RESEARCH

Monitoring, treatment and control of blood glucose and lipids in Ontario First Nations people with diabetes

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ABSTRACT

BACKGROUND: Indigenous people worldwide are disproportionately affected by diabetes and its complications. We aimed to assess the monitoring, treatment and control of blood glucose and lipids in First Nations people in Ontario.

METHODS: We conducted a longitudinal population-based study using administrative data for all people in Ontario with diabetes, stratified by First Nations status. We assessed age- and sex-specific rates of completion of recommended monitoring for low-density lipoprotein (LDL) and glycated hemoglobin (A_{1c}) from 2001/02 to 2014/15. We used data from 2014/15 to conduct a cross-sectional analysis of rates of

achievement of A_{1c} and LDL targets and use of glucose-lowering medications.

RESULTS: The study included 22 240 First Nations people and 1 319 503 other people in Ontario with diabetes. Rates of monitoring according to guidelines were 20%–50% for A_{1c} and 30%–70% for lipids and were lowest for younger First Nations men. The mean age- and sex-adjusted A_{1c} level was higher among First Nations people than other people (7.59 [95% confidence interval (CI) 7.57 to 7.61] v. 7.03 [95% CI 7.02 to 7.03]). An A_{1c} level of 8.5% or higher was observed in 24.7% (95% CI 23.6 to 25.0) of First Nations people, compared to 12.8% (95% CI 12.1 to 13.5) of other people in Ontario. An LDL level

of 2.0 mmol/L or less was observed in 60.3% (95% CI 59.7 to 61.6) of First Nations people, compared to 52.0% (95% CI 51.1 to 52.9) of other people in Ontario. Among those aged 65 or older, a higher proportion of First Nations people than other Ontarians were using insulin (28.1% v. 15.1%), and fewer were taking no medications (28.3% v. 40.1%).

INTERPRETATION: As of 2014/15, monitoring and achievement of glycemic control in both First Nations people and other people in Ontario with diabetes remained suboptimal. Interventions to support First Nations patients to reach their treatment goals and reduce the risk of complications need further development and study.

Diabetes and its related complications are major contributors to morbidity and mortality worldwide.[1–3] Indigenous populations in Canada and around the world are disproportionately affected by diabetes owing to the complex relations among colonization, social disadvantage, stress, trauma and metabolic health.[4–7] In addition to our own work showing persistently higher rates of peripheral vascular disease, stroke, cardiac disease, renal dysfunction and ophthalmologic complications in Ontario First Nations,[8–12] other Canadian and international studies also showed higher complication rates in diverse Indigenous populations.[6,7,13–15]

Glycemic control is fundamental to the management of diabetes and the prevention of complications.[16] Glycated hemoglobin (A_{1c}) is a reliable way to estimate the average level of glucose in the blood.[17] Since A_{1c} levels higher than 7.0% have been associated with an increased risk of microvascular complications,[18–20] treatment guidelines suggest A_{1c} should be measured every 3–6 months to ensure

that glycemic goals are being met or maintained.[21] Since people with diabetes also have an elevated risk for cardiovascular disease,[22–24] management and control of cardiovascular risk factors, particularly lipids such as low-density lipoprotein (LDL) cholesterol, are also important.[25–27] Guidelines further recommend that a full lipid profile be measured every 1–3 years, depending on cardiovascular risk, and suggest that LDL be consistently less than 2.0 mmol/L.[28] Control of A_{1c} and lipids has been shown to be associated with reduced morbidity and mortality in patients with diabetes.[18,29–32]

One possible reason for the high burden of complications among Indigenous people with diabetes may be failure to achieve control of these 2 key clinical parameters. We examined differences between Status First Nations people with diabetes in Ontario and all other Ontario residents with diabetes in rates of monitoring of A_{1c} and lipids, achievement of targets for A_{1c} and LDL outlined in clinical guidelines, and patterns of medication use to help attain these targets.

Methods

We conducted a retrospective population-based cohort study in Ontario, Canada. Data evaluated in this study were sourced from comprehensive linked health administrative data sets related to Ontario's single-payer publicly funded health care system housed at ICES, an independent, not-for-profit organization.[33] The general approach including a description of the major data sets used and the characteristics of the study cohort are described in detail elsewhere.[34] We created annual cohorts of the population with diabetes for each fiscal year between Apr. 1, 1995, and Mar. 31, 2015. All people from the Registered Persons Database (Ontario residents eligible for a health card) who were alive at the beginning of each year, had a prior diagnosis of diabetes (Ontario Diabetes Database),[35] had contact with the health care system within the previous 7 years, and were aged 105 years or younger were included in these cohorts. In partnership with the Chiefs of Ontario, the project team conducted the reviews required under the ICES–Chiefs of Ontario Data Governance agreement to allow linkage to the Indian Register. The Indian Register lists all people who are registered with the federal government as members of a First Nation that is recognized under the *Indian Act*. This allowed us to identify people who were registered as having First Nations Status; all other Ontario residents were considered to be the population of "other people in Ontario."

