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RESEARCH ARTICLE

The diabetes cascade of care through the 14 years in Iran: findings of nationwide STEPS surveys 2007–2021

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Abstract

Background Diabetes as the leading cause of mortality and morbidity, have been increased by about 35% from 2011 to 2015 worldwide. The objective of this study was to assess the trend and pattern of diabetes and prediabetes prevalence in Iran and also evaluate the diagnosis and status of diabetes management.

Methods The results of this study are extracted from the National Stepwise approach to non-communicable disease risk factor surveillance (STEPS), conducted in 2007, 2011, 2016, and 2021 in Iran. We evaluated all obtained data by questionnaires (demographic, epidemiologic, risk-related behavioral data), physical measurements, and laboratory measures.

Results The prevalence of diabetes almost doubled from 2007 to 2021 among adults 25 years old and above. Diabetes prevalence increased from 10.85% (95% CI:10.30–11.40) in 2016 to 14.15% (13.42–14.87) in 2021. Prediabetes prevalence increased from 18.11% (17.46- 18,76) in 2016 to 24.81% (23.88–25.74) in 2021. Diabetes diagnosis stayed constant hence; diabetes coverage improved from 56.87% (54.21–59.52) to 65.04% (62.40- 67.69). Despite an enhancement in diabetes diagnosis and coverage, diabetes effective care did not improve significantly during 2016 and 2021, with a number of 35.98% (32.60- 39.36) in 2016 and 31.35% (28.20- 34.51) in 2021.

Conclusion The prevalence of diabetes and prediabetes in Iran is almost doubled during the past 14 years. Although, several health policies had been developed to improve the screening and quality of diabetes care; there are still significant gaps in the effective control of diabetes. Accordingly, the current care plan should be reviewed.

Keywords Diabetes · Trend · Survey study · STEPS

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List of abbreviations

ADA	American Diabetes Association
COVID-19	Coronavirus disease 2019
FPG	Fasting blood glucose
GPAQ 1	Global Physical Activity Questionnaire version 1
HbA1c	Glycated hemoglobin A1c
NCD	Non-communicable disease
NGO	Non-Governmental Organisation
OHA	Oral Hypoglycemic Agents
PCA	Principal component analysis
STEPS	Stepwise approach to non-communicable disease risk factor surveillance
WHO	World Health Organization

Introduction

Diabetes as a leading cause of morbidity and mortality worldwide is an important global public concern with a tremendous economic burden on society [1, 2]. According to World Health Organization WHO estimations, the number of people with diabetes will increase from 135 million in 1995 to 300 million in 2025 and the increase will be more prominent in developing countries (170% in developing countries and 42% in developed countries) [3]. Also, diabetes is associated with a greater impact on reducing life expectancy in developing countries, which is mainly due to lifestyle and modernization of the society rather than genetic or ethnic characteristics [4].

In Iran, the prevalence of diabetes in adults aged 25–70 years increased by 35% from 2011 to 2015 [5]. It is estimated that nearly 9.2 million Iranians are likely to have diabetes by the year 2030 [6]. A significant percentage of people in Iran (about 30%) are unaware of their illness and delay in the diagnosis of diabetes is associated with complications as well as the increase in costs of management [7, 8]. Diabetes has always been one of the top ten leading causes of death in Iran and thus assessing the prevalence and its changes is a priority, especially to help policymakers [9].

Although the trend of diabetes in Iran has been summarized in the previous reports [5] an update of diabetes prevalence in 2021 and critical appraisal of data on T2DM as well as related risk factors are lacking. Moreover, the previous study was point estimated and we tried to enhance the estimation method by applying sample and population weights.

The purpose of the present study was to provide comprehensive information regarding the trend of diabetes and prediabetes at the national and subnational levels in Iran and to evaluate the diagnosis and also treatment and control of diabetes based on the results of the STEP-wise approach to non-communicable disease risk factor surveillance (STEPS) study during 2007–2021.

Methods

Overview

In the current study, we used data from Iran STEPS 2007, 2011, 2016, and 2021 surveys. STEPS is a national large-scale cross-sectional study of individuals aged ≥ 18 years recruited from urban and rural areas of all 31 Iran's provinces depleting a stratified random cluster sampling method. Only participants aged more than 25 years were eligible for lab measurements. In brief, STEPS 2007 was conducted on 29,991 individuals, 2011 on 12,104 individuals, 2016 on 31,50 individuals, and 2021 on 27,874 participants.

These surveys were conducted based on the standardized approach devised by the WHO, known as STEPS, to monitor NCD risk factors on a national level. The detailed methodology of this survey has been described elsewhere [10, 11].

Study design

The STEPS contains three phases, including (1) Questionnaire-based assessment, (2) Anthropometric measurement, and (3) Biochemical measurements. All STEPS participants were provided with detailed information regarding the study's objectives and methods. Informed consent was obtained from all participants. All the participants included in this study were aged 18 years or above. Only participants aged more than 25 years were eligible for lab measurements.

Variable definitions

Participants were divided into six age groups (25–34, 35–44, 45–54, 55–64, 65–74, and above). Diabetes was defined as Fasting Plasma glucose (FPG), or current self-reported diabetes medication [based on the intake of Oral Hypoglycemic Agents (OHA) and/or insulin injection]. Pre-diabetes was defined as $100 < FPG \leq 125$ mg/dl among those who were not recognized as diabetic. Diabetes diagnosis was defined as individuals' self-report based on their physician's diagnosis among all diabetic patients. Diabetes coverage is defined as the proportion of diabetic individuals who had taken medication routinely. American Diabetes Association (ADA) criteria were used to define diabetes effective care; accordingly, patients with $FPG < 130$ mg/dl were considered as having effective care [12].

The number of successfully completed years of schooling was used to define education, which was categorized into

four subgroups [0 (Illiterate), 1–6, 7–12, and > 12 years] to define education level. Principal component analysis (PCA) was utilized to calculate the participants' wealth index from household asset data. Individuals' wealth indices were categorized into five quintiles from the poorest (first quintile) to the richest (fifth quintile). We used Global Physical Activity Questionnaire version 1 (GPAQ 1) to measure physical activity and the MET-min score was used to represent weekly physical activity [13]. Hypertension was defined as the presence of one of the following terms: systolic blood pressure ≥ 140 mmHg, or diastolic blood pressure ≥ 90 mmHg, or self-reported anti-hypertensive medications.

Data sources

Age-standardization of provincial diabetes and prediabetes prevalence was achieved according to the 2016 National Population and Housing Census conducted by Iran's Statistical Center. A total of eight studies based on WHO STEPS have been surveyed in Iran in 2005, 2006, 2007, 2008, 2009, 2011, 2016, and 2021. The studies from 2006, 2008, and 2009 were excluded; because they did not contain biochemical measures including blood glucose. Moreover, the study from 2005 was excluded due to the differences in the sampling frame. We applied population and sampling weights to estimate the most accurate prevalence of diabetes and prediabetes.

