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Original Research

Impact of the COVID-19 Pandemic on Diabetes Care for Adults With Type 2 Diabetes in Ontario, Canada

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A R T I C L E I N F O

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A B S T R A C T

Objectives: The COVID-19 pandemic and related public health prevention measures have led to a disruption of the delivery of routine care and may have had an impact on the quality of diabetes care. Our aim in this study was to evaluate the extent to which structure, process and outcome quality measures in diabetes care changed in the first 6 months of the pandemic compared with previous periods.
Methods: A before-and-after observational study was conducted of all community-living Ontario residents >20 years of age and living with diabetes. The patients were divided into 3 cohorts: a pandemic cohort, alive March to September 2020 (n=1,393,404); reference cohort 1, alive March to September 2019 (n=1,415,490); and reference cohort 2, alive September 2019 to February 2020 (n=1,444,000). Outcome measures were in-person/virtual visits to general practitioners and specialists, eye examinations, glycated hemoglobin (A1C) and low-density lipoprotein (LDL) testing, filled prescriptions, and admissions to emergency departments (EDs) and hospitals for acute and chronic diabetes complications.
Results: The probability of an in-person visit to a general practitioner decreased by 47% (95% confidence interval [CI], 47% to 47%) in the pandemic period compared with both previous periods. The probability of having an eye exam was lower by 43% (95% CI, 44% to 43%), an A1C test by 28% (95% CI, 29% to 28%) and an LDL test by 31% (95% CI, 31% to 31%) in the pandemic period compared with the same 6-month period the year before. There were very small decreases in drug prescriptions and decreases of 18% and 16% in ED and hospital visits for complications.
Conclusions: We observed disruptions to both structure and process measures of diabetes care in Ontario during the first wave of the pandemic.

Mots clés:
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R É S U M É

Objectifs : La pandémie de la COVID-19 et les mesures de prévention de la santé publique qui y sont associées ont causé des perturbations dans la prestation des soins courants et peuvent avoir eu des répercussions sur la qualité des soins en diabète. L'objectif de notre étude était d'évaluer jusqu'à quel point les mesures de la structure, des processus et de la qualité des résultats en matière de soins en diabète avaient changé dans les 6 premiers mois de la pandémie par rapport aux périodes précédentes.
Méthodes : Nous avons évalué les études observationnelles avant-après de tous les résidents ontariens de > 20 ans et diabétiques qui vivent dans la communauté. Nous avons réparti les patients en 3 cohortes : la cohorte de pandémie, en vie de mars à septembre 2020 (n = 1 393 404); la cohorte de référence 1, en vie de mars à septembre 2019 (n = 1 415 490); et la cohorte de référence 2, en vie de septembre 2019 à février 2020 (n = 1 444 000). Les instruments de mesure de résultat étaient les consultations en personne/virtuelles avec les praticiens généraux (PG) et les spécialistes; les examens ophtalmologiques, les

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dosages de l'hémoglobine glyquée (A1c) et des lipoprotéines de faible densité (LDL), et les ordonnances remplies; les admissions aux services des urgences (SU) et dans les hôpitaux en raison des complications à long terme du diabète.

Résultats : Par rapport aux 2 périodes précédentes, la probabilité de consulter en personne un PG a diminué de 47 % (intervalle de confiance [IC] à 95 %, de 47 % à 47 %) durant la pandémie. Par rapport à la même période de 6 mois durant l'année avant la pandémie, nous avons noté que durant la pandémie la probabilité de subir un examen ophtalmologique était inférieure à 43 % (IC à 95 % à, de 44 % à 43 %), un dosage de l'A1c, de 28 % (IC à 95 %, de 29 % à 28 %) et un dosage de LDL, de 31 % (IC à 95 %, de 31 % à 31 %). Nous avons observé une très faible diminution des ordonnances de médicaments et une diminution respective de 18 % et de 16 % des consultations au SU et à l'hôpital en raison de complications.

Conclusions : Nous avons observé des perturbations dans les mesures de la structure et des processus en matière de soins en diabète en Ontario durant la première vague de la pandémie.

