Universal Drug Coverage and Socioeconomic Disparities in Health Care Costs Among Persons With Diabetes

Wanrudee Isaranuwatchai,[1,2,3] Ghazal S. Fazli,[2,4] Arlene S. Bierman,[5,6] Lorraine L. Lipscombe,[2,5,7,8] Nicholas Mitsakakis,[2,9,10] Baiju R. Shah,[2,5,7,11] C. Fangyun Wu,[5] Ashley Johns,[4] and Gillian L. Booth[2,4,5,7]

Diabetes Care 2020;43:2098–2105 | https://doi.org/10.2337/dc19-1536

OBJECTIVE

To examine whether neighborhood socioeconomic status (SES) is a predictor of non-drug-related health care costs among Canadian adults with diabetes and, if so, whether SES disparities in costs are reduced after age 65 years, when universal drug coverage commences as an insurable benefit.

RESEARCH DESIGN AND METHODS

Administrative health databases were used to examine publicly funded health care expenditures among 698,113 younger (20–64 years) and older (≥65 years) adults with diabetes in Ontario from April 2004 to March 2014. Generalized linear models were constructed to examine relative and absolute differences in health care costs (total and non-drug-related costs) across neighborhood SES quintiles, by age, with adjustment for differences in age, sex, diabetes duration, and comorbidity.

RESULTS

Unadjusted costs per person-year in the lowest SES quintile (Q1) versus the highest (Q5) were 39% higher among younger adults ($5,954 vs. $4,270 [Canadian dollars]) but only 9% higher among older adults ($10,917 vs. $9,993). Adjusted non-drug costs (primarily for hospitalizations and physician visits) were $1,569 per person-year higher among younger adults in Q1 vs. Q5 (modeled relative cost difference: 35.7% higher) and $139.3 million per year among all individuals in Q1. Scenarios in which these excess costs per person-year were decreased by ≥10% or matched the relative difference among seniors suggested a potential for savings in the range of $26.0–$128.2 million per year among all lower-SES adults under age 65 years (Q1–Q4).

CONCLUSIONS

SES is a predictor of diabetes-related health care costs in our setting, more so among adults under age 65 years, a group that lacks universal drug coverage under Ontario's health care system. Non-drug-related health care costs were more than one-third higher in younger, lower-SES adults, translating to >$1 billion more in health care expenditures over 10 years.

In 2018, more than 30 million Americans were estimated to have diabetes, with projections calling for another 30 million by the year 2060 (1). The rise in diabetes prevalence in recent decades has considerable implications for health system management and resource allocation in the U.S., Canada, and worldwide (1–4).

[1]Centre for Excellence in Economic Analysis Research, St. Michael's Hospital, Toronto, Ontario, Canada
[2]Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada
[3]Health Intervention and Technology Assessment Program, Bangkok, Thailand
[4]MAP Centre for Urban Health Solutions, Li Ka Shing Knowledge Institute of St. Michael's Hospital, Unity Health Toronto, Toronto, Ontario, Canada
[5]ICES, Toronto, Ontario, Canada
[6]Lawrence S. Bloomberg Faculty of Nursing, University of Toronto, Toronto, Ontario, Canada
[7]Department of Medicine, University of Toronto, Toronto, Ontario, Canada
[8]Women's College Research Institute, Women's College Hospital, Toronto, Ontario, Canada
[9]Biostatistics Research Unit, University Health Network, Toronto, Ontario, Canada
[10]Division of Biostatistics, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
[11]Sunnybrook Research Institute, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

Corresponding author: Gillian L. Booth, Gillian.Booth@unityhealth.to

Received 1 August 2019 and accepted 25 May 2020

This article contains supplementary material online at https://doi.org/10.2337/figshare.12385550.

While rates of hospitalizations for cardiovascular events, end-stage kidney disease, and other complications have fallen significantly in recent decades (5–10), hospital care remains the largest contributor to the high costs of diabetes care (2–4). In the U.S., approximately one in four health care dollars was spent on individuals with diabetes in 2017, leading to an estimated $237 billion in direct medical costs and an average of $16,752 per person with diabetes each year (3). However, total costs attributable to diabetes, including indirect costs from disability and premature mortality, are likely to have been considerably higher.

Low income is a strong risk factor for adverse diabetes outcomes, including avoidable hospitalizations, amputation, end-stage renal disease, cardiovascular events, and overall mortality (10–15). Canadian research reported a 50% higher incidence of cardiovascular events among low-income adults with diabetes living in Ontario relative to high-income groups—but only among those under age 65 years (11). Differences across income groups were substantially diminished after age 65 years, the age at which universal drug coverage commences under the province's health plan. A similar phenomenon was observed with respect to mortality, end-stage renal disease incidence, and glycemic control (10–12,16). Despite considerable gains in overall survival in recent decades, the gap in mortality between richer and poorer people with diabetes has widened among younger groups, yet remained stable among those over age 65 years (10). Escalating drug costs may have compounded existing disparities (17,18). In the face of high out-of-pocket costs, low-income groups who lack adequate insurance coverage are more likely to restrict their use of prescription medications—an act that, in itself, can lead to poorer health outcomes (19–23).