We measured rurality using the Rurality Index for Ontario, with the 3 categories of urban (0–9), semiurban (10–39) and rural (≥ 40), and "No score," which represents primarily remote and small rural areas.[36] We used the Rurality Index for Ontario rather than the 2017 Statistics Canada Remoteness Index as the latter was generated with the use of data that postdate our study and was not yet linked for use with the other data sets at ICES. We measured comorbidity using the Johns Hopkins' Aggregated Diagnosis Groups (ADGs) (low = 4 or fewer, medium = 5–9, high = 10 or more).[37] We used a combination of residence codes, recorded when people are admitted to an emergency department or hospital (information obtained from the Canadian Institute for Health Information Discharge Abstract Database and National Ambulatory Care Reporting System) and postal codes from the Registered Persons Database to determine which First Nations people were residing in First Nations communities.[34]

Table 1: Demographic characteristics of First Nations people living in or outside of First Nations communities and other people in Ontario with diabetes, 2014/15

| | First Nations people | | | | Other people in Ontario | |
| | Living in First Nations communities | | Living outside of First Nations communities | | | |
Characteristic	With diabetes *n* = 8605	Total *n* = 55 311	With diabetes *n* = 13 635	Total *n* = 102 889	With diabetes *n* = 1 319 503	Total *n* = 13 248 443
Sex						
Male	4100 (47.6)	28 754 (52.0)	6212 (45.6)	50 590 (49.2)	684 856 (50.6)	6 489 437 (49.0)
Female	4505 (52.4)	26 557 (48.0)	7423 (54.4)	52 299 (50.8)	634 647 (49.4)	6 759 006 (51.0)
Age group, yr						
≤ 19	97 (1.1)	17 965 (32.5)	157 (1.2)	26 884 (26.1)	10 144 (0.8)	2 829 983 (21.4)
20–34	526 (6.1)	13 019 (23.5)	889 (6.5)	27 815 (27.0)	38 580 (2.9)	2 635 661 (19.9)
35–49	2028 (23.6)	10 660 (19.3)	3147 (23.1)	22 258 (21.6)	170 422 (12.9)	2 745 274 (20.7)
50–64	3459 (40.2)	9324 (16.9)	5557 (40.8)	18 279 (17.8)	450 294 (34.1)	2 863 509 (21.6)
65–74	1649 (19.2)	2885 (5.2)	2568 (18.8)	5174 (5.0)	337 116 (25.5)	1 213 258 (9.2)
≥ 75	846 (9.8)	1458 (2.6)	1317 (9.7)	2479 (2.4)	312 947 (23.7)	960 758 (7.3)
Rurality*						
Urban	467 (5.4)	2990 (5.4)	5979 (43.8)	49 338 (48.0)	959 829 (72.7)	9 693 463 (73.2)
Semiurban	928 (10.8)	5527 (10.0)	3252 (23.8)	24 732 (24.0)	253 219 (19.2)	2 545 162 (19.2)
Rural	2001 (23.2)	13 639 (24.7)	2655 (19.5)	18 486 (18.0)	99 080 (7.5)	941 948 (7.1)
No score	5209 (60.5)	33 155 (55.9)	1749 (12.8)	10 333 (10.0)	7375 (0.6)	67 870 (0.5)
Comorbidity†						
Low	2315 (26.9)	30 635 (55.4)	2214 (16.2)	40 782 (39.6)	243 256 (18.4)	5 116 120 (38.6)
Medium	3405 (39.6)	17 421 (31.5)	5286 (38.8)	40 334 (39.2)	558 712 (42.3)	5 605 860 (42.3)
High	2885 (33.5)	7255 (13.1)	6135 (45.0)	21 773 (21.2)	517 535 (39.2)	2 526 463 (19.1)

*Measured with the Rurality Index for Ontario.
†Measured with the Johns Hopkins' Aggregated Diagnosis Groups (ADGs) (low = 4 or fewer, medium = 5–9, high = 10 or more).

Statistical analysis

We calculated age- and sex-specific and adjusted rates of A_{1c} and lipid monitoring for each fiscal year using data from the Ontario Health Insurance Plan and the definitions established by Health Quality Ontario (2 A_{1c} measurements or 1 complete lipid profile in a year).[38] We calculated age- and sex-standardized rates, along with γ-distributed 95% confidence intervals (CIs),[39] using a direct standardization based on the 2001 Ontario census population.[40] The numerator for the rate was those in the yearly cohort who received A_{1c} or lipid monitoring (see Appendix 1, available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.191039/-/DC1, for definitions). In addition, for the subset of people with a valid test result in the Ontario Laboratory Information System (OLIS), we assessed the proportion of people with diabetes whose A_{1c} and lipid values were controlled.[33] We categorized A_{1c} levels as good (≤ 7%), fair (> 7.0 to < 8.5) or poor (≥ 8.5). A person was considered to have lipids under control if the LDL value was 2.0 mmol/L or less. For both A_{1c} and lipid control analyses, the denominator was restricted to those with at least 1 test recorded in OLIS in 2014/15. For people with more than 1 result for a test, we selected the most recent value. We estimated age- and sex-adjusted proportions and differences using marginal estimates from logistic regression.[41]

