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Current status of glucose, blood pressure and lipid management in type 2 diabetes clinic attendees in Isfahan, Iran

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ABSTRACT

Aims/Introduction: To estimate the prevalence of meeting American Diabetes Association clinical practice recommendations for hemoglobin A1c (HbA1c), blood pressure (BP) and low-density lipoprotein cholesterol (LDLC) among Iranian type 2 diabetes clinic attendees, and to identify the factors associated with therapeutic target achievement.

Materials and Methods: A total of 2,640 patients with type 2 diabetes (944 men and 1,696 women) from Isfahan Endocrine and Metabolism Research Center outpatient clinics, Iran, were examined. The main outcome measures were HbA1c, BP and LDLC, in accordance with the American Diabetes Association recommendations. The mean (standard deviation) age of participants was 49.6 years (9.3 years) with a mean (standard deviation) duration of diabetes of 5.0 years (4.9 years) at initial registration.

Results: The percentages of patients who had HbA1c <7%, BP <140/90 mmHg and LDLC <100 mg/dL was 37.4% (95% confidence interval [CI] 35.6–39.3), 35.3% (95% CI 33.5–37.3) and 48.9% (95% CI 47.0–50.8), respectively. The proportion of patients meeting all three goals was 7.7% (95% CI 6.7–8.8). Lower BP, cholesterol level and higher education at registration, and higher follow up but lower number of follow-up visits affected achievement of all three goals.

Conclusions: The present study highlights that a substantial proportion of Iranian type 2 diabetes clinic attendees did not meet the American Diabetes Association clinical practice recommendations, and shows the difficult challenges physicians face when treating patients with type 2 diabetes.

INTRODUCTION

The goal of management of type 2 diabetes is improving the efficiency of diabetes care, and to maintain blood glucose, blood pressure (BP) and cholesterol levels in the near-normal range to prevent vascular complications associated with type 2 diabetes, improving their chances of survival as well as their quality of life. It is well established that improved BP, lipid and glycemic control lead to a decrease in development and progression of vascular complications[1–4]. Therefore, the American Diabetes Association (ADA) recommends that patients with type 2 diabetes achieve a hemoglobin A1c (HbA1c) <7%, BP <140/90 mmHg and low-density lipoprotein cholesterol (LDLC) <100 mg/dL[5]. Despite these clinical practice recommendations, and the availability of evidence-based guidelines and vast knowledge about the complications of diabetes, clinical goals for diabetes outcomes are not being achieved in routine care as a result of insufficient treatment, continuously progressing characteristic of diabetes, changing life styles, various causes of diabetes and so on[2,3,5–7]. Although abundant studies have examined the ADA recommendations for clinical practice for HbA1c, BP and LDLC in cross-sectional reports, mostly in developed countries, just a few studies have reported the results of a longitudinal analysis on the proportion of patients achieving all three goals in clinical practice settings, and none of them were undertaken in Middle Eastern countries and in Iranian patients with type 2 diabetes receiving routine care.

There is also limited information about which patient characteristics are associated with poorer control of BP, lipid and glycemia. Information on predictors of poor control of these risk

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factors can lead to identification of patients who might have more difficulty controlling their diabetes.

The primary objectives of the present study, therefore, were to estimate the proportion of patients with type 2 diabetes meeting HbA1c, BP and LDLC goals in accordance with the ADA recommendations, and to identify the factors associated with therapeutic target achievement using routinely collected data from a clinical information system for diabetes at Isfahan Endocrine and Metabolism Research Center, Iran. Our hypothesis was that in adult patients with type 2 diabetes, HbA1c, BP and LDLC are not sufficiently controlled. The present study could also serve as a platform for future comparison with other studies and with the results obtained in other parts of Iran.

PATIENTS AND METHODS

Data Source

The present study was a prospective registry analysis that used data from the clinical information system at Isfahan Endocrine and Metabolism Research Center, Iran, an ongoing data collection initiative in central Iran to collect, analyze and disseminate data in a standardized manner. The recruitment methods and examination procedures of the Isfahan Endocrine and Metabolism Research Center outpatient clinics have been described before[8]. Briefly, clinical data were collected for all consecutive patients at the first attendance and at review consultations (usually annually) using standard encounter forms. These included an examination of ocular fundus, lens, limbs and BP, and construction of a problem list by the clinician, including measurement of height, weight, fasting plasma glucose (FPG), HbA1c, urine protein, triglyceride, cholesterol, LDLC, high-density lipoprotein cholesterol and serum creatinine, and reporting of smoking as part of a completed questionnaire on demography, family history and smoking by the patient.

All patients were referred for the diabetes education program after the start of the therapy by qualified nutritionists. The diabetes education classes included six 2-h classes emphasizing the importance of carbohydrate counting, exercise, oral and injectable medications, and microvascular and macrovascular complications of diabetes. The mechanisms of actions of diabetes medications along with proper dosing and use were reviewed, the definition and proper treatment for hypoglycemia were explained, and the importance of exercise and proper foot care were described. A computerized patient registry provided data on patient characteristics, medications and laboratory values.