In Canada, prescription medications fall outside the scope of the Canada Health Act, with wide variations in drug financing across provinces (24). In Ontario, the Drug Benefit Program provides universal coverage to individuals over age 65 years but only provides coverage for younger people who require government assistance for basic living expenses (including those with long-term disabilities) and individuals with excessive drug costs relative to their income. The majority of adults with diabetes who are under age 65 years must pay out of pocket or receive coverage from third-party insurers, with varying degrees of copayments and deductibles.

The aim of this study was to examine whether socioeconomic status (SES) is a predictor of non-drug-related health care costs among adults with diabetes within a publicly funded health care system that universally covers the costs of hospital, laboratory, and physician services for all but within which universal coverage of medications commences only after age 65 years. Based on prior studies that demonstrated a greater association between SES and adverse health outcomes among younger adults, we tested the association between SES and non-drug-related health care expenditures separately among younger (20–64 years old) and older (≥65 years old) adults with diabetes, with the hyopthesis being that SES disparities would be reduced in populations over age 65 years who receive universal drug coverage as an insurable benefit.

RESEARCH DESIGN AND METHODS

Study Population

We conducted a population-based, retrospective cohort study using administrative databases held at ICES, an independent nonprofit research institute. These data include anonymous health records for all permanent residents living in Ontario, Canada (~14 million) and capture both inpatient and outpatient services, as well as prescription drug claims reimbursed through the Ontario Drug Benefit program. Individual records were linked across databases using unique, encoded identifiers and analyzed at ICES. This study received ethics approval from the institutional review board at Sunnybrook Health Sciences Centre.

The study population included all adults with diabetes living in Ontario on 31 March 2004 and receiving coverage under the province's health care program for a minimum of 5 years prior. Individuals were identified from the Ontario Diabetes Database (ODD), which uses a highly sensitive (89%) and specific (98%) algorithm based on hospitalization and physicians' services records to identify individuals with physician-diagnosed diabetes (25). The ODD excludes individuals with gestational diabetes mellitus but is unable to discriminate between type 1 and type 2 diabetes.

Variables and Data Sources

The main independent variable in this study was SES at baseline. Because individual measures of income were not available, we used an area-level measure of SES created from data collected for the Canadian Census. To do so, we assigned individuals to small geographic units (dissemination areas [DAs]) that are fairly homogeneous with respect to social characteristics and population size (~500 individuals), based on their location of residence at baseline (1 April 2004). A postal code conversion file (2006 PCCF+) created by Statistics Canada was used to assign income quintiles to each DA based on the median household income level reported for that DA at the time of the 2006 Canadian Census. To account for differences in the costs of living (e.g., housing prices) in different cities, towns, or regions, this algorithm ranked DAs within a given census metropolitan or agglomeration area (e.g., Toronto) or within small town/rural areas according to their median household income level before dividing DAs into quintiles. Those in the lowest income category were classified as quintile (Q) 1 and those in the highest income category as Q5.

Age, sex, location of residence, and vital status were derived from the Registered Persons Database. Clinical variables included the number of primary care visits in the year prior to baseline, duration of diabetes, level of comorbidity, and history of major cardiovascular disease (CVD) events or coronary/cerebral revascularization within the preceding 5 years, based on the relevant diagnosis and procedure codes from hospital discharge records (Supplementary Table 1). Because the earliest records in the ODD were from 1991, diabetes duration was categorized into the following: ≤2 years, >2–5 years, >5–10 years, and >10 years. Comorbidity was assigned to individuals using the Johns Hopkins Adjusted Clinical Groups (ACG) system to create a manageable number of case-mix categories (collapsed ambulatory diagnostic groups [CADGs]) based on diagnostic codes for conditions other than diabetes listed in hospital records and physicians' services claims in the 2 years prior to baseline.

Outcomes

The cohort was followed for cumulative non-drug-related health care costs (primary outcome) incurred by the province's public health care plan between 1 April 2004 and 31 March 2014—or earlier if they died or moved out of province. Secondary outcomes included cumulative total health care costs and service-specific costs incurred over the same period of time. Health care costs (in 2014 Canadian dollars) were derived by summing the costs incurred for each type of service covered by Ontario's Ministry of Health and Long-Term Care (MOHLTC), namely, hospitalizations, outpatient physician services, outpatient laboratory and diagnostic tests, emergency department visits, prescription drugs, same-day procedures, home care services, and complex continuing care (a value applied to patient complexity during hospital admissions), using a validated algorithm established at ICES (26). The following databases were used to obtain health care costs: the Canadian Institute for Health Information Discharge Abstract Database, the National Ambulatory Care Reporting System, the Ontario Health Insurance Plan database, the Ontario Drug Benefit program database, the Home Care Database, and the Continuing Care Reporting System. Costs were further categorized into drug- and non-drug-related costs (total − drug costs) and costs per service type.

Statistical Analysis

Descriptive analyses were carried out to compare total, non-drug-related, and service-specific health care costs per person-year among individuals in each income quintile and age-group. Because our models examined only direct health care costs, we also generated Kaplan-Meier curves to compare age- and sex-adjusted all-cause survival, according to income quintile and age-group.

