Level of A1C control and its predictors among Lebanese type 2 diabetic patients

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Abstract

Aim: Lebanon is among the top 10 countries with the highest prevalence of diabetes in the Middle East region with estimates reaching as high as 16.6% in adults aged 20–79 years. The objective of this study was to assess the level of A1C control among a cohort of type 2 diabetic patients and factors associated with uncontrolled A1C.

Methods: We carried out a retrospective observational study among type 2 diabetes mellitus patients attending an outpatient endocrinologist's clinic between June 2008 and July 2012 in Beirut, Lebanon. Two groups were compared, based on their diabetic control (A1C $< 7\%$ and A1C $\geqslant 7\%$).

Results: A total of 551 patients were included in this study, where 31.8% attained A1C control. Crude analyses showed that some factors were significantly associated with uncontrolled A1C, and these were long-standing diabetes, diabetes-related complications, uncontrolled blood pressure, lipid profile, as well as the use of metformin, sulfonylurea, or insulin. When multivariate analysis was carried out, the chances of having uncontrolled A1C were significantly higher among patients who developed neuropathy (odds ratio [OR] 2.08, 95% confidence interval [CI] 1.11–3.90), had uncontrolled triglycerides (OR 1.98, 95% CI 1.33–2.94), used insulin (OR 4.52, 95% CI 2.32–8.83), and sulfonylureas (OR 2.88, 95% CI 1.88–4.40).

Conclusion: Uncontrolled diabetes is more likely to exist in patients with neuropathy, uncontrolled triglycerides and those using insulin or sulfonylurea. Further research is needed to confirm the findings.

Keywords: A1C control, diabetes mellitus type 2, Lebanon, predictors

Introduction

Diabetes mellitus (DM) is a serious worldwide health concern which has been increasing significantly in the last decade. It is becoming an epidemic of our time creating a major and challenging public health problem confronting every nation on the globe [Badran and Laher, 2012; Leite *et al.* 2013]. According to the World Health Organization (WHO) fact sheet (2011), 347 million people worldwide are living with diabetes. Moreover, WHO projects that diabetes will be the seventh leading cause of death in 2030 [World Health Organization, 2011]. DM is predicted to increase at an annual growth of 2.2%, increasing the number of diabetic patients by 54% from 2010 to 2030 [Shaw *et al.* 2010].

Type 2 diabetes mellitus (T2DM) is the most common form of diabetes accounting for almost 80–90% of all diagnosed cases of diabetes [Leite *et al.* 2013]. It is also becoming more prevalent among children, adolescents and younger adults [Chen *et al.* 2012]. The increase in prevalence of T2DM can be attributed to the social modernization, sedentary lifestyles, and the increased high-calorie food consumption, as well as increased obesity [Badran and Laher, 2012]. Other risk factors of DM include abnormal lipid levels, physical inactivity, hypertension, smoking, and family history of DM [Chen *et al.* 2012].

Being diagnosed with T2DM can have major impact on patient's physical, mental, and social well-being [Angela, 2013]. As stated by the 2011 National Diabetes Fact Sheet, diabetics have higher rates of cardiovascular disorders, hypertension, retinopathy, nephropathy, neuropathy,

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and amputations [Centers for Disease Control and Prevention, 2011]. T2DM is also associated with psychological, cognitive, and sexual problems which may lead to depression in the diabetic patient [Inzucchi *et al.* 2012; Mitkov *et al.* 2013]. Moreover, T2DM may affect employment, contribute to work loss and health-related work limitations. All of that will affect productivity and inflict financial and economic burdens on the society [Tunceli *et al.* 2005]. If T2DM is not properly managed, this may result in debilitating complications that directly impact the patient's quality of life [Angela, 2013].

Many clinical studies have shown that the development of complications in diabetic patients is related to the level of glycemic control which must be monitored closely [Kuritzky and Samraj, 2011; Mitka, 2012; Quah *et al.* 2013]. Glycated hemoglobin (A1C) is a useful index for measuring glycemic control which, if elevated, has shown to be associated with DM-related complications. Moreover, elevated A1C is associated with higher rates of morbidity and mortality [Currie *et al.* 2010; Zavrelova *et al.* 2011]. For better glycemic control, the American Diabetic Association (ADA) recommends performing the A1C test at least twice a year in those meeting the glycemic goal and quarterly in patients whose therapy has changed or who are not meeting glycemic goals [American Diabetes Association, 2011, 2013; Sidorenkov *et al.* 2013]. Factors contributing to A1C control include demographic (age, body mass index [BMI], diabetes duration, family history), medical (complications of diabetes, hypertension, dyslipidemia, pharmacological treatment), or lifestyle (diet, exercise) factors [Mansour *et al.* 2013].

