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Research

Hospital admission rates and emergency department use in relation to glycated hemoglobin in people with diabetes mellitus: a linkage study using electronic medical record and administrative data in Ontario

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Abstract

Background: The Canadian Primary Care Sentinel Surveillance Network (CPCSSN) collects extensive data on primary care patients but it currently does not gather reliable information on outcomes in other settings. The objectives of this study were to link electronic medical record (EMR) data from Ontario patients in the CPCSSN with administrative data from the Institute for Clinical Evaluative Sciences (ICES), to assess the representativeness of the CPCSSN population, and to identify people with diabetes in the CPCSSN data and describe their emergency department (ED) visits and hospital admissions over a 2-year period (2010–2012) by HbA_{1c} level.

Methods: We conducted a cross-sectional study linking 2014 Ontario CPCSSN data with ICES administrative data and a retrospective cohort study using the 2014 data extraction linked with data from the Ontario health care registry, hospital discharge abstracts and a database of emergency department visits. Demographics of CPCSSN patients were compared with those of the Ontario population. Patients with a CPCSSN diagnosis of diabetes were compared by HbA_{1c} category for ED visits, hospital admissions and diagnosis of diabetes-related complications.

Results: The linkage rate was 99%. We identified 12 358 patients with diabetes, 2356 of whom were missing data on HbA_{1c}, for a final sample of 10 002. Patients with diabetes had a mean age of 64 years. Those with a higher HbA_{1c} were younger, more likely to be male, had a lower income, had more comorbidities and were more likely to live in rural or suburban areas than patients with a lower HbA_{1c}. Over the study period 31.8% of patients had 1 or more ED visits and 13.7% had a hospital admission for a diabetes-related complication. Patients with HbA_{1c} greater than 8 had significantly more hospital admissions, ED visits and diabetes-related complications than patients with a lower HbA_{1c}.

Interpretation: The linkage between EMR and administrative data was successful. In this study population, higher HbA_{1c} values were associated with increased ED visits and hospital admissions, with an increasing gradient as HbA_{1c} increased from less than 7% to greater than 8%.

The prevalence of type 2 diabetes mellitus is increasing in North America as a result of population aging and increasing rates of obesity.[1,2] Glycated hemoglobin (HbA_{1c}) has been shown to be a good surrogate measure of diabetes control.[3] There is evidence that people with higher HbA_{1c} levels are more likely to experience long-term complications such as chronic cardiovascular disease, retinopathy and end-stage renal disease.[4] As well, people with diabetes mellitus are more likely to be admitted to hospital than people without the disease.[5] Electronic medical records (EMRs) are increasingly being used in research and are seen as a valuable source of data to study chronic diseases in practice.[6] The value of EMR data increases when they are linked with other data sources so that process of care as well as outcomes of care can be studied.[7]

This study uses EMR data from patients in the Ontario network of the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) linked to population-based administrative data. CPCSSN is a network of networks across Canada that extracts, transforms and stores de-identified health data from over 1.5 million patients.[8] The

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extractions are done every 3 months for chronic disease surveillance, practice improvement and research. CPCSSN has validated case definitions for 8 chronic diseases including diabetes mellitus, and the case definitions in the database have been shown to have a high positive predictive value.[9] The data in CPCSSN are from a representative population of people who attend primary care practices in Canada, but they are not representative of the general population.[10] While CPCSSN has rich data on care delivery in the primary care setting, it currently does not have reliable information on outcomes such as mortality or health care utilization in other settings, such as hospitals or emergency departments (EDs).

The Institute for Clinical Evaluative Sciences (ICES) is a not-for-profit research institute encompassing a community of research, data and clinical experts and a secure and accessible array of Ontario's health-related data, including hospital discharges, ED attendance and health care registration. Linkage of these data to CPCSSN can fill the data gap and allow for the conduct of studies exploring health services utilization and meaningful outcomes. The objectives of this study were to link ICES and CPCSSN data, to evaluate the success of the data linkage and to identify people with diabetes in the CPCSSN data and describe their ED visits and hospital admissions over a 2-year period by HbA_{1c} level.