Statistical analysis

All prevalence proportion have been presented with 95% Confidence Intervals (95% CI) in the tables after applying weights to the samples, based on the population size, age, and gender distribution (survey analysis) for the STEPS 2016 and 2021; hence, for the 2007 and 2011 weights calculated only based on population size. Multiple logistic regression was applied to determine the risk factor associated with diabetes prevalence, diagnosis, coverage, and effective care in 2021. All baseline variables (Sex, Age category, Area of residency, Education, Wealth index quintiles, Marital Status, BMI category, Insurance, Low physical activity, and Hypertension) were included in the multiple logistic models. All statistical analyses were performed by R software version 4.1.2 (http://www.r-project.org, RRID: SCR_001905.).

Results

The prevalence of diabetes doubled from 2007 to 2021 (7.23% (6.59,7.87) and 14.15% (13.42,14.87), respectively) (Fig. 1). Diabetes prevalence increased in all age categories except in 25–34 and 35–44 aged groups (from 2.66% (1.92, 3.40) and 5.84% (4.88,6.8) in 2007 to (0.37% (0.99,1.76) and 3.83% (3.2,4.45) in 2021 (Fig. 2). In 2021, Highest prevalence of diabetes was observed in individuals aged 65–74 years and was more prevalent in urban areas compared to rural areas (15.19% vs. 10.96%). Also, the most