Patients

Between 1992 and 2013, a total of 15,347 patients with gestational diabetes, and type 1 and type 2 diabetes were registered in the system. Type 1 diabetes and women with diabetes diagnosed only during pregnancy were excluded. In order to be included in the analyses, a patient had to have ≥2 HbA1c, BP and LDLC measurements. However, the present study used data for just 2,640 (944 (35.8%) men and 1,696 (64.2%) women) patients with type 2 diabetes for whom complete data were available.

Predictors of controlled BP, lipid and HbA1c (measured by ion-exchange chromatography) were assessed using the following data from the patient's registration consultation: sex, age at diagnosis, age, educational level, time since diagnosis of diabetes, body mass index (BMI; weight/height^2 [kg/m^2]), smoking status (never, current), FPG, serum creatinine, triglyceride, cholesterol, high-density lipoprotein cholesterol (measured using standardized procedures), LDLC (calculated by the Friedwald equation[14]) and BP (systolic and diastolic) at initial registration, and the number of follow-up visits and follow-up duration.

Height (assessed at baseline only) and weight were measured with participants in light clothes and without shoes using standard apparatus. Weight was measured to the nearest 0.1 kg on a calibrated beam scale. Height was measured to the nearest 0.5 cm with a measuring tape. A physician measured the systolic and diastolic BPs of seated participants after they had been seated for 10 min by using a mercury column sphygmomanometer and standard techniques.

The study was carried out in accordance with the guidelines proposed in the World Medical Association Declaration of Helsinki of 1975, as revised in 2008[9], and was approved by the institutional review board of Isfahan University of Medical Sciences, Iran. Informed consent was obtained from all patients included in the study.

Definitions

HbA1c level of <7% (<53 mmol/mol), BP <140/90 mmHg and LDLC <100 mg/dL was used to show optimal glycemic, BP and LDLC control; this benchmark was established by the recent ADA as the clinical practice recommended target[5]. Smoking was estimated from self-report, and categorized in current and non-smokers.

The physician defined diabetes as FPG ≥200 mg/dL or pharmacological treatment. If FPG was ≥126 mg/dL and <200 mg/dL, a second FPG was measured on another day. If the second FPG was also ≥126 mg/dL, participants were considered as persons with type 2 diabetes. Those with FPG <126 mg/dL underwent a standard oral glucose tolerance test (75-g glucose 2 h), and if FPG was ≥126 and/or 2-h plasma glucose was ≥200 mg/dL, patients were considered to have type 2 diabetes[10].

Statistical Analysis

Statistical methods used included the descriptive statistics for continuous variables and percentages for categorical variables, Student's *t*-test (for normally distributed variables), Mann–Whitney *U*-test (for not normally distributed variables), χ^2-test, forward stepwise multiple logistic regression model to determine independent predictors of optimal BP, LDLC and HbA1c, and all three goals were attained using SPSS version 18.0 for Windows (SPSS Inc., Chicago, IL, USA), which simultaneously adjusts for other covariates. For multiple logistic regression analysis, age, age at diagnosis of diabetes, FPG, systolic BP,

total cholesterol, triglyceride, BMI, years since diabetes diagnosis, follow-up period and number of follow-up visits were included as continuous variables. BP, LDLC, HbA1c and sex were included as dichotomous variables. Educational level (less than high school, high school and college graduate) were included as trichotomous variables, and therapeutic regimen (diet, oral agent, insulin, and insulin and oral agent) as quadrichotomous variables. Four separate models were constructed using the following dependent variables: achievement of (i) BP <140/90; (ii) HbA1c <7; and (iii) LDLC <100; and all three goals at last clinic visit. Age-adjusted means were calculated and compared using general linear models. We used non-overlapping 95% confidence intervals (CI) as an indicator of significance and did not adjust for multiple testing, because this could have led to misinterpretation of the data[11]. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

RESULTS

Characteristics

Patients had mean (standard deviation) duration of diabetes 5.0 years (4.9 years) and mean age of 49.6 years (9.3 years) at initial registration. The average time of follow up was 10.9 years (4.3 years) (range 4–20 years). The average number of follow-up visits was 34.1 times (20.3 times; range 4–114 visits). A total of 23.6% of men and 1.3% of women were smoking. The mean (standard deviation) BMI was 28.2 kg/m^2 (4.5 kg/m^2). Most of the patients at enrolment were obese or overweight (77.3%).

The characteristics of patients at initial registration and last clinic visit are presented in Table 1. Patients at the last clinic visit had higher weight, BMI and creatinine, and had lower FPG, HbA1c, triglyceride, cholesterol, LDLC and systolic BP than at initial registration ($P < 0.001$). The frequency of insulin use was higher at the last clinic visit, whereas the frequency of hypoglycemic medication and diet was lower at the last visit. A total of 44.9% of all patients were using hypoglycemic medication, and 45.8% were treated with insulin (including 32.0% who used both insulin and oral agents) by the last visit. A total of 19.2% of the patients had systolic BP ≥140 mmHg, 58% had diastolic BP ≥90 mmHg and half of the patients (50.5%) had LDLC ≥100 mg/dL. A total of 62.6% of patients had HbA1c ≥7%, and 14.0% of participants had HbA1c levels that were higher than 9.5% at the last clinic visit. The mean (standard deviation) of HbA1c was 7.7% (1.8), and FPG was 155.3 mg/dL (56.8 mg/dL) by the last clinic visit. The proportion of patients meeting individual (except BP) and all three goals increased significantly at the last clinic visit. The proportion of patients with normal weight (BMI <25 kg/m^2) decreased during the study period.