We also assessed the use of glucose-lowering drugs among patients with diabetes who were 65 years or older at the beginning of 2014/15. To capture medication prescriptions for glucose-lowering drugs, we used the Drug Identification Number database to identify all glucose-lowering medications and linked these to the Ontario Drug Benefit Program database to capture prescription information. The Ontario Drug Benefit Program database includes only publicly funded medications, so this analysis was restricted to all people 65 years of age or older. We used drug records from Apr. 1, 2014, through Mar. 31, 2015, for this analysis. We assessed the pharmacotherapy regimen, the distribution of different classes of medication and types of insulin prescribed.

We conducted all analyses using SAS Enterprise Guide version 7.1 (SAS Institute).

Ethics approval

In addition to Ontario First Nations data governance processes, including review and approval by the Data Governance Committee, our project was reviewed and approved by the research ethics boards at Queen's University and Laurentian University.

Results

Table 1 presents the demographic characteristics of First Nations people living in or outside of First Nations communities and other people in Ontario with diabetes and the total population. The age- and sex-specific rates per 100 people with diabetes per year who were considered to have had completed A_{1c} screening as recommended are presented in Figure 1. In 2014/15, these
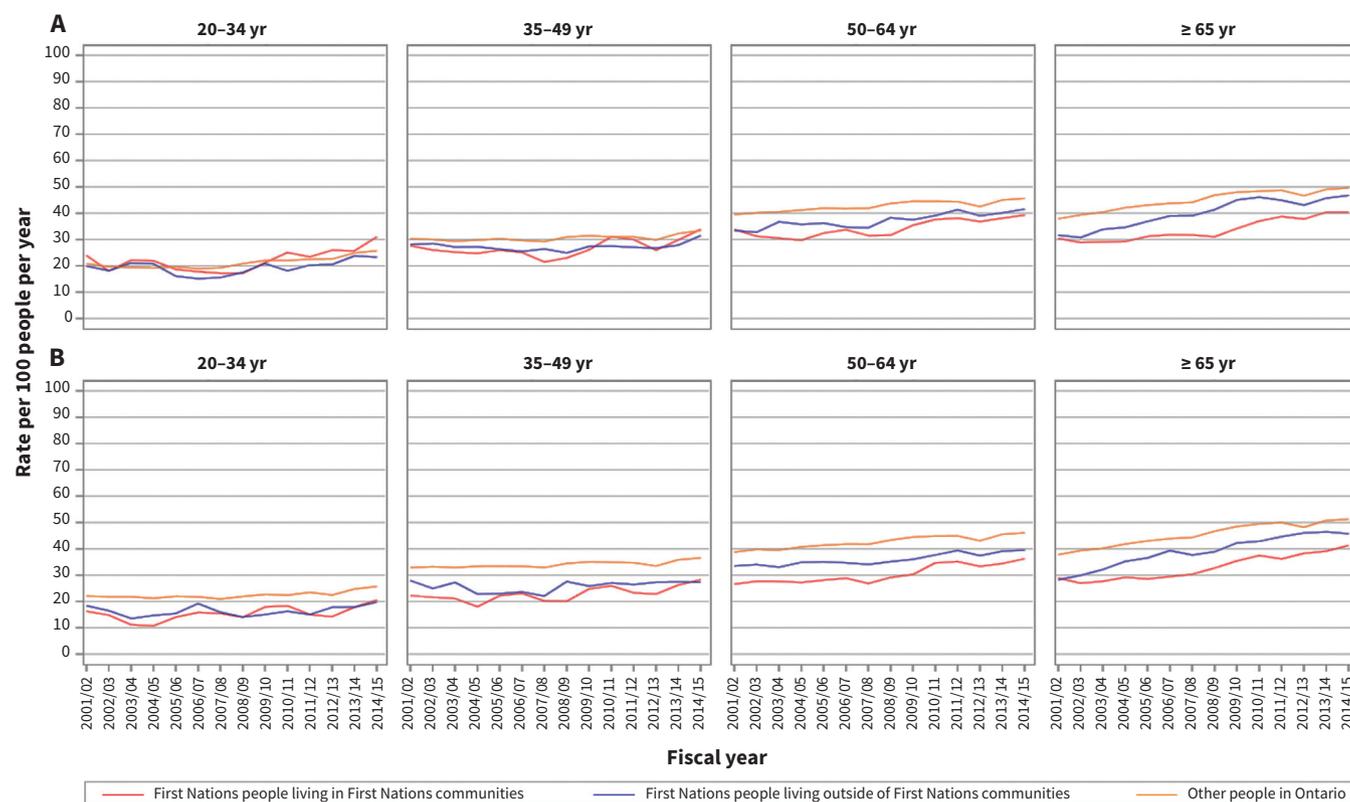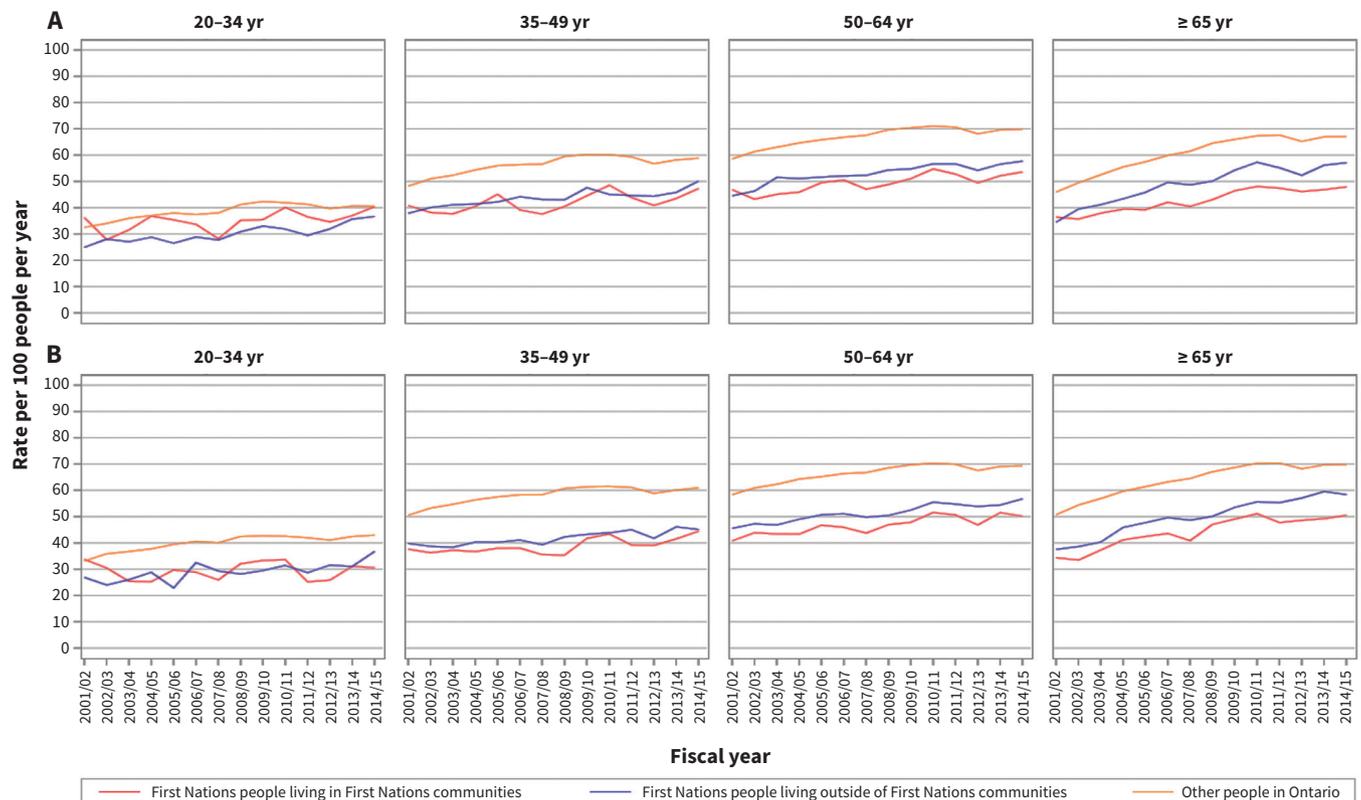

Figure 1: Age- and sex-specific rates per 100 people per year of glycated hemoglobin monitoring completed as per guidelines (2 tests per year) among First Nations people with diabetes living in and outside of First Nations communities and other people with diabetes in Ontario, 2001/02 to 2014/15. (A) Women. (B) Men.

ranged from almost 20% among First Nations men aged 20–34 to just over 50% among other men in Ontario aged 65 or older. The age- and sex-specific rates of lipid screening per 100 people with diabetes per year are presented in Figure 2. In 2014/15, these ranged from 30% among First Nations men aged 20–34 living in First Nations communities to about 70% among other men in Ontario aged 50 or older, and other women in Ontario aged 50–64. Rates increased over time in all groups. They were significantly lower among First Nations people than other people in Ontario, with the lowest rates observed for younger people regardless of sex, First Nations status or location of residence. The gap between First Nations people and other people in Ontario was larger for men than for women and for older versus younger age groups, with absolute values ranging from 1%–2% for A_{1c} monitoring in younger men to 20% for lipid monitoring in men and women aged 65 or older (Figure 2). For First Nations people aged 50 or older, lower rates were noted among those living in First Nations communities than those living outside First Nations communities.

