Health-Related Quality of Life and Health-Adjusted Life Expectancy of People With Diabetes in Ontario, Canada, 1996–1997

DOUGLAS G. MANUEL, MD, MSC, FRCP[1,2]
SUSAN E. SCHULTZ, MA, MSC[2]

OBJECTIVE — To estimate the burden of illness from diabetes using a population health survey linked to a population-based diabetes registry.

RESEARCH DESIGN AND METHODS — Measures of health-related quality of life (HRQOL) from the 1996/97 Ontario Health Survey (n = 35,517) were combined with diabetes prevalence and mortality data from the Ontario Diabetes Database (n = 487,576) to estimate the impact of diabetes on life expectancy, health-adjusted life expectancy (HALE), and HRQOL.

RESULTS — Life expectancy of people with diabetes was 64.7 and 70.7 years for men and women, respectively—12.8 and 12.2 years less than that for men and women without diabetes. Diabetes had a large impact on instrumental and basic activities of daily living, more so than on functional health. HALE was 58.3 and 62.7 years, respectively, for men and women—11.9 and 10.7 years less than that of men and women without diabetes. Eliminating diabetes would increase Ontario life expectancy by 2.8 years for men and 2.6 years for women; HALE would increase by 2.7 and 3.2 years for men and women, respectively.

CONCLUSIONS — The burden of illness from diabetes in Ontario is considerable. Efforts to reduce diabetes would likely result in a "compression of morbidity." An approach of estimating diabetes burden using linked data sources provides a robust approach for the surveillance of diabetes.

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The dramatic rise in average age of death in developed countries has brought the realization that longevity should be accompanied with improvements in health-related quality of life (HRQOL). In the 1980s, Fries (1) introduced the term "compression of morbidity" to describe the consequence of the view that onset of disease would be delayed by improving health behavior. Others have raised the possibility that increasing life expectancy will result in an increase in the proportion of the population living in poor health, with the consequent increased burden on society and health care services (2–5). The World Health Organization (WHO) succinctly summarizes these concerns by stating that "adding years to life" is an empty victory without "adding life to years" (6).

Because diabetes has the potential to impact both mortality and morbidity, it is helpful to consider both factors when assessing its health burden. However, there have been difficulties estimating the diabetes-related burden from this perspective using traditional sources of data. Population-based estimates of diabetes prevalence and/or HRQOL are frequently estimated through population-based health surveys (7,8). Self-reporting in population health surveys has been shown to underreport the prevalence of diabetes by up to half compared with physician-diagnosed diabetes (9). Population-based estimates of mortality are often derived from vital statistics (10). This method, again, may underrepresent the burden of diabetes since physicians commonly do not identify diabetes as the underlying cause of death on death certificates (11).

In this study, we estimated HRQOL and mortality for people with diabetes in Ontario, Canada, in 1996–1997 (population 11.2 million) using a population health survey that was directly linked to a diabetes registry, the Ontario Diabetes Database (ODD). The ODD allows for validated, population-based estimates of both mortality and physician-diagnosed diabetes. This linkage overcomes the limitations of previous estimations of diabetes burden by measuring population-based diabetes prevalence without relying on self-reported diabetes status and by estimating HRQOL and mortality impact in the same diabetic population, without relying on cause of death coding on death certificates.

Because it is possible to have high morbidity but low mortality, and vice versa, it is also helpful to consider both factors in combination. Summary measures of population health (SMPH) have been developed for this purpose (12). These measures fall into two major class-

From the [1]Department of Public Health Sciences, University of Toronto, Toronto, Canada; and [2]Institute for Clinical Evaluative Sciences, University of Toronto, Toronto, Canada.

Address correspondence and reprint requests to Dr. Douglas G. Manuel, Institute for Clinical Evaluative Sciences G106-2075 Bayview Ave., Toronto, Ontario, M4N 3M5 Canada. E-mail: doug.manuel@ices.on.ca.