Research design and methods

Setting

This study used data from the 4 Ontario Networks of CPCSSN, which are situated in the most populous parts of the province (London, Hamilton, Toronto and Eastern Ontario) and do not include patients from the more rural or remote parts of Ontario.

Data sources

Ontario CPCSSN data were extracted in 2014; the extraction included data from all years in the EMR chart. The CPCSSN EMR data extractions were stored as an anonymized database in a secure facility at Queen's University. The EMR patient data collected included health condition(s); risk factors such as smoking, blood pressure and body mass index (BMI); laboratory results; prescribed medication and referrals. We linked to the following ICES databases: the hospital Discharge Abstract Database (2010–2012), which contains patient-level data related to hospital admissions, and the National Ambulatory Care Reporting System (2010–2012), which contains data on patient visits to EDs from the Canadian Institute for Health Information (CIHI). CIHI has done extensive data quality assessments on both of these databases. We also used the 2014 Registered Persons Database, which is Ontario's health care registry.

Design

The first part of the study was cross-sectional. The Ontario CPCSSN database extracted in 2014 was sent to ICES in an encrypted file. Each patient in the database has a unique CPCSSN number that can be linked to identifiable information (health insurance number, date of birth and sex) at the practice site. Patient identifiers linked to the CPCSSN number were sent separately from each practice to ICES, which is permitted to receive and use personal health information through a special designation under Ontario's Personal Health Information Protection Act. Each patient was assigned a unique encoded ICES identifier for linkage to administrative data.

The second part of the study was a retrospective cohort study. Patients older than 18 years of age who had a CPCSSN EMR record in 2010 and a CPCSSN diagnosis of diabetes were identified and followed from 2010 to 2012 for admission to hospital or ED. The CPCSSN case detection algorithm for diabetes was as follows: a minimum of 2 occurrences of the International Classification of Diseases, 9th revision (ICD9) code for diabetes (250) in bills within 2 years; or the presence of the ICD9 code 250 or free text indicating diabetes in the summary health profile of the chart; or the presence of hypoglycemic medication(s); or the presence of at least 1 HbA_{1c} of 7% (53 mmol/mol) or greater; or the presence of 2 or more fasting blood glucose results of 7 mmol/L or more within the same 12-month period. The presence of polycystic ovarian syndrome, gestational diabetes, secondary (chemically induced) diabetes, nonspecific hyperglycemia or neonatal diabetes mellitus made the medication criteria alone insufficient for case definition. The sensitivity, specificity and positive predictive value of the algorithm against chart review were 95.6%, 97.1% and 87%, respectively.[9] We used a look-back period of 2 years (2008–2010) to determine a diabetes diagnosis. Patients with diabetes were identified by the CPCSSN algorithm, and HbA_{1c} values were extracted for each patient. The Discharge Abstract Database and National Ambulatory Care Reporting System were searched for CPCSSN patients for hospital admissions, ED visits, and most responsible diagnosis by HbA_{1c} category (last before admission and mean over the 2-year period). HbA_{1c} was categorized as less than 7% (53 mmol/mol), 7.0%–8.0% and greater than 8% (64 mmol/mol).

Analysis

The data linkage was done by linking the patient CPCSSN number and common patient identifiers held by ICES (health insurance number, age and sex). The proportion of those with a match was calculated. The demographics of the Ontario CPCSSN population were compared with those of the Ontario population for representativeness using measures of socioeconomic status, rurality, resource utilization and extent of chronic disease. We employed a combination of bivariate and multivariate statistical analyses using SAS software (SAS Enterprise Guide, version 6.1). We first examined patients' sociodemographic and health status characteristics by HbA_{1c} categories in bivariate analysis. The variables included were age, sex, income quintiles, immigrant status, rurality and an index of morbidity burden using