We used a generalized linear model (GLM) with log link and γ distribution to examine the relation between income quintile and non-drug-related health care costs incurred between 1 April 2004 and 31 March 2014, with follow-up time as an offset. Individuals were censored at the time of death or loss of health care coverage, indicating a move out of province. Based on prespecified hypotheses, we stratified our analyses by age-group (20–64 and ≥65 years) and adjusted for age, sex, CVD, diabetes duration, and comorbidity. The choice of the model was based on findings from the modified Park test. Pearson correlation test, deviance residuals, and Akaike information criterion statistics were also examined to assess the fit of the data prior to final model selection. The adjusted costs per person-year for each income quintile and age category were derived from the GLM models through recycled prediction estimation (27). The output of these models reported an observed excess cost per person-year among lower income quintiles (Q1–Q4) compared with Q5 for a given age-group. As a sensitivity analysis, we repeated our analyses for those aged 20–39, 40–54, and 55–64 years to assess whether results were consistent across all ages under 65 years.

From these models, we calculated the adjusted cost difference among all individuals in a given quintile in excess of those in Q5 by multiplying the cost per person-year × the number of individuals in that quintile. We then examined scenarios where the non-drug-related costs per person-years among younger adults (<age 65 years) were progressively reduced by 10–50% and, finally, where the relative differences in costs per person-years were considered to be the same as in those aged ≥65 years.

RESULTS

Overall, there were 681,026 individuals in our cohort, 54% of whom were between the ages of 20 and 64 years (N = 371,085). Table 1 reports the baseline characteristics of the study population by income quintile and age-group. In general, adults over age 65 years had a longer duration of diabetes, more comorbidities, and higher numbers of hospitalizations and physician visits compared with younger adults. Individuals from the lowest-SES group had greater use of health services regardless of age. However, there were few other notable differences in baseline characteristics according to SES.

Figure 1 reports unadjusted health care costs per person-year by age category and income quintile. Overall, the total health care costs in our sample were $4.3 billion per year. Across all age-groups, there was an inverse association between SES and health care expenditures (Fig. 1). While total costs increased sharply with age, the relative difference between Q1 and Q5 was substantially higher among adults 20–64 years of age ($6,128 vs. $4,371 [+40.2%]) compared with those aged ≥65 years ($11,640 vs. $10,480 [+11.1%]). Among younger groups, this pattern persisted for both drug- and non-drug-related health care costs (Supplementary Figs. 1 and 2). More than half of all costs were related to hospitalizations, including inpatient services, emergency department visits, same day surgery, home care, and complex continuing care. As demonstrated in Supplementary Fig. 3, age- and sex-adjusted survival rates were diminished among lower-income groups. This was particularly so among adults under age 65 years, where the lowest income quintile demonstrated a more marked decline in survival after ≥3 years of follow-up relative to other income groups.

After adjustment for baseline age, sex, diabetes duration, prior CVD, and comorbidities and censoring for death on follow-up, non-drug-related health care costs remained significantly higher among adults in Q1 relative to Q5, ranging from 41.3% higher among those aged 20–39 years to 28.6% higher among those aged 55–64 years ($P < 0.001$ for all comparisons) (Fig. 2). Although relative differences in non-drug-related health care costs were inversely associated with age, excess costs in Q1 versus Q5 were lower than expected in older adults, ranging from 12.0% in those aged 65–74 years to 6.5% among those aged ≥75 years (Fig. 2).

Among all adults aged 20–64 years, the modeled-adjusted non-drug-related costs were $1,569 (95% CI 1,563–1,575) more per person-year in Q1 relative to Q5 (difference: +31.8%) (Table 2) or $139.3 million per year in total. Among adults aged ≥65 years, the relative difference in non-drug-related costs in Q1 versus Q5 was substantially lower (difference +10.9%) than that observed in younger age-groups, although absolute differences were similar given the substantially higher costs of care in seniors.

Models whereby the relative SES gradient in younger adults (<65 years) was considered to be same as that observed in older adults (≥65 years) suggested an estimated reduction in non-drug-related costs of $688 per person-year and $78.4 million per year overall among all younger adults in Q1 (Fig. 3). Scenarios whereby the adjusted non-drug-related