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Abbreviations: ADL, basic activity of daily living; CIDI, Composite International Diagnostic Interview; DALY, disability-adjusted life-year; HALE, health-adjusted life expectancy; HRQOL, health-related quality of life; HUI3, Health Utilities Index; IADL, instrumental activity of daily living; NPHS, National Population Health Survey; ODD, Ontario Diabetes Database; OHS II, 1996/97 Ontario Health Survey; RPDB, Registered Persons Database; SMPH, summary measures of population health; WHO, World Health Organization.

es: positive measures of health expectancy (13,14), such as health-adjusted life expectancy (HALE), and measures of health gaps, such as loss of healthy life-years (15) or disability-adjusted life-years (DALYs) (10). Health expectancy adjusts life expectancy to the amount of time spent in less-than-perfect health or with disability. HALE, estimated in this study, uses a utility- or value-based HRQOL measure, which expresses HRQOL as a summary value relative to perfect health. HALE was chosen instead of DALYs since, like life expectancy, it is a more intuitive measure that is meaningful for a wide audience. In addition, HALE uniquely allows for the examination of expansion/contraction of morbidity. DALYs are more commonly used to compare the burden of different diseases, often across different countries—an objective that was not part of this study.

RESEARCH DESIGN AND METHODS

Data sources

Cross-sectional data on HRQOL was derived from the 1996/97 Ontario Health Survey (OHS II) (16). The Ontario Ministry of Health sponsored Statistics Canada to augment the Ontario sample of the 1996–1997 National Population Health Survey (NPHS) to be able to produce reliable local-level estimates. A total of 48,770 households were selected through stratified, multilevel cluster sampling of all private dwellings in Ontario, with local planning regions as the primary sampling unit. Residents of Indian reserves, long-term care institutions, prisons, and remote areas, as well as foreign service personnel, were excluded. Respondents were contacted in person at their dwelling or by telephone. The actual survey was a telephone interview with two components. A 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%. A further subgroup of survey respondents agreed to allow their survey responses to be linked to health care data; however, of the 35,517 (96.3%) who agreed to this, only 23,403 (65.6%) were linked to the central health administrative registry (the Registered Persons Database [RPDB], discussed later in this section) due to a technical difficulty resulting in missing OHS II demographic information. This technical problem did not bias the linkage process toward any particular group of respondents (17).

The OHS II, as part of the NPHS, was a two-stage probability sample. The final survey weight represents both the selection probabilities and poststratification adjustments to match the sample to population characteristics (18). A new survey weight was calculated specifically for the linkable portion of the survey. All analyses were weighted to represent the Ontario population in 1996–1997. To account for survey-design effects, standard errors and coefficients of variation were estimated with the bootstrap technique (19–21).

Although the OHS II contained self-reported diabetes status, in this study, the diabetes status of survey respondents was established by directly and individually linking them to the ODD. The ODD is a population-based disease registry that was created through physician payment, hospital discharge data, and the RPDB. The ODD has been validated in previous studies and found to be sensitive and specific for identifying persons with diabetes. The algorithm used to create the ODD specified that any patient with two physician service claims bearing a diagnosis of diabetes within a 2-year period or with one hospitalization with a diagnostic code for diabetes would be identified as having diabetes (9,22).

The third linked data source used in the study was the RPDB, which contained basic demographic information on all persons eligible for health insurance coverage in Ontario. The RPDB is linked to vital statistics data collected by the Office of the Registrar General (156,610 Ontario residents deaths in 1996–1997), thereby allowing for mortality estimates for people with and without diabetes. Approximately 93% of vital statistics deaths were linked to individual RPDP registrants. Age- and sex-specific adjustments were applied to correct for underestimation. Information on the cause of death from vital statistics is not known for people in RPDB. The death rate from diabetes as a main underlying cause of death for all Ontarians was obtained from Statistics Canada vital statistics data. The postcensal population estimates for 1996–1997 for each age and sex group were from Statistics Canada.

Variable definition and classification

Sociodemographic measures. The study population was described in terms of education level, household income, and ethnic origin. Education was defined as the highest level of education completed. Household income was adjusted for family size and categorized into four levels according to practices of Statistics Canada. The lowest category corresponds to Statistics Canada's low-income cut-off (23,24). Ethnic origin was classified using an approach that allows individuals to self-define their ethnic origin based on questions regarding country of birth, ethnic origin, and race or color.