Aggregated Diagnosis Groups (ADGs) from the Johns Hopkins Adjusted Clinical Groups System (www.acg.jhsph.org). We then examined the association between HbA_{1c} categories and hospital admissions and ED visits for all causes and for acute diabetes complications (including hyperglycemia, hypoglycemia, skin and soft tissue infection or foot ulcer) and chronic complications (including cardiovascular complications, renal failure and lower extremity amputation). We tested the relationships with χ^2 tests for categorical variables and *t* tests for continuous variables. Finally, 2 separate logistic regression analyses were carried out to calculate the likelihood of hospital admission and ED visits, each controlling for the sociodemographic and health status characteristics of the patients. Results were expressed in terms of odds ratios (OR) with 95% confidence intervals (CIs).

Ethics approval

The study protocol was approved by both the Research Ethics Board of Queen's University and Sunnybrook Health Sciences Centre.

Results

We successfully linked 98.7% of CPCSSN patient EMR records to administrative records. In total, 115 039 patients older than 18 years of age were identified in the Ontario CPCSSN data set. The characteristics of patients in the CPCSSN sample compared with those of all adult Ontario residents are shown in Table 1. CPCSSN patients were slightly older, included a higher proportion of women, were less likely to be immigrants, were more likely to live in urban areas, had a higher household income and had a higher proportion of comorbid chronic disease. There were 12 358 people with a CPCSSN diagnosis of diabetes mellitus identified in the Ontario CPCSSN database linked with administrative data; 2356 patients without HbA_{1c} values were excluded from the analysis.

The demographics of the patients with diabetes mellitus are shown in Table 2. The mean age of the sample was 63.5 years, with variation by HbA_{1c} category: mean age was 65.7 years for patients with HbA_{1c} less than 7% (53 mmol/mol), 64.7 years for patients with HbA_{1c} between 7% and 8% and 58.2 years for patients with HbA_{1c} greater than 8% (64 mmol/mol). Patients with higher HbA_{1c} were on average younger and more likely to be male, to be in a lower income group, to have more comorbidities and to reside in rural or suburban areas than patients with HbA_{1c} less than 7% (53 mmol/mol).

Patients who were missing HbA_{1c} measurements were compared with those who had a measurement. Patients with missing HbA_{1c} data were younger (mean age 61 yr v. 64 yr, $p < 0.001$) and had fewer chronic conditions (ADG category 0, 2.5% v. 0.9%, $p < 0.001$) (Appendix 1, available at www.cmajopen.ca/content/5/3/E557/suppl/DC1).

Over the 2 years of follow-up, 31.8% of patients had at least one ED visit and 13.7% had a hospital admission for a diabetes-related complication. The number of hospital admissions, admission diagnoses and the number of ED visits are shown in Table 3. Patients with an HbA_{1c} greater than 8% (64 mmol/mol) had significantly more hospital admissions, ED visits and diabetes-related complications than patients with lower HbA_{1c} values. Patients with HbA_{1c} greater than 8% (64 mmol/mol) had more ED visits for both hypoglycemia and hyperglycemia as well as hospital admissions for soft tissue infection and any acute complication. Further, patients who had HbA_{1c} results between 7% and 8% had higher hospital admission and ED visit rates as well as higher diabetes complication rates than those whose HbA_{1c} was less than 7%. Hospital admission rates for chronic cardiovascular conditions also increased as HbA_{1c} increased.

After adjustment for patient sociodemographic profile and medical complexity, both ED visits (OR 1.49, 95% CI 1.33–1.68) and hospital admissions (OR 1.51, 95% CI 1.29–1.77) were significantly more likely for patients with HbA_{1c} values greater than 8% than for patients with HbA_{1c} values less than 7%; the odds of ED visits and hospital admissions for patients with HbA_{1c} values of 7%–8% fell in between (Table 4, Table 5).