Prevalence of Achieved Individual and Triple Goals

Of the 2,640 patients with type 2 diabetes, 988 had HbA1c <7% (37.4%; 95% CI 35.6–39.3), 932 had BP <140/90 mmHg (35.3%; 95% CI 33.5–37.1) and 1,201 had LDLC <100 mg/dL (45.5; 95% CI 43.6–47.4) at the last clinic visit (Table 1).

The proportion of attainment of all three therapeutic target achievements was 7.7% (n = 204; 95% CI 6.7–8.8). The proportion of attainment of two goals was 44.0% (n = 1,161; 95% CI 42.1–45.9), one goal 78.2% (n = 2,065; 95% CI 76.6–79.8) and 21.8% (n = 575; 95% CI 20.2–23.4) did not meet any of the three goals.

Factors Associated With Individual and Triple Target Achievement

To determine the influence of potential factors on meeting each goal, univariate analysis was first carried out (Table 2). An age-adjusted analysis showed that those with HbA1c ≥7% were younger at diabetes diagnosis, and had a higher duration of diabetes, FPG, HbA1c, cholesterol and LDLC, were taking an oral agent or insulin treatment, and had lower education at initial registration. Those with BP ≥140/90 mmHg were older and older at diabetes diagnosis, women, and had a higher BMI, BP, HbA1c, triglycerides, cholesterol and LDLC, but a lower level of education at initial registration. Those with LDLC ≥100 mg/dL were women, and had a higher HbA1c, cholesterol and LDLC, but lower high-density lipoprotein cholesterol at initial registration.

Table 3 shows the group means (standard error) and proportions for those patients with type 2 diabetes who attained all of the three goals and attained some goals. Those who attained all of the three goals were more likely to be men, and had lower systolic and diastolic BP, FPG, HbA1c, cholesterol, triglyceride, and LDLC, and had a higher educational level at initial registration. Those who attained all of the three goals had a higher proportion of oral agent use, but a lower portion of insulin use at the last clinic visit.

The prevalence of attaining some goals was also analyzed with a multivariate model. Multiple logistic regression showed that high school education (odds ratio [OR] 1.69, 95% CI 1.09–2.69), higher systolic BP (OR 1.01, 95% CI 1.002–1.023) and cholesterol (OR 1.006, 95% CI 1.002–1.009) at initial registration, and higher follow-up duration (OR 1.07, 95% CI 1.01–1.12) significantly increased and number of follow-up visits (OR 0.98, 95% CI 0.97–0.99) significantly decreased the risk of not attaining all of the three goals compared with those attaining all of the three goals (Table 4). No other variables were significant.

The strength and statistical significance of the relationship of baseline characteristics to HbA1c ≥7%, BP ≥140/90 mmHg and LDLC ≥100 mg/dL were also tested by multiple logistic regressions. The findings of this analysis showed that younger age at diagnosis of diabetes, higher FPG at initial registration and higher follow-up duration significantly increased, and treatment with insulin, insulin and oral agent, and the number of follow-up visits significantly decreased the risk of having HbA1c values ≥7% compared with HbA1c <7%. Those with BP ≥140/90 mmHg were older and older at diabetes diagnosis, and had

Table 1 | Characteristics of 2,640 patients with type 2 diabetes mellitus at registration and last follow-up visit