T2DM needs skillful management and is approached with nonpharmacologic and pharmacologic therapies. Educating patients on lifestyle modification and self-monitoring of blood glucose, eating a healthy diet, undergoing regular physical activity, maintaining a normal body weight and avoiding tobacco use can prevent or delay the onset of T2DM and the progression of its complications [Brunetti and Kalabalik, 2012; World Health Organization, 2013]. These lifestyle modifications in addition to concomitant pharmacological therapy are recommended to manage hyperglycemia in T2DM. The American Association of Clinical Endocrinologists (AACE) provides recommendations for treatment selection and it stratifies its recommendations according to the patient's baseline A1C level and recommends combination therapy if A1C exceeds 7.5% [Brunetti and Kalabalik, 2012].

In 2011, it has been reported that Lebanon was among the top 10 countries with the highest prevalence of DM worldwide. In 2012, the International Diabetes Federation estimated the prevalence of DM in Lebanon to be 16.6% in adults aged 20–79 years [International Diabetes Federation, 2011]. On the other hand, Hirbli and colleagues reported a prevalence of 15.8% in greater Beirut region, in 2005 [Hirbli *et al.* 2005]. Nevertheless, very little is known about the degree of diabetic control in Lebanon. Accordingly, this study was carried out to assess the level of A1C control among a cohort of T2DM patients and factors associated with uncontrolled A1C.

Methods

Study design and setting

We carried out a retrospective observational study of T2DM patients attending an outpatient endocrinologist's tertiary care clinic in Beirut, Lebanon. The selected clinic serves patients from across all regions of Lebanon mainly from Mount Lebanon and greater Beirut that is home to 53.6% of the population, and from a variety of socioeconomic backgrounds (mainly middle to high).

Inclusion/exclusion criteria and sampling

Patients eligible in this study were those diagnosed with T2DM and who attended the clinic between June 2008 and July 2012. Most of the patients were new referrals. As for the old patients, data were collected from their last visit. Excluded from this study were patients who were pregnant, below 18 years of age, not on antidiabetic pharmacotherapy, or having missing values for their A1C.

The sample selected in the study was based on screening patients' files consecutively, and selecting patients according to the eligibility criteria.

Data collection

Data collection was carried out by chart review of the included patients using a data collection sheet which was structured specifically for the purpose of this study. Information collected included

DM-related variables that might influence values of A1C. More specifically, it included the date of visit, patient demographic data (such as age and gender), social habits (smoking and alcohol use), BMI, and family history of DM. DM-specific information was also collected and included DM duration, complications and lab results (A1C and fasting blood sugar [FBS]).

Diabetes complications were collected at the same time of the laboratory workup, and confirmed clinically and biochemically as needed. Moreover, information on the currently used antidiabetic medications was collected; specifically, metformin, sulfonylureas, incretin mimetics, thiazolidinediones, insulin, and others. Furthermore, we differentiated between patients using insulin alone, or insulin in combination with any other antidiabetic medication. We also divided patients into categories according to the number of antidiabetic medications used (1, 2, and ⩾3). Moreover, data on blood pressure, hypertension status, lipid panel, as well as the use of other medications (anti-hypertensive agents and statins) were collected.

The outcome for this study was the target for T2DM management, being either controlled or uncontrolled. Patients with an A1C value of <7% were considered to be diabetically controlled and were referred to as the 'A1C controlled' group throughout this study, whereas those having an A1C value of ⩾7% were considered diabetically uncontrolled and were referred to as the 'A1C uncontrolled' group [American Diabetes Association, 2011, 2013]. Other lab findings were categorized with results being controlled according to the accepted cut off points, such as FBS 70–130 mg/day, blood pressure (BP) <130/80 mmHg, low-density lipoprotein (LDL) <100 mg/dl, high-density lipoprotein (HDL) >40 mg/dl in men and >50 mg/dl in women, as well as triglycerides (TG) <150 mg/dl.

