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Is glycemia control in Canadians with diabetes individualized? A cross-sectional observational study

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ABSTRACT

Objective Diabetes guidelines recommend individualized glycemic targets: tighter control in younger, healthier patients and consideration of more moderate control in the elderly and those with coexisting illnesses. Our objective was to examine whether glycemic control varied by age and comorbidities in Canadian primary care.

Research design and methods Cross-sectional study using data from the electronic medical records of 537 primary care providers across Canada; 30 416 patients with diabetes, aged 40 or above, with at least one encounter and one hemoglobin A1c (HbA1c) measurement between 1 January 2012 and 31 December 2013. The outcome was the most recent HbA1c, categorized into three levels of control: tight (<7.0% or <53 mmol/mol), moderate (7.0%–8.5%, 53 mmol/mol–69.5 mmol/mol) and uncontrolled (>8.5% or >69.5 mmol/mol). We adjusted for several factors associated with glycemic control including treatment intensity.

Results Younger patients (aged 40–49) were more likely to have moderate as opposed to tight control than the older patients (aged 80+) (OR 1.28; 95% CI 1.11 to 1.49, p=0.001). The youngest were also more likely to have uncontrolled as opposed to moderately controlled glycemia (OR 3.39; 95% CI 2.75 to 4.17, p<0.0001). Patients with no or only one comorbidity were more likely to have moderate as opposed to tight control than those with three or more comorbidities (OR 1.66;95% CI 1.46 to 1.90, p<0.0001).

Conclusions Levels of glycemic control, given age and comorbidities appear to differ from guideline recommendations. Research is needed to understand these discrepancies and develop methods to assist providers in personalizing glycemic targets.

Significance of this study

What is already known about this subject?

- Recent guidelines recommend consideration of patients' individual circumstances when setting blood sugar targets. Tighter control, as measured by a lower hemoglobin A1c (HbA1c), is appropriate for younger, healthier patients and consideration of less intensive control may be advisable for older, sicker patients. Some studies done prior to guideline changes have found that older patients had lower HbA1c values than younger patients.

What are the new findings?

- Young patients were more likely to have poorly controlled blood sugar while older patients and patients with more illnesses were more likely to have tighter control.

How might these results change the focus of research or clinical practice?

- This study points to possible undertreatment in some younger, healthier patients and overtreatment in some older, sicker patients. Research is needed to understand barriers to setting and implementing individual targets for blood sugar control.

INTRODUCTION

Hemoglobin A1c (HbA1c) represents average blood glucose levels over 3 months and is a valuable indicator of glycemic control in persons with diabetes.[1 2] Past guidelines recommended an HbA1c target of 7% (53 mmol/mol) or less for most patients.[3 4] Following the publication of the Veterans Affairs Diabetes Trial (VADT), Action to Control Cardiovascular Risk in Diabetes (ACCORD) and Action in Diabetes and Vascular Disease (ADVANCE) studies in 2008 and 2009[5–7] and concerns about cardiovascular safety associated with intensive control,[8] recommendations for glycemic targets were reassessed. In 2012, participants in a consensus development conference convened by the American Diabetes Association provided a report recommending higher targets for older persons with diabetes and those in poorer health.[9] In addition, a position statement was published by the American Diabetes Association and the European Association for the Study of Diabetes supporting a similarly individualized approach.[10] The most recent American and Canadian Diabetes Association guidelines emphasized less stringent targets (HbA1c ≤8.0% (64 mmol/mol) in the USA and ≤8.5% (69 mmol/mol)

Research questions

- Why are younger patients more likely to have uncontrolled glycemic levels? Why do older patients and those with more comorbidities attain hemoglobin A1c (HbA1c) levels in tighter ranges? (A question requiring a qualitative approach.)
- What could be done about this? How could family physicians and other clinicians looking after patients with diabetes work with patients to determine targets for glycemic goals? Are targets being discussed and agreed upon on?
- Current practice targets for quality improvement (eg, percentage of patients with HbA1c less than 7%) may not consider individualized targets. Is there a system that could be set up to better measure and monitor achieved HbA1c values compared with appropriate patient-centered targets for patients and populations with diabetes?