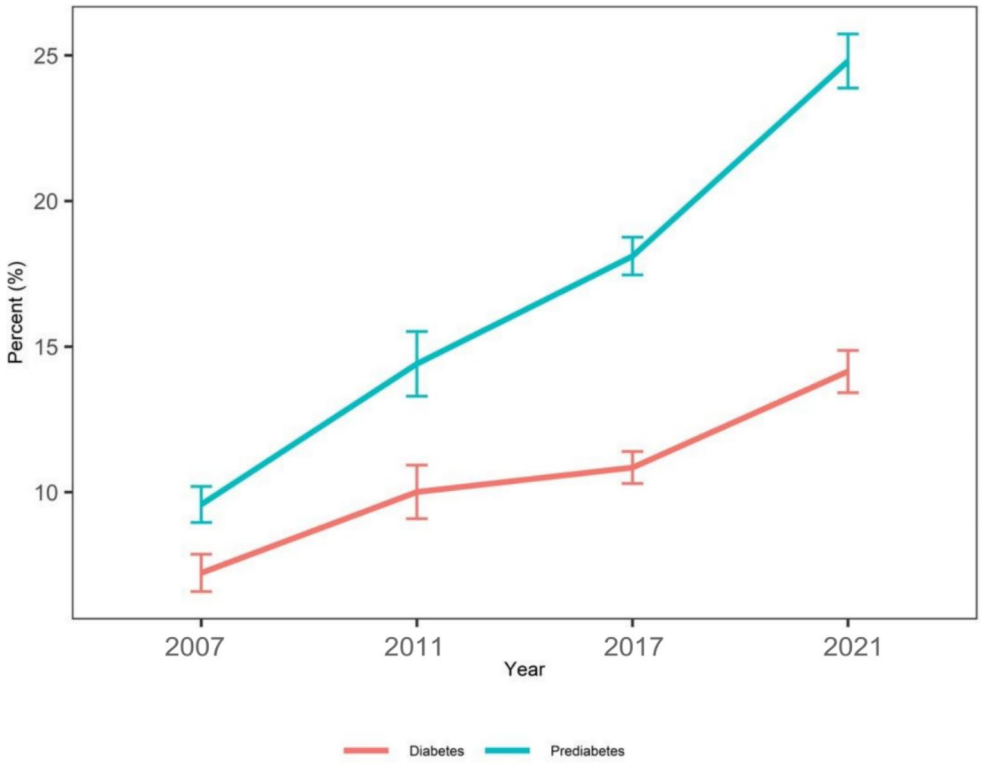

Fig. 1 Diabetes and Prediabetes prevalence pattern during study periods

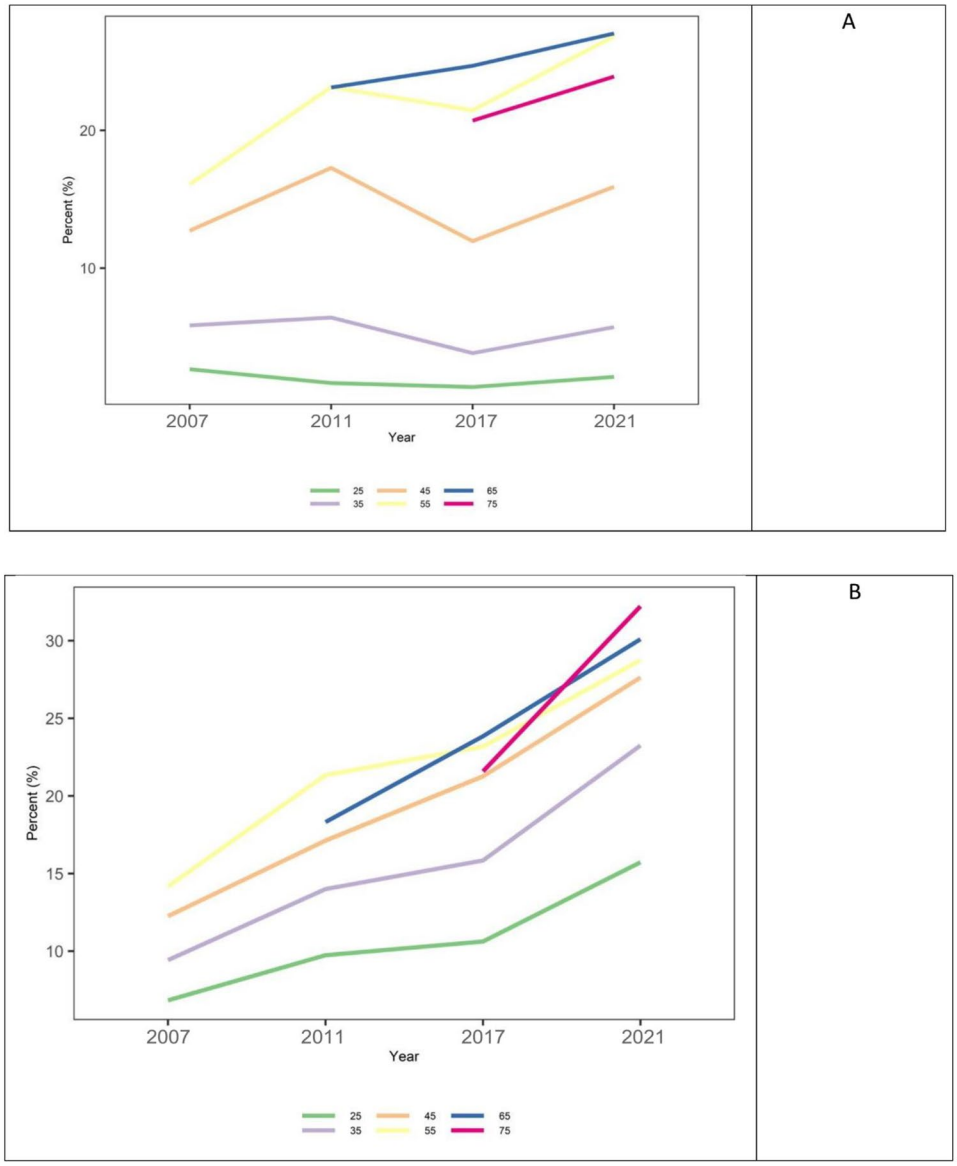

Fig. 2 Diabetes (**A**) and prediabetes (**B**) pattern in different age groups

increase rate was observed in individuals with more than 12 years of education from 2011 to 2021 (4.68–10.01%). The diabetes prevalence increased mostly in individuals with the lowest wealth index from 7.02% to 2011 to 13.31% in 2021. Normal-weight individuals, with $18.5 \leq BMI < 25$, had the highest increase in the term of diabetes prevalence from 4.33 to 9.18%. Moreover, the diabetes prevalence almost doubled in obese individuals ($30 \leq BMI$) from 11.31 to 21.77% between 2007 and 2021. Individuals with and without health insurance had almost the same rate of diabetes prevalence increase rate during the study period (Table 1). The detailed prevalence of diabetes in each STEPS study is demonstrated in Table 1.

Table 2 summarizes the prevalence of prediabetes during the study period. The Prediabetes prevalence in 2007 increased from 9.58 to 24.81% in 2021 with a 158.98% of relative change. This pattern was detected in all categories of ages (Fig. 2); Hence, individuals aged 35–44 years experienced the highest rate of escalation (from 9.43% to 2007 to 23.25% in 2021). The prevalence increase rate is almost equal in rural and urban areas (157.17% and 158.11%). Prediabetes prevalence had the same pattern as diabetes in different wealth indices, which increased the most in the poorest individuals from 9.85 to 26.36%. Between different categories of BMI levels, the highest increase rate was observed in underweight individuals ($18.5 < BMI$) from 6.75% to 2007 to 19.82% in 2021. The prevalence increase rate is almost equal in individuals with and without insurance (156.05% and 160.69%).

Table 1 Prevalence of diabetes based on general characteristics of the participants

Variable	Category	2007 N (%) (95%CI)	2011 N (%) (95%CI)	2016 N (%) (95%CI)	2021 N (%) (95%CI)
Total		1670 (7.23) (6.59,7.87)	712 (10.01) (9.09,10.93)	1999 (10.85) (10.3,11.4)	2443 (14.15) (13.42,14.87)
Sex	Female	952 (7.38) (6.65,8.11)	470 (11.07) (9.88,12.26)	1172 (11.55) (10.79,12.3)	1456 (14.71) (13.76,15.65)
	Male	718 (7.06) (6,8.13)	242 (8.78) (7.36,10.2)	827 (10.01) (9.23,10.8)	987 (13.45) (12.32,14.57)
Age category	25–34 years	100 (2.66) (1.92,3.4)	23 (1.66) (0.94,2.39)	59 (1.37) (0.99,1.76)	65 (2.1) (1.47,2.73)
	35–44 years	264 (5.84) (4.88,6.8)	66 (6.41) (4.69,8.13)	174 (3.83) (3.2,4.45)	258 (5.72) (4.66,6.78)
	45–54 years	568 (12.72) (10.62,14.82)	175 (17.28) (14.39,20.18)	476 (11.96) (10.7,13.22)	576 (15.91) (14.29,17.53)
	55–64 years	738 (16.08) (14.48,17.67)	324 (23.15) (20.65,25.66)	667 (21.47) (19.73,23.21)	838 (26.83) (24.66,29)
	65–74 years	0 (0) (0,0)	124 (23.12) (18.61,27.63)	410 (24.69) (22.08,27.31)	535 (27.04) (24.35,29.73)
	75 years and above	-	-	213 (20.71) (17.82,23.6)	171 (23.91) (19.36,28.46)
Area of residency	rural	546 (5.76) (4.94,6.57)	188 (7.08) (5.76,8.4)	534 (8.08) (7.37,8.78)	602 (10.96) (9.97,11.95)
	urban	1124 (7.86) (7.01,8.71)	524 (11.27) (10.09,12.45)	1465 (12.04) (11.32,12.76)	1841 (15.19) (14.28,16.1)
Education	0	-	322 (15.64) (13.65,17.63)	618 (18.19) (16.77,19.61)	663 (21.41) (19.62,23.2)
	1–7	-	192 (10.92) (9.14,12.69)	631 (12.3) (11.16,13.43)	850 (18.6) (17.13,20.07)
	7–12	-	165 (7.99) (6.46,9.52)	511 (8.15) (7.31,9)	335 (11.25) (9.72,12.77)
	12+	-	32 (4.68) (2.54,6.82)	239 (7.34) (6.28,8.4)	575 (10.01) (8.84,11.18)
Wealth index quintiles	Poorest	-	122 (7.02) (5.41,8.63)	320 (8.17) (7.17,9.17)	513 (13.31) (11.91,14.7)
	2	-	162 (10.54) (8.39,12.7)	456 (12.4) (11.15,13.65)	484 (15.48) (13.74,17.22)
	3	-	155 (10.23) (8.24,12.21)	461 (13.12) (11.74,14.5)	468 (13.48) (12.05,14.91)
	4	-	193 (12.85) (10.7,15)	394 (11.05) (9.84,12.25)	470 (14.55) (12.89,16.2)
	Richest	-	77 (8.17) (6.07,10.27)	324 (9.55) (8.3,10.8)	389 (14.09) (12.13,16.05)
Marital Status	Married	-	-	1616 (10.66) (10.06,11.25)	2040 (14.39) (13.58,15.2)
	Single	-	-	24 (1.93) (1.1,2.75)	55 (3.38) (2.17,4.59)
	Divorced/separate with partner	-	-	40 (10.7) (7.08,14.32)	41 (11.67) (6.28,17.07)
	Widow	-	-	285 (22.56) (19.67,25.44)	307 (25.39) (22.22,28.56)
BMI category	BMI < 18.5	23 (1.75) (0.86,2.64)	6 (1.16) (0.01,2.32)	14 (2.32) (1.07,3.56)	16 (2.6) (1.18,4.01)
	18.5 ≤ BMI < 25	384 (4.33) (3.66,5.01)	124 (5.16) (3.93,6.39)	376 (6.96) (6.1,7.82)	459 (9.18) (7.98,10.37)
	25 ≤ BMI < 30	692 (7.94) (6.63,9.25)	289 (11.86) (10.16,13.56)	774 (11.23) (10.31,12.15)	955 (13.47) (12.37,14.56)
	30 ≤ BMI	571 (11.31) (9.85,12.77)	290 (16.93) (14.68,19.19)	760 (16.44) (15.19,17.69)	1002 (21.77) (20.14,23.41)
Insurance	No	214 (4.81) (3.85,5.77)	-	71 (6.84) (5.05,8.64)	142 (9.43) (7.16,11.71)
	Yes	1455 (7.96) (7.19,8.73)	712 (10.01) (9.09,10.93)	1902 (11.14) (10.56,11.71)	2281 (14.61) (13.85,15.38)
Low physical activity	No	223 (6.77) (5.57,7.97)	284 (8.92) (7.65,10.19)	709 (9.97) (9.09,10.84)	985 (12.35) (11.33,13.36)
	Yes	217 (9.47) (7.86,11.08)	398 (12.82) (11.24,14.4)	1159 (12.58) (11.77,13.39)	1328 (16.94) (15.79,18.1)
Hypertension	No	738 (4.96) (4.4,5.52)	52 (18.36) (12.8,23.93)	796 (6.57) (6.04,7.11)	818 (7.67) (6.98,8.37)
	Yes	909 (14.5) (12.62,16.38)	404 (19.29) (17.1,21.47)	1174 (20.73) (19.45,22.02)	1618 (25.71) (24.19,27.23)