Introduction

The COVID-19 pandemic was declared by the World Health Organization on March 11, 2020, and, according to preliminary reports, resulted in major disruptions to routine medical services worldwide, especially for those living with diabetes and chronic diseases (1–3). On March 15, the chief medical officer of health in Ontario directed health-care organizations and providers to stop or substantially scale back all nonessential or elective services until further notice (4,5). As a result, physicians and allied health networks were required to postpone routine patient visits, which included those living with diabetes and other chronic diseases, to reduce the risk of COVID-19 infection. The public, also worried about contracting the virus in clinical and hospital settings, cancelled or drastically reduced their appointments and daily travel, especially in the first few months of the pandemic (3,4,6,7).

Living with diabetes requires extensive self-management routines, lifestyle adjustments, medicines and regular contact with health-care professionals, most of which takes place in primary care settings (8–10). According to the Diabetes Canada 2018 guidelines, high-quality diabetes care should include regular physician visits that provide opportunities to reduce the risk of diabetes complications through appropriate physical examination such as foot and eye examinations, careful monitoring of glucose management and lipid levels through laboratory tests and prescriptions of drugs that can reduce risk of cardiovascular and kidney complications (10,11). Accepted clinical guidelines for evidenced-based care and routine public reporting of quality-of-care measures for those living with diabetes, including physician visits, key processes of care measures and health outcomes that may be avoided with appropriate care, has become routine in many jurisdictions, including Ontario (12–15). Moreover, diabetes has major implications for health-care costs and health complications (10,16–18), making this patient population especially vulnerable to disruptions in routine care.

Social distancing and reduced access to medical care during the COVID-19 pandemic could have important impacts on quality of care for those with diabetes (4,6). Many studies have shown that diabetes is one of the major comorbidities associated with development of severe COVID-19–related adverse outcomes and mortality (19–24). Thus, decreases in quality of care for diabetes could have an immediate impact on morbidity and mortality related to COVID-19 infections as well as a longer term impact on mortality and morbidity due to diabetes itself. Some work based on surveys of providers and patients has raised concerns about quality of care for those with diabetes during the COVID-19 pandemic (2,3), but evidence using accepted markers of quality of care has been minimal at the population level (25). To our knowledge, only 1 recent study has focussed on diabetic foot complications and related procedures in Ontario, Canada (26). In this study, we used well-defined and accepted quality-of-diabetes-care measures of structure, process and outcomes and population-based data from Ontario to evaluate the extent to which the quality of care for those with diabetes had changed during the first wave of the COVID-19 pandemic (March 1, 2020, to August 31, 2020). We hope this study can inform our understanding of the impacts of the COVID-19 pandemic on care for those with diabetes and guide efforts to improve and maintain quality.

Methods

Study design and setting

We conducted this population-based pre/post study using linked provincial administrative health databases to assess changes in total diabetes-related visits in primary care, specialists, emergency department (ED) and hospital settings, including procedures, testing and prescriptions, for all residents of Ontario, Canada, living with diabetes. We compared rates of use of these outcomes in the first 6 months of the COVID-19 pandemic (March 1, 2020, to August 31, 2020) to 2 previous 6-month periods (March 1, 2019, to August 31, 2019, and September 1, 2019, to February 29, 2020). Ontario is the most populated province in Canada, with an estimated 2020 population of 14,734,014 (27). All permanent residents in the province have full coverage for necessary physician, hospital and diagnostic services without copayments or deductibles.

Data sources and collation

We conducted the study using linked health administrative databases at ICES (formerly known as the Institute for Clinical Evaluative Sciences) Central, Toronto, Ontario. The Ontario Health Insurance Plan (OHIP) claims database provides records of all health-care services delivered by physicians to patients eligible for coverage. The Registered Person Database provides demographic information for all patients covered under OHIP, including neighbourhood income quintiles generated by the Postal Code Conversion File. The ICES-derived Ontario Diabetes Database (ODD) allows for the identification of persons living with diabetes. The Canadian Institute for Health Information Discharge Abstract Database and National Ambulatory Care Reporting System contain records on all inpatient hospital admissions, and all hospital- and community-based ambulatory care, including ED visits. The Ontario Drug Benefit Claims Database captures drug benefit claims for seniors and low-income recipients. These data sets were linked using unique encoded identifiers and analyzed at ICES. ICES is an independent, nonprofit research institute with legal status under Ontario's health information privacy law that allows it to collect and analyze health-care and demographic data, without consent, for health system evaluation and improvement. Many of the measures employed in this study have been used in previous research and public reporting on diabetes and primary care metrics in Ontario (4,6,13,28–31).