Interpretation

Our results showing that patients with higher HbA_{1c} values had more ED visits and higher hospital admission rates than patients with lower HbA_{1c} values provide a richer understanding of the impact of diabetes control as measured by HbA_{1c} values on health care utilization. Others have studied the relationship between HbA_{1c} and utilization of health services. Menzin and colleagues did a retrospective analysis of a cohort of 9887 patients with diabetes in a group health plan. They found that people with diabetes with HbA_{1c} levels greater than 10 had a greater risk of hospital admission than those with HbA_{1c} levels less than 7 but not than those with HbA_{1c} values between 7 and 10. They also found that there was a higher cost of hospitalization associated with a higher HbA_{1c} value.[11]

Our study demonstrated strong associations between HbA_{1c} values and hospital and ED utilization at even lower HbA_{1c} values, similar to Yu and Simmons' findings in a linkage study of 4704 people with diabetes from 18 general practices in Cambridgeshire, England. They found a nonlinear relationship between HbA_{1c} levels and all-cause, diabetes-associated and cardiovascular-associated hospital admissions, with a meaningful increase in risk of admission at a HbA_{1c} threshold of 7.7%.[12]

There is also evidence that a reduction in HbA_{1c} levels over time is associated with a reduction in both health care utilization and costs.[13] The clear association between glycemic control and utilization of health services in Ontario has important implications for people with diabetes, practitioners and policy-makers. Increased support for educational programs to improve diabetes control may reduce the number of diabetic complications and reduce ED visits and hospital admissions in this population.

Table 1: Comparison of Ontario patients in the Canadian Primary Care Sentinel Surveillance Network with the Ontario population

Characteristic	No. (%)* CPCSSN *n* = 115 039	No. (%)* Ontario *n* = 10 300 555	*p* value
Age in 2011, yr			< 0.001
Mean (95% CI)	51.03 (50.93–51.13)	47.66 (47.65–47.67)	
Median (IQR)	51 (37–64)	47 (33–60)	
Age group in 2011, yr			
19–34	24 926 (21.7)	2 784 789 (27.0)	< 0.001
35–49	29 998 (26.1)	2 972 495 (28.9)	
50–64	32 341 (28.1)	2 666 329 (25.9)	
65–74	14 740 (12.8)	1 001 007 (9.7)	
75–84	9 531 (8.3)	626 098 (6.1)	
> 85	3 503 (3.0)	249 837 (2.4)	
Male	46 721 (40.6)	4 991 857 (48.5)	< 0.001
Income quintile†			
1 (lowest)	19 950 (17.3)	1 957 809 (19.0)	< 0.001
2	19 461 (16.9)	2 032 256 (19.7)	
3	21 315 (18.5)	2 049 351 (19.9)	
4	23 049 (20.0)	2 143 524 (20.8)	
5 (highest)	30 262 (26.3)	2 076 792 (20.2)	
9 (unknown)	1 002 (0.9)	40 823 (0.4)	
Immigrated to Canada in past 10 years	8 042 (7.0)	1 143 311 (11.1)	< 0.001
Rurality Index of Ontario category			
Urban	71 894 (62.5)	7 445 676 (72.3)	< 0.001
Suburban	38 641 (33.6)	1 988 531 (19.3)	
Rural	3 617 (3.1)	782 232 (7.6)	
Missing	887 (0.8)	84 116 (0.8)	
Resource utilization band†			
0	4 442 (3.9)	1 002 617 (9.7)	< 0.001
1	5 168 (4.5)	590 414 (5.7)	
2	18 346 (15.9)	1 730 943 (16.8)	
3	61 026 (53.0)	5 096 860 (49.5)	
4	18 734 (16.3)	1 402 376 (13.6)	
5	7 323 (6.4)	477 345 (4.6)	
No. of associated diagnostic groups			
0	4 446 (3.9)	1 002 765 (9.7)	< 0.001
1–4	50 990 (44.3)	4 365 228 (42.4)	
5–9	48 295 (42.0)	3 963 489 (38.5)	
≥ 10	11 308 (9.8)	969 073 (9.4)	
Mean (95% CI)	5.11 (5.09–5.13)	4.74 (4.74–4.74)	< 0.001
Median (IQR)	5 (3–7)	4 (2–7)	
Health condition			
Hypertension	34 741 (30.2)	2 717 743 (26.4)	< 0.001
Diabetes	13 360 (11.6)	1 150 934 (11.2)	< 0.001
CHF	3 090 (2.7)	226 162 (2.2)	< 0.001
Asthma	15 499 (13.5)	1 334 846 (13.0)	< 0.001
COPD	10 021 (8.7)	761 326 (7.4)	< 0.001
AMI	2 173 (1.9)	162 566 (1.6)	< 0.001
Mental health	27 305 (23.7)	2 325 243 (22.6)	< 0.001