Table 1—Baseline characteristics of cohort by income quintile

	Age 20–64 years					Age ≥65 years				
	Q1 (lowest)	Q2	Q3	Q4	Q5 (highest)	Q1 (lowest)	Q2	Q3	Q4	Q5 (highest)
Sample size	88,766	80,751	73,333	68,386	59,849	73,101	69,761	60,117	56,122	50,840
Age	50.5 ± 9.8	51.0 ± 9.7	51.0 ± 9.8	51.2 ± 9.7	51.7 ± 9.6	74.9 ± 6.9	74.7 ± 6.7	74.6 ± 6.8	74.6 ± 6.7	74.8 ± 6.9
Female (%)	49.2	46.6	45.5	44.6	42.9	55.6	51.9	50.1	48.4	46.8
History of previous CVD* (%)	4.9	4.9	4.8	4.8	4.7	10.9	10.8	10.9	10.9	10.6
Diabetes duration (%)										
≤2 years	21.3	22.0	21.9	22.3	22.6	13.4	14.2	14.0	14.5	14.5
>2–5 years	25.6	26.2	26.7	26.5	26.5	19.6	20.1	20.2	20.4	20.3
>5–10 years	29.9	29.2	29.3	28.9	28.6	29.5	29.6	29.9	29.7	30.4
>10 years	23.2	22.6	22.5	22.4	22.3	37.5	36.2	35.9	35.4	34.8
No. of primary care visits in prior year	7.6 ± 7.7	7.4 ± 7.7	7.1 ± 7.4	7.0 ± 7.5	6.7 ± 7.5	10.0 ± 9.8	9.6 ± 9.6	9.5 ± 9.2	9.5 ± 9.2	9.1 ± 9.0
Comorbid chronic conditions**										
Unstable (%)	36.6	35.5	35.0	34.6	34.5	64.2	63.8	63.9	64.3	64.5
Stable (%)	64.0	64.2	63.8	63.2	62.4	81.0	81.2	81.1	81.2	80.2
No. of hospitalizations/py during follow-up	0.27 ± 1.7	0.24 ± 1.6	0.22 ± 0.9	0.21 ± 1.9	0.21 ± 2.1	0.74 ± 4.3	0.72 ± 4.8	0.70 ± 4.7	0.69 ± 3.96	0.66 ± 4.1
LOS/py during follow-up	2.6 ± 11.4	2.2 ± 10.9	1.9 ± 9.6	1.8 ± 9.8	1.7 ± 9.9	8.1 ± 22.6	7.5 ± 22.3	7.3 ± 22.1	7.1 ± 22.4	6.9 ± 21.3

Data are means ± SD unless otherwise indicated. LOS, length of stay; py, person-year. *History of major CVD events or coronary/cerebral revascularization within the preceding 5 years, based on diagnosis and procedure codes from hospital discharge records. **From John Hopkins CADGs for unstable (CADG5) and stable (CADG6) chronic medical conditions.

costs per person-year were reduced by 10–50% were associated with an estimated decrease of $26.0–$130.2 million per year among all adults <65 years of age in Q1–Q4.

CONCLUSIONS

From our analysis, health care costs were up to 41% greater for low-SES Ontarians with diabetes compared with those in the highest-SES group, with a stepwise increase in health care costs with decreasing neighborhood income. However, the incremental costs incurred by lower-SES groups were relatively diminished among seniors, who receive universal drug coverage as an insurable benefit, compared with those under age 65 years, who rely largely on private insurance or pay out of pocket for medications.

Other studies from the same health care setting yielded similar findings with respect to the relationship between SES and adverse diabetes outcomes, including CVD, end-stage renal disease, and all-cause mortality, with more marked associations observed in those under age 65 years (10–12). Taken together, these findings highlight a potential role for prescription drug coverage to help curb adverse health outcomes and excess costs associated with low SES. In the last two decades, premature morbidity and mortality from diabetes have fallen tremendously, due in large part to growing evidence on the effectiveness of glucose-, blood pressure–, and cholesterol-lowering therapies to reduce diabetes complications and their adoption into practice (5–10,28,29). However, in our setting, reductions in mortality appear to be lagging in low-income populations with diabetes, specifically, those under age 65 (10). This group is less likely to have private insurance coverage for prescription drugs as a means of filling the gap in public insurance and therefore are more prone to restrict medications because of high drug costs (19). In contrast, the use of evidence-based therapies in our setting is high among seniors with diabetes irrespective of SES (29).

Canada is currently the only country in the Organisation for Economic Co-operation and Development (OECD)

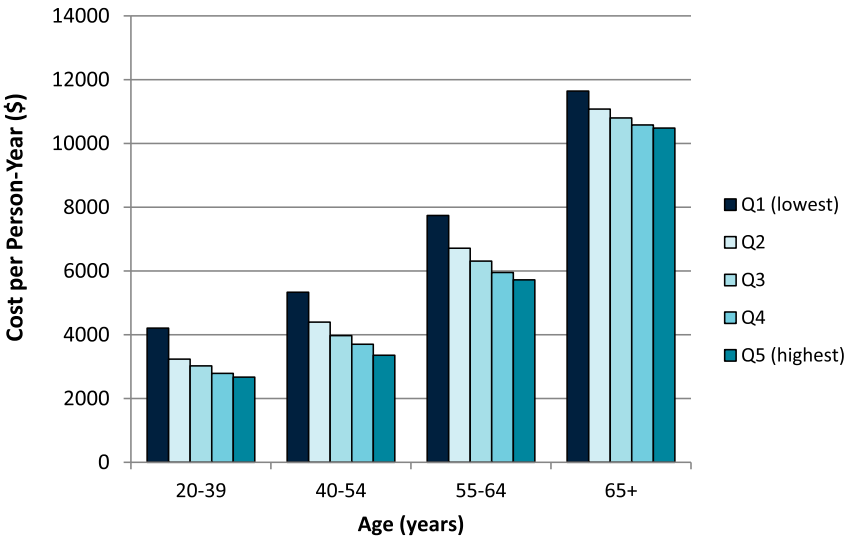

Figure 1—Unadjusted total health care costs per person-year between 2004 and 2014 among people with diabetes, by age category and neighborhood income quintile.

