Journal of Diabetes & Metabolic Disorders (2023) 22:355–366
https://doi.org/10.1007/s40200-022-01149-2

RESEARCH ARTICLE

Management goal achievements of diabetes care in Iran: study profile and main findings of DiaCare survey

Gita Shafiee[1] · Safoora Gharibzadeh[2] · Nekoo Panahi[3] · Farideh Razi[4] · Seyed Masoud Arzaghi[5] · Vahid Haghpanah[3,6] · Afshin Ostovar[7] · Alireza Raeisi[8] · Alireza Mahdavi-Hezareh[1] · Bagher Larijani[3] · Ensieh Nasli Esfahani[4] · Ramin Heshmat[1]

Received: 24 April 2022 / Accepted: 12 October 2022 / Published online: 2 November 2022

Abstract

Aim This paper presented the methodology and main findings of a population-based survey to determine diabetes care status among type 2 diabetic subjects in Iran. The current study assessed treatment goal achievements in type 2 diabetics, diabetes care service utilization, prevalence of diabetes complications, and psychological effects of diabetes in a representative sample of Iranian population in urban and rural areas.

Materials and Methods This nationwide study was conducted between 2018 and 2020 as the observational survey entitled "Diabetes Care (DiaCare)". We studied a representative sample of participants with type 2 diabetes, aged 35–75 years, living in urban and rural areas in all thirty- one provinces of Iran. Data were collected by an interviewer in a form of a questionnaire that includes demographic and socioeconomic status, family and drug history, lifestyle, and self-reported psychological status according to a Patient's Health Questionnaire (PHQ). Management goal achievements, diabetes care service utilization, diabetes complications and psychological effects of diabetes were also assessed. Physical measurements were measured based on standard protocol. Fasting blood glucose (FBG), HbA1c, lipid profile, and also urine albumin to creatinine ratio were obtained from all participants of the study.

Results Overall, 13,334 people with type 2 diabetes in 31 provinces of Iran completed the survey (response rate: 99.6%). In total 13,321 participants, 6683(50.17%) women and 6638(49.83%) men were included in our analysis. Thirteen recruited patients refused after the consenting process and did not respond. The mean age (SD) of total participants was 54.86 ± 9.44 years and 71.50% were from the urban areas. 13.66% of diabetic patients had achieved the triple target of management [controlled HbA1c, blood pressure, and Low-Density Lipoprotein-Cholesterol (LDL-C)] in the whole country. While 28.74% of people had controlled HbA1c and 33.40% of them had controlled FBG. Diabetic subjects living in rural areas had less controlled HbA1c (23.93 vs. 29.48), controlled FBG (29.50 vs. 34.20) and controlled triple targets (10.45 vs. 14.32) than those living in urban areas. Diabetic neuropathy and diabetic foot were more common in women than men, while end-stage of renal disease (ESRD) was more common in men than women.

Conclusions This population-based study provided representative information about diabetes care in Iran. The high prevalence of diabetes and low proportion of diabetes control in Iran implies that it is necessary to identify factors associated with poor treatment goal achievements. Besides, general improvements in management and care of diabetes are mandatory.

Keywords Diabetes Care · Methodology · Management Goal Achievements · Iran

Introduction

The estimated global prevalence of diabetes by the IDF had increased from 151 million adults in year 2000 to 451 million (8.4%) in 2017 [1] and expected to reach 693 million (9.9%) in 2045 [1]. About 50% of the diabetic people do not know that they have diabetes [1]. According to the IDF diabetes Atlas, 9th edition, 2019, three out of each four diabetics

✉ Ensieh Nasli Esfahani
n.nasli@yahoo.com

✉ Ramin Heshmat
rheshmat@tums.ac.ir

Extended author information available on the last page of the article

(352 million people) had been recorded to be in the working age group and in 2019, the highest age-standardized prevalence of diabetes was 12.2%, expected to reach 13.3%, and 13.9% in 2030 and 2045; respectively in Middle East and North Africa (MENA) region [2].

The prevalence of diabetes was estimated to be 11.4% (4.5 million) in Iran in the fourth round of the periodic National Survey of Risk Factors for Non-communicable Diseases project in 2011, and more than one quarter of them were not previously detected [3]. By 2030, 9.2 million Iranians will have diabetes [4].

Type 2 diabetes (T2DM) accounts for more than 85% of the clinically registered Iranian diabetic patients [5]. This chronic progressive disease, especially if not well managed, has substantial consequences, including microvascular and macrovascular complications leading to repeated hospitalization and premature death. Globally, diabetes is one of the top 10 causes of death, and is associated with 11.3% of global deaths from all causes among the 20–79 years age group. A recent systematic review and meta-analysis showed that the estimated prevalence of diabetic foot ulcer, cardiovascular disease, retinopathy, neuropathy and nephropathy in Iranian diabetics were 3%, 33%, 36%, 38%, and 43%, respectively [6]. It has also been observed that most type 2 diabetics have one or more comorbidities influencing the self-care of diabetes and its progression, which needs to be considered in their care [7].

More than 66% of type 2 diabetic patients had HbA1c above 7% in a recent study conducted in three Iranian provinces [8]. In a study on 348 diabetic patients, poor glycemic control, low medication adherence, and inadequate self-care activities were observed with mean HbA1c of 8.39 ± 2.03 and 33% of patients had levels higher than 9% [9].

The high prevalence of diabetes and its complications imposes a significant burden on health care resources and costs and the main step to avoid these complications is to achieve glycemic control. Self-care is an essential factor for diabetes control [10] and self-care training has shown positive impacts on both quality of life and control among women [11]. The economic burden of diabetes in Iran is predicted to increase markedly in the coming decades [4]. According to findings of a qualitative study in Iran, removing perceived self-care barriers, improving medical welfare and social support [10] could help in better glycemic control. Identification and implementation of effective plans to prevent and manage diabetes should be considered as a public health priority.

The quality of care for diabetes in Iran seems to be improving. Between 2005 and 2011, diabetes awareness improved and the rate of cases with undiagnosed diabetes dropped nearly 50% from 45.7% to 24.7% [3]. Besides, a substantial increase in the use of anti-hyperglycemic [12, 13], antihyperlipidemic and antihypertensive medications have been reported through 2011[12]; however, by then, the utilization of diabetes medicines was still relatively low despite the affordability of essential diabetes medications [13]. The current understanding of the quality of care is incomplete.