Population

Three study cohorts were constructed by identifying all community-dwelling residents in Ontario diagnosed with non-gestational diabetes within at least 2 years before the first day of entry into each cohort (i.e. index dates: March 1, 2019; September 1, 2019; and March 1, 2020, respectively), ≥20 years of age as of the index date, eligible for OHIP coverage as of the index date, resided within the community (i.e. not living in long-term care facilities at any time during the study period) and alive at the end of cohort time frame (Supplementary Figure 1). The algorithm used to identify persons with diabetes from the ODD has a sensitivity of 86% and specificity of 97% (32). More information on the algorithm has been published elsewhere (32). We excluded from the study those who were not Ontario residents, ≤19 years of age, had missing or invalid birthday/sex information, had a missing health card number and those who died during the study period. We identified common comorbidities, such as hypertension, congestive heart failure, acute myocardial infarction, chronic obstructive pulmonary disease, asthma, dementia and other mental health issues, within this patient population using OHIP, Discharge Abstract Database and National Ambulatory Care Reporting System (33,34).

Study outcomes

The outcomes in the study were identified using ICES databases and ICES-validated disease-specific registries (28–31). Study outcomes were organized using Donabedian's Structure, Process, Outcome framework (35):

1. *Structure* (access to care and context measures): a) total general practitioner/family physician (GP/FP) visits, including in-person and virtual visits; and b) total specialist visits, including in-person and virtual visits.
2. *Process* (processes of diabetes care metrics): a) eye exams, defined as those ≥40 years of age who had a retinal exam within each cohort time frame; b) glycated hemoglobin (A1C) tests for those ≥40 years of age; c) low-density lipoprotein (LDL) test for those ≥40 years of age; and d) angiotensin-converting enzyme inhibitor, angiotensin II receptor blocker and statin prescriptions filled within each cohort for those ≥65 years of age.
3. *Outcomes* (health/utilization metrics): a) acute complications of diabetes, defined as having at least 1 visit to the ED or hospital admission with diagnosis for the following conditions during each cohort time frame: hyperglycemia, hypoglycemia or soft tissue infection; and b) chronic complication of diabetes, defined as having at least 1 visit to ED or hospital admission with diagnosis for one of the following during each cohort time frame: cardiovascular disease, chronic renal disease or amputation.

Statistical analysis

Descriptive statistics for the sampled data and study cohorts are presented with frequencies and percentages. The structure, process and outcome measures were dichotomized and treated as binary dependent variables within the time frame for follow up in each cohort as follows: reference cohort 1, March 1, 2019, to August 31, 2019; reference cohort 2, September 1, 2019, to February 29, 2020; and the pandemic cohort, March 1, 2020, to August 31, 2020. Standardized differences were calculated to ensure that all 3 cohorts were balanced to minimize potential confounding. A standardized difference of <0.1 would suggest cohorts are not substantially different based on the predictors being examined (36). More information on the methodology and interpretation of this approach can be found elsewhere (36).

A multivariate logistic regression analysis was used to model binary outcomes. Generalized estimation equations, with exchangeable covariance structure, were used to account for the repeated measures within patients. The adjusted regression analysis included the covariates of cohort, age, sex, income quintile, individual comorbidities and health regions measured at the index date for each time period. Adjusted risk for each outcome and each cohort was calculated using our multivariate logistic regression model. The change in adjusted risks and their 95% confidence intervals (CIs) for each outcome for the comparison of the pandemic period to each of the 2 previous periods—reference cohort 1 (to account for potential seasonality) and reference cohort 2 (to account for potential temporal trends)—were calculated. SAS version 9.4 (SAS Institute, Cary, North Carolina, United States) was used for the analysis, with the GENMOD procedure with binary distribution and log link. All tests were two-sided and $p<0.05$ was considered statistically significant.

Ethics approval

This study was conducted in accordance with research ethics board guidelines and policies at the University of Toronto and approval (No. 41386) was granted. Furthermore, all studies carried out within ICES are subject to a privacy impact assessment and approval from the ICES's privacy and legal office. The protocol for this study was approved by ICES and the data sufficiently de-identified and small cells suppressed to protect privacy. All analyses for this study were conducted using an encrypted remote connection to Data Access Services at ICES, a secure server where the data and analytical software are housed.

Results

Table 1 summarizes each study cohort and characteristics of all community-dwelling residents who were OHIP insured and had been diagnosed with diabetes. The standardized difference calculated between cohorts did not yield any numeric values >0.1, indicating they are balanced.