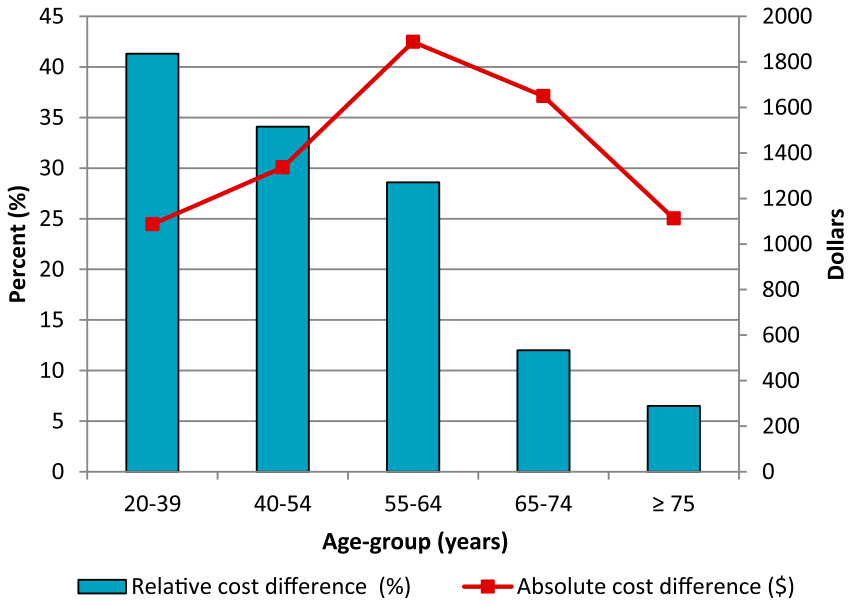

Figure 2—Adjusted differences in non-drug-related health care costs per person-year between adults with diabetes in the lowest versus highest neighborhood income quintile, by age-group. Differences in cost were derived from GLMs using a recycled prediction method to enable the retransformation of the log link function while adjusting for age, sex, CVD, diabetes duration, and comorbidity.

with a publicly funded health care system that does not does include prescription drug coverage for citizens of all ages (30). Moreover, Canada spends more on medications per capita than comparable OECD countries with universal health care. While there are compelling arguments in support of implementing a national pharmacare strategy in Canada, doing so would likely require a shift in the allocation of health care dollars from other non-drug sectors to provincial drug plans. However, this may not be as costly as previously thought. Morgan et al. (31) estimated that expansion of Canada's Medicare system to include medications could result in increased government drug spending of only $1 billion annually, while decreasing private spending through private drug plans and out-of-pocket costs by $8.2 billion each year, for a net reduction of $7.3 billion annually. These estimates rely on reductions in generic and brand-name drug costs through bulk purchasing, negotiation of drug prices, and product selection but would place Canadian drug spending closer to or on par with other OECD countries, with the exception of the U.S.

Findings from our study are highly relevant to the current discourse on health care reform in the U.S. Americans face a growing barrier to accessing prescription medications due to rising drug prices. The list price of insulins nearly tripled between 2002 and 2013, with further rises in the years since, despite more modest increases in net manufacturers' pricing (17,18). This phenomenon is due to complex changes in drug pricing resulting in rebates and discounts that are passed on to intermediary stakeholders in the insulin supply chain but not to patients at the point of sale (18). As a direct result, out-of-pocket costs for insulin have risen considerably among the uninsured, those with cost-sharing health plans with high co-payments and deductibles, and those affected by the Medicare Part D coverage gap known as the "donut hole." While its full impact is not yet known, there is evidence that rising medication costs and loss of insurance coverage may have had detrimental effects on medication adherence and diabetes-related health outcomes (32–36). Prior to 2010, there were substantial declines in rates of hospital admission for hyperglycemia, amputation, and CVD among young and middle-aged Americans with diabetes; however, these rates have since plateaued or risen (32–34). Over this same period, there was a parallel increase in the number of emergency department visits and days

Table 2—Unadjusted and adjusted differences in mean non-drug costs across income quintiles, by age-group, in Canadian dollars

	Age 20–64 years					Age ≥65 years				
	Q1 (lowest)	Q2	Q3	Q4	Q5 (highest)	Q1 (lowest)	Q2	Q3	Q4	Q5 (highest)
Sample size	88,766	80,751	73,333	68,386	59,849	73,101	69,761	60,117	56,122	50,840
Modeled costs*										
Adjusted mean cost/py	5,138	4,546	4,343	4,103	3,898	12,894	12,474	12,161	11,804	11,515
Total adjusted mean cost/quintile/year (millions)	544.0	421.5	354.9	312.4	261.6	850.9	772.7	649.2	593.8	532.8
Modeled cost differences**										
Adjusted cost difference/py in excess of Q5	1,569	808	526	254	Ref	1,650	1,137	767	344	Ref
% increase in adjusted cost/py relative to Q5	31.8%	14.3%	9.9%	5.0%	Ref	10.9%	7.7%	5.3%	2.5%	Ref
Total adjusted cost/quintile/py in excess of Q5 (millions)	139.3	65.3	38.6	17.4	Ref	120.6	79.3	46.1	19.3	Ref

$P < 0.0001$ for costs comparisons across quintiles. py, person-year; Ref, reference. *Derived from GLMs adjusted for age, sex, CVD, diabetes duration, and comorbidity. **Adjusted cost differences were derived from GLMs using a recycled prediction method to enable the retransformation of the log link function while adjusting for covariates.