Note: AMI = acute myocardial infarction, CI = confidence interval, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disorder, IQR = interquartile range.
Data sources: Ontario CPCSSN 2014 data extraction, Ontario Registered Persons Database, Hospital Discharge Abstracts and the National Ambulatory Care Registry.
*Unless stated otherwise.
†Resource utilization bands are estimates of health resource use grouped by overall morbidity level (0 = non user, 1 = healthy user, 2 = low morbidity, 3 = moderate morbidity, 4 = high morbidity, 5 = very high morbidity).

Table 2: Characteristics of Ontario patients with diabetes in the Canadian Primary Care Sentinel Surveillance Network, by HbA_{1c} category

Characteristic	HbA_{1c}, no. (%)*					
	< 7% *n* = 5526	7%–8% *n* = 2662	> 8% *n* = 1814	Missing *n* = 2356	Total *n* = 12 358	*p* value
Age, yr						
Mean ± SD	65.68 ± 13.13	64.70 ± 13.31	58.15 ± 13.70	60.99 ± 16.21	63.47 ± 14.17	< 0.001
Median (IQR)	67 (57–76)	66 (56–74)	58 (49–67)	62 (51–73)	64 (54–74)	< 0.001
Age group, yr						
18–39	198 (3.6)	106 (4.0)	151 (8.3)	264 (11.2)	719 (5.8)	< 0.001
40–74	3783 (68.5)	1907 (71.6)	1441 (79.4)	1557 (66.1)	8688 (70.3)	
> 75	1545 (28.0)	649 (24.4)	222 (12.2)	535 (22.7)	2951 (23.9)	
Sex†						
Female	2768 (50.1)	1252 (47.0)	823 (45.4)	1185 (50.3)	6028 (48.8)	< 0.001
Male	2758 (49.9)	1410 (53.0)	991 (54.6)	1171 (49.7)	6330 (51.2)	
Income quintile						
1 (lowest)	1064 (19.3)	587 (22.1)	466 (25.7)	447 (19.0)	2564 (20.7)	< 0.001
2	1008 (18.2)	506 (19.0)	354 (19.5)	420 (17.8)	2288 (18.5)	
3	1053 (19.1)	536 (20.1)	355 (19.6)	451 (19.1)	2395 (19.4)	
4	1101 (19.9)	495 (18.6)	300 (16.5)	491 (20.8)	2387 (19.3)	
5 (highest)	1249 (22.6)	517 (19.4)	327 (18.0)	460 (19.5)	2553 (20.7)	
Missing	51 (0.9)	21 (0.8)	12 (0.7)	87 (3.7)	171 (1.4)	
No. of associated diagnostic groups						
0	47 (0.9)	22 (0.8)	20 (1.1)	59 (2.5)	148 (1.2)	< 0.001
1–4	1804 (32.6)	917 (34.4)	673 (37.1)	808 (34.3)	4202 (34.0)	
5–9	2685 (48.6)	1322 (49.7)	843 (46.5)	1015 (43.1)	5865 (47.5)	
≥ 10	990 (17.9)	401 (15.1)	278 (15.3)	474 (20.1)	2143 (17.3)	
Rurality Index of Ontario category						
Urban (0–9)	3283 (59.4)	1550 (58.2)	975 (53.7)	1353 (57.4)	7161 (57.9)	< 0.001
Suburban (10–39)	2117 (38.3)	1044 (39.2)	796 (43.9)	873 (37.1)	4830 (39.1)	
Rural (≥ 40)	76 (1.4)	48 (1.8)	34 (1.9)	45 (1.9)	203 (1.6)	
Missing	50 (0.9)	20 (0.8)	9 (0.5)	85 (3.6)	164 (1.3)	