Data on frequency and percent of structure, process and outcome measures by study cohort are reported in Supplementary Table 1.

Table 2 provides a summary of the adjusted and unadjusted estimates of the relative risks for changes in each of the measures between the pandemic period and 2 pre-pandemic periods. The probability of total visits to GPs and specialists went down by 12% (95% CI, 12% to 12%; $p<0.001$) and 13% (95% CI, 13% to 13%), respectively, with probability of an in-person visit to a GP decreasing by almost half at 47% (95% CI, 47% to 47%). There were large increases in the probability of virtual visits to both types of providers. The probability of having an eye exam went down by about 43% (95% CI, 44% to 43%) and the probability of an A1C by 28% (95% CI, 29% to 28%) and a lipid blood test by 31% (95% CI, 31% to 31%). The probability of a filled prescription for preventive drug therapy was basically unchanged. There were some differences in the probability complication rates across the 2 comparison periods, but the overall pattern was of a lower probability of visits for acute complications by 16% (95% CI, 17% to 14%) and chronic

Table 1
Ontario diabetic population by study cohort, health region and characteristics

	Reference cohort 1 (March 1, 2019, to August 31, 2019), n (%)	Reference cohort 2 (September 1, 2019, to February 29, 2020), n (%)	Pandemic cohort (March 1, 2020, to August 31, 2020), n (%)	Standardized difference for reference cohort 1 and reference cohort 2	Standardized difference for pandemic cohort and reference cohort 1	Standardized difference for pandemic cohort and reference cohort 2
Sex						
Male	732,132 (52.5%)	744,052 (52.6%)	758,376 (52.5%)	−0.000446	−0.000472	−0.000918
Female	661,272 (47.5%)	671,438 (47.4%)	685,624 (47.5%)	0.000446	0.000472	0.000918
Age, years						
20–29	22,811 (1.6%)	23,435 (1.7%)	24,277 (1.7%)	−0.001457	0.003457	0.002000
30–39	54,891 (4.0%)	55,569 (4.0%)	57,034 (4.0%)	0.000404	0.000592	0.000995
40–49	137,472 (9.9%)	137,882 (9.7%)	138,568 (9.6%)	0.002808	−0.006122	−0.003314
50–59	288,312 (20.7%)	290,229 (20.5%)	291,843 (20.2%)	0.003282	−0.008260	−0.004978
60–69	379,395 (27.3%)	385,453 (27.3%)	391,820 (27.2%)	−0.000041	−0.001377	−0.001419
70–79	327,293 (23.5%)	335,979 (23.7%)	345,476 (24.0%)	−0.003795	0.006666	0.002871
≥80	183,230 (13.1%)	186,943 (13.2%)	194,982 (13.5%)	−0.001689	0.010390	0.008701
Income quintile						
Q1 (lowest income)	325,069 (23.3%)	328,569 (23.2%)	334,404 (23.2%)	0.002763	−0.004047	−0.001285
Q2	303,060 (21.7%)	307,263 (21.7%)	313,228 (21.7%)	0.001029	−0.001405	−0.000376
Q3	286,488 (20.6%)	290,991 (20.6%)	297,136 (20.6%)	0.000066	0.000420	0.000487
Q4	254,123 (18.2%)	259,686 (18.3%)	265,329 (18.4%)	−0.002805	0.003543	0.000738
Q5 (highest income)	222,669 (16.0%)	226,868 (16.0%)	231,738 (16.0%)	−0.001290	0.001857	0.000567
Missing	1,995 (0.1%)	2,113 (0.1%)	2,165 (0.1%)	−0.001597	0.001766	0.000169
Comorbidities						
Hypertension	891,148 (64.0%)	915,155 (64.7%)	919,634 (63.7%)	−0.014572	−0.005581	−0.020153
CHF	95,980 (6.9%)	104,058 (7.4%)	100,198 (6.9%)	−0.018014	0.002001	−0.016013
AMI	66,952 (4.8%)	65,819 (4.6%)	64,930 (4.5%)	0.007304	−0.014645	−0.007342
COPD	222,599 (16.0%)	231,013 (16.3%)	229,626 (15.9%)	−0.009380	−0.001998	−0.011378
Asthma	221,306 (15.9%)	228,129 (16.1%)	231,162 (16.0%)	−0.006389	0.003443	−0.002946
Dementia	36,583 (2.6%)	33,394 (2.4%)	31,254 (2.2%)	0.017080	−0.030158	−0.013101
Other mental health	303,136 (21.8%)	306,436 (21.6%)	300,994 (20.8%)	0.002579	−0.022242	−0.019663
Health regions						
North-West	25,294 (1.8%)	25,449 (1.8%)	25,613 (1.8%)	−0.002709	0.005055	0.002345
North-East	62,737 (4.5%)	63,129 (4.5%)	64,098 (4.4%)	−0.000017	0.001618	0.001601
East	131,613 (9.4%)	133,667 (9.4%)	136,537 (9.5%)	0.000078	0.000343	0.000421
Central-East	442,136 (31.7%)	450,930 (31.9%)	461,591 (32.0%)	0.002057	−0.003073	−0.001016
South-West	115,446 (8.3%)	116,816 (8.3%)	119,156 (8.3%)	0.001304	−0.003127	−0.001823
Central-West	242,268 (17.4%)	246,117 (17.4%)	251,951 (17.4%)	0.001180	−0.001212	−0.000032
Toronto	289,575 (20.8%)	294,574 (20.8%)	298,608 (20.7%)	−0.000712	−0.002531	−0.003244
Unkown	84,335 (6.1%)	84,808 (6.0%)	86,446 (6.0%)	0.002565	−0.002770	−0.000205