Diabetes/prediabetes prevalence in each province and geographical inequalities

Between 2007 and 2021, the highest increase in diabetes prevalence was in Ilam province from 3.43 to 9.29% (Supp Table 1) (Fig. 3). Sex-stratified age-standardized diabetes prevalence is illustrated in Fig. 4. During the 14 years of the study, the highest increase in prediabetes prevalence was in Alborz province from 2.43 to 23.06% (Supp Table 2) (Fig. 3). Sex-stratified age-standardized prediabetes prevalence is illustrated in Fig. 4. The highest to lowest diabetes and prediabetes prevalence ratios were estimated to compare the trend of differences between provinces in consequent years (Supp Tables 3 and 4). The ratio for diabetes prevalence decreased from 4.17 (highest: 13.56% (Qom), lowest: 3.25% (Hamedan)) in 2007, to 2.79 (Highest:

Table 2 Prevalence of prediabetes based on general characteristics of the participants

Variable	Category	2007 N (%) (95%CI)	2011 N (%) (95%CI)	2016 N (%) (95%CI)	2021 N (%) (95%CI)
Total		2108 (9.58) (8.96,10.2)	883 (14.41) (13.3,15.52)	3462 (18.11) (17.46,18.76)	4273 (24.81) (23.88,25.74)
Sex	Female	1090 (9.48) (8.62,10.33)	533 (13.92) (12.6,15.24)	1790 (17.24) (16.37,18.11)	2311 (23.55) (22.32,24.77)
	Male	1018 (9.69) (8.78,10.6)	350 (14.98) (13.11,16.85)	1672 (19.16) (18.18,20.14)	1962 (26.4) (24.97,27.83)
Age category	25–34 years	296 (6.84) (5.77,7.91)	122 (9.74) (7.94,11.55)	475 (10.63) (9.59,11.68)	540 (15.73) (14.02,17.43)
	35–44 years	470 (9.43) (8.29,10.57)	139 (14) (11.55,16.45)	736 (15.85) (14.65,17.05)	940 (23.25) (21.42,25.08)
	45–54 years	620 (12.26) (10.92,13.6)	187 (17.13) (14.45,19.8)	835 (21.27) (19.69,22.85)	1131 (27.63) (25.71,29.55)
	55–64 years	722 (14.17) (12.75,15.58)	332 (21.35) (19.05,23.66)	744 (23.19) (21.41,24.97)	915 (28.75) (26.54,30.96)
	65–74 years	0 (0) (0,0)	103 (18.32) (14.41,22.24)	422 (23.85) (21.44,26.25)	537 (30.1) (27,33.21)
	75 years and above	-	-	250 (21.59) (18.87,24.3)	210 (32.22) (26.06,38.38)
Area of residency	rural	779 (8.92) (7.99,9.85)	244 (10.44) (8.76,12.13)	1115 (16.68) (15.7,17.67)	1249 (22.85) (21.52,24.18)
	urban	1329 (9.86) (9.07,10.64)	639 (16.06) (14.65,17.47)	2347 (18.73) (17.9,19.55)	3024 (25.45) (24.3,26.61)
Education	0	-	327 (16.14) (14.08,18.19)	731 (20.18) (18.74,21.61)	832 (29.12) (26.93,31.3)
	1–7	-	236 (15.04) (12.79,17.29)	1089 (20.2) (18.9,21.5)	1232 (25.91) (24.13,27.68)
	7–12	-	239 (13.21) (11.38,15.04)	1142 (17.24) (16.14,18.34)	800 (25.31) (23.23,27.4)
	12+	-	81 (13.72) (10.31,17.13)	500 (14.74) (13.34,16.15)	1378 (22.37) (20.81,23.93)
Wealth index quintiles	Poorest	-	145 (9.85) (7.92,11.78)	636 (15.28) (14,16.55)	867 (26.36) (24.07,28.66)
	2	-	208 (16.06) (13.48,18.65)	705 (18.36) (16.96,19.76)	772 (24.07) (22.04,26.1)
	3	-	208 (14.99) (12.64,17.34)	683 (17.89) (16.49,19.28)	863 (24.93) (23,26.85)
	4	-	233 (17.8) (15.21,20.39)	676 (19.12) (17.57,20.67)	871 (26.09) (24.06,28.12)
	Richest	-	84 (11.5) (8.44,14.56)	663 (19.59) (17.94,21.24)	685 (22.82) (20.47,25.17)
Marital status	Married	-	-	2884 (18.54) (17.82,19.27)	3614 (25.01) (24.01,26.02)
	Single	-	-	189 (12.89) (10.98,14.8)	244 (20.28) (16.6,23.97)
	Separated	-	-	50 (14.25) (9.88,18.63)	82 (19.97) (14.15,25.8)
	Widow	-	-	271 (19.24) (16.8,21.67)	333 (29.68) (25.98,33.37)
BMI category	BMI < 18.5	45 (6.75) (4.27,9.24)	12 (4.77) (1.55,7.99)	82 (11.63) (9.05,14.21)	72 (19.82) (14.55,25.09)
	18.5 ≤ BMI < 25	595 (7.24) (6.36,8.13)	203 (9.56) (8.01,11.11)	808 (13.69) (12.61,14.78)	1055 (20.67) (19.08,22.27)
	25 ≤ BMI < 30	766 (9.05) (8.03,10.07)	352 (16.69) (14.69,18.7)	1343 (18.86) (17.79,19.94)	1701 (24.84) (23.37,26.31)
	30 ≤ BMI	702 (14.33) (12.72,15.93)	311 (20.61) (17.97,23.25)	1104 (23.74) (22.3,25.18)	1421 (29.58) (27.69,31.47)
Insurance	No	355 (8.98) (7.53,10.43)	-	179 (17.93) (14.88,20.99)	320 (23.41) (20.16,26.65)
	Yes	1751 (9.76) (9.08,10.44)	-	3226 (18.11) (17.44,18.77)	3922 (24.99) (24.01,25.96)
Low Physical activity	No	284 (9.47) (7.97,10.97)	419 (15.06) (13.39,16.73)	1361 (18.14) (17.13,19.16)	1961 (25.26) (23.83,26.68)
	Yes	198 (10.27) (8.44,12.09)	393 (14.35) (12.69,16.02)	1691 (18.22) (17.27,19.17)	1952 (24.91) (23.54,26.29)
Hypertension	No	1193 (8.28) (7.56,9.01)	36 (16.5) (9.56,23.44)	2089 (16.12) (15.37,16.87)	2381 (22.23) (21.11,23.34)
	Yes	874 (13.6) (12.32,14.88)	370 (18.24) (16.1,20.37)	1310 (22.7) (21.39,24)	1881 (29.37) (27.73,31.02)