Therefore, in this comprehensive population-based study, we planned to investigate the current status of diabetes care in a representative sample of Iranian adults with type 2 diabetes at the national level. Treatment goal achievements in type 2 diabetics, diabetes care service utilization, and prevalence of diabetes complications and psychosocial effects of diabetes were assessed.

Materials and methods

The DiaCare was a nationwide observational, population-based survey to determine diabetes care status among diabetic type 2 subjects in Iran. This study was conducted between 2018 and 2020 in all thirty- one provinces of Iran.

Study population and sampling framework

The target population contained diabetic subjects aged 35–75 years in urban and rural areas across the country.

The inclusion criteria were diagnosis of type 2 diabetes according to ADA recommendations [14] at least 3 months before study entry in individuals aged between 35 and 75 years, able to understand and complete questionnaires, and signed patient informed consent form. While individuals suffering from other types of diabetes (e.g. gestational diabetes and type 1 diabetes), people with obvious cognitive impairment, non-Iranian households, current temporary insulin therapy, and absence at the time of the interview, were not included.

We used different sampling methods for selecting primary sampling units (clusters) like as systematic random sampling, stratify sampling and also cluster sampling. Sample size was equal subjects in each province, and divided between urban/ rural areas using the proportion to the population of areas in the provinces.

In order to calculate the number of statistical units in each cluster we used the following equation:

$$\mathrm{Deff} = 1 + \rho\mathrm{cs}(\mathrm{M} - 1)$$

Where

Deff Design Effect

M optimal size of each cluster = 12 = [0.03 × 4] (the proportion of the expenses to reach every statistical unit to expenses of data gathering for every member of the cluster was estimated to be 4)

ρ cs interclass correlation coefficient estimated to be 0.03 based on experts' opinion

So, by calculation

$$Deff = 1 + 0.03\ (12 - 1) = 1.33$$

The sample size of the study was described based on the equation:

$$Ncs = Nsrs \times Deff$$

N cs	the real sample size for cluster sampling
N srs	the determined sample size for simple random sampling
Deff	Design Effect = 1.33
Sampling range	total number of inhabitants in a region / Number of clusters in a region

About 384 participants were needed for estimation of 0.25 proportions in an unlimited population of each province with an absolute error of 5% and a confidence interval of 95% using a cluster simple sampling method with a design effect of 1.33 [15].

With a sample size of 384 subjects and a loss rate (f) of 10%, the sample size was 432 subjects in each province (or 36 clusters of 12 subjects from 4 age and sex groups), 3 subjects in each age and sex groups, a total of 13,392 subjects at national level in 31 provinces. This was the maximum sample size that helped to achieve a good estimate of the primary aims of the study.

Clusters were the primary sampling units (PSU) and to find the first household in each cluster, a systematic random sampling approach was used. A cumulative list of households within each region was provided with unique ten-digit postal codes.

The sampling interval was determined by dividing the total number of households within each region by the number of clusters in the region. The first household of the primary cluster was identified through randomly selecting a number between 1 to a much less than or equal to the sampling interval. The primary household of the second cluster was located through adding the sampling interval to the random number. For next clusters (cluster three, cluster 4, cluster 5, and so on.), identified the primary household via adding the sampling range to the running total of adding the sampling interval to the random number.

The right side neighbors (clockwise direction) of the first household in every cluster had been decided on as the rest households of that cluster. Households that were not Iranian or no longer present at the time of interview for 3 times of referral were excluded from the survey. In each household, the person(s) with type 2 diabetes identified. If more than one person had diabetes in a household, the participant was selected through a predefined random method. Stratification was conducted on selecting 3 equal age and sex strata in each cluster as mentioned previously.

The study protocol was reviewed and approved by the Ethics Committee of the Endocrinology and Metabolism Research Institute (EMRI) of the Tehran University of Medical Sciences (TUMS) (Ethic Code: IR.TUMS.EMRI.REC.1396.00165).

Measurements

Questionnaire

After finding eligible participants, the aim of the study were described and they were invited to the nearest health center and written informed consent was gained from members. Data were gathered by an interviewer in the form of a questionnaire. The final questionnaire results were obtained from several questionnaires with formerly assessed validity and reliability [16–18]. The whole process was supervised and managed with the aid of a group of healthcare specialists.

The final questionnaire consists 105 questions in 9 sections including the following:

- Demographic characteristic of patients
- Social-economic status (SES)
- Diabetes Care Services Utilization
- Family history about diabetes
- Drug history
- Information about the diagnosis of Diabetes and treatment
- Diabetic complications
- Diet, physical activity, smoking
- Self-reported questionnaire about PHQ (Patient Health Questionnaire)

Physical measurements

Anthropometrical measurements were obtained from the participants putting on light clothes and after taking of their shoes. Bodyweight was measured on a scale located on flat floor with an accuracy of 0.1 kg and height was measured without shoes to the nearest 0.1 cm. Waist circumference was measured using of a non-elastic tape at a point midway between the anterior superior iliac spine and the lowest rib in the mid-expiration phase, in the standing position. Hip circumference was measured over the biggest part of the buttocks.

Blood pressure (BP) was measured in the sitting position on the right arm by a mercury sphygmomanometer with the

suitable cuff size. It was measured 2 times at five min intervals, and the mean was registered.

Blood sampling and laboratory assessments

A blood sample was taken after 8–12 h of fasting and also a first morning void urine sample was collected from each study participant. Laboratory measurements consisted of fasting blood glucose (mg/dl), triglycerides, low-density lipoprotein (LDL), high-density lipoprotein (HDL), serum cholesterol, urea, creatinine, HbA1c, and also urine albumin to creatinine ratio. Blood samples were centrifuged at a health care center or laboratory of each province, allocated, and sent to the central laboratory in the Endocrinology and Metabolism Research Institute (EMRI), for analysis within 36 h after sampling. All samples were analyzed when internal quality control met the acceptable criteria.

Data management

The process of data management involved converting the data collected using data collection tools, most commonly Case Report Forms (CRFs), into electronic data that can then be statistically analyzed.