AMI, acute myocardial infarction; *CHF*, congestive heart failure; *COPD*, chronic obstructive pulmonary disease; *Q*, quintile.

complications by 9% (95% CI, 10% to 7%), and for both ED at 18% (95% CI, 19% to 16%) and hospital complications at 16% (95% CI, 19% to 14%).

The analysis of absolute differences (Table 3) shows that total GP visits dropped by 11% (95% CI, 11.23 to 10.92) and total specialist visits by 7.9% (95% CI, 8.17 to 7.81). In-person GP visits dropped by 40.7% (95% CI, 40.91% to 40.6%), whereas virtual visits increased by 54.3% (95% CI, 54.24% to 54.54%). Specialist visits dropped by 7.7% (95% CI, 7.94% to 7.59%) in person and rose by 34.3% (95% CI, 34.16% to 34.45%) virtually. Eye exams dropped by 5% (95% CI, 5.09% to 4.91%), A1C dropped by 18.9% (95% CI, 19.12% to 18.8%) and LDL tests by 14.9% (95% CI, 15.09% to 14.8%), respectively. Angiotensin-converting enzyme/angiotensin II receptor blocker and statin scripts dropped by about 1.3% (95% CI, 1.46% to 1.13%). Other complications changed by <1%, including acute outcomes by 0.33% (95% CI, 0.38% to 0.29%); chronic outcomes by 0.16% (95% CI, 0.21% to 0.11%); ED complications by 0.37% (95% CI, 0.41% to 0.33%); and hospital complications by 0.16% (95% CI, 0.19% to 0.13%).

Discussion

In this pre/post study, we have demonstrated that there were major disruptions to structures and processes of diabetes care during the COVID-19 pandemic. There were substantial reductions in the number of people with diabetes who saw their GP/FP in-person over 6 months, dropping from 77% before the pandemic to 36.7% during the pandemic. In-person specialist visits were also reduced by about 8%. There were major increases in virtual care for both GP/FP and specialists, consistent with other studies examining the shift from in-person to virtual care (4,6). However, many critical processes of diabetes care were disrupted during this time frame, as demonstrated in the 5% absolute decrease in eye exams, 19% drop in A1C tests and 15% drop in LDL tests during the pandemic.

Acute and chronic complications of diabetes were used as proxies for health outcomes and both were largely unchanged. It is too early to know with certainty actual health outcomes associated with the first wave of COVID-19; however, we suspect that diabetes complications have not gone down, but rather the reductions in these outcomes suggest that people were less likely to seek care. This is further supported by the relative drop in acute and chronic complications within ED and hospital settings for any cause in those with diabetes compared with previous time points. Therefore, we found there were observable disruptions to both structures and processes of diabetes care in the province during the first wave of the COVID-19 pandemic. Furthermore, that the reductions in visits for diabetes complications observed are consistent with possible barriers to ED and hospital care, driven either by reluctance of those with diabetes to seek care or institutional care systems overwhelmed with COVID-19, indicates that those individuals were unable to seek or receive care.