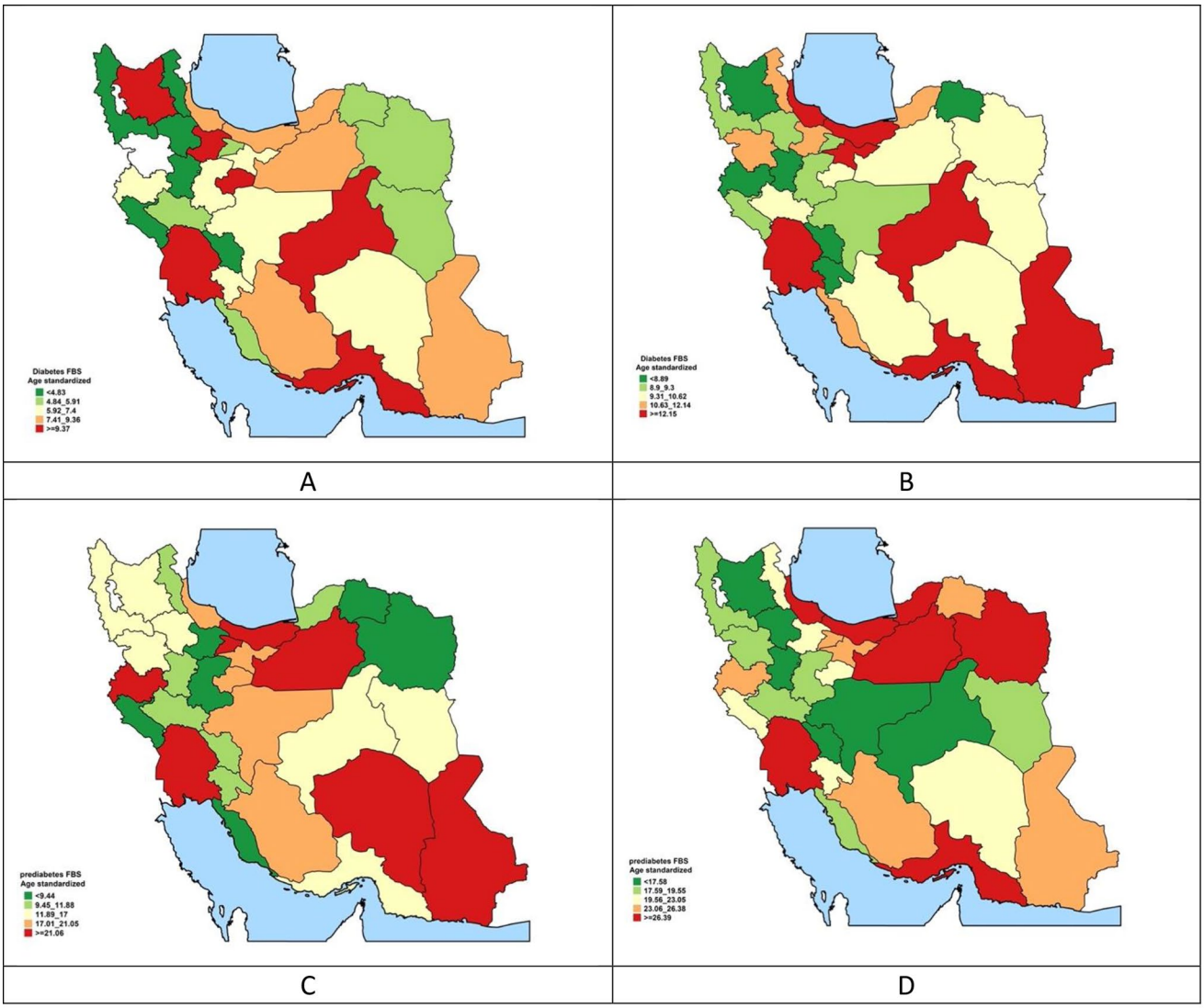

Fig. 3 Age standardized diabetes (A.2007, B.2021) and prediabetes (C.2007, D.2021) prevalence

16.29% (Khuzestan), Lowest: 5.84% (Kermanshah)) in 2021, although the highest prevalence observed in 2011 with a number of 7.11. The prediabetes prevalence ratio consistently decreased during the study period from 8.83 to 2007 to 1.94 in 2021.

Diabetes cascade of care

Diabetes prevalence increased from 10.85% to 2016 to 4.15% in 2021; meanwhile, diabetes diagnosis did not meet any significant changes during these years (74.63–73.28%) (Table 3); hence, diabetes treatment coverage increased significantly from56.87% in 2016 to 65.04% in 2021. Despite an enhancement in diabetes treatment coverage, diabetes effective care did not face any significant changes from 2016 to 2021 (35.98% and 31.35%, respectively).