Among people with diabetes who had valid results for at least 1 A_{1c} test in OLIS in 2014/15, the mean age- and sex-adjusted A_{1c} level was higher for First Nations people than for other people in Ontario (difference 0.56%, 95% CI 0.54 to 0.59), a clinically significant finding (Table 2). Among people with

diabetes who had valid results for at least 1 LDL test in OLIS in 2014/15, the mean age- and sex-adjusted LDL level was slightly lower for First Nations people than for other people in Ontario (difference –0.21 mmol/L, 95% CI –0.23 to –0.19) (Table 2), but this is likely not clinically significant. Good control of A_{1c} was significantly less likely (47.9% [95% CI 46.6 to 48.0] v. 59.5% [95% CI 58.7 to 60.3]) and poor control significantly more likely (24.7% [95% CI 23.6 to 25.0] v. 12.8% [95% CI 12.1 to 13.5]) to be observed in First Nations people than in other people in Ontario. There were also differences between the groups in LDL levels, with First Nations people being more likely to be at target values (60.3% [95% CI 59.7 to 61.6] v. 52.0% [95% CI 51.1 to 52.9]). Among other people in Ontario, the proportion of those with good control of A_{1c} increased with increasing degrees of comorbidity, whereas there was no consistent relation between comorbidity and A_{1c} control in First Nations people. For both First Nations people and other people in Ontario, target levels for lipids were more likely to be achieved among those with higher levels of comorbidity.

Good glycemic control was related to rurality, with the highest level of control in urban areas and lowest in the most rural areas (Table 3). This was true for both First Nations people and other people in Ontario. There were no clinically significant differences in lipid control by rurality.

Figure 2: Age- and sex-specific rates per 100 people per year of lipid monitoring completed as per guidelines (once per year) among First Nations people with diabetes living in and outside of First Nations communities and other people with diabetes in Ontario, 2001/02 to 2014/15. (A) Women. (B) Men.

Table 2: Age- and sex-adjusted* glycemic and lipid control in First Nations people and other people in Ontario with diabetes,† 2014/15

| | | | | % (95% CI) of First Nations people‡ | | |
| | | | | Living outside of First Nations communities *n* = 9148 | Living in First Nations communities *n* = 5607 | |
Variable	% (95% CI) of First Nations people‡ *n* = 14 755	% (95% CI) of other people in Ontario‡ *n* = 985 865	Difference			Difference
A$_{1c}$ level, mean (95% CI), %	7.59 (7.57 to 7.61)	7.03 (7.02 to 7.03)	0.56 (0.54 to 0.59)	7.56 (7.53 to 7.60)	7.91 (7.86 to 7.95)	0.34 (0.28 to 0.40)
A$_{1c}$ category, %						
≤ 7.0	47.9 (46.6 to 48.0)	59.5 (58.7 to 60.3)	−12.3 (−13.1 to −11.5)	48.0 (46.4 to 49.6)	39.5 (37.9 to 41.1)	8.5 (6.9 to 10.1)
> 7.0 to < 8.5	27.4 (26.5 to 27.9)	27.7 (27.0 to 28.5)	−0.6 (−1.3 to 0.1)	26.3 (24.8 to 27.8)	28.2 (26.7 to 29.7)	−1.9 (−3.4 to −0.4)
≥ 8.5	24.7 (23.6 to 25.0)	12.8 (12.1 to 13.5)	11.5 (10.8 to 12.1)	25.7 (24.2 to 27.2)	32.3 (30.8 to 33.8)	−6.6 (−8.1 to −5.1)
LDL level, mean (95% CI), mmol/L	1.95 (1.93 to 1.96)	2.15 (2.15 to 2.16)	−0.21 (−0.23 to −0.19)	2.06 (2.04 to 2.08)	2.02 (2.00 to 2.05)	−0.04 (−0.07 to −0.00)
LDL category, mmol/L						
≤ 2	60.3 (59.7 to 61.6)	52.0 (51.1 to 52.9)	8.7 (7.8 to 9.6)	54.5 (52.6 to 56.4)	56.0 (54.1 to 57.9)	−1.5 (−3.4 to 0.4)
> 2 to < 3	27.8 (27.1 to 28.8)	30.5 (29.7 to 31.3)	−2.4 (−3.2 to −1.6)	30.7 (28.9 to 32.5)	30.4 (28.5 to 32.2)	0.3 (−1.5 to 2.1)
≥ 3	11.9 (11.4 to 12.5)	17.5 (17.0 to 18.1)	−5.6 (−6.1 to −5.0)	14.8 (13.5 to 16.2)	13.6 (12.3 to 15.0)	1.2 (−0.2 to 2.5)

Note: A1$_c$ = glycated hemoglobin, CI = confidence interval, LDL = low-density lipoprotein.
*For means and differences in mean, we used general linear models to adjust for age and sex; for proportions and differences in proportion, we used logistic regression to adjust for age and sex.
†Those who had a test recorded in the Ontario Laboratory Information System in 2014/15 (for A$_{1c}$, most recent recorded value from any of these observation codes: 4548–4, 71875–9, 59261–8, 17855–8, 17856–6, 41995–2; for LDL, most recent recorded value from observation code 39469–2).
‡Except where noted otherwise.