With regard to disruptions in processes of diabetes care, we believe that, although virtual visits increased, there were major decreases in in-person services, such as eye exams, A1C and LDL testing and ED visits, many of which are critical components of diabetes care. Services such as eye and foot examinations are difficult to administer remotely and may have lasting implications

Table 2
Unadjusted and adjusted risk ratios for study outcomes

	Comparisons	Unadjusted RR (95% CI)	Unadjusted p value	Adjusted RR (95% CI)	Adjusted p value
Structure (access to care and context measures)					
GP visit (total)	Pandemic vs RC 1	0.88 (0.88–0.88)	<0.0001	0.88 (0.88–0.88)	<0.0001
	Pandemic vs RC 2	0.88 (0.88–0.88)	<0.0001	0.88 (0.88–0.88)	<0.0001
GP visit (in person)	Pandemic vs RC 1	0.53 (0.53–0.53)	<0.0001	0.53 (0.53–0.53)	<0.0001
	Pandemic vs RC 2	0.53 (0.53–0.53)	<0.0001	0.53 (0.53–0.53)	<0.0001
GP visit (virtual)	Pandemic vs RC 1	36.41 (35.94–36.88)	<0.0001	36.42 (35.95–36.89)	<0.0001
	Pandemic vs RC 2	33.52 (33.11–33.94)	<0.0001	33.63 (33.21–34.04)	<0.0001
Specialist visit (total)	Pandemic vs RC 1	0.87 (0.87–0.87)	<0.0001	0.87 (0.87–0.87)	<0.0001
	Pandemic vs RC 2	0.87 (0.87–0.88)	<0.0001	0.88 (0.87–0.88)	<0.0001
Specialist visit (in person)	Pandemic vs RC 1	0.87 (0.87–0.88)	<0.0001	0.87 (0.87–0.87)	<0.0001
	Pandemic vs RC 2	0.88 (0.88–0.88)	<0.0001	0.88 (0.88–0.88)	<0.0001
Specialist visit (virtual)	Pandemic vs RC 1	39.23 (38.57–39.91)	<0.0001	39.19 (38.53–39.86)	<0.0001
	Pandemic vs RC 2	36.52 (35.93–37.12)	<0.0001	36.75 (36.16–37.36)	<0.0001
Process (processes of diabetes care metrics)					
Eye exam	Pandemic vs RC 1	0.58 (0.57–0.58)	<0.0001	0.57 (0.56–0.57)	<0.0001
	Pandemic vs RC 2	0.60 (0.59–0.60)	<0.0001	0.59 (0.59–0.59)	<0.0001
A1C test	Pandemic vs RC 1	0.72 (0.71–0.72)	<0.0001	0.72 (0.71–0.72)	<0.0001
	Pandemic vs RC 2	0.73 (0.73–0.73)	<0.0001	0.73 (0.73–0.73)	<0.0001
LDL test	Pandemic vs RC 1	0.69 (0.69–0.69)	<0.0001	0.69 (0.69–0.69)	<0.0001
	Pandemic vs RC 2	0.72 (0.72–0.73)	<0.0001	0.73 (0.72–0.73)	<0.0001
ACE inhibitor/ARB	Pandemic vs RC 1	0.98 (0.98–0.99)	<0.0001	0.98 (0.98–0.99)	<0.0001
	Pandemic vs RC 2	0.99 (0.99–0.99)	<0.0001	0.99 (0.99–0.99)	<0.0001
Statin	Pandemic vs RC 1	0.98 (0.98–0.99)	<0.0001	0.98 (0.98–0.99)	<0.0001
	Pandemic vs RC 2	0.99 (0.99–0.99)	<0.0001	0.99 (0.99–0.99)	<0.0001
Outcomes (health/utilization metrics)					
Acute complications	Pandemic vs RC 1	0.84 (0.83–0.86)	<0.0001	0.84 (0.83–0.86)	<0.0001
	Pandemic vs RC 2	0.90 (0.89–0.92)	<0.0001	0.92 (0.90–0.93)	<0.0001
Chronic complications	Pandemic vs RC 1	0.94 (0.93–0.95)	<0.0001	0.91 (0.90–0.93)	<0.0001
	Pandemic vs RC 2	0.92 (0.91–0.93)	<0.0001	0.92 (0.91–0.93)	<0.0001
ED complications	Pandemic vs RC 1	0.82 (0.80–0.83)	<0.0001	0.82 (0.81–0.84)	<0.0001
	Pandemic vs RC 2	0.90 (0.88–0.91)	<0.0001	0.90 (0.89–0.92)	<0.0001
Hospital complications	Pandemic vs RC 1	0.83 (0.81–0.86)	<0.0001	0.84 (0.81–0.86)	<0.0001
	Pandemic vs RC 2	0.86 (0.84–0.88)	<0.0001	0.87 (0.85–0.89)	<0.0001