Ethical considerations

The study was approved by the Faculty of Pharmacy at the Beirut Arab University, as well as by the director of the clinic from where the patients were recruited. No consent forms were filled, as this study was a retrospective observational chart review. Moreover, confidentiality of all information collected in this study was guaranteed, as well as all data were protected through appropriate measures.

Statistical analyses

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 21. Descriptive statistics was carried by calculating the number and percent for categorical variables and mean and standard deviation for continuous variables. Association between A1C control and the different variables available was carried out by using the chi-square for categorical predictors and independent sample *t*-test for continuous ones. For categorical variables, odds ratios (OR) and 95% confidence intervals (CI) were calculated.

Moreover, to assess the effect of potentially confounding variables, as well to identify the individual impact of the predictors, we carried out stepwise multivariate logistic regression analysis, while reporting the OR and 95% CI. Variables included in the model were those found to be of statistical or clinical significance. A p-value of ≤ 0.05 was considered statistically significant.

Results

In this study, the charts of a total of 700 T2DM patients were evaluated for inclusion. Those on no diabetes medication (88 patients) were excluded from the analyses. Similarly, 61 patients were excluded for missing A1C values, yielding a total of 551 patients who were finally included in the analyses (Figure 1).

Demographic characteristics of the study sample stratified according to A1C control are presented in Table 1. Of the 551 patients included in this study, 175 patients (31.8%) attained A1C control (A1C <7), whereas the remaining patients (68.2%) were diabetically uncontrolled (A1C ⩾7). The average age was 58.5 years (SD 12.4) for the A1C uncontrolled group, and 59.5 years (SD 12.0) for the A1C controlled group, with no statistically significant difference (p = 0.41). There was no association between gender and the two groups, where 58.5% were males in the A1C uncontrolled group and 55.4% males in the A1C controlled group (p = 0.5). As for BMI, there was no difference in the average BMI between the two groups, where 48.7% of the A1C uncontrolled group were obese (BMI ⩾30) as compared with 40.4% among the A1C controlled group (OR 1.15, 95% CI 0.64–2.07). Although there was no significant difference in smoking habits between the two groups, nevertheless, the A1C controlled group were more likely to be alcohol users

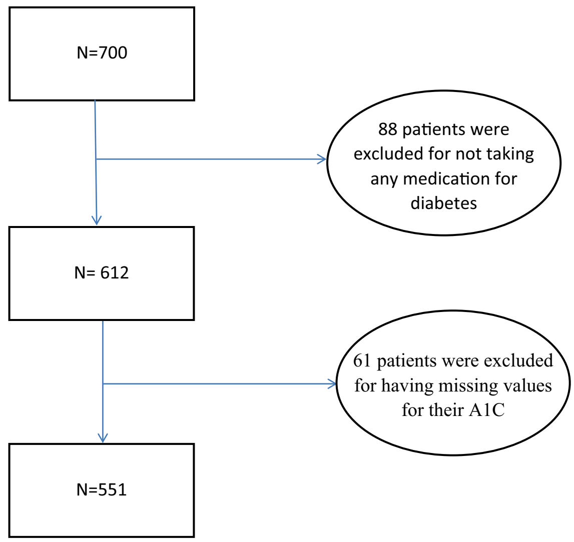

Figure 1. Exclusion criteria for the A1C analysis.

(26.9%) *versus* the A1C uncontrolled group (19.4%), with a *p*-value of 0.05. As for the duration of DM, the A1C uncontrolled group were more likely to have a longer duration of DM; of 6–10 years (OR 2.93, 95% CI 1.55–5.54) and >10 years (OR 3.94, 95% CI 2.03–7.63). Although not statistically significant, the A1C controlled group were more likely to have family history of diabetes (71.4%) compared with the A1C uncontrolled group (66.0%). Regarding the diabetes-related complications, the A1C uncontrolled group were more likely to have macrovascular complication (p = 0.01), neuropathy ($p < 0.0001$), retinopathy (p = 0.04) and albuminuria (p = 0.006) as compared with the A1C controlled group. Finally, A1C uncontrolled group had higher SBP (mean = 133.6 mmHg) and DBP (mean = 79.7 mmHg) as compared with the A1C controlled group (mean SBP = 129.6 mmHg and mean DBP = 78.7 mmHg), with significant *p*-values.