HRQOL measures. The HRQOL measure used to calculate HALE in this study was the Health Utilities Index (HUI3) (25). The HUI3 is a utility-based, multiattribute health classification system that estimates a summary value of individual health in which 0.0 = "dead" and 1.0 = "perfect health" (states worse than death are also possible) based on preference scores for different health states (26). 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 five or six possible levels ranging from unrestricted to a highly disabled state (see Torrance et al. [27] for a description of health states). The eight attributes were combined using preference scores from the HUI mark III version using the following multi-attribute utility function (28):

$$\mu = 1.371\,(\mu_1 * \mu_2 * \mu_3 * \mu_4 * \mu_5 * \mu_6 * \mu_7 * \mu_8) - 0.371 \quad (1)$$

Other measures of HRQOL are described in the online appendix (available at http://care.diabetesjournals.org). These measures were selected to reflect HRQOL domains similar to those in the International Classification of Functioning, Disability and Health (29). Measures of physical functioning included vision, mobility, dexterity, and pain. Mental or

psychological functioning included measures of emotion and cognition. All these measures are attributes of the HUI3. Psychological distress was based on the Composite International Diagnostic Interview (CIDI) (16). The questions yield a score between 0 and 24, with a higher score indicating more distress. The score was then grouped into four categories as listed by Rhodes et al. (30).

Disability was estimated using measures of long-term disability and the need for assistance with either basic activities of daily living (ADLs) or instrumental activities of daily living (IADLs). Social participation was measured by the need to restrict normal activities at home, school, work, or leisure due to a long-term health problem and whether a working age (15–75 years of age) person was not working for health reasons.

Finally, the mean HUI3 and self-rated health were included as two global measures of HRQOL. The measure of self-rated health asked respondents to rate their health on a five-level scale: poor, fair, good, very good, or excellent.

Analysis methods

HRQOL measures. For the HRQOL measures, age-sex standardized weighted prevalences were estimated for the Ontario population with and without diabetes. Bootstrapping programs and data supplied by Statistics Canada for use with the OHS II were used to calculate variance estimates (21). Statistical error for the prevalence ratios were estimated using the method outlined in Weiss et al. (31).

According to Statistics Canada guidelines, estimates with a coefficient of variation between 16.5 and 33.0 should be treated with caution due to high sampling variability, and those >33.0 are not reported. All estimates, including mortality, were standardized to the 1991 Canadian population. Statistical error for standardized estimates were calculated using the gamma method (32).

Life-table analysis. Period life tables for 1996–1997 were calculated using 20 standard age-specific mortality rates (<1, 1–4, 5–9,. . . , ≥90 years) by sex for people with and without diabetes using Chiang's method (33) except for an adaptation for the final age-group (34). For people with diabetes, all-cause mortality from the ODD was used. HALE was calculated using a modified Sullivan method (35). 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 those with and without diabetes, HALE was estimated by weighting the years of life lived according to the mean HUI3 values by age and sex for each population. Statistical error for life expectancy and HALE were calculated using the methods of Chiang and Mathers et al., respectively (32,36).

Diabetes-deleted estimates. The overall impact of diabetes on the health of Ontarians was examined by estimating the effect on the population's health if diabetes was eliminated (37). This estimate reflects both the number of people with a condition and their mortality risk and HRQOL in relationship to the overall population. For example, eliminating a condition that is uncommon will have a small influence on overall population health, even if people with the condition have a low life expectancy or HALE; a more common disease will have the potential for a large population impact, especially if it affects health—in terms of mortality or HRQOL—at a young age. The cause-deleted methodology is based on the assumption that when a particular disease or condition is removed from the population, the pattern of morbidity and mortality in those without the disease/condition generalizes to the entire population (38,39).