This consists of the following stages:

- Completion and collection of the paper CRFs
- Database Management Systems
- Data entry
- Data Validation and data cleaning

Paper CRFs were completed at the site by the investigator. Copies of CRFs were kept at the sites according to the protocol. Completed CRFs were collected after Monitoring visits. Paper CRFs were stored securely at all times and only be accessible by authorized personnel e.g. in a locked filing cabinet in a locked office. Then, CRFs were transferred to a Research center for data entry by courier to ensure safe delivery. After collecting CRFs at the site, the next step was to develop the database to store the data. The database management software used by the Research center was network login and user ID protected to prevent unauthorized access to the data and allowed different levels of database access control (e.g. Database, Table, and record). Double data entry by two persons was carried out without interpretation or modification, followed by comparing both datasets. Moreover, a third person was responsible for a confirmatory verification or a visual check, that the entered data matched the records in CRF hard copies.

All information in the original records and certified copies of original records about activities conducted as part of a clinical study that was necessary for reconstruction and evaluation of the study were called "Source Data". Source Data Verification (SDV) for all required data was carried out by the Research center Monitoring Unit during site monitoring visits. Data validation was carried out at various stages during the study. SDV involved checking the data entered the CRFs against that in the source records.

When data were entered into the database by the data entry group, the database had software that enabled automatic data entry checks. The final dataset was 'locked' and password-protected to ensure access was restricted for final analysis and report. The Data Manager provided a copy of the final locked dataset to the sponsor before the statistical analysis was performed.

Statistical methods and Analysis Plans

Weighting methods

Provinces and sampling clusters were considered as strata and primary sample units (PSU), respectively. Since the sampling has been done during 1397 and 1398, as a reference population to define weights we used the average population of these two consecutive years, based on the predicted population by the Iranian statistical society. For each participant, two weights were defined: 1) gender weight, and 2) location weight. Weight of gender was calculated as the ratio of the total number of female/ or male aged 35–75 yrs. to the corresponding country's number. Likewise, the location's weight was calculated as the ratio of all 35–75 yrs. residents of urban/ or rural in the province to the sum of the country. Since every 12 related participants labeled as a cluster, to capture the correlation between nearby subjects clustering effect was also considered.

Endpoint evaluation

In each province, the proportion of patients with controlled HbA1c, FBS, or achieved triple targets, with 95% CI that was calculated based on the cluster robust standard error, were reported in genders, different age groups, and residence of living (Urban/ Rural). A country level analysis of outcomes was calculated via survey proportion, adjusted for gender, age, and the area of residents.

Definitions

In this paper, we reported the primary and secondary endpoints of the study in the total country. Therefore in this part, we defined these variables.

- **Primary objective**

– To assess the current status of diabetes control in adult people with type 2 diabetes of Iran:

Controlled HbA1c: HbA1c level ≤ 7%

Controlled FBG: FBG = 80-130 mg/d

Triple target: HbA1c < 7% + Normal blood pressure (SBP/DBP < 140/90 mmHg) + Low Density lipoprotein- Cholesterol (LDL- C) < 100 mg/dl

- **Secondary objective(s)**

– To assess the Diabetic Care Services Utilization:

Access to health care included: Access to insurance, Physician Access, Pharmacy Access, and Lab Access

– To assess the prevalence of diabetic complications (Diabetic feet/Neuropathy and nephropathy):

Neuropathy: The United Kingdom Screening Test (UKST) was applied to score for symptoms of peripheral sensory neuropathy. Maximum signs score was 10, graded as follows: Normal 0-2; Mild 3-5; Moderate 6-8; Severe 9-10 [19].

The diabetic foot was defined based on having moderate or severe neuropathy or having an amputation.

Diabetic Nephropathy: random urine albumin creatinine ratio < 30 mg/g Normal; 30-300 mg/g Micro; and > 300 mg/g Macro-albuminuria. The presence of micro- or macro-diabetic nephropathy was considered [20]

Kidney disease status: Normal: Estimated glomerular filtration rate (GFR) > 90 mL/min/1.73 m^2); Stage 2: GFR = 60-89 mL/min/1.73 m^2; Stage 3: GFR = 30-59 mL/min/1.73 m^2; Stage 4: GFR = 15-29 mL/min/1.73 m^2); Stage 5: GFR < 15 mL/min/1.73 m^2 [21].

End- Stage of Renal Disease (ESRD): Patients on dialysis, or those living with a kidney transplant, or having GFR < 15 mL/min/1.73 $m.^2$

– To evaluate the psychological impact of diabetes:

Patient Health Questionnaire (PHQ): This questionnaire examines disorders including Somatoform disorders, Major depressive disorders, other depressive disorders, Panic disorders, Anxiety disorders, Bulimia nervosa, Binge eating disorders, and Alcohol abuse [22].

Quality of Life (SF-12)[17].

Analysis Plan

Quantitative data were described as mean and standard deviation (SD) for normally distributed data, based on the Shapiro–Wilk test, while non-normal variables were presented as median (interquartile range: P25-P75). Categorical data were expressed as numbers and percentages. Total country summary statistics were survey adjusted and provincial levels were reported as No. and percentage. To account for the survey effect, between groups (male/female or urban/rural) comparisons, in the total country, were done by regression for survey data.

In maps, the percentage of achieved goals were divided into 5 equal groups (Quintiles), and provinces were categorized based on these cut points. Based on the standard latest shape files of Iran, data were plotted.

All statistical analysis was done by STATA (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.), and P-value less than 0.05 was considered as statistical significance.

Results

According to the protocol of the study, 13,392 patients with diabetes type 2 living in 31 provinces should enter the study. Overall, 13,334 people with type 2 diabetes in 31 provinces of Iran completed the survey (response rate: 99.6%). In total 13,321 participants, 6683(50.17%) women and 6638(49.83%) men were included in our analysis. Thirteen recruited patients refused after the consenting process and did not respond. The characteristics of the study participants are presented in Table 1. The mean age (SD) of the total participants was 54.86 (9.44) years and 71.50% were from the urban areas. The median diabetes duration was 72 months and the mean (SD) HbA1c was 8.53(0.09) percent. Also, this table shows that 13.66% of diabetic patients have achieved the triple target of management in the whole country. While 28.74% of people had controlled HbA1c and 33.40% of them had controlled FBG.