Characteristics	Mean (SD) or proportion		Difference (95% CI)
	Registration	Last follow-up visit	
Age (years)	49.6 (9.3)	60.5 (10.6)	10.9 (100.7, 11.0)*
Age at diagnosis (years)	44.6 (9.2)	–	–
Years since diabetes diagnosis	5.0 (4.9)	15.9 (6.9)	10.9 (10.7, 11.0)*
No. follow-up visit	–	34.1 (20.3)	–
Follow-up duration (years)	–	10.9 (4.3)	–
Weight (kg)	71.4 (12.3)	73.5 (12.5)	2.1 (1.8, 2.4)*
Height (cm)	159.1 (8.8)	–	–
BMI (Kg/m^2)	28.3 (4.4)	29.3 (5.0)	1.1 (0.9, 1.2)*
Systolic BP (mmHg)	123.3 (18.0)	122.2 (18.3)	−1.1 (−1.9, −0.3)*
Diastolic BP (mmHg)	76.1 (12.2)	76.6 (10.3)	0.5 (−0.05, 1.1)
Fasting plasma glucose (mg/dL)	186.0 (70.0)	155.3 (56.8)	−30.7 (−33.9, −27.5)*
HbA1c (%)	8.6 (2.2)	7.7 (1.8)	−0.9 (−1.0, −0.8)*
Creatinine (mol/L)	0.90 (0.63)	1.06 (0.43)	0.16 (0.13, 0.18)*
Estimated glomerular filtration rate (mL/min)	111.1 (38.6)	94.3 (30.5)	−16.8 (−18.2, −15.4)*
Triglyceride (mg/dL)	217.5 (140.2)	163.6 (82.4)	−54.1 (−58.9, −48.9)*
Cholesterol (mg/dL)	216.8 (49.2)	176.1 (37.8)	−40.7 (−42.8, −38.7)*
High density lipoprotein (mg/dL)	44.9 (11.5)	44.9 (12.1)	0.0 (−0.54, 0.40)
Low density lipoprotein (mg/dL)	128.3 (41.5)	104.5 (31.5)	−23.8 (−25.6, −22.0)*
Sex (%)			
Men	944 (35.8)	–	–
Women	1,696 (64.2)	–	–
Therapeutic regimen (%)			
Diet	569 (21.6)	245 (9.3)	−12.3 (−14.2, −10.4)*
Oral agent	1,809 (68.5)	1,185 (44.9)	−23.6 (−26.3, −21.0)*
Insulin	193 (7.3)	364 (13.8)	6.5 (4.8, 8.1)*
Insulin and oral agent	69 (2.6)	846 (32.0)	29.4 (27.6, 31.3)*
Education (%)			
Less than high school	1,788 (70.6)	–	–
High school	472 (18.6)	–	–
College graduate	271 (10.7)	–	–
Smoking (%)			
Non-smoker	2,481 (94.0)	–	–
Current-smoker	159 (6.0)	–	–
HbA1c (%)			
<7%	679 (25.7)	988 (37.4)	11.7 (9.2, 14.2)*
7–9.5%	1,172 (44.4)	1,283 (48.6)	4.2 (1.5, 6.9)*
>9.5%	789 (29.9)	369 (14.0)	−15.9 (−18.1, −13.7)*
LDLC <100 mg/dL	598 (22.7)	1,201 (45.5)	22.8 (20.4, 25.3)*
Systolic BP <140 mmHg	2,054 (77.8)	2,132 (80.8)	−3.0 (−5.7, −0.5)*
Diastolic BP <90 mmHg	1,223 (46.3)	1,108 (42.0)	−4.3 (−7.0, −1.7)*
BP <140/90 mmHg	1,986 (75.2)	932 (35.3)	−39.9 (−42.4, −37.5)*
HbA1c <7%, BP <140/90 mmHg and LDLC <100 mg/dL	156 (5.9)	204 (7.7)	1.8 (0.4, 3.1)*
Weight category (%)			
Normal weight (BMI <25.0 kg/m^2)	579 (22.7)	445 (17.4)	−5.3 (−7.4, −3.1)*
Overweight (BMI 25–29.9 kg/m^2)	1,169 (45.8)	1,073 (42.0)	−3.8 (−6.5, 1.0)*
Obese (BMI ≥30.0 kg/m^2)	804 (31.5)	1,034 (40.5)	9.0 (6.4, 11.6)*

Total number of at risk is not the same for each variable because of missing values. *P < 0.001. BMI, body mass index; BP, blood pressure; CI, confidence interval; HbA1c, hemoglobin A1c; LDLC, low-density lipoprotein cholesterol.

a higher BMI and BP at initial registration. Those with LDLC ≥100 mg/dL were younger and had higher cholesterol, but a lower number of follow-up visits (Table 4).

DISCUSSION

Control of BP, lipid and glycemia are essential components for the prevention of type 2 diabetes complications. These

Table 2 | Prevalence rate and odds ratio of hemoglobin A1c <7.0% (<53 mmol/mol), blood pressure <140/90 mmHg and low-density lipoprotein cholesterol <100 mg/dL by baseline variables in 2,640 patients with type 2 diabetes, Isfahan, Iran