Diabetes-deleted mortality rates were calculated by subtracting the all-cause mortality rate for people with diabetes from the overall mortality rate for each age-sex group. Diabetes-deleted life expectancy was calculated by substituting the diabetes-deleted mortality rates for the overall mortality rates in the life table (40). Diabetes-deleted HRQOL was calculated in a similar manner by removing all people with diabetes from the OHS II sample and recalculating the mean HUI3 for each age-sex group. The diabetes-deleted mean HUI3 values were used to calculate diabetes-deleted HALE. All analyses were performed using SAS version 8.2 for Unix, except life tables that were created in Microsoft EXCEL (life tables for this study are available at http://www.ices.on.ca).

RESULTS

— Diabetes was not self-reported by 53.2% of people who have the disease, as defined in the ODD and previously described by Hux et al. (9). Since diabetes status in the ODD has been comprehensively validated, this low self-reported diabetes prevalence represents true underreporting (9).

Table 1 shows the sociodemographic characteristics of the study population. Sixty-one percent of people with diabetes in Ontario are 55 years or older; 21% of women with diabetes had low income (5.4% of men); 12.1% of people with diabetes were from South or West Asia.

Table 2 shows measures of HRQOL for people with and without diabetes. Generally, people with diabetes reported few functional limitations. For instance, although diabetes is one of the leading causes of blindness, most people with diabetes report no restrictions in vision (95.6% of women and 98.1% of men with diabetes report no vision difficulties). Diabetes had a greater effect on degree of disability and social participation than physical function: 17.9% of women and 12.3% of men with diabetes reported needing assistance with IADL, about twice the proportion of people without diabetes ($P < 0.005$); 10.5% of men and 7.9% of women with diabetes reported that they were not working due to illness or disability compared with 7.9% and 3.7%, respectively, for men and women without diabetes ($P < 0.005$ for male difference, $P < 0.05$ for women).

Table 3 shows mortality and HALE estimates for people with and without diabetes. Almost one-quarter of all people who died in Ontario in 1996–1997 had diabetes (18,320 people per year). However, only 12.5% of the people who died in Ontario had diabetes identified as the "most responsible underlying cause" of death on their death certificate. The age-standardized death rate for people with diabetes was more than twice that of people without diabetes (1,369 per 100,000 for men with diabetes versus 588 for men without diabetes; 1,315 per 100,000 for women with diabetes versus 533 for women without diabetes). This increased death rate translates into a life expectancy 12.8 years less than men without diabetes and 12.2 years less than women without diabetes.

HALE was 58.3 years for men with diabetes, as compared with 70.2 years for those without diabetes, and 62.7 years for women with diabetes, as compared with 73.5 years for those without diabetes (all differences $P < 0.005$). The ratio of HALE to life expectancy can be interpreted as the proportion of life spent in good

Table 1—*Sociodemographic characteristics among Ontarians with and without diabetes, 1996–1997*

	Men						Women					
	With diabetes			Without diabetes			With diabetes			Without diabetes		
Characteristic	*n*† (unweighted)	*n*‡ (weighted)	% (weighted)	*n* (unweighted)	*n* (weighted)	% (weighted)	*n* (unweighted)	*n* (weighted)	% (weighted)	*n* (unweighted)	*n* (weighted)	% (weighted)
Age (years)												
12–39	78	40,920	12.8	4,916	2,331,855	54.9	100	46,277	16.9	5,300	2,299,996	51.4
40–54	196	85,218	26.6	2,444	1,062,570	25.0	148	64,826	23.7	2,557	1,095,743	24.5
55–69	338	119,093	37.2	1,636	574,374	13.5	266	81,905	29.9	2,033	665,569	14.9
70+	251	74,738	23.4	916	282,488	6.6	293	80,608	29.5	1,591	418,159	9.3
Highest level of education*												
College/university graduation	223	91,588	33.6	3,043	1,428,049	33.5	162	61,980	28.5	3,735	1,439,909	31.9
High school graduation+	254	97,707	32.3	3,441	1,480,259	35.2	261	92,177	37.6	4,316	1,676,009	37.5
<High school graduation	366	122,739	34.2	3,343	1,296,068	31.4	377	117,903	33.9	3,364	1,332,369	30.6
Adjusted household income*												
High	94	26,193	13.1¶	684	316,757	15.6	188	53,909	8.2¶	1,686	457,582	14.2
Upper-middle	248	84,716	26.6	1,736	804,118	30.0	232	66,200	23.3	2,761	931,365	27.3
Low-middle	262	88,888	29.5	2,764	1,279,966	19.1	188	64,312	23.7	3,450	1,233,493	21.1
Low	105	37,192	5.4¶	1,453	673,007	7.5	48	17,684	21.0	1,500	647,182	10.4
Unknown	154	82,980	25.9	2,542	1,177,439	27.7	151	71,511	26.1¶	2,084	1,209,844	27.0