Table 3: Good glycemic control and good lipid control by rurality among First Nations people and other people in Ontario with diabetes, 2014/15

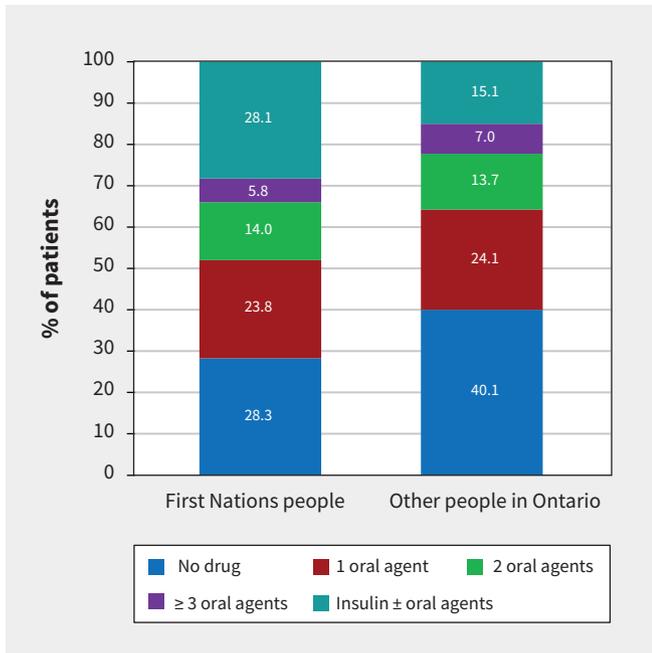| | First Nations people | | | | Other people in Ontario | | | | |
Variable; rurality	Numerator	Denominator	Crude rate	Standardized rate (95% CI)*	Numerator	Denominator	Crude rate	Standardized rate (95% CI)*	Rate ratio† (95% CI)
Good glycemic control‡									
Urban	2268	4589	49.4	51.8 (49.3 to 54.2)	431 195	719 153	60.0	59.4 (59.3 to 59.6)	0.87 (0.83 to 0.91)
Suburban	1553	3239	47.9	49.7 (47.1 to 52.4)	114 087	193 670	58.9	57.5 (57.1 to 57.8)	0.87 (0.82 to 0.91)
Rural	1201	2892	41.5	44.5 (41.7 to 47.3)	39 981	70 263	56.9	55.2 (54.7 to 55.8)	0.81 (0.76 to 0.86)
No score	1582	4035	39.2	42.9 (40.6 to 45.3)	1414	2779	50.9	49.9 (47.1 to 52.7)	0.86 (0.80 to 0.93)
Good lipid control§									
Urban	1993	3649	54.6	59.7 (56.7 to 62.7)	327 380	641 465	51.0	50 (49.8 to 50.2)	1.19 (1.14 to 1.26)
Suburban	1414	2596	54.5	57.1 (53.8 to 60.4)	86 928	158 092	55.0	52.3 (51.9 to 52.6)	1.09 (1.03 to 1.16)
Rural	1009	1806	55.9	59.5 (55.3 to 63.6)	29 116	52 330	55.6	52.7 (52 to 53.3)	1.13 (1.05 to 1.21)
No score	1414	2540	55.7	58.9 (55.5 to 62.3)	956	1836	52.1	50 (46.6 to 53.3)	1.18 (1.08 to 1.29)

Note: A$_{1c}$ = glycated hemoglobin, CI = confidence interval, LDL = low-density lipoprotein.
*Standardized for age and sex to the 2001 Ontario census population.
†Ratio of the standardized rate for First Nations people to the standardized rate for other people in Ontario.
‡A$_{1c}$ level 7% or less.
§LDL level 2.0 mmol/L or less.

Figure 3: Distribution of pharmacotherapy regimens among First Nations people and other people in Ontario aged 65 years or more with diabetes, 2014/15.

Figure 3 presents a summary of the types of pharmacotherapy regimens used by people with diabetes in 2014/15, and Figure 4 provides additional detail on the medication classes used. First Nations people were less likely to be taking no medications than other people in Ontario. They were more likely to be using insulin and less likely to have received a dipeptidyl peptidase 4 inhibitor than other people in Ontario. First Nations people were also more likely to be using basal insulin (alone or in combination) and less likely to be using premixed insulin or meal-only insulin than other people in Ontario.