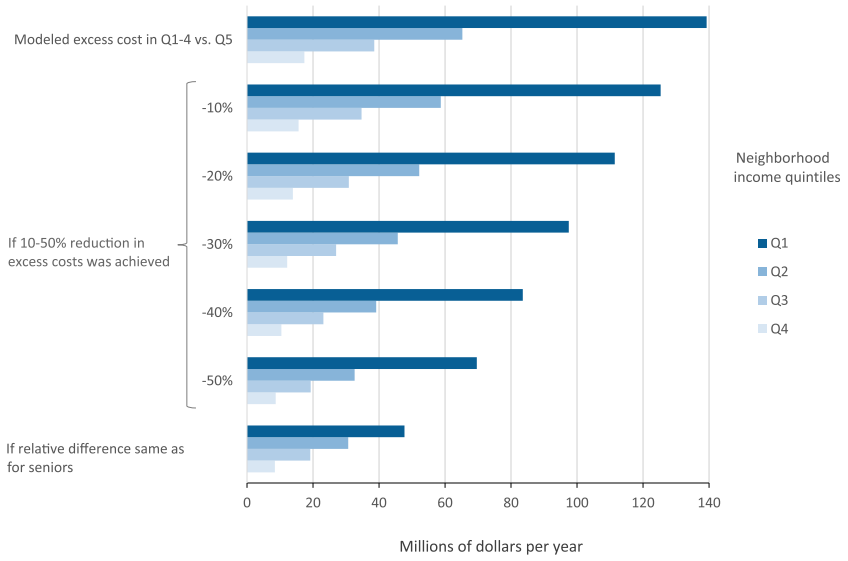

Figure 3—Adjusted differences in non-drug-related health care costs per year among all adults with diabetes living in lower-income (Q1–Q4) relative to high-income (Q5) neighborhoods. Differences in cost were derived from GLMs using a recycled prediction method to enable the retransformation of the log link function while adjusting for age, sex, CVD, diabetes duration, and comorbidity. Costs per person were summed for all individuals in a given quintile.

spent in hospital among low-income groups with diabetes whose health insurance switched from a low- to high-deductible plan (35). In contrast, natural experiments resulting in increased insurance coverage have had opposite effects. For example, the expansion of Medicare (Part D) in 2006 to include medication coverage was associated with reductions in out-of-pocket spending, medication nonadherence, non-drug expenditures, and overall mortality among Medicare beneficiaries who had limited drug coverage prior to enrollment (37,38). Furthermore, evidence from a randomized controlled trial that enrolled beneficiaries of a large commercial insurer in the U.S. suggested that provision of drug coverage could improve outcomes following acute myocardial infarction, without increasing non-drug-related health care spending (39). Findings from our study and others are even more relevant today given the current situation many Americans are facing. The COVID-19 pandemic has led to a sharp rise in unemployment rates, with resultant loss of employer-sponsored health insurance, leaving increasing numbers of people with and people without diabetes uninsured (40). This has created further barriers for patients to access prescription drugs, as well as ongoing diabetes care, and inevitably will contribute to increases in avoidable and costly hospital admissions, emergency department visits, and other diabetes-related adverse events.

Strengths of this study include its large, population-level design, thus reducing the potential for selection bias and providing sufficient power to examine health care costs within subgroups of the population defined by age and SES. However, there are limitations to our analysis that merit discussion. Firstly, we assumed that providing universal coverage for essential medications to people with diabetes who are not currently receiving these benefits (i.e., younger groups with diabetes) would reduce the relative gap in non-drug-related health care costs to levels commensurate with those of populations who do receive universal drug coverage (i.e., older groups with diabetes). Other factors may contribute to the relatively wider SES differences in younger adults (e.g., fewer cost-related barriers to healthy food and exercise facilities among high-income groups) or relatively narrower SES differences in older adults (survival bias leading lower-SES groups to be relatively healthier; old age security payments; less social support, worse care transitions, and greater need for home care, regardless of SES). However, none of these reasons would cause a sudden shift in the SES gradient at age 65 years. Secondly, it is possible that individuals with diabetes complications suffered a decline in SES from loss of employment due to disability, prior to commencement of this study. However, while we cannot rule out some element of reverse causality, a previous study found the same income gradient in health outcomes among individuals with newly diagnosed diabetes as among those with preexisting diabetes diagnoses (11). Thirdly, we did not examine SES disparities in indirect costs, which may be far greater due to the increased likelihood of disability and premature death among lower-income groups. Since those who died no longer incurred health care costs, the excess mortality observed among lower-income groups provides additional insight into the high cost of low SES. Fourth, SES was based on neighborhood rather than individual income; however, these tend to be closely correlated and neighborhood SES performs well when individual measures are unavailable (41). Furthermore, we did not treat SES as a time-varying covariate in our models. This may have led to some degree of misclassification, particularly for young adults who may have been students or unemployed at the time of cohort entry. However, this bias would be expected to favor our null hypothesis, since the likelihood that wealthier students might live in less wealthy neighborhoods seems greater than the possibility that lower-SES students would live in high-SES areas. Fifth, our diabetes algorithm was unable to discriminate between type 1 and type 2 diabetes. Although type 1 diabetes comprises a small proportion of all diabetes cases, its higher prevalence at younger ages may have contributed to variations in the association between SES and health care expenditures in younger verses older groups. Finally, we accounted for differences in follow-up time between individuals by reporting costs per person-year but did not consider fluctuations in costs over time.