A laboratory data of study sample stratified according to A1C control is presented in Table 2. The A1C uncontrolled group had higher mean FBS (mean 199.5, SD 77.9) as compared with the controlled group (mean 121.1, SD 26.5), with a significant *p*-value (<0.0001). On the other hand, the overall lipid profile (LDL, HDL, TG, and total cholesterol [TC]) was better for the controlled group. More specifically, uncontrolled group were more likely to have an LDL level ⩾100 mg/dl as compared with the controlled group, which was not statistically significant (OR 1.44, 95% CI 0.82–2.53). Similar results were found for the HDL values, where the uncontrolled group had worse HDL levels as compared with the controlled group, with nonsignificant *p*-value (0.23). On the other hand, the A1C uncontrolled group were more likely to have uncontrolled levels of TG (⩾150 mg/dl) and TC (⩾100 mg/dl) as compared with the A1C controlled group (OR 2.08, 95% CI 1.42–3.04 and OR 1.81, 95% CI 1.19–2.75, respectively).

Table 3 summarizes the medications used by the study sample stratified according to A1C control. The antidiabetic medication reported to be used most frequently among the whole sample was metformin (81.7%), followed by sulfonylurea (48.6%), and incretin mimetics (20.3%). As for the insulin, it was noted that insulin alone and insulin in combination with other agents were used by 19.6% and 12.7%, respectively. Moreover, 39.2% used one antidiabetic medication, whereas 41.6% and 19.2% used 2 and ⩾3 medications, respectively. When comparing the two groups, metformin was the only medication that was found to significantly reduce the chances of having uncontrolled A1C (OR 0.47, 95% CI 0.28–0.80). On the other hand, the use of sulfonylureas was found to significantly increase the chances of being uncontrolled (OR 2.85, 95% CI 1.95–4.16). Similar significant results were obtained with patients using insulin alone or in combination with other antidiabetic medications (OR 4.21, 95% CI 2.29–7.76 and OR 4.83, 95% CI 2.16–10.78, respectively). Patients using two medications, compared with those using one, were more likely to be uncontrolled (OR 2.35, 95% CI 1.58–3.50), as well as for those using ⩾3 medications (OR 3.73, 95% CI 2.12–6.56). As for the use of antihypertensive agents and statins, none of the individual medications assessed was found to be significantly associated with A1C control.

Finally, Table 4 presents the results of the multivariate analyses identifying the predictors of poor A1C control. Although diabetes duration was not found to be statistically associated with A1C control, nevertheless it was found that the longer the duration of diabetes the more likely the patient will be diabetically uncontrolled. The chances of having uncontrolled A1C were significantly higher among patients who developed neuropathy (OR 2.08, 95% CI 1.11–3.90), had elevated triglycerides (OR 1.98, 95% CI 1.33–2.94), used insulin (OR 4.52, 95% CI 2.32–8.83), or used sulfonylureas (OR 2.88, 95% CI 1.88–4.40).

Table 1. Study sample demographic characteristics stratified according to A1C control.