We reported on the use of lipid-lowering agents, which is similar for First Nations people and other people in Ontario, in another paper.[8]

Interpretation

The frequency of testing to monitor glycemic control in Ontario increased between 2001/02 and 2014/15 but remained suboptimal, with 50% or less of all people with diabetes receiving 2 or more A_{1c} tests per year; rates were as low as 20% among younger First Nations men. Rates of annual lipid testing were somewhat higher, but these tests were still completed in only about half of First Nations people and two-thirds of other people in Ontario with diabetes. In addition, among those with valid results, glycemic control was significantly worse among First Nations people than other people in Ontario with diabetes, with more than 30% of those in First Nations communities and 25% of those living outside First Nations communities having A_{1c} levels of 8.5% or higher, compared to about 13% of other people in Ontario with diabetes. Conversely, lipid control was slightly better among First Nations people with diabetes. First Nations people were more likely than other people in Ontario to be using insulin
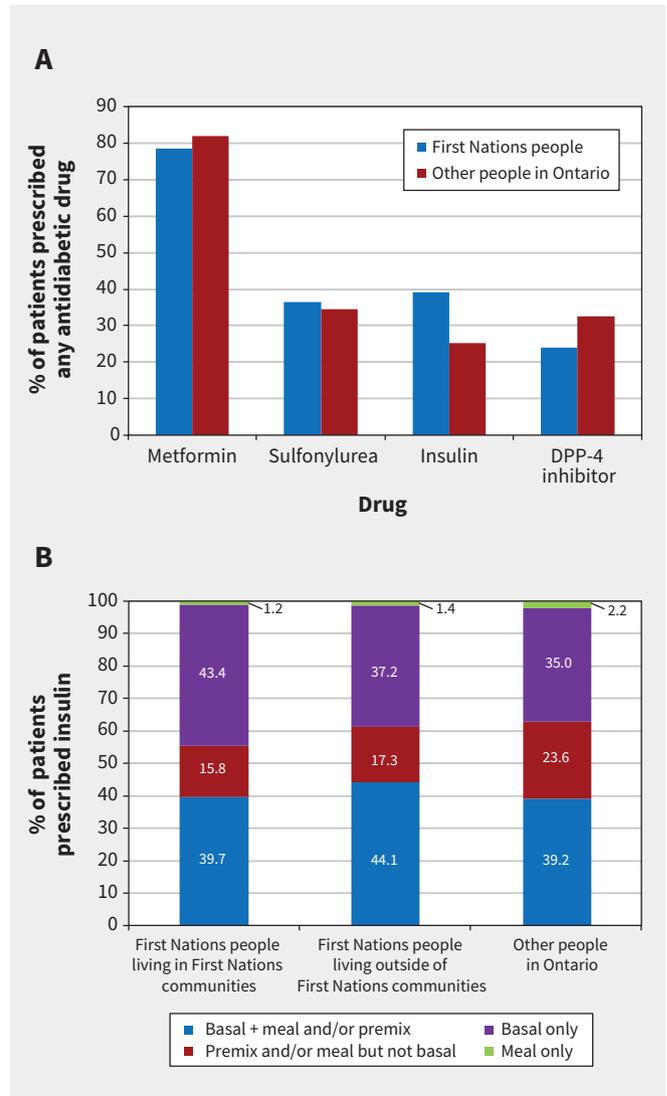
Figure 4: Medications for glycemic control by class among First Nations people and other people in Ontario aged 65 years or older with diabetes, 2014/15. (A) Oral agents and insulin. (B) Insulin by type. Note: DPP-4 = dipeptidyl peptidase 4.

and less likely not to be prescribed any glucose-lowering medications, but further analysis is required to determine the intensity and appropriateness of treatment, particularly as diabetes onset is more common at younger ages among First Nations people[42] and the current analysis was limited to those aged 65 or older. The observed relations between increasing comorbidity and achievement of target A_{1c} levels for other people in Ontario and of lipid targets for all groups may be due to higher levels of access to and use of health care services by these patients.[43]

Prior studies on treatment and control of diabetes in First Nations settings in Canada have also shown lower rates of monitoring and achievement of glycemic control. In the First Nations Diabetes Clinical Management Epidemiologic (CIRCLE) study,[44] glycemic control, but not lipid control, was worse in First Nations patients with diabetes than in the general population in the earlier Diabetes in Canada Evaluation (DICE) cohort study, which used a similar methodology.[45] The CIRCLE investigators also

found high rates of treatment with glucose-lowering medications and low numbers of people receiving no medications among First Nations people.[44] A study from Alberta showed that First Nations people with diabetes and without chronic kidney disease had lower rates of recommended A_{1c} or LDL testing than their non–First-Nations counterparts and also were less likely to achieve A_{1c} targets but not LDL targets.[46]

Improving glycemic control is an essential element of any strategy to limit the impact of diabetes on individuals and society. Because the OLIS data were acquired at ICES during the present study, we were unable to perform any longitudinal analysis of the links between the levels of glycemic control we observed and the high rates of complications reported in our other papers.[8–12] However, it is highly likely that HbA_{1c} level sare an important driver of the observed differences in outcomes, given the well-known strong association between glycemic control and complications of diabetes. Leiter and colleagues[47] highlighted the difficulties in achieving glycemic control in their recent report combining results from the Diabetes Mellitus Assessment of Clinical Management in Ontario (DM-ACTION) and Diabetes Mellitus Improving Patient Care in Our Communities (DM-IMPACT) studies. Patient factors and therapeutic inertia on the part of clinicians were identified as key barriers to achieving targets.