Characteristics	*n* (%)	HbA1c <7.0%	Age-adjusted OR (95% CI)	BP <140/ 90 mmHg	Age-adjusted OR (95% CI)	LDLC <100 mg/dL	Age-adjusted OR (95% CI)
n (%)	2,640 (100)	988 (37.4)	–	964 (36.5)	–	1,290 (48.9)	–
Age (years)							
30–40	346 (13.1)	117 (33.8)	1.00	206 (59.7)	1.00	170 (49.1)	1.00
40–49	970 (36.8)	354 (36.5)	1.12 (0.87, 1.45)	402 (41.4)	0.48 (0.37, 0.61)***	451 (46.5)	0.90 (0.70, 1.14)
50–59	938 (35.6)	357 (38.1)	1.20 (0.92, 1.55)	282 (30.1)	0.29 (0.22, 0.38)***	457 (48.7)	0.98 (0.76, 1.25)
≥60	384 (14.6)	157 (40.9)	1.35 (1.00, 1.82)	40 (10.4)	0.08 (0.05, 0.12)***	212 (55.2)	1.27 (0.95, 1.70)
Age at diabetes diagnosis (years)							
<30	110 (4.2)	25 (22.7)	1.00	66 (60.0)	1.00	51 (46.4)	1.00
30–59	2,341 (89.5)	877 (37.5)	2.04 (1.29, 3.21)**	839 (35.8)	0.37 (0.25, 0.55)***	1,139 (48.7)	1.10 (0.75, 1.61)
≥60	166 (6.3)	75 (45.2)	2.80 (1.63, 4.81)***	19 (11.4)	0.09 (0.05, 0.16)***	86 (51.8)	1.24 (0.77, 2.02)
Years since diabetes diagnosis							
<5	1,576 (60.2)	645 (40.9)	1.00	627 (39.8)	1.00	745 (47.3)	1.00
5–7.9	480 (18.3)	169 (35.2)	0.76 (0.61, 0.94)*	158 (32.9)	0.85 (0.68, 1.06)	243 (50.6)	1.12 (0.91, 1.37)
8–11.9	298 911.40	95 (31.9)	0.63 (0.48, 0.82)**	83 (27.9)	0.72 (0.55, 0.96)*	158 (53.0)	1.22 (0.95, 1.57)
≥12	266 (10.2)	71 (26.7)	0.46 (0.34, 0.62)***	58 (21.8)	0.69 (0.50, 0.95)*	130 (48.9)	0.99 (0.76, 1.29)
BMI (kg/m^2)							
<25	580 (22.7)	207 (35.7)	1.00	241 (41.6)	1.00	301 (51.9)	1.00
25–29	1,174 (45.9)	464 (39.5)	1.01 (0.80, 1.26)	453 (38.6)	0.86 (0.70, 1.07)	576 (49.1)	0.89 (0.73, 1.09)
≥30	806 (31.5)	285 (35.4)	1.19 (0.99, 1.44)	213 (26.4)	0.43 (0.34, 0.55)***	377 (46.8)	0.82 (0.67, 1.02)
Systolic BP (mmHg)							
<140	2,054 (77.8)	772 (37.6)	1.00	903 (44.0)	1.00	987 (48.1)	1.00
140–159	424 (16.1)	161 (38.0)	0.96 (0.77, 1.20)	26 (6.1)	0.10 (0.07, 0.15)***	277 (53.5)	1.18 (0.96, 1.47)
≥160	162 (6.1)	55 (34.0)	0.78 (0.55, 1.10)	3 (1.9)	0.04 (0.01, 0.11)***	76 (46.9)	0.89 (0.64, 1.23)
Diastolic BP (mmHg)							
<80	2,091 (79.2)	787 (37.6)	1.00	871 (41.7)	1.00	1,021 (48.8)	1.00
80–90	416 (15.8)	154 (37.0)	0.95 (0.76, 1.18)	55 (13.2)	0.23 (0.17, 0.32)***	207 (49.8)	1.01 (0.82, 1.25)
≥90	133 (5.0)	47 (35.3)	0.88 (0.61, 1.27)	6 (4.5)	0.07 (0.03, 0.16)***	62 (46.6)	0.89 (0.62, 1.26)
Fasting plasma glucose (mg/dL)							
<100	96 (3.6)	49 (51.0)	1.00	55 (57.3)	1.00	48 (50.0)	1.00
100–125	383 (14.5)	186 (48.6)	0.91 (0.58, 1.43)	148 (38.6)	0.46 (0.28, 0.74)**	181 (47.3)	0.87 (0.55, 1.36)
≥126	2,161 (81.9)	753 (34.8)	0.51 (0.34, 0.78)**	729 (33.7)	0.36 (0.23, 0.56)***	1,061 (49.1)	0.93 (0.62, 1.41)
HbA1c, % (mmol/mol)							
<7.0 (<53)	679 (25.7)	366 (56.8)	1.00	321 (47.3)	1.00	356 (52.4)	1.00
7–9.4 (53–79)	1,172 (44.4)	411 (35.1)	0.41 (0.33, 0.49)***	388 (33.1)	0.57 (0.46, 0.69)***	566 (48.3)	0.83 (0.69, 1.00)
≥9.5 (≥80)	789 (29.9)	191 (24.2)	0. 24 (0.19, 0.30)***	223 (28.3)	0. 45 (0.36, 0.56)***	368 (46.6)	0.77 (0.63, 0.95)*
Triglyceride (mg/dL)							
<150	889 (33.7)	355 (39.9)	1.00	330 (37.1)	1.00	442 (49.7)	1.00
150–449	1,608 (60.9)	585 (36.4)	0.86 (0.73, 1.02)	557 (34.6)	0.89 (0.74, 1.06)	782 (48.6)	0.96 (0.81, 1.13)
≥450	143 (5.4)	48 (33.6)	0.78 (0.53, 1.13)	45 (4.8)	0.67 (0.45, 1.00)*	66 (46.2)	0.88 (0.62, 1.25)
Cholesterol (mg/dL)							
<200	1,032 (39.1)	427 (41.4)	1.00	449 (43.5)	1.00	600 (58.1)	1.00
200–219	456 (17.3)	188 (41.2)	0.98 (0.78, 1.22)	145 (31.8)	0.61 (0.48, 0.77)***	215 (47.1)	0.64 (0.51, 0.80)***
>220	1,151 (43.6)	372 (32.3)	0.66 (0.55, 0.79)***	338 (29.4)	0.57 (0.47, 0.68)***	474 (41.2)	0.50 (0.42, 0.59)***
HDLC (mg/dL)							
≥40	1,734 (65.7)	638 (36.8)	1.00	617 (35.6)	1.00	808 (46.6)	1.00
<40	906 (34.3)	350 (38.6)	0.93 (0.79, 1.10)	315 (34.8)	0.98 (0.82, 1.17)	482 (53.2)	0.78 (0.66, 0.91)**
LDLC (mg/dL)							
<100	598 (24.5)	244 (40.8)	1.00	234 (26.0)	1.00	374 (62.5)	1.00
≥100	1,844 (75.5)	677 (36.7)	0.83 (0.68, 0.99)*	666 (74.0)	0.66 (0.54, 0.80)***	827 (44.8)	0.48 (0.40, 0.58)***
Sex (%)							
Men	944 (35.8)	373 (39.5)	1.00	366 (38.8)	1.00	498 (52.8)	1.00
Women	1,696 (64.2)	615 (36.3)	0.89 (0.75, 1.05)	565 (33.3)	0.62 (0.52, 0.74)***	792 (46.7)	0.80 (0.68, 0.94)**

Table 2 (*Continued*)

Characteristics	*n* (%)	HbA1c <7.0%	Age-adjusted OR (95% CI)	BP <140/ 90 mmHg	Age-adjusted OR (95% CI)	LDLC <100 mg/dL	Age-adjusted OR (95% CI)
Therapeutic regimen (%)							
Diet	569 (21.6)	266 (46.7)	1.00	218 (38.3)	1.00	275 (48.3)	1.00
Oral agent	1,809 (68.5)	658 (36.4)	0.39 (0.27, 0.56)***	615 (34.0)	0.97 (0.67, 1.39)	887 (49.0)	0.98 (0.71, 1.36)
Insulin	193 (7.3)	49 (25.4)	0.64 (0.53, 0.78)***	72 (37.3)	0.93 (0.76, 1.14)	93 (48.2)	1.01 (0.83, 1.22)
Insulin and oral agent	69 (2.6)	15 (21.7)	0.31 (0.17, 0.56)***	27 (39.1)	1.27 (0.74, 2.16)	35 (50.7)	1.07 (0.65, 1.76)
Education (%)							
Less than high school	1,788 (70.6)	636 (35.6)	1.00	539 (30.1)	1.00	858 (48.0)	1.00
High school	472 (18.6)	183 (38.8)	1.19 (0.96, 1.47)	231 (48.9)	1.97 (1.59, 2.45)***	244 (51.7)	1.19 (0.97, 1.46)
College graduate	271 (10.7)	132 (48.7)	1.74 (1.35, 2.26)***	130 (48.0)	2.23 (1.70, 2.92)***	142 (52.4)	1.20 (0.93, 1.55)
Smoker (%)	159 (6.0)	53 (33.3)	1.01 (0.71, 1.42)	46 (28.9)	0.87 (0.60, 1.27)	85 (53.5)	0.82 (0.59, 1.14)

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. Total number of at risk is not the same for each variable because of missing values. Odds ratio (OR; with 95% confidence interval [CI]) calculated by multiple logistic regression. BMI, body mass index; BP, blood pressure; HbA1c, hemoglobin A1c; HDLC, high density lipoprotein cholesterol; LDLC, low density lipoprotein cholesterol.

findings suggest that just 7.7% of patients with type 2 diabetes met all three therapeutic target achievements. The average HbA1c level in our type 2 diabetes patients was 7.7% at the last clinic visit. This is similar to HbA1c in the UK (7.8%), the USA (7.7%)[12] and Eastern Europe (7.7%)[13]. The estimate of HbA1c control, defined as HbA1c <7%, was 37.4%. This compares unfavorably with the USA, with 52.5% of patients maintaining a HbA1c level below 7.0%, which is almost 15% higher than the present results[14]; Korea with 45.6%, which is almost 8% higher than the present results[15]; or rural Spain, with 44.3%[16]. In the Insulin Resistance and Atherosclerosis Study, which had somewhat different definitions of control; 41% of diabetic participants had HbA1c <7%[17]. A study from Taiwan reported that 34.5% of patients showed a HbA1c level below 7%[18]. Another study from Eastern Europe reported that 35.8% of patients maintained a HbA1c level below 7.0%, which is slightly lower than the present study[13]. Achieving good glycemic control seems to be an extremely difficult target in both developed and developing countries. Our data from a large clinical information system at Isfahan Endocrine and Metabolism Research Center, Iran, also showed that just 35.3% reached the BP goal and 45.5% reached the LDLC goal. In the Insulin Resistance and Atherosclerosis Study, 32% of patients with type 2 diabetes had BP <130/85 mmHg, and 35% had a LDLC <130 mg/dL[17]. In Eastern Europe, approximately 20% of patients with type 2 diabetes met the target values for BP, cholesterol and LDLC[13]. The national Diabetes Registry in Denmark showed 13% of type 2 diabetes patients met a target BP of 130/80 mmHg and 28% for cholesterol[19]; and in a French nationwide type 2 diabetes survey, 29% of patients met the slightly higher target BP of <140/80 mmHg[20].

There are significant differences in studies of therapeutic target achievement that have been reported so far. However, studies carried out in Europe, North America and Asia showed that patients with type 2 diabetes are not adequately treated, and most patients do not meet all three goals[13,14,18,21–36].

In the present study, 7.7% of type 2 diabetes clinic attendees met all three goals, which is higher than 5.2–7.3% reported in the USA during 1988–2000[21,22], 5.4% reported by an international survey from seven Asian countries[29], 3.6% reported by the International Diabetes Management Practice Study[30], 4.1% reported from Taiwan[18], 5% reported from Italy[36] and 7% reported from Canada[35], but lower than 13.2–18.8% reported for the USA during 2003–2010, 17.3% reported in Iowa City Veterans Affairs Medical Center 2008–2009[25], 10.1% in the Look Action for Health in Diabetes 2000–2004[26], 22% reported in community-based endocrinology practice study 2000–2004[27] and similar to 8.0% reported in the Polish patients with type 2 diabetes of more than 10 years' duration[28]. The differences in lifestyles; socioeconomic status; medical treatment system; the need for a team approach including doctors, nurses, nutritionists and physical therapists; and research methods could be the reason for the lower goal achievement in the present study.

As expected, most of the patients in the present study were overweight or obese, and through the follow-up period, we observed a statistically significant increase in weight among these patients. We found that BMI was not predictive of poor glycemic, lipid control and all three risk factors. Obesity was not related to poor glycemic and lipid control, probably because among patients with type 2 diabetes, there are patients with good glycemic and lipid control who have gained weight and there are patients with poor glycemic and lipid control who have lost weight because of the disease process. We found that BMI was predictive of poor BP control.

Younger age at diabetes diagnosis was associated with poorer glycemic and BP control, because their duration of diabetes was

Table 3 | Age and age-adjusted means (standard error) and proportions of selected baseline characteristics in 210 patients with type 2 diabetes who attained all of the three goals and 2,430 patients who attained some of the goals

Variables	Attained all goals Mean (SD)	Attained some goals Mean (SD)	Difference (95% CI)
Age (years)	46.8 (0.65)	49.8 (0.19)	3.0 (1.67, 4.33)***
Age at diagnosis (years)	43.1 (0.65)	44.7 (0.19)	1.6 (0.28, 2.92)*
Years since diabetes diagnosis	4.1 (0.33)	5.1 (0.10)	1.0 (0.30, 1.70)**
Height (cm)	160.8 (0.63)	158.9 (0.18)	−1.9 (−3.17, −0.63)**
Weight (kg)	70.1 (0.87)	71.5 (0.25)	1.4 (−0.34, 3.17)
Body mass index (kg/m^2)	27.4 (0.32)	28.3 (0.09)	0.9 (0.26, 1.54)**
Systolic BP (mmHg)	116.3 (1.17)	123.9 (0.34)	7.6 (5.06, 10.10)***
Diastolic BP (mmHg)	71.7 (0.84)	76.5 (0.24)	4.8 (2.81, 6.79)***
Fasting glucose (mg/dL)	166.2 (4.90)	187.8 (1.42)	21.6 (10.3, 32.9)***
HbA1c (%)	7.3 (0.16)	8.7 (0.05)	1.4 (1.09, 1.71)***
Creatinine (mol/L)	0.89 (0.04)	0.91 (0.01)	0.02 (−0.07, 0.11)
Estimated glomerular filtration rate (mL/min)	106.8 (2.47)	111.5 (0.71)	4.7 (−0.83, 10.2)
Triglyceride (mg/dL)	197.9 (9.85)	219.2 (2.84)	21.3 (1.26, 41.30)*
Cholesterol (mg/dL)	196.3 (3.42)	218.5 (0.99)	22.2 (14.10, 30.30)***
HDLC (mg/dL)	44.6 (0.81)	44.9 (0.23)	0.3 (−1.34, 1.94)
LDLC (mg/dL)	115.1 (3.01)	129.4 (0.87)	14.3 (7.37, 21.20)***
	n (%)	*n* (%)	
Men	96 (47.1)	847 (34.8)	−12.3 (−19.40, −5.18)***
Overweight (BMI ≥25)	142 (69.6)	1838 (75.7)	5.8 (0.70, 12.40)
High blood pressure (≥140/90 mmHg)	0.0 (0.0)	654 (26.8)	26.8 (25.10, 28.60)***
High HbA1c (≥7%)	0.0 (0.0)	1,858 (76.3)	76.3 (74.60, 78.00)***
High LDLC (≥100 mg/dL)	0.0 (0.0)	1,728 (70.9)	70.9 (69.10, 72.70)***
Therapeutic regimen at last clinic visit			
Diet	53 (26.0)	516 (21.2)	−4.8 (−11.00, 1.43)
Oral agent	136 (66.7)	1,673 (68.7)	2.0 (−4.71, 8.74)
Insulin	10 (4.9)	183 (7.5)	2.6 (−0.53, 5.75)
Insulin and oral agent	5 (2.5)	64 (2.6)	0.1 (−2.04, 2.39)
Education (%)			
Less than high school	105 (51.5)	1,683 (69.1)	17.6 (10.50, 24.70)***
High school	59 (28.9)	413 (17.0)	−12.0 (−18.40, −5.57)***
College graduate	37 (18.1)	234 (9.6)	−8.5 (−13.90, −3.12)***
Smoking (%)			
Non-smoker	194 (95.1)	2,287 (93.9)	−1.2 (−4.33, 1.90)
Current smoker	10 (4.9)	149 (6.1)	1.2 (−1.9, 4.33)

*$P < 0.001$, **$P < 0.01$, ***$P < 0.001$. Differences in the mean or percentage values of variables between attained all goals and not attained all goals. BMI, body mass index; HbA1c, hemoglobin A1c; HDLC, high density lipoprotein cholesterol; LDLC, low density lipoprotein cholesterol.

greater than those diagnosed at older ages. Type 2 diabetes often has an insidious onset, making it difficult for studies to assess how HbA1c, BP and lipid changes with respect to duration of diabetes.