Figure 1 shows the proportions of patients with achieved diabetes control among adult people with type

Table 1 Characteristics of participants according to gender: The DiaCare study

	Total	Men	Women	P-value
Number (%)	13,321	6638(49.83)	6683(50.17)	
Age (Years)	54.86 ± 9.44	54.90 ± 9.60	54.83 ± 9.29	0.66
Age groups				
35 to 44 years	1962(14.80)	1010(15.30)	952(14.31)	0.13
45 to 54 years	4796(35.97)	2338(35.41)	2431(36.53)	
55 to 64 years	4131(31.16)	2031(30.77)	2099(31.54)	
65 to 75 years	2395(18.07)	1223(18.52)	1172(17.61)	
Area				
Urban (%)	9525(71.50)	4750(49.87)	4775(50.13)	0.89
Rural (%)	3796(28.50)	1888(49.74)	1908(50.26)	
Education (Years)	5 (0—10)	7(4–12)	4(0–7)	< 0.001
Duration of diagnosis of diabetes (Months)	72(36–120)	72(36–120)	72(36–120)	0.13
Achieving controlled HbA1c (%)	3100(28.74)	1491(27.47)	1609(29.99)	0.45
Achieving controlled FBG (%)	4021(33.40)	1983(31.17)	2037(35.58)	0.19
Achieving Triple targets (%)	1344(13.66)	694(14.56)	650(12.76)	0.48
HbA1c (%)	8.53 ± 0.69*	8.62 ± 0.11*	8.45 ± 0.09*	0.24
FBG(mg/dl)	170 ± 48 ± 2.10	174.22 ± 3.58	166.74 ± 2.69	0.11
TG(mg/dl)	148(105, 200)	148(111,201)	147(99, 200)	NS
Cholesterol	174.87 ± 1.28	167.57 ± 1.82	182.03 ± 1.80	< 0.001
HDL-C(mg/dl)	46.44 ± 0.31	42.96 ± 0.44	49.86 ± 0.49	< 0.001
LDL-C(mg/dl)	96.42 ± 0.77	93.06 ± 1.14	99.70 ± 1.04	< 0.001
SBP(mmHg)	111(122.5- 135)	120(110–135)	125(115–134.5)	NS
DBP(mmHg)	80(70–82.5)	79(70–82)	80(70- 82.5)	NS
HTN (%)	3579(23.11)	1747(21.61)	1832(24.25)	0.22

Data are presented as mean ± standard deviation(SD), number (percent) or median(interquartile range)

HbA1c Hemoglobin A1c, *FBG* Fasting Blood Glucose, *TG* Triglycerides, *HDL-C* High-density lipoprotein cholesterol, *LDL-C* Low-density lipoprotein cholesterol, *SBP* Systolic Blood Pressure, *DBP* Diastolic Blood Pressure, *HTN* Hypertension

*Mean ± Linearized S.E

2 diabetes in different provinces of Iran. The dark blue color indicates the provinces that have better control of HbA1c, FBG, and triple targets than others.

Table 2 shows that the best proportion of achieved diabetic control was in controlled FBG and the lowest percentage was in achieving the triple target. Also, patients lived in rural areas had less controlled HbA1c (23.93% vs. 29.48%), controlled FBG (29.50% vs. 34.20%) and controlled triple targets (10.45% vs. 14.32%) than those living in urban areas.

In terms of access to health care, more than 92 percent of participants had access to a physician, pharmacy, and laboratory. However, 54% of people had access to a glucometer and used it almost twice a week to measure their blood sugar (Table 3).

Table 4 described that diabetic neuropathy and diabetic foot were more common in women than men, while ESRD was more common in men than women. In total, 37.29% of patients had diabetic foot and 49.54% of them had diabetic nephropathy. As regards kidney disease status, most of the participants 54.01% were in stage 2 of chronic kidney disease; 59.84% of women compared to 48.08% of men. ESRD represented 7.13% of the sample population, 9.55% of men and 4.73% of women .

In Table 5, we evaluated the psychological effects of diabetes according to a self-reported questionnaire. Among women, somatoform disorder (22.8 vs. 6.72), major depression (9.99 vs. 2.90), panic disorder (3.59 vs. 1.93) and anxiety disorder (8.31 vs. 3.99) were more than men (all $P < 0.001$). While the percentage of men with alcohol abuse was about 8 times more than women (12.65 vs. 1.63).

Adverse Drug Reactions (ADRs) to any anti-diabetic treatment were not recorded from the sites during the course of the study.

Discussion

This comprehensive population-based study shows the current status of diabetes care in a representative sample of Iranian adults with type 2 diabetes at the national level. We