in Canada) for older individuals with diabetes living with multiple comorbidities, individuals with extensive cardiovascular disease or patients with a limited life expectancy; more stringent targets (≤6.5%) could be considered for young patients with recently diagnosed diabetes to further reduce the risk of nephropathy and retinopathy.[1 2 11] In the USA, about half of the patients with diabetes would have a recommended target of ≥7% (53 mmol/mol).[12]

Some studies have shown that older persons may be more likely to have HbA1c values ≤7% (53 mmol/mol) than younger persons[13 14] indicating possible overtreatment in some elders.[15] Overtreatment in elders was defined as the use of glucose-lowering medications (other than metformin) associated with an increased risk of adverse effects such as hypoglycemia in order to attain tight glycemic control.[15]

A reasonable interpretation of current recommendations is to individualize therapy by focusing efforts to achieve tighter glycemic control in younger, healthier patients and by considering patients' goals and preferences to set individualized, somewhat less stringent HbA1c targets for older patients or those with multiple comorbidities.

The extent to which primary care practitioners in Canada have individualized therapy is unclear. To investigate this issue, we used the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) database. CPCSSN is a nationally representative repository of Canadian primary care electronic medical record (EMR) data updated on a quarterly basis.[16] As part of a 2013 CPCSSN report, HbA1c levels were found to be lower among older individuals with diabetes compared with younger individuals.[17] This observation appeared to be inconsistent with the amended practice guidelines and required further investigation.

Our objective was to examine whether glycemic control varied by age and comorbidities in primary care practices across Canada and whether this variation indicated patterns consistent with recommendations to individualize glycemic levels by considering patient characteristics.

RESEARCH DESIGN AND METHODS

Data sources and study population

We used a retrospective cross-sectional design and applied the The Strengthening the Reporting of Observational Studies in Epidemiology checklist for reporting observational studies.[18] Routinely collected clinical EMR data contained in the CPCSSN central database was used for this study[16]; CPCSSN is Canada's largest EMR-based chronic disease surveillance system[16], and it includes data collected from 11 primary care practice-based research networks in eight provinces. Consenting family physicians and other primary care providers participating in CPCSSN contribute de-identified EMR data to a regional CPCSSN repository; patients can opt-out if they choose to do so. Data from all participating networks are aggregated in a single central database.[16 19] The distribution of the CPCSSN patient population is reasonably similar to that of Canadian census.[17] CPCSSN providers are somewhat younger, more likely to be female and more likely to practice in an academic setting than the source population of Canadian family physicians.[20] Eighty per cent of Canadian family physicians reported using EMRs in 2014[21]; EMR data therefore reflects the majority of primary care records.

We used EMR data extracted as of 31 December 2013 using procedures previously described.[16] CPCSSN case definition algorithms have been validated against chart audits for eight chronic conditions (diabetes, hypertension, chronic obstructive pulmonary disease, depression, osteoarthritis, dementia, parkinsonism and epilepsy) in multiple sites across Canada.[22] The case definition for diabetes was shown to have a sensitivity of 96% and specificity of 97%.[22] The seven other validated chronic conditions were used as our measure of comorbidity.

To be included in our final dataset, individuals were required to meet the CPCSSN case definition for diabetes: be at least 40 years of age as of 31 December 2013, have at least one encounter with their practice in 2012 or 2013 and have at least one recorded HbA1c value during the 2 years of interest. We chose a lower bound of 40 years for patient age because of the lower proportion of patients with type 1 diabetes after age 40. The data do not allow us to reliably categorize the type of diabetes, and this study focused on individuals with type 2 diabetes.

Our primary outcome was the most recent value of HbA1c extracted from the EMR within our observation period. We used HbA1c ranges based on the Canadian Diabetes Association target categories: tight control (<7% (53 mmol/mol)), moderate control (7%–8.5% (53–69.5 mmol/mol)) and uncontrolled glycemic levels (>8.5% (69.5 mmol/mol)).[1] We measured factors associated with glycemic control, including demographic variables (age, gender) and clinical variables: medication treatment intensity, comorbidities, body mass index (BMI), blood pressure, lipid values, urine albumin:creatinine ratio (ACR) and number of clinical encounters with primary care provider.