Higher age, living in urban areas, up to 7 years of education, being married or widow, higher BMI, low physical activity, and hypertension were associated with diabetes prevalence in 2021 (Table 4).

Diabetes in individuals of higher age was likely to be diagnosed except in patients aged 75 years and above (OR:1.76; CI:0.66 to 4.69). Patients in the highest wealth index quintiles had the highest risk of being diagnosed with diabetes compared to other wealth index groups (OR:1.69; CI:1.03 to 2.76). Moreover, being hypertensive and having insurance coverage were the two factors that increased the diagnosis of diabetes (Table 5).

Diabetes treatment coverage predictors are listed in Table 6. Patients aged between 55 and 64 years old, were the most covered individuals (OR:4.05; CI:1.72 to 9.52). The richest patients were more covered significantly (OR:1.76; CI:1.13 to 2.75). Having insurance and hypertension were

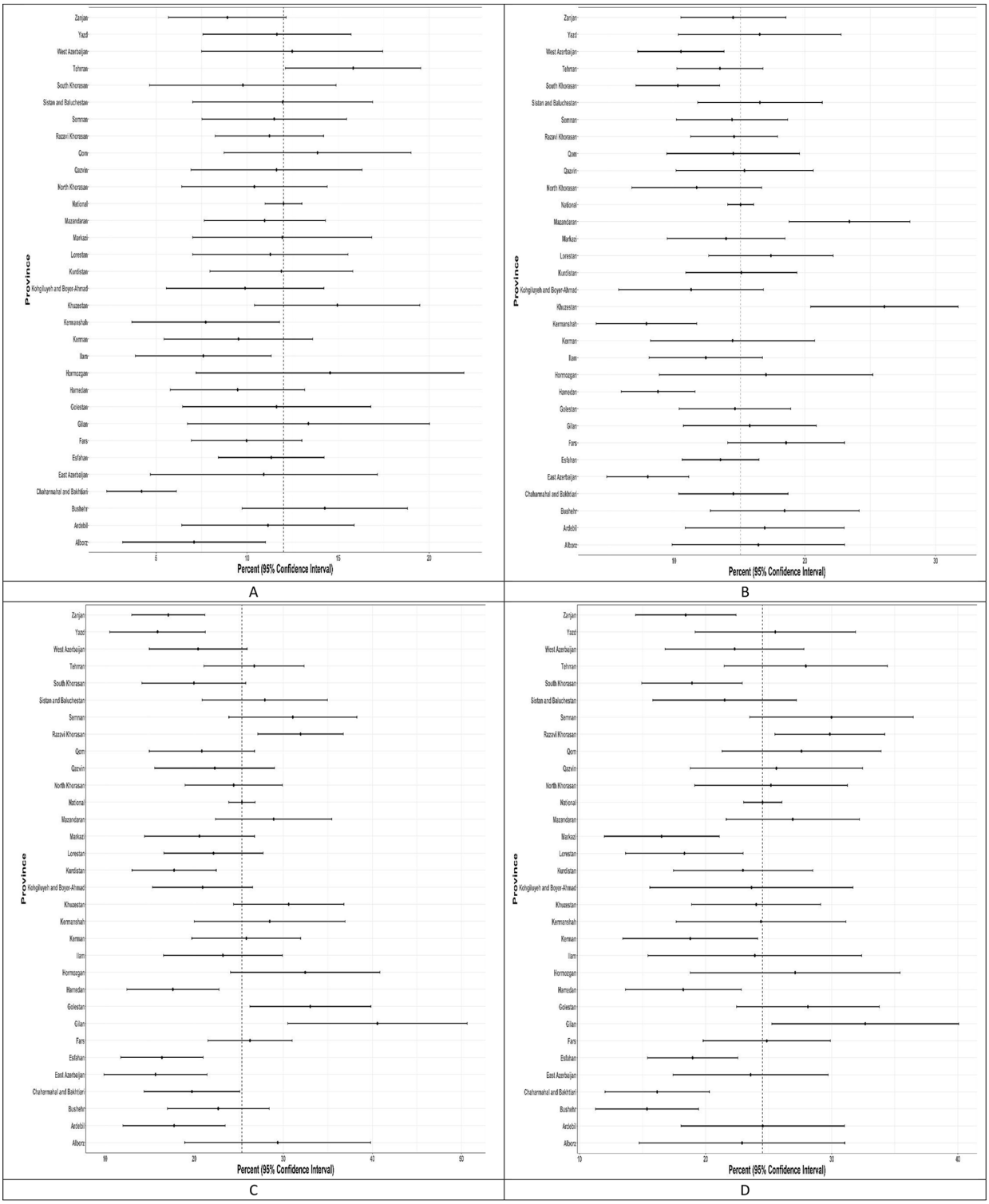

Fig. 4 Age standardized prevalence of diabetes (A. Male, B. Female) and prediabetes (C. Male, D. Female) in 2021

Table 3 The diabetes cascade of care

Variable	2007 N (%) (95%CI)	2011 N (%) (95%CI)	2016 N (%) (95%CI)	2021 N (%) (95%CI)
Diabetes prevalence	1670 (7.23) (6.59,7.87)	712 (10.01) (9.09,10.93)	1999 (10.85) (10.3,11.4)	2443 (14.15) (13.42,14.87)
Diabetes diagnosis	1029 (60.84) (56.43,65.24)	509 (68.56) (63.83,73.28)	1493 (74.63) (72.4,76.87)	1804 (73.28) (70.83,75.74)
Diabetes coverage	889 (51.12) (46.4,55.83)	454 (59.52) (54.69,64.34)	1160 (56.87) (54.21,59.52)	1596 (65.04) (62.4,67.69)
Diabetes effective care	348 (41.98) (36.89,47.08)	160 (35.57) (30.05,41.1)	423 (35.98) (32.6,39.36)	523 (31.35) (28.2,34.51)

Table 4 Variables associated with the prevalence of diabetes

Variable		OR (95%CI)	P-value
Age (25–34 as reference)	35–44	2.69(1.79,4.03)	< 0.001
	45–54	6.85(4.68,10.04)	< 0.001
	55–64	11.46(7.74,16.97)	< 0.001
	65–74	10.67(7.10,16.05)	< 0.001
	75 and above	8.57(5.22,14.08)	< 0.001
Urban		1.22(1.05,1.41)	0.007
Years of education (0 years as reference)	0–7	1.26(1.05,1.51)	0.011
	7–12	1.08(0.85,1.38)	0.499
	12+	1.12(0.88,1.41)	0.338
Wealth index (Poorest as reference)	2nd quintile	1.15(0.93,1.43)	0.175
	3rd quintile	1.04(0.85,1.27)	0.673
	4th quintile	1.05(0.84,1.31)	0.64
	Richest	1.07(0.83,1.38)	0.564
Marital Status (Single as reference)	Married	1.60(1.02,2.51)	0.038
	separated	1.57(0.71,3.47)	0.259
	widow	1.66(1.02,2.72)	0.041
BMI (BMI < 18.5 as reference)	18.5 ≤ BMI < 25	3.44(1.76,6.72)	< 0.001
	25 ≤ BMI < 30	4.04(2.07,7.86)	< 0.001
	30 ≤ BMI	6.24(3.19,12.17)	< 0.001
Insurance		1.03(0.76,1.40)	0.818
Low physical activity		1.31(1.13,1.50)	< 0.001
Hypertension		2.14(1.81,2.52)	< 0.001

also associated with higher coverage among diabetic patients (Table 6).