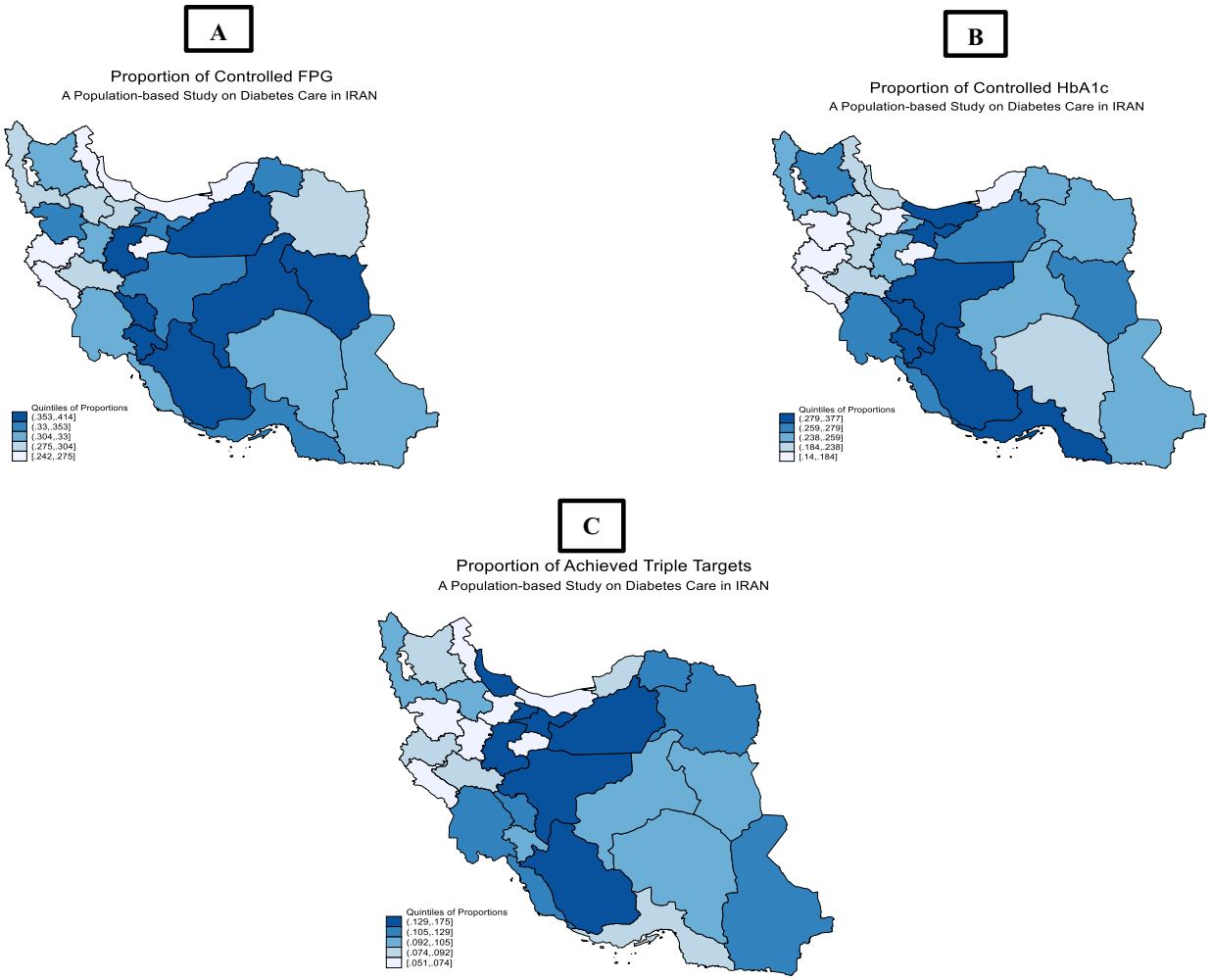

Fig. 1 Proportions of patients with achieved diabetes control among adult people with type 2 diabetes in different provinces of Iran: The DiaCare study

presented the impact of gender, age groups, and urban versus rural residency on diabetes treatment goal achievements. Moreover, health care accessibility, prevalence of diabetic complications, and psychological status of diabetics were also provided.

Overall control

We observed controlled HbA1c and FBG respectively in 28.74% and 33.40% of type 2 diabetic patients in Iran at the national level. However, only 13.66% of them achieved the triple target of management. The proportions varied between different regions and provinces. Controlled HbA1c ranged from 14 to 38%, controlled FBG from 24 to 41%, and triple goal achievement from 6 to 15% in different provinces. So, an overall substantial proportion of diabetics were not well managed and controlled. In a similar study originated from Iran's national non-communicable diseases risk factor surveillance survey of 2005, conducted to depict the first national picture of the quality of care provided for known diabetic patients in Iran, it was shown that about 97% of the patients had poor control according to their most recent HbA1c levels; however, at that time only 6.4% of participants had an HbA1c test during the year before questioning [23]. Previous studies have shown inadequate glycemic control in about 75% of patients in the UK, European countries, and developing countries [24–26]. Only 3.6% of type 2 diabetic patients from 17 developing countries attained all three recommended targets (blood pressure, LDL cholesterol, and HbA1c) according to the International Diabetes Management Practice Study in 2008 [26]. A target HbA1c level < 7% is recommended for most patients with type 2 diabetes; however, a more relaxed or more stringent target should be aimed at patients according to their age, presence or absence of comorbidities, life expectancy, risk of hypoglycemia, or present complications [27] and individualizing glycemic targets might increase the proportions of patients considered adequately controlled. Despite the availability of

Table 2 Evaluation of patients with Achieved diabetes control in adult people with type 2 diabetes of Iran: The DiaCare study

	Total	Men	Women	P-value
Achieving controlled HbA1c				
Percent(Range)	28.74(26.20–31.42)	27.04(22.91–31.60)	29.98(25.92–34.88)	0.45
Age groups				
35–44 yrs	33.15(26.32–40.77)	28.42(19.69–39.13)	37.96(28.42–48.53)	0.32
45 to 54 yrs	27.47(23.00–32.46)	25.33(19.33–32.45)	29.37(23.26–36.33)	
55 to 64 yrs	25.41(21.77–29.43)	26.52(20.78–33.19)	24.31(18.67–31.01)	
65 to 75 yrs	30.74(24.52–37.74)	27.88(19.82–37.68)	33.72(25.87–42.58)	
Area				
Urban	29.48(26.43–32.73)	27.45(22.38–33.17)	31.47(26.29–37.14)	0.08
Rural	23.93(20.84–27.32)	25.04(21.30–29.19)	22.86(18.78–27.54)	
Achieving controlled FBG				
Percent(Range)	33.40(30.60–36.32)	31.23(26.61–36.25)	35.50(31.71–39.81)	0.19
Age groups				
35–44 yrs	30.30(23.97–37.48)	28.22(20.75–37.11)	32.41(22.70–43.92)	0.13
45 to 54 yrs	32.12(27.78–36.80)	28.47(22.38–35.46)	35.35(28.88–42.40)	
55 to 64 yrs	34.16(30.19–38.36)	34.17(28.48–40.35)	34.14(28.39–40.41)	
65 to 75 yrs	35.89(29.96–42.28)	31.60(23.02–41.64)	40.35(32.33–48.93)	
Area				
Urban	34.20(30.89–37.67)	31.33 (25.58–37.72)	37.00(32.24–42.03)	0.08
Rural	29.50(25.68–33.64)	30.74(27.53–34.15)	28.30(22.61–34.77)	
Achieving Triple targets				
Percent(Range)	13.66(11.97–15.52)	14.55(11.74–17.90)	12.76(9.98–16.16)	0.48
Age groups				
35–44 yrs	16.48(11.27–23.47)	16.30(9.16–27.32)	16.68(10.20–26.07)	0.95
45 to 54 yrs	13.46(10.52–17.07)	14.85(10.35- 20.86)	12.20(8.73- 16.80)	
55 to 64 yrs	12.61(9.60–16.40)	13.38(9.22–19.02)	11.85(7.52–18.19)	
65 to 75 yrs	12.87(9.19- 17.72)	13.60(8.61- 20.82)	12.08(7.21- 19.54)	
Area				
Urban	14.32(12.34–16.56)	15.18(11.86- 19.24)	13.46(10.18–17.59)	0.02
Rural	10.45(8.84–12.32)	11.51(9.31- 14.15)	9.42(7.48- 11.79)	

Data are presented as percent (range)

Table 3 Access to Health Care of participants according to gender: The DiaCare study

	Total	Men	Women	P-value
Basic Insurance	12,943(95.25)	6442(95.12)	6501(95.38)	0.86
Physician Access	12,535(93.77)	6306(94.23)	6229(93.32)	0.38
Pharmacy Access	12,415(95.84)	6242(96.51)	6173(95.19)	0.02
Lab Access	12,152(92.84)	6125(93.67)	6026(92.03)	0.11
Glucometer Access	6340(54.81)	3348(57.13)	2991(52.54)	0.06
Using Glucometer per week	1.81(1.63- 1.99)	1.74(1.54–1.94)	1.88(1.57–2.19)	0.46

Data are presented as number (percent) or median (interquartile range)

new medications and technologies, still, a substantial number of individuals are not at their glycemic goal pointing to the importance of medication adherence [28]. Failure to achieve glycemic control target could be multi-factorial, including poor medications, lack of knowledge regarding diabetic management and self-care, diabetes duration, lower education level, and poor economic status among all [8, 29, 30].