We estimated medication treatment intensity by measuring the number of diabetes medication classes for each patient. The maximal effect of medication on HbA1c is likely to be seen 3 months or more after a drug has been prescribed.[23] For this reason, we extracted all diabetes medications prescribed during an observation period extending from 9 months to 3 months prior to the last HbA1c. These drugs were grouped into medication classes (metformin, sulfonylureas, thiazolidinediones, glucagon-like peptide-1 agonists, dipeptidyl peptidase 4 inhibitors, insulins) following the Canadian and American Diabetes Association's recommendations for classification.[2 23] In some Canadian provinces, refills for insulin can be obtained without a prescription[24]; for this class of medication, we considered a patient to be on an insulin if there was evidence of any prescription for this drug, with the latest observation being at least 3 months prior to the reference HbA1c measure.

Each class of medication decreases HbA1c by 0.5%–1.5% (5.5 mmol/mol–16.4 mmol/mol),[1] with the exception of insulin, which does not have a ceiling effect. We summed the number of classes of diabetes medications present during the observation period: patients in group 0 (lowest intensity) had no diabetes prescriptions, those in group 1 had one class of medications prescribed, those in group 2 had two classes and those in group 3 (highest intensity) had three or more classes. We classified all patients on insulin as being in the highest intensity group (group 3). This is similar to the approach taken by De Vries and colleagues to classify potential overtreatment of glycemia.[25]

Statistical analysis

All statistical analyses were conducted using SAS software V.9.3 (SAS Institute). Our outcome of interest was the most recent HbA1c measured for each patient, grouped into glycemic control ranges (tight control, moderate control, uncontrolled). We used contingency tables to describe bivariate associations between our categorical response variable (HbA1c control) and our categorical covariates (age group, gender, number of comorbidities, systolic blood pressure, low density lipoprotein, urine ACR, BMI, medication treatment intensity and number of primary care encounters). We employed a random intercept multinomial logistic regression model to model these data. The multinomial logistic regression model accounts for the discrete nature of our response variable, whereas the inclusion of a random intercept in the linear predictor of this model is used to account for the positive correlation between responses arising from the same cluster (here the same physician). The main focus of this analysis is to estimate the impact of age and comorbidities on the probability of being included into each glycemic range, after controlling for the other variables in the models.

This study was reviewed and approved by the Research Ethics Board (REB) at the University of Toronto. CPCSSN has received REB approval from Health Canada and each host university for all participating practice-based research networks. All participating primary care providers have provided written informed consent for the collection and analysis of their EMR data.

RESULTS

Data from 537 primary care providers were included in our dataset. There were 48 143 patients aged 40 and above with diabetes and 30 416 (63.2%) had been seen at least once and had at least one HbA1c during the 2 years of interest; these patients comprised the final sample included in this study.

Patient characteristics and HbA1c ranges are presented in table 1.

The proportion of individuals within each age range by number of classes of medication prescribed is presented in table 2. Patients (7.1%) in the oldest age category were receiving high intensity treatment (three or more classes of medications or insulin), while 11.4% of patients in the youngest age category were in the high medication intensity group. The association between age and medication intensity was significant (p<0.0001).

Table 3 presents the results of the bivariate analyses. We examined three ranges of glycemic control; therefore, there are three comparisons (or models) of interest: (1) moderate versus tight glycemic control, (2) uncontrolled versus tight glycemic control and (3) uncontrolled versus moderate glycemic control. Increasing age and increasing number of comorbid conditions were associated with higher ORs of being in the tight or moderate glycemic ranges.

Table 4 presents the results of the multivariate analyses. We controlled for all variables in table 3, with the exception of urine albumin to creatinine ratio as it was missing in 51% of the sample.

After adjusting for other covariates including medication intensity, younger patients (aged 40–49) were more likely than older patients (80+) to have moderate glycemic control compared with tight glycemic control (OR 1.28; 95% CI 1.11 to 1.49, p=0.001). Younger patients (aged 40–49) were more likely than the older patients (80+) to have uncontrolled glycemic control compared with moderate glycemic control (OR 3.39; 95% CI 2.75 to 4.17, p<0.0001). In other words, younger patients were more likely to have uncontrolled glycemia than older patients.