Note: IQR = interquartile range, SD = standard deviation.
*Unless stated otherwise.
†As recorded in the Registered Persons Database.

Limitations

This study has several limitations. It is a retrospective study of patients with diabetes in Ontario. It analyzed data from a sample of patients who attend family physicians and nurse practitioners in practices that use EMRs and belong to the CPCSSN sample, and the sample may not be representative. We were not able to determine the type of diabetes each patient had, nor the length of time each patient had diabetes. Nineteen percent of the patients did not have an HbA_{1c} measurement in our database. This may have been because they did not have the test done; more likely it was because the results were not recorded electronically in the EMR. Some practices will only receive laboratory results on paper, which are then scanned into the EMR and not available for analysis. As well, we did not assess what other chronic diseases these patients had that influenced the likelihood of hospital admission, although ADG categories were similar between groups.[14] This study does not allow causal inferences to be made, although the measurement of HbA_{1c} levels preceded the occurrence of outcomes in this study. We were unable to account for other risk factors such as diet, physical activity, obesity, blood pressure control, lipid levels or health care utilization before the observation period.

Table 3: Emergency department visits, hospital admissions and discharge diagnoses for Ontario patients with diabetes in the Canadian Primary Care Sentinel Surveillance Network, by HbA_{1c} category

Variable	HbA_{1c}, no. (%)				
	< 7% *n* = 5526	7%–8% *n* = 2662	> 8% *n* = 1814	Total *n* = 10 002	*p* value
No. of emergency department visits					
0	3867 (70.0)	1812 (68.1)	1141 (62.9)	6820 (68.2)	< 0.001
1	910 (16.5)	477 (17.9)	315 (17.4)	1702 (17.0)	
2	359 (6.5)	170 (6.4)	160 (8.8)	689 (6.9)	
≥ 3	390 (7.1)	203 (7.6)	198 (10.9)	791 (7.9)	
No. of hospital admissions for diabetes-related complications					
0	4830 (87.4)	2267 (85.2)	1536 (84.7)	8633 (86.3)	< 0.001
1	503 (9.1)	282 (10.6)	168 (9.3)	953 (9.5)	
2	127 (2.3)	61 (2.3)	61 (3.4)	249 (2.5)	
≥ 3	66 (1.2)	52 (2.0)	49 (2.7)	167 (1.7)	
Hyperglycemia					
No	5519 (99.9)	2656 (99.8)	1789 (98.6)	9964 (99.6)	< 0.001
Yes	7 (0.1)	6 (0.2)	25 (1.4)	38 (0.4)	
Hypoglycemia					
No	5512 (99.7)	2631 (98.8)	1783 (98.3)	9926 (99.2)	< 0.001
Yes	14 (0.3)	31 (1.2)	31 (1.7)	76 (0.8)	
Hyperglycemia and/or hypoglycemia					
No	5506 (99.6)	2625 (98.6)	1763 (97.2)	9894 (98.9)	< 0.001
Yes	20 (0.4)	37 (1.4)	51 (2.8)	108 (1.1)	
Any acute complication of diabetes					
No	5421 (98.1)	2580 (96.9)	1706 (94.0)	9707 (97.1)	< 0.001
Yes	105 (1.9)	82 (3.1)	108 (6.0)	295 (2.9)	
Any chronic complication of diabetes*					
No	5411 (97.9)	2574 (96.7)	1745 (96.2)	9730 (97.3)	< 0.001
Yes	115 (2.1)	88 (3.3)	69 (3.8)	272 (2.7)	
Cardiovascular condition					
No	5437 (98.4)	2589 (97.3)	1757 (96.9)	9783 (97.8)	< 0.001
Yes	89 (1.6)	73 (2.7)	57 (3.1)	219 (2.2)	
Lower extremity amputation					
No	5521 (99.9)	2659 (99.9)	1808 (99.7)	9988 (99.9)	0.054
Yes	≤ 5 (0.1)	≤ 5 (0.1)	6 (0.3)	14 (0.1)	
Skin and soft tissue infection or foot ulcer					
No	5439 (98.4)	2612 (98.1)	1753 (96.6)	9804 (98.0)	< 0.001
Yes	87 (1.6)	50 (1.9)	61 (3.4)	198 (2.0)	