	Total population					
	With diabetes			Without diabetes		
	N (unweighted)	*N* (weighted)	% (weighted)	*N* (unweighted)	*N* (weighted)	% (weighted)
Ethnic origin*						
Canadian/U.S.	370	119,853	24.6	6523	2,585,886	30.1
European	1,048	329,172	44.4	12,055	4,515,142	52.2
Aboriginal/black/Latin American	46	17,735	3.8¶	406	222,980	2.6
South or West Asian	55	47,473	12.1¶	401	338,007	3.9
Other	139	73,169	15.1	1,786	972,028	11.2

*Standardized to the 1991 Canadian population; †the unweighted *n* refers to the number of survey respondents (actual observations); ‡the weighted *n* is the survey sample weighted up to the community-dwelling Ontario population (does not include people in institutions, in the Armed Forces, or living in remote communities); ¶estimate should be treated with caution due to high sampling variability (coefficient of variation between 16.5 and 33.0). Data sources: OHS II, Ontario Health Insurance Plan, RPDB.

Table 2—*HRQOL of Ontarians with and without diabetes, 1996–1997**

	Men			Women		
	Prevalence‡ among those with diabetes (%)	Prevalence among those without diabetes (%)	Prevalence ratio‡	Prevalence among those with diabetes (%)	Prevalence among those without diabetes (%)	Prevalence ratio‡
Measures of physical functioning						
Vision (% with vision problems not corrected by lenses)	1.9‖	1.7	1.1	4.4‖	2.4	1.8
Mobility (% with mobility problems)	4.1	2.5	1.6¶	4.9	3.1	1.6¶
Dexterity (% with dexterity problems)	1.0‖	0.6	1.6	1.3‖	1.0	1.4
Pain (% reporting chronic pain)	13.6‖	9.8	1.4	17.3	12.7	1.4
Measures of mental/psychological functioning						
Emotion (% reporting less than perfect emotional state)	17.5	14.4	1.2	20.3	14.1	1.4¶
Cognition (% reporting less than perfect cognition)	17.5‖	17.9	1.0	21.3	20.9	1.0
Distress level						
None	39.3	41.3	1.0	25.3	34.8	0.7§
Low	21.8	27.3	0.8	24.7	27.2	0.9
Medium	24.4‖	21.1	1.2	22.8	23.3	1.0
High	14.5‖	10.3	1.4	27.3	14.7	1.9§
Measures of activity						
Has long-term disability (lasting 6 months or more)	20.3	8.5	2.4§	15.1	9.6	1.6§
Needs assistance with ADLs	2.3*	1.4	1.6	2.9‖	1.9	1.6
Needs assistance with IADLs	12.3	5.6	2.2§	17.9	10.0	1.8§
Severity of disability						
None	72.4	87.3	0.8§	74.7	83.5	0.9§
Mild	16.9	7.8	2.2§	13.0	8.4	1.6¶
Moderate	9.0‖	3.6	2.5§	9.5	6.3	1.5¶
Severe	1.7‖	1.3	1.3	2.8‖	1.8	1.6
Measures of social participation						
Restriction of normal activities	25.4	11.7	2.2§	19.4	14.3	1.4§
Current working status (those <70 years of age only)						
Currently working	66.5	74.1	0.9	43.3	61.5	0.7§
Not working (illness/disability)	10.5‖	3.0	3.5§	7.9	3.7	2.1¶
Not working (family responsibilities)	—	—	—	25.9	11.7	2.2§
Not working (other reasons)	23.0‖	22.6	1.0	22.9	23.1	1.0
Global measures of health status						
Self-rated health of "good" or better	84.8	92.1	0.9§	80.7	90.9	0.9§
HUI Score (mean)	0.896	0.924		0.886	0.909	