Patients with fewer comorbidities (0–1) were more likely than patients with multiple comorbidities (3+) to have moderate glycemic control compared with tight glycemic control (OR 1.66; 95% CI 1.46 to 1.90, p<0.0001).

Lastly, increasing medication intensity was associated with poorer glycemic control, particularly for younger people. Patients on intensive medication management had an OR of 5.43 of being in the moderate control as opposed to tight control (95% CI 4.78 to 6.17, p<0.0001). After controlling for all variables, younger people receiving intensive medication management had a mean

Table 1 Patient characteristics and HbA1c ranges

Patient characteristics	Variable	N (% of patients within characteristic group)	Tight control: HbA1c<7%, N (% of patients within HbA1c control range)	Moderate control: HbA1c 7%–8.5%, N (% of patients within HbA1c control range)	Not controlled: HbA1c >8.5%, N (% of patients within HbA1c control range)
All patients in sample		30 416	16 705 (54.92)	9298 (30.57)	4413 (14.51)
Age range in years	40–49	2506 (8.24)	1162 (46.37)	687 (27.41)	657 (26.22)
	50–59	6253 (20.56)	3123 (49.94)	1833 (29.31)	1297 (20.74)
	60–69	9041 (29.72)	4902 (54.22)	2816 (31.15)	1323 (14.63)
	70–79	7545 (24.80)	4414 (58.53)	2420 (32.07)	709 (9.04)
	80+	5073 (16.68)	3104 (61.19)	1542 (30.40)	427 (8.42)
Number of comorbidities*	0–1	6783 (22.30)	3398 (50.10)	2197 (32.39)	1188 (17.51)
	2–3	20 578 (67.6)	11 430 (55.55)	6268 (30.46)	2880 (13.99)
	4 or more	3055 (10.04)	1877 (61.44)	833 (27.27)	345 (11.29)
Gender	Male	15 942 (52.41)	8532 (53.53)	4945 (31.02)	2463 (15.45)
	Female	14 475 (47.59)	8172 (56.46)	4353 (30.07)	1950 (13.47)
	Missing	1 (0)	-	-	-
sBP >130 mm Hg	No	15 821 (52.02)	8985 (56.79)	4662 (29.47)	2174 (13.74)
	Yes	12 338 (40.56)	6601 (53.51)	3870 (31.36)	1867 (15.13)
	Missing	2257 (7.42)	1119 (49.58)	766 (33.94)	372 (16.48)
LDL in mmol/L	<2	14 018 (46.09)	7451 (56.15)	4738 (33.80)	1829 (13.05)
	≥2	14 190 (46.65)	8194 (57.75)	3877 (27.32)	2119 (14.93)
	Missing	2208 (7.26)	1060 (48.01)	683 (30.93)	465 (21.06)
Urine albumin to creatinine ratio	<2	8328 (27.38)	4452 (53.46)	2725 (32.72)	1151 (13.82)
	≥2	6570 (21.60)	2944 (44.81)	2273 (34.60)	1353 (20.59)
	Missing	15 518 (51.02)	9309 (59.99)	4300 (27.71)	1909 (12.30)
BMI	<25	3320 (10.92)	2039 (61.42)	890 (26.81)	391 (11.78)
	25–29.9	7564 (24.87)	4426 (58.52)	2270 (30.01)	868 (11.47)
	≥30	12 632 (41.53)	6699 (53.04)	3924 (31.06)	2009 (15.90)
	Missing	6900 (22.69)	3541 (51.32)	2214 (32.09)	1145 (16.59)
Number of encounters in the past 2 years	1–5	4012 (13.19)	2243 (55.91)	1144 (28.51)	625 (15.58)
	6–16	15 199 (49.97)	8603 (56.61)	4577 (30.11)	2019 (13.28)
	17 or more	11 205 (36.84)	5859 (52.29)	3577 (31.92)	1769 (15.79)
Number of classes of medication prescribed	0 (no diabetic medications)	19 353 (63.62)	11 990 (61.95)	5004 (25.86)	2359 (12.19)
	1 (1 class of medications)	5991 (19.70)	3295 (55.00)	2070 (34.55)	626 (10.45)
	2 (2 classes of medications)	2086 (6.86)	780 (37.39)	912 (43.72)	394 (18.89)
	3 (3 classes of medications or insulin)	2986 (9.82)	640 (21.43)	1312 (43.94)	1034 (34.63)

*Includes the CPCSSN validated comorbidities only (hypertension, chronic obstructive pulmonary disease, depression, osteoarthritis, dementia, epilepsy, Parkinson's disease).
BMI, body mass index; HbA1c, hemoglobin A1c; LDL, low density lipoprotein; sBP, systolic blood pressure.

Table 2 Proportion of patients by number of classes of diabetes medications prescribed within each age range

	Number of classes of medication prescribed			
Age range in years	0 (no diabetic medications)	1 (1 class of medications)	2 (2 classes of medications)	3 (3 classes of medications or insulin)
40–49 (N, % within age range)	1663 (66.36)	411 (16.40)	147 (5.87)	285 (11.37)
50–59	3945 (63.09)	1245 (19.91)	422 (6.75)	641 (10.25)
60–69	5580 (61.72)	1840 (20.35)	663 (7.33)	958 (10.60)
70–79	4794 (63.55)	1454 (19.28)	555 (7.36)	740 (9.81)
80+	3371 (66.45)	1041 (20.52)	299 (5.89)	362 (7.14)

HbA1c of 8.71% (72 mmol/mol) and 95% CI 8.42 to 8.99 (69 mmol/mol–75 mmol/mol), while the oldest had a mean HbA1c of 7.70% (61 mmol/mol) and 95% CI 7.52 to 7.88 (59–63 mmol/mol).

A subgroup analysis was done by removing patients not on any medications. Younger patients (aged 40–49) were more likely than older patients (80+) to have moderate glycemic control compared with tight glycemic control but this was no longer significant (OR 1.09; 95% CI 0.84 to 1.41, p=0.5). Younger patients (aged 40–49) were more likely than older patients (80+) to have uncontrolled glycemic levels compared with moderate glycemic levels (OR 2.77; 95% CI 2.00 to 3.84, p<0.0001).

CONCLUSIONS

Guidelines currently recommend tighter glycemic control for younger patients and those with fewer comorbidities and consideration of more moderate control in older patients and those with more comorbidities.[1 2] In this study, we found that the inverse was present. The younger patients were more likely to have poorly controlled glycemic levels while the older patients were more likely to have tight rather than moderate control. Those with more comorbidities were more likely to have tight rather than moderate control than those with fewer comorbidities. High medication intensity was associated with poorer glycemic control; this was more pronounced in younger patients. These effects remained after controlling for gender, cardiovascular risk factors or frequency of healthcare contacts.

The balance between risks and benefits associated with glycemic control changes with age. Glycemic control is particularly important at younger ages because of the cumulative effects of poor glycemic control on microvascular and macrovascular complications. Conversely, the risks of tighter control and polypharmacy may be greater in the elderly. Our findings highlight an imbalance, with relative undertreatment of glycemia in some younger patients coupled with possible overtreatment of some older patients.

As part of choosing wisely, the American Geriatrics Society recommended against tight glycemic control and caution with prescriptions of medications other than metformin in most older patients.[26] We found that a considerable proportion of older patients in Canada were receiving multiple classes of glucose-lowering medications. Further studies exploring appropriate glycemic targets in the context of ageing, multimorbidity and polypharmacy could be of benefit.

A recent study found that patients with multiple comorbidities had lower HbA1c values than those without comorbidities.[27] We found as well that a greater number of comorbidities was associated with a greater likelihood of having tight glycemic control; this persisted after adjustment for multiple other factors, including increasing age. A greater number of healthcare contacts due to complex or multiple conditions may be a contributing factor, as an increase in the number of visits could afford more opportunities to manage glycemia or create an increased sense of patient accountability for their self-management efforts. In one study, HbA1c values were similar in patients with severe mental illnesses and those without; the authors speculated that this could be due to more frequent healthcare contacts for those with mental illness.[28] In our study, however, we found no association between encounter frequency in primary care and glycemic control.