Several studies have explored these issues as they relate specifically to First Nations people and communities in Canada. The authors of a mixed-methods study of 244 health care providers in 19 communities concluded that patient factors were critical but also expressed concern about the risk that this would lead to "patient blaming"; they noted that structural barriers such as the absence of local services or transportation difficulties were also important.[48] Kulhawy-Wibe and colleagues[49] conducted a qualitative study in 5 Alberta First Nations communities and concluded that there were many First-Nations–specific structural barriers to accessing diabetes self-management supports, including lack of local or culturally relevant resources. The Screening for Limb, I-Eye, Cardiovascular and Kidney (SLICK) complications program in Alberta developed mobile screening programs to help mitigate barriers to access,[50] and the Transformation of Indigenous Primary Healthcare Delivery (FORGE AHEAD) program is evaluating quality-improvement interventions in multiple communities across Canada.[51] Those investigators also reviewed the literature for best practices in diabetes and obesity prevention and treatment in Indigenous populations and noted that there is a pressing need for more studies of interventions to address this area.[6,51]

Research on patient and provider experiences in Canada has shown that there are important social and cultural drivers of diabetes outcomes among Indigenous adults that need to be addressed to help empower patients to achieve good control.[52,53] The most recent Diabetes Canada guidelines recommend the use of care frameworks that are designed to help clinicians better understand the impacts of colonialism (including residential schools), ongoing inequities in care and structural barriers to care on their patients, and to develop strategies to create strong therapeutic relationships with patients, to help mitigate these challenges.[7,54]

Limitations

In addition to the general limitations related to using administrative data outlined by Slater and colleagues,[34] there are some additional limitations particular to the present study. It is important to recognize that the diagnostic accuracy of the algorithm used to identify people with diabetes in First Nations populations is not known. In addition, this algorithm does not distinguish between type 1 and type 2 diabetes. The Ontario Laboratory Information System began incorporating hospital laboratory data on a regional basis, so hospital-based laboratories in northwestern Ontario, where there is a large First Nations population, were not contributing to OLIS during the period of the study. Our laboratory monitoring outcomes were based on Ontario Health Insurance Plan claims and are therefore missing data from hospital-based testing that is funded by global base budgets. In addition, there is no capture or reporting of results of point-of-care A_{1c} tests, which may be conducted as part of organized diabetes care in some regions. It is difficult to be certain about the direction of bias these limitations may have introduced, but it is possible that they contributed to an underestimation of the differences in A_{1c} control (owing to the relations between rurality and both A_{1c} control and First Nations status) and an overestimation of the differences in up-to-date testing if hospital-based or point-of-care testing is more common for First Nations people than for other people. We also used only the most recent result for patients with more than 1 test result. We do not expect that this introduced systemic bias into the results comparing groups, as this was the case for all groups.

With respect to medication data, as we relied on the data for provincially funded drugs, any medications provided by private or federal funding programs such as the Non-Insured Health Benefits are not included, which may have contributed to underestimation of medication use. Since we limited our analysis of medications to people aged 65 or older, and since the provincial drug benefit system is the first-line insurer for all those in this age group in Ontario, including First Nations people, we feel that this is likely an issue only for medications that were not covered under the provincial health benefits plan (glucagon-like peptide-1 receptor agonists such as liraglutide and exenatide, and sodium–glucose transport protein 2 inhibitors such as dapagliflozin and canagliflozin were approved before March 2015 but were not on the Ontario Drug Benefit formulary). The Non-Insured Health Benefits program uses a formulary-based system similar to that of the Ontario Drug Benefit Program to determine eligibility for coverage of specific medications. There is a risk of misclassification for patient location, as address data from the Ontario Health Insurance Plan are not always current. We have mitigated this to the extent possible with administrative data by using the more current "residence code" for patients with hospital or emergency department encounters preferentially if there was a discrepancy. We were unable to account for socioeconomic status in our analyses. Finally, there may have been changes in outcomes since 2014/15, but these are likely to have been small in magnitude.

Conclusion

Monitoring for glycemic control remains inadequate for more than half of all Ontarians with diabetes and is even lower among First Nations people. The high rates of poor glycemic control noted for First Nations people are concerning, and glycemic control needs to be improved. This will require addressing many factors including difficulties accessing care, access to healthy foods and the long-term impacts of colonization. Robust studies of interventions designed to improve glycemic control by addressing these factors are urgently needed to inform changes in policy and practice.

References

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