Diabetes effective care was significantly lower in patients aged between 45 and 54 and 65–74 years old (OR:0.29 and 0.30, respectively). Furthermore, patients in the 3rd quintile of the wealth index were less likely to have controlled glucose levels (OR:0.44; CI:0.27 to 0.70) (Table 7).

Table 5 Variables associated with the diagnosis of diabetes

Variable		OR (95%CI)	P-value
Age (25–34 as reference)	35–44	2.58(1.09,6.09)	0.03
	45–54	2.52(1.11,5.69)	0.026
	55–64	3.60(1.58,8.21)	0.002
	65–74	2.80(1.19,6.06)	0.018
	75 and above	1.75(0.65,4.69)	0.261
Urban		1.18(0.88,1.57)	0.259
Years of education (0 years as reference)	0–7	1.56(1.09,2.23)	0.014
	7–12	1.24(0.78,1.97)	0.357
	12+	0.90(0.59,1.39)	0.653
Wealth index (Poorest as reference)	2nd quintile	0.98(0.66,1.45)	0.931
	3rd quintile	1.22(0.82,1.84)	0.318
	4th quintile	0.87(0.56,1.34)	0.535
	Richest	1.68(1.03,2.75)	0.037
Marital Status (Single as reference)	Married	0.93(0.40,2.13)	0.868
	separated	3.38(0.92,12.36)	0.065
	widow	1.64(0.65,4.13)	0.29
BMI (BMI < 18.5 as reference)	18.5 ≤ BMI < 25	2.50(0.83,7.52)	0.101
	25 ≤ BMI < 30	2.50(0.85,7.39)	0.096
	30 ≤ BMI	2.30(0.77,6.83)	0.132
Insurance		2.08(1.18,3.66)	0.011
Low physical activity		1.23(0.94,1.61)	0.129
Hypertension		2.25(1.68,3.02)	< 0.001

Table 6 Variables associated with the treatment coverage of diabetes

Variable		OR (95%CI)	P-value
Age (25–34 as reference)	35–44	2.85(1.18,6.87)	0.02
	45–54	3.10(1.33,7.22)	0.009
	55–64	4.04(1.72,9.51)	0.001
	65–74	3.24(1.35,7.77)	0.008
	75 and above	2.57(0.95,6.89)	0.061
Urban		1.08(0.82,1.43)	0.558
Years of education (0 years as reference)	0–7	1.38(0.99,1.92)	0.056
	7–12	1.19(0.76,1.85)	0.429
	12+	0.85(0.56,1.27)	0.432
Wealth index (Poorest as reference)	2nd quintile	1.07(0.75,1.54)	0.693
	3rd quintile	1.17(0.79,1.71)	0.418
	4th quintile	0.97(0.66,1.44)	0.914
	Richest	1.75(1.12,2.74)	0.013
Marital Status (Single as reference)	Married	0.88(0.37,2.06)	0.77
	separated	1.56(0.44,5.43)	0.483
	widow	1.34(0.53,3.38)	0.534
BMI (BMI < 18.5 as reference)	18.5 ≤ BMI < 25	2.14(0.65,7.05)	0.209
	25 ≤ BMI < 30	2.35(0.72,7.65)	0.154
	30 ≤ BMI	2.12(0.65,6.93)	0.211
Insurance		1.90(1.12,3.22)	0.019
Low physical activity		1.07(0.83,1.37)	0.578
Hypertension		2.12(1.61,2.79)	< 0.001

Table 7 Variables associated with the effective care of diabetes

Variable		OR (95%CI)	P-value
Age (25–34 as reference)	35–44	0.36(0.10,1.24)	0.108
	45–54	0.294(0.011,0.946)	0.04
	55–64	0.35(0.11,1.14)	0.083
	65–74	0.30(0.09,0.99)	0.049
	75 and above	0.51(0.14,1.85)	0.307
Urban		1.24(0.88,1.76)	0.210
Years of education (0 years as reference)	0–7	1.21(0.83,1.77)	0.308
	7–12	1.00(0.58,1.73)	0.986
	12+	1.33(0.80,2.22)	0.26
Wealth index (Poorest as reference)	2nd quintile	0.77(0.50,1.19)	0.246
	3rd quintile	0.43(0.27,0.69)	< 0.001
	4th quintile	0.67(0.42,1.09)	0.114
	Richest	0.75(0.43,1.28)	0.298
Marital Status (Single as reference)	Married	0.96(0.28,3.25)	0.957
	separated	0.39(0.078,2.02)	0.267
	widow	0.81(0.22,2.87)	0.745
BMI (BMI < 18.5 as reference)	18.5 ≤ BMI < 25	1.25(0.23,6.84)	0.79
	25 ≤ BMI < 30	1.27(0.24,6.73)	0.773
	30 ≤ BMI	1.53(0.29,8.06)	0.614
Insurance		1.19(0.57,2.48)	0.640
Low physical activity		1.38(1.00,1.89)	0.046
Hypertension		1.01(0.70,1.43)	0.965

Discussion

These national population-based studies evaluated the prevalence, diagnosis, coverage, and effective care of diabetes and prediabetes during a period of 14 years in Iran. According to our findings, the prevalence of both diabetes and prediabetes doubled during the study period. In 2007, Diabetes had a heterogeneous geographical distribution pattern, while in 2021, eastern provinces had a higher prevalence than the national average. In terms of prediabetes, southeastern provinces higher prevalence than the national average; hence, this pattern could be observed in northeastern provinces in 2021. At the national level, diabetes diagnosis, and coverage had also increased between 20 and 30%; however, effective care dropped about 25% during this period.