		Total *N* (%)	Uncontrolled (A1C ⩾7) *N* (%)	Controlled (A1C <7) *N* (%)	OR (95% CI)	*p*-value
Total sample		*N* = 551	*N* = 376	*N* = 175		
Age (years)	Mean (SD)	58.8 (12.3)	58.5 (12.4)	59.5 (12.0)		0.41
	⩾ 65	180 (32.7%)	123 (32.7%)	57 (32.6%)	1.01 (0.69–1.48)	0.97
Gender	Male	317 (57.5%)	220 (58.5%)	97 (55.4%)	0.88 (0.61–1.27)	0.50
BMI (kg/m²)	Mean (SD)	30.5 (5.5)	30.7 (5.7)	29.9 (5.1)		0.13
	Normal (18.5–24.9)	68 (13.5%)	47 (13.7%)	21 (13.0%)	Reference	
	Overweight (25–29.9)	204 (40.5%)	129 (37.6%)	75 (46.6%)	0.77 (0.43–1.38)	0.38
	Obese (⩾ 30)	232 (46.0%)	167 (48.7%)	65 (40.4%)	1.15 (0.64–2.07)	0.65
Current smoker		309 (56.1%)	210 (55.9%)	99 (56.6%)	0.97 (0.68–1.39)	0.87
Alcohol user		120 (21.8%)	73 (19.4%)	47 (26.9%)	0.66 (0.43–1.00)	0.05
Duration of diabetes	Mean (SD)	8.2 (7.5)	9.4 (7.7)	5.7 (6.5)		<0.0001
	< 1 year	60 (11.1%)	32 (8.6%)	28 (16.6%)	Reference	
	1–5	188 (34.9%)	107 (28.9%)	81 (47.9%)	1.16 (0.65–2.07)	0.63
	6–10	148 (27.5%)	114 (30.8%)	34 (20.1%)	2.93 (1.55–5.54)	0.001
	>10	143 (26.5%)	117 (31.6%)	26 (15.4%)	3.94 (2.03–7.63)	<0.0001
Family history of diabetes		373 (67.7%)	248 (66.0%)	125 (71.4%)	0.78 (0.52–1.15)	0.20
Complications	Macrovascular	135 (24.5%)	104 (27.7%)	31 (17.7%)	1.78 (1.13–2.78)	0.01
	Neuropathy	95 (17.2%)	80 (21.3%)	15 (8.6%)	2.88 (1.61–5.17)	<0.0001
	Retinopathy	37 (6.7%)	31 (8.2%)	6 (3.4%)	2.53 (1.04–6.18)	0.04
	Albuminuria	213 (38.7%)	160 (42.6%)	53 (30.3%)	1.71 (1.16–2.50)	0.006
	Any complication	340 (61.7%)	256 (68.1%)	84 (48.0%)	2.31 (1.60–3.34)	<0.0001
Hypertension		420 (76.2%)	291 (77.4%)	129 (73.7%)	1.22 (0.81–1.85)	0.35
SBP (mmHg)	Mean (SD)	132.3 (18.0)	133.6 (17.9)	129.6 (18.0)		0.02
	Uncontrolled (⩾130)	333 (60.4%)	239 (63.6%)	94 (53.7%)	1.50 (1.05–2.16)	0.03
DBP (mmHg)	Mean (SD)	79.3 (5.6)	79.7 (5.6)	78.7 (5.5)		0.05
	Uncontrolled (⩾80)	447 (81.1%)	312 (83.0%)	135 (77.1%)	1.44 (0.93–2.25)	0.10
SBP or DBP	Uncontrolled (either one)	461 (83.7%)	323 (85.9%)	138 (78.9%)	1.63 (1.03–2.60)	0.04

BMI, body mass index; CI, confidence interval; DBP, diastolic blood pressure; OR, odds ratio; SBP, systolic blood pressure; SD, standard deviation

Discussion

One of the most important outcomes of successful T2DM management is achieving glycemic control, thus reducing the risk of diabetic complications. In this study, the link between elevated A1C levels and the factors associated with this uncontrolled A1C were assessed among a random sample of diabetic outpatients attending an endocrinologist's private clinic in Beirut. In our study, the target A1C of <7% was achieved in only 31.8% of the study sample. As for the predictors of uncontrolled A1C, it was found that neuropathy, uncontrolled triglycerides, insulin or sulfonylurea uses were associated with higher A1C.

The poor A1C control in our study (31.8%) is comparable to findings in several studies reported in the literature among T2DM patients. For instance, a study carried out among a cohort of diabetic patients in Lebanon by Taleb and colleagues in 2008 reported a 30% A1C control [Taleb *et al.* 2008]. In the Middle East, similar results were reported, where Al-Khawaldeh and colleagues found that more than half of the subjects studied had poor diabetic control in Amman, Jordan in 2012 [Al-Khawaldeh *et al.* 2012]. Such a poor control has also been reported in Western countries, such as Canada, where Harris and colleagues found that almost half of T2DM patients at primary care settings across Canada did not achieve their glycemic target [Harris *et al.* 2005]. Despite the new easy methods of home-monitoring of blood glucose, as well as the availability of effective pharmacotherapy, the level of A1C

Table 2. Laboratory data of the study sample stratified according to A1C control.