*All estimates age standardized to the 1991 Canadian population; †except HUI Score, which is reported as the mean value; ‡prevalence ratio is the ratio of the prevalence of each characteristic among those with diabetes to the prevalence among those without; ¶$P < 0.05$; §$P < 0.005$; ‖estimate should be treated with caution due to high sampling variability (coefficient of variation between 16.5 and 33.0). Data sources: OHS II, Ontario Health Insurance Plan, RPDB.

health. The ratio of HALE to life expectancy was similar for people with and without diabetes, suggesting that the impact of diabetes on length of life is similar to or slightly smaller than its impact on years of healthy life. Given the present burden of disease, eliminating diabetes will extend overall life expectancy in Ontario by 2.8 years for men and 2.6 years for women. HALE would increase 2.7 years for men and 3.2 years for women.

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

Diabetes has about the same impact

Table 3—*Mortality, life expectancy, and HALE for people with/without diabetes and before/after eliminating diabetes in Ontario, Canada, 1996–1997*

Measure	Men (95% CI)			Women (95% CI)		
	Without diabetes	With diabetes	Rate ratio	Without diabetes	With diabetes	Rate ratio
Population, 1997	5,365,891	232,553		5,513,006	216,658	
Deaths, all-cause (per year)	31,022	9,646		29,900	8,750	
Crude death rate (per 100,000)	580 (572–585)	4,150 (4,065–4,231)	7.2 (6.6–7.9)	542 (536–548)	4,039 (3,954–4,123)	7.4 (6.8–8.1)
Age-adjusted death rate (per 100,000 people)	588 (582–595)	1,369 (1,299–1,438)	2.3 (2.1–2.6)	533 (527–539)	1,315 (1,272–1,357)	2.5 (2.3–2.8)
Deaths with diabetes as the underlying cause		1,135			1,175	
			Difference			Difference
Life expectancy at birth (years)	77.5 (77.4–77.6)	64.7 (63.0–66.4)	12.8 (11.1–14.5)	82.9 (82.9–83.0)	70.7 (69.9–71.5)	12.2 (11.4–13.0)
HALE at birth (years)	70.2 (70.2–70.5)	58.3 (56.3–60.3)	11.9 (9.9–13.9)	73.5 (73.2–73.7)	62.8 (61.4–64.1)	10.7 (9.3–12.1)
HALE/life expectancy ratio	0.91	0.90		0.89	0.89	
	Before eliminating diabetes	**After eliminating diabetes**	**Difference**	**Before eliminating diabetes**	**After Eliminating diabetes**	**Difference**
Life expectancy (years)	76.2 (76.1–76.2)	78.9 (78.8–79.0)	2.8 (2.7–2.9)	81.4 (81.3–81.5)	84.1 (84.0–84.1)	2.6 (2.5–2.8)
HALE (years)	68.9 (68.7–69.2)	71.6 (71.3–71.9)	2.7 (2.3–3.1)	72.2 (71.9–72.5)	75.4 (75.1–75.7)	3.2 (2.8–3.6)

on HRQOL as mortality in men and a larger HRQOL impact in women, suggesting that reducing or eliminating the disease has the potential to "compress morbidity" (meaning that extra years of life would be lived in a state of improved HRQOL). Because diabetes interventions, including hypoglycemic medications and preventive measures, may have a proportionately larger impact on diabetes morbidity than mortality, the actual impact of diabetes interventions may be an even greater improvement in HRQOL than mortality. Reducing conditions that have a higher mortality burden than HRQOL burden, such as cancer, has been predicted to cause an "expansion of morbidity," since people would live longer but the extended years of life would be limited by HRQOL burden of other conditions such as arthritis (41,42).