A1C, glycated hemoglobin; *ACE*, angiotensin-converting enzyme; *ARB*, angiotensin II receptor blocker; *CI*, confidence interval; *ED*, emergency department; *GP*, general practitioner; *LDL*, low-density lipoprotein; *RC*, reference cohort; *RR*, risk ratio.

for diabetes-related complications in the near and long term. This was the case even though eye examination rates for those living with diabetes in Ontario were already suboptimal before COVID-19, potentially further increasing the risk of complications, such as diabetic retinopathy (37). Another study demonstrated increases in diabetes-related foot amputations before COVID-19 in Ontario (38). There is yet further concern given that about one-third of diabetic foot ulcers fail to heal and many with nonhealing ulcers progress to lower extremity amputations (39). Other studies showed that stay-at-home orders and lockdowns have created new norms in health behaviours and living that may be particularly detrimental to the diabetic population, such as isolation, unhealthy diets, decreased physical activity, stress/mental health–related concerns, as well as delaying care-seeking due to fears of contracting COVID-19 (9,40–42). Our findings support assertions presented elsewhere showing there were indicators of reduced care-seeking across other hospital and ED services within the diabetic population (43–45). Further studies are needed on how patient outcomes are related to

Table 3
Absolute difference in study outcomes

Outcome variables	RC 1 (absolute value)	RC 2 (absolute value)	Pandemic cohort (absolute value)	Pandemic vs RC 1, % (95% CI)	Pandemic vs RC 2, % (95% CI)
Structure (access to care and context measures)					
GP visit (total)	77.99%	77.61%	66.92%	−11.07 (−11.23 to −10.92)	−10.69 (−10.84 to −10.53)
GP visit (in person)	77.47%	77.09%	36.72%	−40.76 (−40.91 to −40.60)	−40.37 (−40.53 to −40.21)
GP visit (virtual)	1.26%	1.37%	55.65%	54.39 (54.24 to 54.54)	54.29 (54.14 to 54.44)
Specialist visit (total)	54.74%	54.19%	46.75%	−7.99 (−8.17 to −7.81)	−7.44 (−7.62 to −7.26)
Specialist visit (in person)	54.28%	53.70%	46.52%	−7.77 (−7.94 to −7.59)	−7.19 (−7.36 to −7.01)
Specialist visit (virtual)	0.80%	0.85%	35.11%	34.31 (34.16 to 34.45)	34.26 (34.11 to 34.40)
Process (processes of diabetes care metrics)					
Eye exam	11.08%	10.60%	6.09%	−5.00 (−5.09 to −4.91)	−4.51 (−4.60 to −4.43)
A1C test	63.34%	61.68%	44.38%	−18.96 (−19.12 to −18.80)	−17.30 (−17.46 to −17.15)
LDL test	44.96%	42.55%	30.01%	−14.95 (−15.09 to −14.80)	−12.54 (−12.69 to −12.40)
ACE inhibitor/ARB	84.40%	84.12%	83.10%	−1.30 (−1.46 to −1.13)	−1.02 (−1.18 to −0.85)
Statin	84.40%	84.12%	83.10%	−1.30 (−1.46 to −1.13)	−1.02 (−1.18 to −0.85)
Outcomes (health/utilization metrics)					
Acute complications	2.14%	1.98%	1.81%	−0.33 (−0.38 to −0.29)	−0.17 (−0.21 to −0.12)
Chronic complications	1.84%	1.83%	1.68%	−0.16 (−0.21 to −0.11)	−0.15 (−0.20 to −0.10)
ED complications	2.05%	1.86%	1.68%	−0.37 (−0.41 to −0.33)	−0.18 (−0.22 to −0.14)
Hospital complications	0.97%	0.93%	0.81%	−0.16 (−0.19 to −0.13)	−0.12 (−0.15 to −0.10)

A1C, glycated hemoglobin; *ACE*, angiotensin-converting enzyme; *ARB*, angiotensin II receptor blocker; *CI*, confidence interval; *ED*, emergency department; *GP*, general practitioner; *LDL*, low-density lipoprotein; *RC*, reference cohort.

in-person service disruptions, weight gain, destabilized glucose management, retinopathy, nephropathy, foot amputations and other related complications.