The prevalence of diabetes and prediabetes showed an increasing pattern from 2007 to 2021. Similar to our findings, previous national studies reported an increase in the prevalence of diabetes and prediabetes [5, 14]. The increasing trend of diabetes and prediabetes in Iran is regardless of time period, age distribution, regional focus, diagnostic criteria as well as self-reported or clinically proven status. Thus, due to the several life-threatening complications associated with both diabetes and prediabetes, it is important to pay attention to the increasing trend and consider this issue as a priority in health policies. One of the nine WHO global monitoring framework targets to enable global tracking of progress in preventing and controlling major non-communicable diseases is to halt the rise of diabetes and obesity [15]. Iran, as a low- and middle-income country (LMIC), was not successful to reach this goal in past years.

The increase in the prevalence of diabetes was higher among females, urban areas, and older individuals compared to others. One possible explanation for the higher prevalence of diabetes in females might be the occurrence of gestational diabetes in this group [16], which highlights the necessity of policies to provide high-quality antenatal care for the diagnosis and treatment of gestational diabetes [17]. Moreover, the higher prevalence of obesity and overweight which is mainly due to multi-parity, unhealthy diet behaviors, and low levels of physical activity, is another explanation for the higher prevalence of diabetes in females compared to males [18, 19]. The higher prevalence of diabetes in urban areas can be due to changes in lifestyle, diet, obesity, and physical activity [20, 21]. Moreover, based on previous studies, the proportion of the population who had checked their blood glucose and was diagnosed with diabetes and got the proper treatment was also higher in urban areas [22]. This could also explain the higher prevalence of diabetes in urban areas and highlights the importance of applying screening programs in rural areas. Our study showed that diabetes diagnosis is less likely in elder individuals (< 70 years). This finding could be explained by the lack of typical diabetes symptoms in the elderly. Due to the increasing renal threshold for glucose in the elderly, thirst mechanisms are impaired and typical semiology including polyuria and polydipsia could not be identified in these patients. Moreover, common diabetes symptoms including neuropathy, nephropathy, cardiovascular complications, and recurrent urinary infections are usually wrongly attributed to aging [23].

According to our findings, diabetes diagnosis was 73.28% in 2021 and had an increasing pattern since 2007; however the most diagnostic rate was in 2016 (74.63%), which may be due to the health policies across the country during the past decades to educate people, screen, and treat diabetes. The increase in diabetes diagnosis is in line with previous national studies [14, 24]. Another explanation for increasing in diagnosis is that diabetes prevalence has been increasing during the study period and diagnosis growth could be due to rising prevalence. Diabetes diagnosis is significantly associated with glycemic control and reducing complications in diabetic patients [25] and thus, paying attention to diagnosis is a priority in health policies through social media and screening campaigns.

Despite the high level of diagnosis, the effective care of diabetes is still poor in Iran. Achieving a high level of effective care requires a comprehensive health delivery system providing high-quality services according to the needs of the patients, which may lead to improved health outcomes

[26]. Despite the improvement in diabetes coverage, the effective care of diabetes remains the same during 2016 and 2021. This issue could have resulted from sanctions against Iran, which target the pharmaceutical industries and consumers. Sanctions caused the loss of reliable sources and obtaining low-quality materials which leads to decreased drug efficacy and unexpected toxicity [27]. The other explanation could be the high prevalence of diabetes in Iran, with an increasing rate from about 30% from 10.85% in 2016 to 14.15% in 2021. The inter-provincial difference in the country is the other driver of diabetes effective care [28]. This inequality, which is mainly due to economic and physical barriers, causes the different quality of health services provided in each province and has a strong influence on the screening, diagnosis, and treatment of non-communicable diseases [29]. According to our findings, despite the significant changes in the "highest to lowest diabetes prevalence ratio" among different provinces of Iran, we are far from our goals to come over provincial discrimination in Iran. Other drivers which impact healthcare services are outbreaks and epidemics. Per recent studies, diabetes care indices met a significant decrease during Coronavirus disease 2019 (COVID-19) pandemic [30]. This drop in diabetes care could be explained by the redistribution of health staff and facilities, lockdown policy, and community fear. Further research must be done in order to measure the quality of diabetes care and its improvement over the years in Iran. This lack of effective care is a warning sign and requires appropriate policies to improve the quality of services provided to diabetic patients. It should also be noted that despite the increase in the number of health centers providing diabetic care in the past decade and the significant allocation of costs to diabetic care, the status of diabetes effective care has not changed [31]. To reach the management goals in Iran, collaboration between the government, Non-Governmental Organisation (NGOs), healthcare professionals, and professional medical societies is mandatory [32]. It is suggested that the system of care for managing diabetes should be redesigned to provide accessible and high-quality services to diabetic patients in Iran [33].

Strengths

STEPS studies are the nationwide observational studies, which provide the most novel data regarding all health parameters in Iran with a large population-based sample of both sexes and across a broad age spectrum, in urban and rural areas of all provinces of Iran. Moreover, this study evaluated the different diabetes control parameters and age-standardized prevalence rate and pattern, which could be utilized by policymakers to integrate appropriate diabetes control programs.

Limitations

The present study should be interpreted in the context of several possible limitations. First, the study protocol had some differences in 2007 and 2011 and it was only based on FBS levels, without any questionaries regarding diabetes medication to identify diabetes; hence, we tried to overcome this issue in 2016 and 2021 by adding more specific questions in the questionnaire. Second, the STEPS study was unable to classify diabetes into type 1 and type 2. Based on global goals for diabetes management, 80% of diabetic patients should have a HbA1c level below 8%. We were unable to calculate this factor in our results, which is suggested to consider in future studies.

Conclusion

The prevalence of diabetes and prediabetes in Iran is increasing and despite the high diagnosis, receiving effective care for diabetes is suboptimal. Although, several health policies had been developed in order to improve the screening and quality of diabetes care; however, there are still significant gaps in the effective control of the disease. Further studies are warranted to evaluate the detailed changes in the quality of diabetes care, which is important in understanding current gaps and filling them with proper health policies.

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Authors' contribution Conceptualization: Aslan Ameli, Negar Rezaei, Bagher Larijani, Farshad Farzadfar. Data Curation: Moein Yoosefi, Naser Ahmadi. Formal Analysis: Naser Ahmadi. Investigation: Bagher Larijani and all of the co-authors. Methodology: Aslan Ameli, Ali Sheikhy, Ozra Tabatabaei-Malazy, Naser Ahmadi, Negar Rezaei, Bagher Larijani. Writing—Original Draft Preparation: Aslan Ameli, Ali Sheikhy, Ozra Tabatabaei-Malazy. All of the authors participated in rewriting and finalizing the article and approved it.

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Declarations

Ethical considerations Every participant received detailed information about the survey's objectives and procedures. Participation in the survey was entirely voluntary, and both verbal and written consent were obtained from each participant. The study received ethical approval from the ethical committee of the National Institute for Health Research (ID: IR.TUMS.NIHR.REC.1398.006).

Conflict of interest The authors had no conflicts of interest.

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