The increased mortality ratio in this study was similar to that observed in other populations (11). Consequently, we observed a life expectancy difference between people with and without diabetes that was similar to other studies (43–45). In a related manner, we assumed that if diabetes was eliminated the mortality rate and HRQOL burden for people who had diabetes would be the same as those without diabetes. It is possible that people with diabetes have a higher mortality rate or HRQOL burden from causes that are not directly related to diabetes (i.e., health behavior such as hypertension and obesity), thereby resulting in our study overestimating of the population impact of diabetes. However, it should be noted that reduction in illness from these non–diabetes-related conditions may also be achieved if the prevalence of diabetes is reduced through health promotion or disease prevention that targets common risk factors for other disease. Therefore, reducing diabetes through these methods would potentially exceed the gains in life expectancy and HALE that we report.

The use of linked population health data to examine the health of people with diabetes is potentially useful for several reasons. The use of linked data overcomes reporting bias of self-reported disease status from health surveys and potentially improves vital statistics reports that rely on the most responsible underlying cause of death. The sampling frame of the general population, as opposed to the clinical setting or other specific populations, improves the inferences regarding health of

the general diabetes population compared with previous studies. For example, a recent estimate of U.S. diabetes survival by Narayan et al. (7) used diabetes mortality risk estimates from a North Dakota population and HRQOL utility values based on diabetic patients recruited from specialty clinics. Narayan et al. 's life expectancy estimates for people without diabetes were within 1 year of the U.S. Census Bureau estimates, whereas our study life expectancy estimates were essentially indistinguishable from Statistics Canada's Ontario life expectancy estimates (7), as expected since we used the same mortality sources and similar actuarial life-table methods. Quality-adjusted life-years (QALYs), as estimated by Narayan et al., are different from HALE (7,46), but the larger HRQOL impact in their study was attributable in part to the use of lower utility values of diabetes HRQOL estimated from a population that represented a more severe spectrum of disease than the general diabetes population (47,48). Because an important limitation of our study is the omission of long-term care residents for the estimation of HRQOL, the actual population-based HRQOL utility value is probably somewhat higher than our reported estimate, although the influence on overall HRQOL is likely small since the long-term care population is relatively small (47,49). We adjusted HRQOL impact based on sex and age-group, an important consideration since we observed HRQOL burden was more severe for older people (not shown). In addition, we assumed that the HRQOL burden of diabetes was the difference between the observed HUI3 estimate for people with and without diabetes, whereas Narayan et al. assumed that without diabetes people would have a perfect health (value = 1.0) (7,41).

The additional information in the population health survey along with the well-established life-table techniques used in this study allow for further evaluation of the health influences of diabetes. Furthermore, the commitment in our jurisdiction for future population health surveys, linkable to disease registries and other health administrative databases, provides a potentially robust system for ongoing surveillance and evaluation of the progress toward reducing the burden of diabetes in the overall population or specific subpopulations. For example, the life tables used in this study can be easily modified by health planners to examine the potential impact of reducing the diabetes burden in specific age-groups or to calculate other life-table functions such as lifetime probability of dying from diabetes (50). Population health surveys, such as the OHS and NPHS, typically contain information on sociodemographic factors (socioeconomic status, immigrant and family status, etc.), behavioral risks (smoking, obesity, sedentary lifestyle, etc.), and comorbid health conditions (51). Therefore, it is possible to examine HRQOL and mortality for people with diabetes in these subgroups.

Our study was limited by the inability to differentiate type 1 and type 2 diabetes. The onset of illness is earlier for type 1 diabetes; therefore, the cumulative impact of type 1 diabetes on individual health is likely greater than for type 2 diabetes. However, the impact of diabetes on population health is strongly influenced by type 2 diabetes because it is much more prevalent than type 1 diabetes.

This study has demonstrated that linked databases containing HRQOL, prevalence, and mortality information can be used to estimate the large combined mortality and morbidity burden of diabetes. Furthermore, this approach can be used for a wide range of purposes such as health status comparisons to nondiabetic populations or subpopulations. Overall, linked data are an important source of information for monitoring the health of people with diabetes in the general population.

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