Creating a health system that is both efficient and equitable relies on measures to enhance care and outcomes for the most vulnerable members of society. High out-of-pocket costs for prescription drugs may serve as an important barrier to accessing care for many individuals with diabetes. Low-income groups shoulder a disproportionate burden of these costs, often spending 3%–4% or more of household earnings on drugs and supplies for their management. Our

findings demonstrate that SES is a significant predictor of publicly funded health care costs for adults with diabetes in our setting, and the association between SES and health care expenditures appears to be stronger among younger (<65 years) individuals, for whom drug costs are not universally covered as an insurable benefit, than among older (≥65 years) individuals, for whom drug costs are included. Further research is needed to more fully understand the health impact and costs associated with changes in drug policy.

Funding. This study was funded by Diabetes Canada. G.S.F. is funded by a Health System Impact Fellowship from the Canadian Institutes of Health Research (CIHR). A.S.B. currently works at the Agency for Healthcare Research and Quality. L.L.L. is supported by a CIHR New Investigator Award. G.L.B. is supported by a Clinician–Scientist Merit Award from the Department of Medicine at the University of Toronto. This study was supported by ICES, which is funded by an annual grant from MOHLTC. Parts of this material are based on data and information compiled and provided by MOHLTC and the Canadian Institute for Health Information.

This work was done as an outside activity. The views in this manuscript represent those of the authors and not necessarily the policy or views of the Agency for Healthcare Research and Quality or the U.S. Department of Health and Human Services. The analyses, conclusions, opinions, and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended, and endorsement should not be inferred.

Duality of Interest. No potential conflicts of interest relevant to this article were reported.

Author Contributions. W.I. and G.L.B. conceptualized the study, designed the analyses, and wrote the manuscript. G.S.F., A.S.B., L.L.L., N.M., B.R.S., C.F.W., and A.J. contributed to the design of the analyses, interpreted the data, and edited the manuscript. C.F.W. undertook the analyses. G.L.B. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2020: Estimates of Diabetes and Its Burden in the United States [Internet]. Available from https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf. Accessed 22 June 2020

2. Bommer C, Sagalova V, Heesemann E, et al. Global economic burden of diabetes in adults: projections from 2015 to 2030. Diabetes Care 2018;41:963–970

3. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. Diabetes Care 2018;41:917–928

4. Rosella LC, Lebenbaum M, Fitzpatrick T, et al. Impact of diabetes on healthcare costs in a population-based cohort: a cost analysis. Diabet Med 2016;33:395–403

5. Gregg EW, Li Y, Wang J, et al. Changes in diabetes-related complications in the United States, 1990-2010. N Engl J Med 2014;370:1514–1523

6. Gregg EW, Cheng YJ, Srinivasan M, et al. Trends in cause-specific mortality among adults with and without diagnosed diabetes in the USA: an epidemiological analysis of linked national survey and vital statistics data. Lancet 2018;391:2430–2440

7. Harding JL, Shaw JE, Peeters A, Guiver T, Davidson S, Magliano DJ. Mortality trends among people with type 1 and type 2 diabetes in Australia: 1997-2010. Diabetes Care 2014;37:2579–2586

8. Lind M, Garcia-Rodriguez LA, Booth GL, et al. Mortality trends in patients with and without diabetes in Ontario, Canada and the UK from 1996 to 2009: a population-based study. Diabetologia 2013;56:2601–2608

9. Booth GL, Kapral MK, Fung K, Tu JV. Recent trends in cardiovascular complications among men and women with and without diabetes. Diabetes Care 2006;29:32–37

10. Lipscombe LL, Austin PC, Manuel DG, Shah BR, Hux JE, Booth GL. Income-related differences in mortality among people with diabetes mellitus. CMAJ 2010;182:E1–E17

11. Booth GL, Bishara P, Lipscombe LL, et al. Universal drug coverage and socioeconomic disparities in major diabetes outcomes. Diabetes Care 2012;35:2257–2264

12. Ke C, Kim SJ, Shah BR, et al. Impact of socioeconomic status on incidence of end-stage renal disease and mortality after dialysis in adults with diabetes. Can J Diabetes 2019;43:483–489.e4

13. Booth GL, Hux JE. Relationship between avoidable hospitalizations for diabetes mellitus and income level. Arch Intern Med 2003;163:101–106

14. Amin L, Shah BR, Bierman AS, et al. Gender differences in the impact of poverty on health: disparities in risk of diabetes-related amputation. Diabet Med 2014;31:1410–1417

15. Rawshani A, Svensson A-M, Zethelius B, Eliasson B, Rosengren A, Gudbjörnsdottir S. Association between socioeconomic status and mortality, cardiovascular disease, and cancer in patients with type 2 diabetes. JAMA Intern Med 2016;176:1146–1154

16. Branfield Day L, Austin PC, Shah BR. Universal drug coverage and income-related disparities in glycaemic control. Diabet Med 2020;37:822–827