The ACCORD, ADVANCE and VADT studies found that the impact of tight glycemic control on short-term macrovascular outcomes was uncertain.[5–7] A reduction of about 15% in long-term macrovascular outcomes (largely due to fewer major cardiovascular events) was recently found after extended observational follow-up of the VADT, ACCORD and UK Prospective Diabetes Study (UKPDS) studies, with inconsistent effects on mortality.[29–31]

Recent studies have found improvements in cardiovascular outcomes and reduced mortality with the addition of newer drugs, specifically a glucagon-like peptide-1 agonist, liraglutide,[32] and a sodium-glucose cotransporter 2 inhibitor, empagliflozin.[33] These benefits occurred despite relatively small reductions in HbA1c when compared with usual care. The findings suggest that medication effects other than those associated with improved glycemic control may be predictive of cardiovascular outcomes.[33] The results continue to support an individualized approach to HbA1c targets, taking into account life expectancy, as well as risks of hypoglycemia,

Table 3 Bivariate ORs comparing patient characteristics at different HbA1c ranges

		Moderate vs tight control: HbA1c 7%–8.5% vs. HbA1c <7%		Not controlled vs tight control: HbA1c>8.5% vs. HbA1c <7%		Not controlled vs moderate control: HbA1c >8.5% vs HbA1c 7%–8.5%	
Variable	**Comparison**	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**
Age range in years	40–49 vs 80+	1.11 (0.92 to 1.35)	0.3	3.35 (2.66 to 4.21)	<0.0001	3.03 (2.93 to 3.83)	<0.0001
	50–59 vs 80+	1.20 (1.04 to 1.38)	0.01	2.93 (2.43 to 3.54)	<0.0001	2.45 (2.02 to 2.97)	<0.0001
	60–69 vs 80+	1.14 (1.01 to 1.30)	0.04	1.84 (1.54 to 2.21)	<0.0001	1.62 (1.35 to 1.95)	<0.0001
	70–79 vs 80+	1.18 (1.04 to 1.35)	0.01	1.28 (1.05 to 1.55)	0.02	1.08 (0.88 to 1.32)	0.5
Number of comorbidities*	0–1 vs 3+	1.48 (1.27 to 1.74)	<0.0001	1.64 (1.33 to 2.01)	<0.0001	1.10 (0.89 to 1.36)	0.4
	2–3 vs 3+	1.24 (1.08 to 1.43)	0.002	1.3 (1.09 to 1.56)	0.004	1.05 (0.87 to 1.27)	0.6
Gender	Male vs female	1.10 (1.05 to 1.16)	0.0002	1.21 (1.13 to 1.29)	<0.0001	1.10 (1.02 to 1.18)	0.01
sBP >130 mm Hg	Yes vs no	1.14 (1.08 to 1.21)	<0.0001	1.16 (1.08 to 1.24)	<0.0001	1.02 (0.94 to 1.1)	0.7
LDL >2 mmol/L	Yes vs no	0.73 (0.69 to 0.77)	<0.0001	1.02 (0.95 to 1.1)	0.5	1.41 (1.3 to 1.52)	<0.0001
Urine ACR>2	Yes vs no	1.26 (1.17 to 1.36)	<0.0001	1.87 (1.7 to 2.05)	<0.0001	1.48 (1.34 to 1.63)	<0.0001
BMI	Overweight vs normal/ underweight	1.17 (1.07 to 1.29)	0.0009	1.01 (0.89 to 1.15)	0.9	0.86 (0.75 to 1)	0.04
	Obese vs normal/ underweight	1.34 (1.22 to 1.46)	<0.0001	1.5 (1.33 to 1.69)	<0.0001	1.13 (0.99 to 1.29)	0.07
Number of primary care encounters	6–16 vs 0–5	1.01 (0.93 to 1.09)	0.8	0.80 (0.72 to 0.88)	<0.0001	0.79 (0.71 to 0.89)	<0.0001
	17+ vs –0–5	1.13 (1.04 to 1.23)	0.01	1.01 (0.91 to 1.12)	0.9	0.89 (0.8 to 1)	0.06
Number of medication classes prescribed†	1 vs 0	1.6 (1.50 to 1.71)	<0.0001	1.03 (0.93 to 1.14)	0.5	0.64 (0.58 to 0.71)	<0.0001
	2 vs 0	3.06 (2.76 to 3.39)	<0.0001	2.81 (2.46 to 3.21)	<0.0001	0.92 (0.81 to 1.05)	0.2
	3+ vs 0	5.36 (4.84 to 5.94)	<0.0001	8.85 (7.91 to 9.89)	<0.0001	1.65 (1.5 to 1.82)	<0.0001