Note: Data for patients with missing HbA_{1c} values are excluded.
*Chronic complications include cardiovascular disease, amputations and kidney disease.

Table 4: Estimates of adjusted risk of emergency department visits for Ontario patients with diabetes in the Canadian Primary Care Sentinel Surveillance Network

Variable	Odds ratio (95% CI)
HbA_{1c} category, %	
< 7	1
7–8	1.13 (1.02–1.26)
> 8	1.49 (1.33–1.68)
Sex	
Female	1
Male	1.02 (0.93–1.11)
Age group, yr	
18–39	1
40–74	0.85 (0.69–1.05)
> 75	1.25 (1–1.57)
No. of associated diagnostic groups	
0	1
1–4	0.7 (0.42–1.17)
5–9	1.46 (0.88–2.41)
> 10	2.97 (1.78–4.94)
Income quintile	
1 (lowest)	1
2	0.87 (0.76–0.99)
3	0.75 (0.65–0.86)
4	0.82 (0.72–0.94)
5 (highest)	0.66 (0.57–0.75)
Immigration	
Nonimmigrant	1
Immigrant	0.93 (0.72–1.19)
Rurality Index of Ontario category	
Urban (0–9)	1
Suburban (10–39)	1.61
Rural (≥ 40)	2.03

Note: CI = confidence interval.

Table 5: Estimates of adjusted risk of hospital admission for Ontario patients with diabetes in the Canadian Primary Care Sentinel Surveillance Network

Variable	Odds ratio (95% CI)
HbA_{1c} category, %	
< 7	1
7–8	1.3 (1.13–1.49)
> 8	1.51 (1.29–1.77)
Sex	
Female	1
Male	1.09 (0.97–1.23)
Age group, yr	
18–39	1
40–74	0.99 (0.72–1.35)
≥ 75	2.12 (1.54–2.93)
No. of associated diagnostic groups	
0	1
1–4	0.74 (0.33–1.63)
5–9	1.56 (0.71–3.42)
≥ 10	3.71 (1.68–8.18)
Income quintile	
1 (lowest)	1
2	0.99 (0.83–1.19)
3	0.84 (0.69–1.01)
4	0.97 (0.8–1.16)
5 (highest)	0.8 (0.66–0.96)
Immigration	
Nonimmigrant	1
Immigrant	1.1 (0.78–1.55)
Rurality Index of Ontario category	
Urban (0–9)	1
Suburban (10–39)	1.46 (1.29–1.65)
Rural (≥ 40)	1.65 (1.06–2.57)

Note: CI = confidence interval.

Conclusion

This study demonstrated the successful linking of CPCSSN EMR data with administrative data in Ontario. We found that there was an increase in both ED visits and hospital admissions for all causes and for diabetes-related reasons with higher HbA_{1c} values. Further research is required to better define the optimal HbA_{1c} targets for patients with particular characteristics.

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