17. Hua X, Carvalho N, Tew M, Huang ES, Herman WH, Clarke P. Expenditures and prices of antihyperglycemic medications in the United States: 2002–2013. JAMA 2016;315:1400–1402

18. Cefalu WT, Dawes DE, Gavlak G, et al.; Insulin Access and Affordability Working Group. Insulin access and affordability working group: conclusions and recommendations. Diabetes Care 2018;41:1299–1311

19. Law MR, Cheng L, Dhalla IA, Heard D, Morgan SG. The effect of cost on adherence to prescription medications in Canada. CMAJ 2012;184:297–302

20. Morgan SG, Gladstone EJ, Weymann D, Khan N. The effects of catastrophic drug plan deductibles on older women's use of cardiovascular medicines: a retrospective cohort study. CMAJ Open 2017;5:E198–E204

21. Kesselheim AS, Huybrechts KF, Choudhry NK, et al. Prescription drug insurance coverage and patient health outcomes: a systematic review. Am J Public Health 2015;105:e17–e30

22. Tamblyn R, Laprise R, Hanley JA, et al. Adverse events associated with prescription drug cost-sharing among poor and elderly persons. JAMA 2001;285:421–429

23. Karter AJ, Parker MM, Solomon MD, et al. Effect of out-of-pocket cost on medication initiation, adherence, and persistence among patients with type 2 diabetes: the Diabetes Study of Northern California (DISTANCE). Health Serv Res 2018;53:1227–1247

24. Demers V, Melo M, Jackevicius C, et al. Comparison of provincial prescription drug plans and the impact on patients' annual drug expenditures. CMAJ 2008;178:405–409

25. Lipscombe LL, Hwee J, Webster L, Shah BR, Booth GL, Tu K. Identifying diabetes cases from administrative data: a population-based validation study. BMC Health Serv Res 2018;18:316

26. Wodchis WP, Austin PC, Henry DA. A 3-year study of high-cost users of health care. CMAJ 2016;188:182–188

27. Glick HA, Doshi JA, Sonnad SS, Polsky D. *Economic Evaluation in Clinical Trials*. 2nd ed. Oxford, U.K., Oxford University Press, 2014

28. Alexander GC, Sehgal NL, Moloney RM, Stafford RS. National trends in treatment of type 2 diabetes mellitus, 1994-2007. Arch Intern Med 2008;168:2088–2094

29. Shah BR, Booth GL, Lipscombe LL, Feig DS, Bhattacharyya OK, Bierman AS. Near equality in quality for medication utilization among older adults with diabetes with universal medication insurance in Ontario, Canada. J Eval Clin Pract 2014;20:176–183

30. Paris V, Hewlett E, Auraaen A, Alexa J, Simon L. Health care coverage in OECD countries in 2012 [Internet]. Available from https://www.oecd-ilibrary.org/social-issues-migration-health/health-care-coverage-in-oecd-countries-in-2012_5jlz3kbf7pzv-en. Accessed 18 June 2019

31. Morgan SG, Law M, Daw JR, Abraham L, Martin D. Estimated cost of universal public coverage of prescription drugs in Canada. CMAJ 2015;187:491–497

32. Gregg EW, Hora I, Benoit SR. Resurgence in diabetes-related complications. JAMA 2019;321:1867–1868

33. Geiss LS, Li Y, Hora I, Albright A, Rolka D, Gregg EW. Resurgence of diabetes-related nontraumatic lower-extremity amputation in the young and middle-aged adult U.S. population. Diabetes Care 2019;42:50–54

34. Benoit SR, Hora I, Pasquel FJ, Gregg EW, Albright AL, Imperatore G. Trends in emergency department visits and inpatient admissions for hyperglycemic crises in adults with diabetes in the U.S., 2006-2015. Diabetes Care 2020;43:1057–1064

35. Wharam JF, Zhang F, Eggleston EM, Lu CY, Soumerai SB, Ross-Degnan D. Effect of high-deductible insurance on high-acuity outcomes in diabetes: a Natural Experiment for Translation

in Diabetes (NEXT-D) Study. Diabetes Care 2018; 41:940–948
36. Rabin DL, Jetty A, Petterson S, Saqr Z, Froehlich A. Among low-income respondents with diabetes, high-deductible versus no-deductible insurance sharply reduces medical service use. Diabetes Care 2017;40:239–245
37. McWilliams JM, Zaslavsky AM, Huskamp HA. Implementation of Medicare Part D and nondrug medical spending for elderly adults with limited prior drug coverage. JAMA 2011;306:402–409
38. Huh J, Reif J. Did Medicare Part D reduce mortality? J Health Econ 2017;53:17–37
39. Choudhry NK, Avorn J, Glynn RJ, et al.; Post-Myocardial Infarction Free Rx Event and Economic Evaluation (MI FREEE) Trial. Full coverage for preventive medications after myocardial infarction. N Engl J Med 2011;365:2088–2097
40. Woolhandler S, Himmelstein DU. Intersecting U.S. epidemics: COVID-19 and lack of health insurance. Ann Intern Med 2020;173:63–64
41. Cho KH, Nam CM, Lee EJ, et al. Effects of individual and neighborhood socioeconomic status on the risk of all-cause mortality in chronic obstructive pulmonary disease: a nationwide population-based cohort study, 2002-2013. Respir Med 2016;114:9–17