		Total *N* (%)	Uncontrolled (A1C ⩾7) *N* (%)	Controlled (A1C <7) *N* (%)	OR (95% CI)	*p*-value
Total sample		*N* = 551	*N* = 376	*N* = 175		
FBS (mg/dl)	Mean (SD)	174.6 (75.4)	199.5 (77.9)	121.1 (26.5)		<0.0001
	⩾130	294 (67.1%)	251 (83.9%)	43 (30.9%)	11.7 (7.3–18.8)	<0.0001
LDL (mg/dl)	Mean (SD)	108.0 (38.2)	110.6 (39.5)	102.7 (35.0)		0.03
	<70	68 (14.2%)	43 (13.4%)	25 (15.7%)	Reference	
	70–99.99	150 (31.3%)	91 (28.4%)	59 (37.1%)	0.90 (0.50–1.62)	0.72
	⩾100	261 (54.5%)	186 (58.1%)	75 (47.2%)	1.44 (0.82–2.53)	0.20
HDL (mg/dl)	Mean (SD)	44.0 (12.1)	43.5 (11.5)	45.0 (13.1)		0.23
	Uncontrolled *	278 (57.9%)	190 (59.2%)	88(55.3%)	1.17 (0.80–1.72)	0.42
TG (mg/dl)	Mean (SD)	206.8 (180.8)	228.4 (208.2)	163.1 (90.9)		<0.0001
	Uncontrolled (⩾150)	274 (56.1%)	203 (62.1%)	71 (44.1%)	2.08 (1.42–3.04)	<0.0001
TC (mg/dl)	Mean (SD)	186.3 (49.6)	191.3 (52.8)	176.1 (40.5)		<0.0001
	Uncontrolled (⩾200)	163 (33.3%)	123 (37.4%)	40 (24.8%)	1.81 (1.19–2.75)	0.01

*Uncontrolled for men was at < 40, whereas for women was at < 50.
CI, confidence interval; FBS, fasting blood sugar; HDL, high-density lipoprotein; LDL, low-density lipoprotein; OR, odds ratio; TC, total cholesterol; TG, triglycerides; SD, standard deviation.

Table 3. Medications used by the study sample stratified according to A1C control.

		Total *N* (%)	Uncontrolled (A1C ⩾7) *N* (%)	Controlled (A1C <7) *N* (%)	OR (95% CI)	*p*-value
Total sample		*N* = 551	*N* = 376	*N* = 175		
Antidiabetic agents						
Noninsulin	Metformin	450 (81.7%)	295 (78.5%)	155 (88.6%)	0.47 (0.28–0.80)	0.004
	Sulfonylurea	268 (48.6%)	213 (56.6%)	55 (31.4%)	2.85 (1.95–4.16)	<0.0001
	Incretin mimetics	112 (20.3%)	77 (20.5%)	33 (20.0%)	1.03 (0.66–1.61)	0.90
	Thiazolidinediones	39 (7.1%)	27 (7.2%)	12 (6.9%)	1.05 (0.52–2.13)	0.90
	Others*	22 (4.0%)	20 (5.3%)	2 (1.1%)	4.86 (1.12–21.03)	0.02
Insulin alone		108 (19.6%)	95 (25.3%)	13 (7.4%)	4.21 (2.29–7.76)	<0.0001
Insulin +others		70 (12.7%)	63 (16.8%)	7 (4.0%)	4.83 (2.16–10.78)	<0.0001
Number of medications (Antidiabetic)	1	216 (39.2%)	119 (31.6%)	97 (55.4%)	Reference	
	2	229 (41.6%)	170 (45.2%)	59 (33.7%)	2.35 (1.58–3.50)	<0.0001
	⩾3	106 (19.2%)	87 (23.1%)	19 (10.9%)	3.73 (2.12–6.56)	<0.0001
Antihypertensive agents	ACEi	109 (19.8%)	80 (21.3%)	29 (16.6%)	1.36 (0.85–2.17)	0.20
	ARBs	191 (34.7%)	131 (34.8%)	60 (34.3%)	1.03 (0.70–1.50)	0.90
	BBs	186 (33.8%)	128 (34.0%)	58 (33.1%)	1.04 (0.71–1.52)	0.84
	Diuretics**	154 (27.9%)	110 (29.3%)	44 (25.1%)	1.23 (0.82–1.85)	0.32
	CCBs	102 (18.5%)	68 (18.1%)	34 (19.4%)	0.92 (0.58–1.45)	0.71
	Alpha-2 agonist	7 (1.3%)	6 (1.6%)	1 (0.6%)	2.82 (0.34–23.62)	0.32
Statins		272 (49.4%)	180 (47.9%)	92 (52.6%)	0.83 (0.58–1.19)	0.30

*Those include acarbose or repaglinide.
**Those taking thiazides and spironolactones.
ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BB, beta blockers; CCB, calcium channel blocker; CI, confidence interval; OR, odds ratio.

Table 4. Multivariate analyses of the predictors of uncontrolled A1C.

Predictor	Adjusted OR (95% CI)	*p*-value
Diabetes duration (1–5 years)	0.93 (0.51–1.73)	0.83
Diabetes duration (6–10 years)	1.84 (0.93–3.62)	0.08
Diabetes duration (>10 years)	1.57 (0.76–3.22)	0.22
Neuropathy	2.08 (1.11–3.90)	0.02
Uncontrolled triglyceride	1.98 (1.33–2.94)	0.001
Antidiabetic agent insulin	4.52 (2.32–8.83)	<0.0001
Antidiabetic agent sulfonylurea	2.88 (1.88–4.40)	<0.0001

Variables included in the model were: age, gender, BMI (overweight), BMI (obese), current smoker, alcohol user, diabetes duration (6–10 years), diabetes duration (>10 years), family history of diabetes, macrovascular complications, neuropathy complications, retinopathy complications, albuminuria complications, uncontrolled low-density lipoprotein, uncontrolled high-density lipoprotein, uncontrolled triglycerides, uncontrolled total cholesterol, antidiabetic agents (metformin, sulfonylurea, incretin mimetics, thiazolidinediones, insulin), number of antidiabetic agents.
CI, confidence interval; OR, odds ratio.

control in our study was relatively poor. This may be attributable to many factors, such as a lack of awareness towards the management and complications of T2DM, which might lead to noncompliance to pharmacotherapy, proper diet and regular exercise [Brunetti and Kalabalik, 2012; World Health Organization, 2013].

Moreover, a high percentage of patients was found to be obese (46%) with no significant difference in A1C control between the two groups. This prevalence is alarming and highlights the need for more stringent implementation of diet and weight management in T2DM patients. In addition, the duration of DM in our study was not found to be significantly affecting A1C control; nevertheless, it was found that increasing duration of the disease resulted in higher A1C levels. Although self-care skills could improve with longer duration of DM, yet resistance to medication and the need for higher doses or additional medications may increase over time along with the progressive nature of the disease and this may explain why glycemic control was found to deteriorate with increasing DM duration.

Results from this study demonstrate that the majority (81.7%) of diabetic patients used metformin, followed by 48.6% who used sulfonylureas. These findings fall in line with the American Diabetes Association (ADA), as well as the European Association for the Study of Diabetes (EASD) algorithm for managing diabetes with metformin recommended as a first-line treatment while sulfonylureas as add-on therapy [Centers for Disease Control and Prevention, 2013]. As for incretin mimetics and insulin, they were almost equally prescribed (20.3% and 20.5%, respectively), illustrating how this new class of antidiabetic drugs is being incorporated into treatment regimens as much as insulin, the first antidiabetic class discovered in history.

As for the predictors of poor A1C control in our study, patients with neuropathy were almost twice as likely to have uncontrolled A1C. It has been reported in a study carried out by El-Salem and colleagues that A1C is strongly associated with neuropathy with an adjusted OR of 10.71 ($p < 0.005$) [El-Salem *et al.* 2009]. This might be due to delay in treating the early stages of the disease. On the other hand, some papers did not find an association between complications and A1C control, such as a study carried out by Fox and colleagues among T2DM patients in the UK [Fox *et al.* 2006].

Moreover, diabetics with uncontrolled A1C levels were more likely to have higher triglycerides. Similar results were found in a study carried out by Mullugeta and colleagues who reported that significant correlations were evident between A1C and dyslipidemia, particularly serum TG (correlation coefficient = 0.28, $p < 0.05$) [Mullugeta *et al.* 2012]. Similarly, Goudswaard and colleagues reported worse glycemic control with high levels of TG [Goudswaard *et al.* 2004]. Such an association can be attributed to insulin resistance which causes high TG levels in the blood.