Men and women

Although regarding triple target achievement men had better status, the proportion was dramatically low in both genders; 12.76% among women and 14.56% among men. However, our findings showed that glycemic control (HbA1c and FBG) was poorer among men. This gender difference,

Table 4 Evaluation of diabetic complications in the DiaCare study

	Total	Men	Women	p-value
Neuropathy				
Normal	5789(42.72)	3459(50.85)	2330(34.69)	
Mild	2355(20.36)	1085(19.47)	1270(21.25)	< 0.001
Moderate	3466(23.76)	1373(16.96)	2093(30.46)	
Severe	1706(13.16)	720(12.72)	986(13.6)	
Diabetic foot	5236(37.29)	2140(30.04)	3096(44.42)	< 0.001
Kidney Disease Status				
Normal	2906(22.17)	1668(27.82)	1238(16.62)	
Stage 2	6951(54.01)	3078(48.08)	3873(59.84)	
Stage 3	2782(22.16)	1561(22.59)	122,121.74)	< 0.001
Stage 4	108(1.37)	72(1.12)	108(1.61)	
Stage 5	29(0.002)	36(0.004)	29(0.001)	
Diabetic nephropathy	5393(49.54)	2658(49.79)	2735(49.29)	0.84
ESRD	855(7.13)	467(9.55)	388(4.73)	< 0.01

Data are presented as number (percent)

ESRD End Stage Renal Disease

however, was not similar in all regions and age groups. Women of all ages were more likely to have controlled FBG compared with men and controlled HbA1c was more likely in women compared with men in all age groups except 55 to 64 years, in whom men were more likely to meet the control of HbA1c. Better triple target achievement was observed in men of all age groups except 35 to 44 years. In reports of other countries, usually, women had the poorer conditions. Despite lower levels of FBG and HbA1c at the time of diagnosis in women, after 1 year of diabetes management, a small but significant difference was observed in target HbA1c achievement, in favor of men [31]. Indian women had poorer glycemic control [32]. A significant gender-based disparity was observed on cost-related medication nonadherence among diabetic patients according to US National Health Interview Survey data (2011 to 2014) [33]. However, in a recent study in Saudi Arabia, both genders exhibited comparable HbA1c levels, but men were less likely to have hypertension and more likely to have hyperlipidemia [34]. The risk of hypoglycemia is higher in longstanding diabetes and the elderly which could contribute to lower levels of HbA1c in elderly. A higher incidence of hypoglycemia was shown in men with longstanding diabetes [35].

Urban and rural

Overall, higher proportions of treatment target achievement were observed in those living in urban areas compared to rural. However, the gender gap was different between rural and urban areas. Although urban women had better control of HbA1c and FBG, in rural areas, men were more likely to have glycemic control. This may point to greater gender inequality in rural areas. However, regarding triple target, men had better status compared with women in both urban and rural areas. Conversely, in the rural-provincial general adult population in Denmark, poorly controlled diabetes were observed more commonly in men [36]. In rural areas of Iran, the diabetes treatment coverage rate was 67% based on self-report [37]. Iranian rural primary health workers (Behvarzes) are trained to identify and refer high-risk groups. Behvarz worker density, but not physician density, was significantly associated with diabetes treatment coverage rate and was found to be the only variable predictor of technical efficiency [37]. Therefore, the primary health care system may extend the diabetes treatment coverage by expanding the number and scope of its Behvarzes to also address blood pressure and to improve performance in areas with few primary care personnel [37, 38].

Age

Better FBG was observed among older groups. Age is found to be a major independent predictor for better glycemic control in previous studies with OR of about 0.5 [39, 40] which could partly be explained by the higher risk of hypoglycemia in older age groups.

Table 5 Evaluation of Patient Health status among diabetic patients in the DiaCare study

	Total	Men	Women	P-value
Patient Health Status				
Somatoform Disorder	2077(14.85)	584(6.72)	1493(22.84)	< 0.001
Major Depressive Disorder	660(6.48)	226(2.90)	434(9.99)	< 0.001
Other Depression Disorders	1206(10.53)	407(7.43)	799(13.59)	< 0.001
Panic Disorder	365(2.77)	96(1.93)	269(3.59)	0.04
Anxiety Disorder	755(6.17)	226(3.99)	529(8.31)	< 0.01
Bulimia Nervosa	103(0.008)	46(0.007)	57(1.03)	0.61
Binge Eating	108(0.009)	47(0.007)	61(1.06)	0.58
Alcohol Abuse	557(7.09)	513(12.65)	44(1.63)	< 0.001

Data are presented as number (percent)

Strengths

Most previous studies were hospital-based or clinic-based. The strengths of the present population-based study include the large and representative sample of diabetic patients from the whole country, including urban and rural areas; detailed data collection on disease management; lab findings measured by reliable methods in a single central laboratory. Finally, the sex and age- stratified analysis provided an accurate snapshot to identify gaps in the quality of care.

Limitations

First, patients in the range of 35–75 years were recruited due to resource limitation which could decrease our external validity and our results can only be generalized to patients in this range. Second, type 2 diabetic patients were identified based on self-report leaving behind undiagnosed patients unaware of their disease which includes half of the diabetic patients according to the IDF reports. Therefore, study results can be only generalized to known diabetic patients. Besides, we used HbA1c level < 7% as an index of good glycemic control for all participants without individualization of glycemic targets. This might underestimate the number of patients considered adequately controlled [27].

