 years (Table 4).

## **DISCUSSION**

This study used databases that contain population-based mortality, morbidity and DM prevalence linked together to estimate life expectancy and HALE of people with and without DM. People with DM have a much lower life expectancy and HALE than people without DM. Furthermore, life expectancy and HALE of the entire population would be substantially higher if DM were eliminated, demonstrating that DM is an important burden of disease in the Ontario population.

It is important to not only add “years to life”, but also add “life to years”, meaning improvements in life expectancy should ideally be accompanied by improvements in HRQOL.[22] Efforts to reduce diseases that are fatal will add “years to life”; while reducing diseases that affect HRQOL will add “life to years”. Since DM has a greater impact on mortality than morbidity, reducing or eliminating the disease, given the present burden, would result in an “expansion of morbidity” or more years to life than life to years.[13] People who are alive after diabetes was reduced or eliminated would be, on average, in a lower state of HRQOL. Since many health interventions – including hypoglycaemic medications and preventive measures that target behavioural risk factors – have a disproportionately larger impact on DM morbidity than mortality, the actual impact of health interventions may result in greater improvements in HRQOL than mortality.[13]

It is worth highlighting a few of the advantages of using linked databases when estimating SMPH. Databases that include a current population health survey are well suited to measuring the long-term progress in reducing morbidity from different conditions, as health surveys directly estimate the health status of a population at a defined time period. These estimations of HRQOL for specific conditions are the combined effect of duration and severity of disease along with the impact of health interventions or other health improvements. As the estimation of DALYs usually requires different sources of information for each of these disease properties, this method may have difficulty reflecting differences in the HRQOL impact of diseases in different populations and time periods. For an example of these differences consider what would happen to HRQOL if a new DM medication was introduced that dramatically improved HRQOL. A population-based health survey would capture the current improvement. DALYs, as commonly derived, would require further epidemiologic studies and expert opinion to readjust disability weights for treated people with DM and estimate the proportion of people treated with the new intervention. As there are many factors affecting disease morbidity in different populations that are constantly changing over time – such as socioeconomic conditions, physical and social environment, medical therapies, and health risk behaviour – it would seem unlikely that the current DALY approach could reflect the actual disease morbidity burden in any specific population.

Furthermore, since our linked databases include health administrative information about people who receive different health interventions (drug prescribing, physician consultations, hospital admissions, etc.), it may be possible to assess the health impact of specific interventions on the people who received those interventions[23,24], or the total population.[25]

An important limitation of this study is the omission of residents of long-term care facilities in the morbidity data used in the calculation of HRQOL impact. Since many such residents have DM and/or poor HRQOL, HALE will be overestimated for both those with and without DM.[26]

Health expectancy measures have been criticized because they are prevalence-based, which makes them less suited to monitoring trends in disease occurrence and the impact of disease prevention on future health.[27,28] Because the DM registry used in this study contains information on disease incidence, prevalence and duration of disease, it is possible to estimate the changing HRQOL impact over time and age based on either disease incidence or prevalence, thereby opening novel opportunities to improve estimates of summary measures (including health gap, health expectancy or hybrid measures) by considering the effect of changing disease incidence on future HRQOL.[28]

An additional benefit of using linked data and population health surveys is the ability to adjust summary measure estimates for comorbidity (defined as the effect of a person's HRQOL being influenced by other chronic conditions) by various methods.[29] In this study, we adjusted for comorbidity by assuming the HRQOL burden of DM is equal to the difference in HRQOL between people at the same age and sex with and without DM. This method assumes that if DM was eliminated the HRQOL would improve to the level of people with other people in the population, many of whom have other conditions. Although DALYs have been estimated considering co-morbidity, this is not usually done.[30] In the typically DALY approach, it is

assumed that if DM was eliminated, people would have no disability at all – a situation that is particularly unlikely in older ages.

Finally, our method creates a tight association between the measurement of disease and HRQOL. The typical DALY method often defines different disability weights for different severities of disease, but these severity groups may not be congruent with the measurement of disease incidence. For example, if the definition of disease used to measure disease incidence is broad, thereby capturing people with mild disease, but the disability weight used is based on more severe disease, then the burden of disease will be overestimated. Such definitional differences have been reduced in our study because HRQOL is measured for people within the same disease registry used to estimate disease incidence/prevalence.[31]

There are limitations when estimating SMPH using information from population health surveys. Although there are a least 50 countries that have now conducted population health surveys, they are neither routinely repeated over time, nor easily comparable between populations and seldom have provisions for linkages to other data sources.[32] The latter omission makes it particularly difficult to apply the methods presented in this study in other jurisdictions. However, population health surveys linked to administrative data or disease registries can be an accurate method of ascertaining disease status and may be one of the best ways to estimate population-based HRQOL for persons with chronic conditions such as DM. As such, they could be used to enhance and improve the estimates of the more subjective disability assignment and incidence/prevalence estimation exercises. The DALY project in the Netherlands used health surveys and other sources to improve disability weights for their country and those improved

disability weights have been used in other countries.[33] The approach used in this study is not well suited for acute conditions or other chronic conditions that cannot be accurately identified in population health surveys or linked registries and health care data.

This study has demonstrated that linked databases containing HRQOL and prevalence information can be used to estimate the large combined mortality and morbidity burden of diabetes. This is important, since there is a commitment in Ontario for regular routine large population health surveys (every two years with a sample size >40,000 respondents), so it will be possible to monitor progress in reducing the burden of diabetes and other diseases. With the approach of this study we can potentially measure the progress of reducing the large burden of disease from DM.

**EXHIBITS:**

**TABLE 1 – DIABETES STATUS IN THE 1996/97 ONTARIO HEALTH SURVEY II (OHS II)  
COMPARED TO THE ONTARIO DIABETES REGISTRY (ODD)**

**TABLE 2 - UTILITY WEIGHTS AND PREVALENCE<sup>Φ</sup> FOR DIABETES MELLITUS: OHS II\*  
(HEALTH UTILITIES INDEX [HUI3]) vs. WHO GBD<sup>4</sup>**

**TABLE 3 – MORTALITY, LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY  
(HALE) FOR PEOPLE WITH AND WITHOUT DIABETES MELLITUS (DM), 1996/7, ONTARIO,  
CANADA**

**TABLE 4 – LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY (HALE) FOR  
ONTARIANS WITH AND WITHOUT DIABETES MELLITUS (DM) ELIMINATED, 1996/7**

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**Additional files provided with this submission:**

Additional file 1: Table 1 Self Reported DM.doc : 21KB  
<http://www.pophealthmetrics.com/imedia/1998306158181231/sup1.doc>

Additional file 2: Table 2 Utility Weights-revised2.doc : 32KB  
<http://www.pophealthmetrics.com/imedia/2110756914181145/sup2.doc>

Additional file 3: Table 3 Mortality Life Exp & HALE.doc : 31KB  
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Additional file 4: Table 4 DM-eliminated.doc : 20KB  
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