*Includes the CPCSSN validated comorbidities only (hypertension, chronic obstructive pulmonary disease, depression, osteoarthritis, dementia, epilepsy, Parkinson's disease).
†A prescription for insulin automatically included a patient in group 3.
ACR, albumin to creatinine ratio; BMI, body mass index; HbA1c, hemoglobin A1c; LDL, low density lipoprotein; sBP, systolic blood pressure.

Table 4 Multivariate ORs comparing patient characteristics at different HbA1c ranges

		Moderate vs tight control: HbA1c 7%–8.5% vs HbA1c<7%		Not controlled vs tight control: HbA1c>8.5% vs HbA1c<7%		Not controlled vs moderate control: HbA1c >8.5% vs HbA1c 7%–8.5%	
Variable	**Comparison**	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**	**OR**	**p Value**
Age range in years	40–49 vs 80+	1.28 (1.11 to 1.49)	0.001	4.35 (3.57 to 5.30)	<0.0001	3.39 (2.75–4.17)	<0.0001
	50–59 vs 80+	1.21 (1.08 to 1.35)	0.0008	3.02 (2.55 to 3.57)	<0.0001	2.50 (2.10–2.99)	<0.0001
	60–69 vs 80+	1.09 (0.99 to 1.21)	0.09	1.89 (1.60 to 2.22)	<0.0001	1.73 (1.46–2.06)	<0.0001
	70–79 vs 80+	0.99 (0.89 to 1.09)	0.8	1.10 (0.93 to 1.31)	0.3	1.12 (0.93–1.34)	0.2
Gender	Male vs female	1.04 (0.97 to 1.11)	0.2	1.21 (1.11 to 1.33)	<0.0001	1.17 (1.07–1.29)	0.0009
Number of comorbidities*	0–1 vs 3+	1.66 (1.46 to 1.90)	<0.0001	1.50 (1.24 to 1.80)	<0.0001	0.90 (0.74–1.09)	0.3
	2–3 vs 3+	1.38 (1.23 to 1.54)	<0.0001	1.24 (1.06 to 1.46)	0.008	0.90 (0.76–1.07)	0.2
sBP >130 mm Hg	Yes vs no	1.17 (1.10 to 1.25)	<0.0001	1.32 (1.21 to 1.45)	<0.0001	1.13 (1.03–1.24)	0.01
LDL >2 mmol/L	Yes vs no	0.78 (0.73 to 0.83)	<0.0001	1.03 (0.94 to 1.13)	0.5	1.32 (1.20–1.45)	<0.0001
BMI	Overweight vs normal/ underweight	1.13 (1.02 to 1.26)	0.02	0.93 (0.80 to 1.08)	0.3	0.82 (0.70–0.96)	0.02
	Obese vs normal/ underweight	1.22 (1.11 to 1.35)	0.0001	1.15 (1.00 to 1.33)	0.05	0.95 (0.82–1.10)	0.5
Number of primary care encounters	6–16 vs 0–5	1.03 (0.93 to 1.14)	0.6	0.91 (0.79 to 1.05)	0.2	0.88 (0.76–1.03)	0.1
	17+ vs 0–5	1.16 (1.03 to 1.30)	0.01	1.20 (1.03 to 1.40)	0.02	1.04 (0.88–1.22)	0.6
Number of medication classes prescribed†	1 vs 0	1.59 (1.46 to 1.72)	<0.0001	1.13 (1.00 to 1.28)	0.06	0.71 (0.62–0.81)	<0.0001
	2 vs 0	3.17 (2.79 to 3.60)	<0.0001	3.29 (2.78 to 3.90)	<0.0001	1.04 (0.88–1.23)	0.7
	3+ vs 0	5.43 (4.78 to 6.17)	<0.0001	9.76 (8.44 to 11.29)	<0.0001	1.80 (1.58–2.05)	<0.0001