Conclusions

This population-based study provided representative information about diabetes care in Iran. Glycemic control was observed in about a quarter of patients and only a minority of patients met the triple target criteria (13.66). Overall, middle-aged patients, men, and rural residents were less likely to achieve glycemic control. However, triple goal achievement were slightly better in men. The high prevalence of diabetes and low proportion of diabetes control in Iran implies that it is necessary to identify factors associated with poor treatment goal achievements. Besides, general improvements in management and care of diabetes are mandatory.

Acknowledgements The authors and investigators would like to express their deep gratitude to all the contributors to this national survey, especially to Non-communicable diseases management department at the Ministry of Health and all our colleagues in Medical Sciences Universities and also to all participants in this study.

Authors' contributions All authors read and approved the final paper.

Funding This national survey was funded financially by Sanofi-Aventis Group– Rep Office (IRAN) (Study Number: DIREGL08760). It has not had any role in designing, interpreting or providing data.

Declarations

Conflict of interest Authors declare that they have no conflict of interest.

References

1. Cho NH, Shaw JE, Karuranga S, Huang Y, da Rocha Fernandes JD, Ohlrogge AW, Malanda B. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res Clin Pract. 2018;138:271–81.
2. IDF Diabetes atlas. 9th edition 2019:https://diabetesatlas.org/en/sections/demographic-and-geographic-outline.html.
3. Esteghamati A, Etemad K, Koohpayehzadeh J, Abbasi M, Meysamie A, Noshad S, Asgari F, Mousavizadeh M, Rafei A, Khajeh E, et al. Trends in the prevalence of diabetes and impaired fasting glucose in association with obesity in Iran: 2005–2011. Diabetes Res Clin Pract. 2014;103(2):319–27.
4. Javanbakht M, Mashayekhi A, Baradaran HR, Haghdoost A, Afshin A. Projection of Diabetes Population Size and Associated Economic Burden through 2030 in Iran: Evidence from Micro-Simulation Markov Model and Bayesian Meta-Analysis. PLoS ONE. 2015;10(7): e0132505.
5. Esteghamati A, Larijani B, Aghajani MH, Ghaemi F, Kermanchi J, Shahrami A, Saadat M, Esfahani EN, Ganji M, Noshad S, et al. Diabetes in Iran: Prospective Analysis from First Nationwide Diabetes Report of National Program for Prevention and Control of Diabetes (NPPCD-2016). Sci Rep. 2017;7(1):13461.
6. Moradi Y, Baradaran HR, Djalalinia S, Chinekesh A, Khamseh ME, Dastoorpoor M, Sioofy-Khojine AB, Saed L, Qorbani M. Complications of type 2 diabetes in Iranian population: An updated systematic review and meta-analysis. Diabetes Metab Syndr. 2019;13(3):2300–12.
7. Nowakowska M, Zghebi SS, Ashcroft DM, Buchan I, Chew-Graham C, Holt T, Mallen C, Van Marwijk H, Peek N, Perera-Salazar R, et al. The comorbidity burden of type 2 diabetes mellitus: patterns, clusters and predictions from a large English primary care cohort. BMC Med. 2019;17(1):145.
8. Moradi G, Shokri A, Mohamadi-Bolbanabad A, Zareie B, Piroozi B. Evaluating the quality of care for patients with type 2 diabetes mellitus based on the HbA1c: A national survey in Iran. Heliyon. 2021;7(3): e06485.
9. Jafarian-Amirkhizi A, Sarayani A, Gholami K, Taghizadeh-Ghehi M, Heidari K, Jafarzadeh-Kohneloo A, Morisky DE. Adherence to medications, self-care activity, and HbA1c status among patients with type 2 diabetes living in an urban area of Iran. J Diabetes Metab Disord. 2018;17(2):165–72.
10. Robat Sarpooshi D, Taghipour A, Mahdizadeh M, Peyman N. Enablers of and Barriers to Effective Diabetes Self-Care in Iran: A Qualitative Study. Patient Relat Outcome Meas. 2020;11:109–18.
11. Ahrari F, Mohaqiq Z, Moodi M, Bijari B. The Effect of Self-Care Training on Blood Sugar Control, HbA1C Level, and Life Quality of Diabetic Patients in Birjand, East of Iran: A Randomized Clinical Trial Study. Adv Prev Med. 2021;2021:8846798.
12. Jahangiri-Noudeh Y, Akbarpour S, Lotfaliany M, Zafari N, Khalili D, Tohidi M, Mansournia MA, Azizi F, Hadaegh FJPO. Trends in cardiovascular disease risk factors in people with and without diabetes mellitus: a Middle Eastern cohort study. PLoS One. 2014;9(12):e112639.
13. Sarayani A, Rashidian A, Gholami K. Low utilisation of diabetes medicines in Iran, despite their affordability (2000–2012): a time-series and benchmarking study. BMJ Open. 2014;4(10): e005859.