The present analysis also showed that treatment with an oral agent and insulin at baseline was associated with better glycemic control. This is expected, because patients with more severe hyperglycemia are more likely to have been prescribed an oral agent and/or insulin compared with patients with milder hyperglycemia.

We found that HbA1c, lipid control and attaining all goals increased with the number of follow-up visits. These patients were more likely to consult a physician on a regular basis and, therefore, were more likely to be offered appropriate treatment.

The present findings are consistent with previously published findings that education was associated with better glycemic, BP and lipid control[37]. There are several potential reasons why improvements in glycemic, BP and lipid control might have been concentrated among more educated populations. More educated patients might have better access than lesser educated individuals to the type of integrated, comprehensive medical care that individual with diabetes need in order to successfully manage their illness. Patients with dia-

Table 4 | Risk factors independently related to hemoglobin A1c ≥7%, blood pressure ≥140/90 mmHg, low-density lipoprotein cholesterol ≥100 mg/dL and not attaining all of the three goals for patients with type 2 diabetes (multiple logistic regression analysis)

Variables	Odds ratio (95% confidence interval)			
	HbA1c ≥7%	BP ≥140/90 mmHg	LDLC ≥100 mg/dL	Not attained all goals
Age (years)	–	1.09 (1.07, 1.12)`***	0.99 (0.98, 0.998)*	–
Age at diagnosis (years)	0.98 (0.97, 0.99)*	0.97 (0.94, 0.99)**	–	–
Follow up (years)	1.12 (1.09, 1.16)***	1.16 (1.12, 1.20)***	1.04 (1.01, 1.07)**	1.07 (1.014, 1.124)*
No. follow-up visits	0.99 (0.98, 0.99)***	1.01 (1.003, 1.02)**	0.98 (0.97, 0.99)***	0.98 (0.97, 0.99)**
Fasting plasma glucose (mg/dL)	1.003 (1.002, 1.004)***	1.003 (1.001, 1.004)***	–	–
Therapeutic regimen (%)				
Diet	1.00	–	–	–
Oral agent	0.72 (0.37, 1.44)	–	–	–
Insulin	0.30 (0.16, 0.57)***	–	–	–
Insulin and oral agent	0.48 (0.27, 0.90)***	–	–	–
Education				
Less than high school	1.00	–	–	1.00
High school	0.96 (0.76, 1.19)	–	–	1.69 (1.09, 2.62)*
College graduate	0.68 (0.51, 0.87)*	–	–	1.40 (0.86, 2.27)
Systolic BP (mmHg)	–	1.06 (1.05, 1.07)***	–	1.01 (1.002, 1.023)*
BMI (kg/m^2)	–	1.01 (1.05, 1.10)***	–	–
Cholesterol (mg/dL)	1.002	–	1.01 (1.008, 1.01)***	1.006 (1.002, 1.009)**
Triglycerides (mg/dL)	–	–	0.999 (0.998, 1.00)**	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. BMI, body mass index; BP, blood pressure; HbA1c, hemoglobin A1c; HDLC, high density lipoprotein cholesterol; LDLC, low density lipoprotein cholesterol.

betes who are more educated might have been better able to obtain and understand new information related to diabetes treatment compared with patients with diabetes who are less educated. There also is evidence that people who are more educated adopt medical technologies more rapidly than people who are less educated[38].

These real-life data reflect actual treatment pattern in patients with type 2 diabetes at our center, and allow for observation of patients over time. Several limitations of the present study should be considered when interpreting the results. Because of the single center and non-random selection of patients, we cannot exclude the possibility of selection bias in the registry, and the results might not apply to area/country groups. Although we have not carried out any special studies of the validity or reliability of data for this analysis, previous studies show that these patients are a representative sample of known diabetic patients of Isfahan[39]. Our experience with other parts of the dataset gives us some confidence that the data quality is sufficient for this type of study, and that the present results provide useful additional evidence on the current status of glucose, BP and lipid management. The study was clinic-based, rather than population-based, and so might not contain a clinical spectrum representative of diabetic patients in the community. We used clinical characteristics of patients only at the baseline and at last follow-up visits. We could not rule out the possibility of residual confounding because of unmeasured or inaccurately measured covariates. The present study was limited by possible selection bias by restricting the study to patients who were alive during the whole study period. The possibility exists that the people with diabetes who had the most severe disease or who were in the least good control died before the end of the study and were not included in the sample. This could result in overly optimistic estimates of glycemic, BP and LDLC control. Furthermore, the actual duration of diabetes is difficult to determine. Because many patients with type 2 diabetes have chronic diabetic complications at the time of diagnosis, many patients likely experience a long asymptomatic period of hyperglycemia. This measurement error could affect the analysis of the duration of diabetes.

This is the first report of diabetes outcomes measures in routine care in a Middle Eastern country and provides new data from Iran, which has been underrepresented in past studies.

In conclusion, the present study highlights the difficult challenges physicians face when treating patients with type 2 diabetes, such as the suboptimal control of glycemia, BP and LDLC.

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DISCLOSURE

The authors declare no conflict of interest.

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