*Includes the CPCSSN validated comorbidities only (hypertension, chronic obstructive pulmonary disease, depression, osteoarthritis, dementia, epilepsy, Parkinson's disease).
†A prescription for insulin automatically included a patient in group 3.
ACR, albumin to creatinine ratio; BMI, body mass index; HbA1c, hemoglobin A1c; LDL, low density lipoprotein; sBP, systolic blood pressure.

potential side effects and overall burden of medications all of which tend to be greater in older patients and those with multimorbidities.

The care of patients with diabetes can be complex due to advancing age and multiple coexisting conditions, each associated with guideline recommendations that are not always concordant. A discussion of goals and preferences should occur with patients, and their preferences should be considered when developing personal glycemic targets.[34] Further research is needed to better understand why younger adults and those with few comorbidities experience uncontrolled glycemic levels and to explore glycemic goals and medication intensity for elderly patients. Interventional studies, including enhanced prescribing for those benefiting from lower targets or de-prescribing for those identified as needing less intensive glycemic targets[35] could address the imbalance identified in this study. Clinical decision support systems could also be implemented in EMRs to assist in identifying appropriate targets for different patient populations.

The study had several strengths. It reflected data from routine clinical care for patients with diabetes in community-based primary care. We included a large sample of both patients and primary care providers from multiple settings across Canada. Therefore, this study reasonably reflects current clinical practices for individuals with diabetes receiving primary care in Canada. Data were extracted from multiple different EMR platforms, accounting for a variety of EMR-specific data entry processes by clinicians. Despite these strengths, this study includes several shortcomings. This was a convenience sample of primary care practices that contributed EMR data to CPCSSN, rather than a random sample from the population of all primary care practices. Recent efforts to explore the representativeness of CPCSSN data to the Canadian population of primary care practices have shown that participating physicians are slightly younger and likely to be female compared with the population of physicians who have responded to the National Physician Survey.[17] The cross-sectional design that was used in this study does not permit us to make causal inferences about the direction of the relationships between HbA1c, age and medications in this population. We were unable to collect several variables relevant to individualized glycemic targets, as these are not available in the EMR or are generally not collected in a manner that permits extraction and standardization of data. These variables include hypoglycemic events, diabetes duration, comorbid conditions other than those with CPCSSN validated case definitions and data on life expectancy. Data on ethnicity are currently very limited in Canadian EMRs, so these were not included in our study. Our data does not allow us to differentiate between patients with type 1 and type 2 diabetes. Lastly, it is possible that survivorship bias may have affected our results; patients with very poor glycemic control may have died at an earlier age. However, the association between efforts to decrease HbA1c values and improvements in mortality remains uncertain.

In conclusion, we found that the younger patients were less likely to have tight glycemic control while the older were less likely to have moderate control. Patients with a greater number of comorbidities were more likely to have tight control than those with fewer health conditions. Consequently, there appears to be discrepancies between clinical practice and guideline recommendations to develop individualized HbA1c targets by considering age and number of comorbidities.

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Correction notice This paper has been amended since it was published Online First. Owing to a scripting error, some of the publisher names in the references were replaced with 'BMJ Publishing Group'. This only affected the full text version, not the PDF. We have since corrected these errors and the correct publishers have been inserted into the references.

Contributors MJC and MG contributed to the conception and design. BA was responsible for the acquisition of data. CM, BA and RM contributed substantially to the analysis of data. CHY provided content-specific expertise on diabetes. MJC and MG drafted the initial version of the article. All authors contributed to the interpretation of data. All authors reviewed and revised the article for important intellectual content and gave final approval of the version to be published. MG 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.

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