Unpredictably, we found that patients using either insulin or sulfonylurea were more likely to have uncontrolled A1C levels. Similar research have reported worse A1C control with the use of insulin. For instance, a study carried out in Jordan found that the use of insulin was statistically significant predictor for poor glycemic control [Al-Khawaldeh *et al.* 2012]. Another study carried out in Europe reported a significant association between treatment with insulin and poor A1C control (OR 7.2, 95% CI 4.18–12.52) [Goudswaard *et al.* 2004]. This poor control could be related partially to the unmet need of self-monitoring of blood glucose in diabetic patients on insulin therapy due to the high cost of supplies. As for sulfonylureas, studies also showed worse A1C control in association with using this medication, such as a study carried out by Morgan and colleagues in UK, which reported that sulfonylurea monotherapy resulted in worse A1C control [Morgan *et al.* 2012]. Our results could be attributed to the fact that sulfonylureas and insulin usually serve as add-on therapy for patients who fail to attain the A1C target after their initial first line therapy. It is noteworthy that worse A1C control was associated with use of multiple antidiabetic agents in other findings as well [Benoit *et al.* 2005; Willey *et al.* 2006]. Finally, the findings of this study pertaining to both insulin and sulfonylurea could be due to the fact that this study did not take into account neither the duration of treatment with these agents nor the dosage regimen used, thus it will be inaccurate to draw conclusions based on this finding without further studies.

All other factors considered in this study were not found to significantly affect the level of A1C control. Some of these findings are supported by some, but not all, research. [Goudswaard *et al.* 2004; Fox *et al.* 2006; Ratsep *et al.* 2010; Al-Lawati *et al.* 2012; Angamo *et al.* 2013].

Our study has not shown worse A1C outcomes with use of statins. Based on findings that have associated statin use with increased A1C levels, it was expected to find less A1C control among statins users. In contrast, better, yet not significant, A1C control was achieved by patients receiving statins than in those not treated with statins (52.6% and 47.9%, respectively; $p = 0.3$) [US Food and Drug Administration, 2013].

This study has to be evaluated in light of its strengths and limitations. The main strength of our study is it being among few addressing the state of glycemic control among diabetic patients in Lebanon. As for the limitations, the study was cross-sectional in one center with the last visit only taken into consideration, with no follow-up for patients. Accordingly, no information was available for the number of previous visits to the physician, thus, one reading for some variables may not be representative such as BP, hypertension and albuminuria. Another limitation is the missing information on dosages of medication, duration of treatment, counselling and compliance with lifestyle modifications (diet and exercise).

We carried out the study with a convenient sample, where sample size calculation was not carried out. Nevertheless, we carried out power calculation with the sample achieved. Thus, for the observed prevalence of A1C control of 31.8%, the study had a margin of error of 4% for the estimation of the prevalence at the 95% confidence, where the calculated 95% CI is 28–32.

As for the missing values, most of the variables had complete information, nevertheless, for those variables that had missing information, it did not exceed 5% in any of the variable. Thus, for the multivariate analyses, we replaced the missing values of continuous variables by the mean value of that variable. As for the categorical variables, we replaced the missing values by the available categories in such a way the overall distribution of the variable was maintained.

Finally, generalizability of this study is limited due to the sample selection from a subspecialty clinic, which might have led to an overestimation of the actual level of A1C control in the community.

Conclusion

Results of this study showed that control of DM in Lebanon (31.8%) still needs to be improved and increased efforts are necessary to treat diabetic patients to target, as well as to identify barriers for comprehensive T2DM management. Our study showed a prevalence of DM in patients relatively young in age, which is the age of productivity, which was consistent with other similar studies [Lerman-Garber *et al.* 2010]. This may affect the quality of life of those diabetic patients, their financial status, their sexual functioning, as well as their social well-being [Pera, 2011]. The results of this study present information to healthcare providers regarding the factors influencing A1C control, therefore, it highlights the need for more campaigns to be conducted in Lebanon to emphasize the importance of comprehensive DM management among patients and physicians, as well as pharmacists who should have a role in counselling the patient to promote improved management of diabetes.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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