Promising signs indicating some continuity of care were the shifts to virtual care and the ability of patients to refill needed medications. It was also noted in other studies that, with regard to virtual care, many of the services rebounded to pre-pandemic levels, months after the initial lockdowns (4,6). In terms of age and income, there were no major technological or financial barriers to access in this respect, as 91.2% of virtual visits were provided by phone, a readily available form of communication (6). Moreover, the rate of virtual visits increased similarly across all chronic conditions (including diabetes) and income quintiles (6). Other work has shown that older patients were the highest users of virtual care, a trend similar to that observed in our population (6). However, the lower use of virtual care seen among younger and rural residents may warrant further attention (4,6). It is important to consider the limitations of virtual care, especially by phone. Some disadvantages of virtual visits are physicians' inability to conduct physical examinations, establish therapeutic physician–patient relationships to foster support and observe nonverbal cues such as body language (4). Also, low uptake of smartphones and video may indicate possible age, financial, education, digital or other health system barriers that fail to capitalize on optimal virtual care delivery. Thus, although there has been a large uptake of virtual care, its appropriate role in diabetes care and extent of care remains to be seen. High-quality care for those with diabetes can have a major impact on health and health-care costs. The prevalence of diabetes is expected to increase in Canada (46). It is a major cause of death and poses risks for serious long-term complications, such as blindness, cardiovascular disease, end stage renal disease, hypertension, stroke, neuropathy, lower limb amputation and premature death (18), and it warrants the continual evaluation and monitoring of care quality being delivered during and after the pandemic.

Strengths of this study are its population-wide coverage, use of the most up-to-date health administrative data, validated disease cohorts and service utilization algorithms. There are some limitations in our study. The ODD does not differentiate between type 1 and type 2 diabetes; however, it is known that 90% to 95% of the population are type 2 (28). We were unable to differentiate the type of virtual visits (text, phone, video, etc), but, as noted earlier, it is expected that about 90% were by phone. Diabetes and COVID-19 disproportionally impact racialized individuals (22,28,40), and how those disparities impact access or barriers to care were not examined in this study. Diabetes care and access to care may be slightly or entirely distinct in different jurisdictions; therefore, our results, despite being representative of the Ontario population, may not be generalizable elsewhere. Due to the nature of the data and the way cohorts were constructed, we were unable to differentiate between outcomes in the spring and summer of 2020 for the pandemic cohort. Diabetes patients have been known to suffer from increased mental health conditions and dental diseases, but these outcomes were not assessed here. Due to the unavailability of cause of death at the time of this study and death being a competing risk for outcome measures, we only analyzed individuals living with diabetes and excluded those who died during the observation period. Therefore, mortality due to diabetes complications and service disruptions was not examined. Time itself was not assessed within the analysis as in a time-varying autoregressive model due to limited number of time points, which may partially bias findings. Last, although the impact of COVID-19 lockdowns on diabetes care in the first wave was examined, it was too early to assess health outcomes and consequences of structural care barriers and processes; a follow-up study will be conducted in this setting.

Despite the limitations, we were able to report the extent to which diabetes-related care had been impacted during the initial months of COVID-19, particularly within the context of reduced in-person GP/FP and specialist visits, reflecting structural barriers to care. We noted process barriers to diabetes care, particularly those requiring in-person visits, such as eye examinations, testing and possibly physical examinations, many of which are critical components of diabetes care. Although there was a drastic increase in virtual care, it is unlikely that many of the essential services and testing were adequately supplemented. Although our early health outcomes suggest some reductions in diabetes-related complications, we argue that this was due to reductions in care-seeking and obliging by public stay-at-home orders. Actual health impacts and the consequences of these care disruptions during the early months of the pandemic and beyond will require further study.

Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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Author Disclosures

Conflicts of interest: None.

Author Contributions

J.S.M.: formal analysis, visualization, validation and writing, as well as preparing the original draft, review and editing; N.T. and L.P.: data curation, project administration and writing, and also review and editing; G.M.A.: conceptualisation, funding acquisition, methodology, supervision and validation, and also writing, review and editing.

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