14. American Diabetes A. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2018. Diabetes Care. 2018;41(Suppl 1):S13–27.
15. Esteghamati A, Meysamie A, Khalilzadeh O, Rashidi A, Haghazali M, Asgari F, Kamgar M, Gouya MM, Abbasi M. Third national Surveillance of Risk Factors of Non-Communicable Diseases (SuRFNCD-2007) in Iran: methods and results on prevalence of diabetes, hypertension, obesity, central obesity, and dyslipidemia. BMC Public Health. 2009;9:167.
16. Tabatabaei-Malazy O, Mohajeri-Tehrani M, Madani S, Heshmat R, Larijani B. The prevalence of diabetic peripheral neuropathy and related factors. Iran J Public Health. 2011;40(3):55–62.
17. Montazeri A, Vahdaninia M, Mousavi SJ, Omidvari S. The Iranian version of 12-item Short Form Health Survey (SF-12): factor structure, internal consistency and construct validity. BMC Public Health. 2009;9:341.
18. Pakpour AH, Saffari M, Burri A. Translation and validation of an Iranian version of the Diabetes Quality of Life measure. J Diabetes Investig. 2012;3(5):471–8.
19. Oguejiofor OC, Odenigbo CU, Oguejiofor CB. Evaluation of the effect of duration of diabetes mellitus on peripheral neuropathy using the United Kingdom screening test scoring system, bio-thesiometry and aesthesiometry. Niger J Clin Pract. 2010;13(3):240–7.
20. Hasanato RM. Diagnostic efficacy of random albumin creatinine ratio for detection of micro and macro-albuminuria in type 2 diabetes mellitus. Saudi Med J. 2016;37(3):268–73.
21. Bjornstad P, Cherney DZ, Maahs DM. Update on Estimation of Kidney Function in Diabetic Kidney Disease. Curr Diab Rep. 2015;15(9):57.
22. Spitzer RL, Williams JB, Kroenke K, Linzer M, deGruy FV, 3rd, Hahn SR, Brody D, Johnson JG: Utility of a new procedure for diagnosing mental disorders in primary care. The PRIME-MD 1000 study. JAMA 1994, 272(22):1749–1756.
23. Delavari A, Alikhani S, Nili S, Birjandi RH, Birjandi F. Quality of care of diabetes mellitus type II patients in Iran. Arch Iran Med. 2009;12(5):492–5.
24. Fox KM, Gerber Pharmd RA, Bolinder B, Chen J, Kumar S. Prevalence of inadequate glycemic control among patients with type 2 diabetes in the United Kingdom general practice research database: A series of retrospective analyses of data from 1998 through 2002. Clin Ther. 2006;28(3):388–95.
25. Alvarez Guisasola F, Mavros P, Nocea G, Alemao E, Alexander CM, Yin D. Glycaemic control among patients with type 2 diabetes mellitus in seven European countries: findings from the Real-Life Effectiveness and Care Patterns of Diabetes Management (RECAP-DM) study. Diabetes Obes Metab. 2008;10(Suppl 1):8–15.
26. Chan JC, Gagliardino JJ, Baik SH, Chantelot JM, Ferreira SR, Hancu N, Ilkova H, Ramachandran A, Aschner P, Investigators I. Multifaceted determinants for achieving glycemic control: the International Diabetes Management Practice Study (IDMPS). Diabetes Care. 2009;32(2):227–33.
27. Minambres I, Mediavilla JJ, Sarroca J, Perez A. Meeting individualized glycemic targets in primary care patients with type 2 diabetes in Spain. BMC Endocr Disord. 2016;16:10.
28. Edelman SV, Polonsky WH. Type 2 Diabetes in the Real World: The Elusive Nature of Glycemic Control. Diabetes Care. 2017;40(11):1425–32.
29. Zhu VJ, Tu W, Marrero DG, Rosenman MB, Overhage JM. Race and medication adherence and glycemic control: findings from an operational health information exchange. AMIA Annu Symp Proc. 2011;2011:1649–57.
30. Tan MY, Magarey J. Self-care practices of Malaysian adults with diabetes and sub-optimal glycaemic control. Patient Educ Couns. 2008;72(2):252–67.
31. Choe SA, Kim JY, Ro YS, Cho SI. Women are less likely than men to achieve optimal glycemic control after 1 year of treatment: A multi-level analysis of a Korean primary care cohort. PLoS ONE. 2018;13(5): e0196719.
32. Haghighatpanah M, Nejad ASM, Haghighatpanah M, Thunga G, Mallayasamy S. Factors that Correlate with Poor Glycemic Control in Type 2 Diabetes Mellitus Patients with Complications. Osong Public Health Res Perspect. 2018;9(4):167–74.
33. Bhuyan SS, Shiyanbola O, Deka P, Isehunwa OO, Chandak A, Huang S, Wang Y, Bhatt J, Ning L, Lin WJ, et al. The Role of Gender in Cost-Related Medication Nonadherence Among Patients with Diabetes. J Am Board Fam Med. 2018;31(5):743–51.
34. Aa K. Impact of Gender on Type II Diabetes Glycemic and Cardiovascular Markers Control and Treatment. Pak J Biol Sci. 2020;23(12):1643–9.
35. Li FF, Zhang Y, Zhang WL, Liu XM, Chen MY, Sun YX, Su XF, Wu JD, Ye L, Ma JH. Male Patients with Longstanding Type 2 Diabetes Have a Higher Incidence of Hypoglycemia Compared with Female Patients. Diabetes Ther. 2018;9(5):1969–77.
36. Bruun-Rasmussen NE, Napolitano G, Kofoed-Enevoldsen A, Bojesen SE, Ellervik C, Rasmussen K, Jepsen R, Lynge E. Burden of prediabetes, undiagnosed, and poorly or potentially subcontrolled diabetes: Lolland-Falster health study. BMC Public Health. 2020;20(1):1711.
37. Qorbani M, Farzadfar F, Majdzadeh R, Mohammad K, Motevalian A. Technical efficiency of rural primary health care system for diabetes treatment in Iran: a stochastic frontier analysis. J Diabetes Metab Disord. 2017;16:33.
38. Farzadfar F, Murray CJ, Gakidou E, Bossert T, Namdaritabar H, Alikhani S, Moradi G, Delavari A, Jamshidi H, Ezzati M. Effectiveness of diabetes and hypertension management by rural primary health-care workers (Behvarz workers) in Iran: a nationally representative observational study. Lancet. 2012;379(9810):47–54.
39. Ki M, Baek S, Yun YD, Kim N, Hyde M, Na B. Age-related differences in diabetes care outcomes in Korea: a retrospective cohort study. BMC Geriatr. 2014;14:111.
40. Shamshirgaran SM, Mamaghanian A, Aliasgarzadeh A, Aiminisani N, Iranparvar-Alamdari M, Ataie J. Age differences in diabetes-related complications and glycemic control. BMC Endocr Disord. 2017;17(1):25.

Authors and Affiliations

Gita Shafiee[1] · Safoora Gharibzadeh[2] · Nekoo Panahi[3] · Farideh Razi[4] · Seyed Masoud Arzaghi[5] · Vahid Haghpanah[3,6] · Afshin Ostovar[7] · Alireza Raeisi[8] · Alireza Mahdavi-Hezareh[1] · Bagher Larijani[3] · Ensieh Nasli Esfahani[4] · Ramin Heshmat[1]

[1] Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Endocrinology and Metabolism Research Institute, Tehran University of Medical Sciences, NO 10, Jalale-Al-Ahmad Ave, Chamran Highway, Tehran, Iran

[2] Department of Epidemiology and Biostatistics, Pasteur Institute of Iran, Tehran, Iran

[3] Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

[4] Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Shahrivar St., North Kargar Ave, Tehran, Iran

[5] Elderly Health Research Center, Endocrinology and Metabolism Population Science Institute, Tehran University of Medical Sciences, Tehran, Iran

[6] Biobank Research Infrastructure, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

[7] Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

[8] School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran