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Smoking Status and Determinants Among Iranian Adults with Diabetes: Findings from the National STEPS 2021 Survey

Nazgol Behgam
Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
Sarmad Salehi
Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
Samaneh Akbarpour
Sleep Breathing Disorders Research Center, Tehran University of Medical Sciences, Tehran, Iran
Ozra Tabatabaei-Malazy
Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
Soroush Mozafari
Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
Samaneh Asgari
Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Nazila Rezaei
nazila_r@yahoo.com

Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

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Abstract

Background

Understanding patterns of active and passive smoking among individuals with diabetes is essential for targeted prevention, improved glycemic control, and reduction of cardiometabolic complications. Evidence from low- and middle-income countries, including Iran, remains limited.

Methods

We used data from the 2021 WHO STEPS survey, a nationally representative population-based study conducted across all 31 provinces of Iran. Adults aged 25 years and older were included. Diabetes was defined by self-reported physician diagnosis, use of glucose-lowering medications, fasting plasma glucose ≥ 126 mg/dL, or HbA1c ≥ 6.5%. Among 18,119 eligible participants, 3,078 adults with complete data met the criteria for diabetes and were included in weighted analyses. We estimated the prevalence of current smoking and passive smoke exposure and compared glycemic and cardiometabolic indicators across smoking categories. Survey-weighted logistic regression models were applied to identify determinants of smoking behavior.

Results

Overall, 12.2% of adults with diabetes were current smokers and 26.0% reported passive exposure to tobacco smoke. Smoking patterns varied substantially by sex, age, BMI, residence, and employment status. Compared with never smokers, current smokers had lower HDL cholesterol, higher triglyceride levels, and lower systolic blood pressure. Male sex strongly predicted current smoking, whereas being 60 years or older was associated with lower odds of both active smoking and passive exposure.

Conclusions

Active and passive smoking are common among Iranian adults with diabetes and show marked gender differences. Their associations with unfavorable lipid profiles underscore the need for integrating gender-responsive tobacco control approaches into diabetes care and prevention programs.

Trial Registration:

Not applicable (secondary analysis of the nationally conducted WHO STEPS 2021 survey).

Introduction

Diabetes mellitus (DM) is a growing global health challenge, particularly in low- and middle-income countries (LMICs) where demographic transitions, urbanization, and lifestyle changes have accelerated disease burden [1]. The North Africa and Middle East (MENA) region has experienced one of the world's highest increases in DM prevalence and is projected to see a 96% rise by 2045. Within this region, Iran exemplifies this trend, where the national prevalence of diabetes nearly doubled from 7.2% in 2007 to 14.2% in 2021 [2, 3]. Given this rapid rise, understanding modifiable risk factors, both biological and behavioral, has become essential for guiding national prevention and management strategies.

Smoking is a well-established modifiable risk factor for the development and progression of type 2 diabetes mellitus (T2DM), contributing to insulin resistance, β-cell dysfunction, systemic inflammation, and a greater burden of vascular complications [4–6]. Among individuals already diagnosed with diabetes, both active and passive smoking can accelerate disease progression and interfere with key aspects of diabetes management such as medication adherence, physical activity, stress regulation, and dietary control, ultimately undermining glycemic control and increasing the risk of adverse outcomes [4, 7, 8]. Understanding smoking in this population, therefore, requires attention to both its biological effects and its influence on daily disease management behaviors.

These dynamics may be particularly salient in Iran, where distinct sociocultural norms shape tobacco use patterns. More than 25% of Iranian males are current smokers, whereas females, though rarely active smokers, are disproportionately exposed to second-hand smoke through household and social environments that permit indoor smoking [9–11]. This gender-specific exposure pattern likely influences how smoking interacts with diabetes management; males must navigate entrenched cultural norms that reinforce smoking as a social practice, while females with diabetes often face unavoidable passive exposure within the home. Hookah (waterpipe) use, a culturally rooted social activity in Iran, adds further complexity and carries health risks comparable to cigarette smoking[12]. Together, these unique exposure pathways suggest that smoking and passive exposure are deeply embedded in the disease-management ecosystem of Iranian individuals with diabetes.

Despite this, national evidence on smoking patterns among people with diabetes in Iran remains limited. Prior studies have typically relied on clinical samples or regional datasets, reported widely varying prevalence estimates (3.9%–9.6%) [13, 14], inconsistently defined smoking status, and rarely assessed passive exposure or its potential metabolic correlates. Few studies have evaluated differences in glycemic control or cardiometabolic risk factors across smoking groups within a nationally representative diabetic population[15].

To address these gaps, this study used data from the nationally representative 2021 WHO STEPS survey to estimate the prevalence of active and passive smoking among adults with diabetes in Iran, identify demographic and clinical correlates of tobacco exposure, and examine differences in glycemic control and cardiometabolic indicators across smoking groups. Based on prior global evidence and biological plausibility, we hypothesized that both active and passive smoking would be associated with less favorable metabolic profiles and poorer glycemic control. By integrating biomedical, behavioral, and

sociocultural dimensions of tobacco exposure, this study aims to provide evidence to support culturally adapted and gender-sensitive tobacco-control strategies within diabetes care in Iran.

Materials and Methods

Study Design

This study is a secondary analysis of the 2021 Iranian WHO STEPwise approach to noncommunicable disease (NCD) risk factor surveillance survey. The STEPS survey employs a standardized methodology to generate nationally and provincially representative estimates of behavioral, metabolic, and biochemical risk factors. The 2021 round used a multistage, stratified cluster sampling design across all 31 provinces of Iran and included adults aged 18 years and older from both urban and rural areas. The achieved national response rate was 97.73%, and fewer than 3% of primary sampling units declined participation, providing a high degree of representativeness. Sampling parameters, including stratification, cluster selection, age–sex weighting, and household sampling probabilities, were incorporated into the final survey weights. These weights were applied in all descriptive and analytical analyses to ensure that findings reflect the national adult population. Detailed methodological documentation of STEPS 2021 is available elsewhere [16].

Data collection followed the standardized STEPS structure. In the first stage, trained interviewers administered a structured questionnaire adapted from the WHO STEPS instrument (version 3.2).[17] In the second stage, trained personnel obtained anthropometric and physical measurements, and in the third stage, biochemical samples were collected and analyzed in certified provincial laboratories using standardized protocols.

Study Population

A total of 18,119 adults aged 25 years and older completed all three STEPS stages. Type 2 diabetes mellitus was identified using a combination of criteria: self-reported physician diagnosis, current use of glucose-lowering medication, fasting plasma glucose of at least 126 mg/dL, or hemoglobin A1c of at least 6.5%. Self-reported diagnosis was based on participants' confirmation that a healthcare professional had previously informed them of having diabetes. Because self-report may introduce misclassification, the inclusion of laboratory-based diagnostic criteria helped strengthen case ascertainment. After excluding individuals with missing key variables, including physical activity, employment status, creatinine, blood pressure, and histories of cardiovascular disease or cancer, the final analytic sample included 3,078 adults with diabetes. (Fig. 1).

Figure 1. **Flow diagram of participant selection for the study of smoking status among Iranian adults with diabetes.**

Clinical and Laboratory Measurements

Demographic information (age, sex, marital status, education, employment, insurance status, and household assets) and behavioral characteristics (tobacco use, alcohol consumption, physical activity, medical history, and medication use) were collected through interviewer-administered questionnaires.

Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ) in accordance with the WHO STEPS methodology and reported as metabolic equivalent task (MET)-minutes per week. The Persian version used in the STEPS survey underwent translation, back-translation, expert review, and pilot testing following WHO cultural adaptation procedures; however, no formally published psychometric validation of the Persian GPAQ is currently available, and the potential for measurement error cannot be excluded. Participants were classified as physically active if they met the WHO recommendations of engaging in at least 150 minutes of moderate-intensity activity per week or an equivalent combination of activities [16, 18, 19]. The validity and reliability of the GPAQ for assessing physical activity in the Iranian population have been established in previous national studies[20–22] .

Anthropometric measurements included weight (kg) and height (cm), measured using calibrated instruments with participants wearing minimal clothing and no shoes. Waist circumference was measured midway between the lowest palpable rib and the iliac crest. Weight measurements were verified using a 5-kg calibration weight after each equipment relocation[16].

Blood pressure (BP) was measured three times at three-minute intervals using a standard Beurer sphygmomanometer, following a 15-minute rest in a seated position. The average of the second and third measurements was used for analysis[16].

Biochemical assessments included fasting blood glucose (FBG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG), analyzed using an automated Cobas C311 analyzer (Hitachi High-Technologies Corporation, Japan). Low-density lipoprotein cholesterol (LDL-C) was estimated using the Friedewald formula [23]. Glycated hemoglobin (HbA1c) was measured using high-performance liquid chromatography (HPLC). Urinary albumin concentrations were obtained using the Prestige Premium 24i analyzer. Inter- and intra-assay coefficients of variation were maintained below 5% [16].

Variable Definitions

Education was categorized as: illiterate (0 years), 1–6 years, 7–11 years, and ≥ 12 years. Marital status was classified as married versus unmarried (never married, widowed, or separated). Employment status was classified as employed or unemployed, with retired individuals categorized as unemployed.

Smoking status was categorized into three mutually exclusive groups. Never-smokers were defined as individuals who reported never having used any form of tobacco. Current smokers included those who actively smoked cigarettes or hookah at the time of the survey. Passive smokers were those who did not

smoke themselves but reported regular exposure to second-hand smoke at home or in the workplace in the past 30 days. Smoking intensity was defined as the average number of cigarettes smoked per day. Hookah sessions were converted to cigarette equivalents using a factor of 1 session = 10 cigarettes, based on toxicological comparisons of nicotine and harmful emissions [24]. Smoking duration was defined as the number of years an individual had smoked, and cumulative smoking exposure was computed by multiplying smoking intensity by duration.

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI was categorized as normal (< 25 kg/m^2), overweight (25–29.9 kg/m^2), or obese (≥ 30 kg/m^2) [25].

Hypertension (HTN) was defined as a SBP ≥ 140 mmHg, DBP ≥ 90 mmHg, or current use of antihypertensive medications [26]. Controlled hypertension was defined as SBP < 140 mmHg and DBP < 90 mmHg among treated individuals [27].

Diabetes mellitus (DM) was identified by any of the following: a self-reported previous diagnosis of diabetes by a physician (assessed by the question: 'Have you ever been told by a doctor or other health professional that you have diabetes?'), current use of glucose-lowering medications, fasting plasma glucose ≥ 126 mg/dL, or HbA1c ≥ 6.5% [28, 29].

Dyslipidemia was defined according to the Adult Treatment Panel III (ATP-III) criteria as meeting any of the following: total cholesterol ≥ 200 mg/dL, LDL-C ≥ 100 mg/dL, HDL-C < 40 mg/dL for males or < 50 mg/dL for females, triglycerides ≥ 150 mg/dL, or current use of lipid-lowering medications. Controlled cholesterol was defined as total cholesterol < 200 mg/dL[30] .

Chronic kidney disease (CKD) was defined as estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m^2 or urine albumin-to-creatinine ratio (UACR) ≥ 30 mg/g, according to KDIGO guidelines [31].

Self-reported history of cardiovascular disease (CVD) or cancer was determined by affirmative responses to the questions: “Have you ever had a heart attack?”, “Have you ever had a stroke?”, or “In the past 12 months, has a healthcare provider told you that you have cancer?”

Comorbidity among participants with type 2 diabetes was defined as the presence of one or more of the following: CVD, cancer, hypertension, or CKD.

Undiagnosed conditions (diabetes, hypertension, dyslipidemia) were defined in participants who met clinical criteria but did not report a prior diagnosis.

Statistical Analysis

All analyses accounted for the complex survey design through the application of sampling weights, stratification variables, and clustering. Continuous variables were summarized as weighted means with

95% confidence intervals (CIs), and categorical variables as weighted percentages with 95% CIs. Differences across smoking status groups were assessed using survey-weighted one-way ANOVA for continuous variables and chi-square tests for categorical variables. Survey weights were derived from age, sex, and urban–rural distributions at the provincial level based on the 2016 Iranian census to ensure nationally representative estimates.

Associations between covariates and smoking status (current vs. never, passive vs. never) were examined using survey-weighted logistic regression models. Covariates were selected a priori based on prior literature and biological plausibility. A forward stepwise variable selection approach was applied, with variables entering the model at $p < 0.20$ and retained at $p < 0.05$. This method was used to achieve model parsimony while reducing the risk of overfitting; however, given known limitations of stepwise procedures, findings were interpreted cautiously. To ensure the robustness of our findings, we additionally performed a manual model-building sensitivity analysis, which yielded a variable selection pattern consistent with those obtained from the stepwise approach. Collinearity was evaluated using variance inflation factors (VIF), and no variable exceeded a VIF of 10.

Missing data were handled using complete case analysis. Because missingness was < 5% for all variables included in the models, imputation was not performed. All analyses were conducted in Stata version 14 (StataCorp LLC, College Station, TX, USA), with $p < 0.05$ considered statistically significant.

Ethical Considerations

This secondary analysis used anonymized data from the 2021 national STEPS survey, with prior written informed consent obtained from all participants. Ethical approval was granted by the Ethics Committee of the Endocrine & Metabolism Research Institute, Tehran University of Medical Sciences (IR.TUMS.EMRI.REC.1403.103). The fully anonymized dataset was accessed on February 2, 2025, ensuring no access to identifiable information. For research involving human participants, all methods were performed in accordance with the relevant regulations and the Declaration of Helsinki. The manuscript also includes a statement confirming that informed consent was obtained from all participants.

Results

In the STEPS 2021 survey, 3,078 adults met the criteria for diabetes. Among them, 61.8% (95% CI: 59.28–64.30) had never smoked, 12.2% (95% CI: 10.64–14.00) were current smokers, and 26.0% (95% CI: 23.77–28.29) reported passive exposure to tobacco smoke. The distribution of smoking status differed significantly by age group, sex, place of residence, BMI category, and employment status ($p < 0.05$). Detailed weighted prevalence estimates are presented in Table 1.

Table 1
Prevalence of smoking status in patients with diabetes*: STEPS 2021

Variables	Never-smoker [a] (N = 1908)	Current smoker [b] (N = 367)	Passive smoker [c] (N = 803)	P-value
Total population	61.8 (59.28, 64.30)	12.22 (10.64, 14.00)	25.96 (23.77, 28.29)	
Age (years)	59.28 (58.47, 60.09)	56.49 (54.97, 58.00)	56.48 (55.16, 57.81)	< 0.001
BMI (kg/m2)	29.38 (29.06, 29.70)	28.02 (27.28, 28.76)	30.00 (29.55, 30.46)	< 0.001
Age (years)				< 0.001
- **< 60**	56.88 (53.46, 60.23)	13.46 (11.36, 15.87)	29.67 (26.63, 32.90)	
- **≥ 60**	67.35 (63.55, 70.94)	10.83 (8.56, 13.61)	21.82 (18.76, 25.21)	
Sex				< 0.001
- **Female**	65.97 (62.69.10)	4.68 (3.62, 6.04)	29.35 (26.34, 32.56)	
- **Male**	56.09 (52.11, 59.99)	22.63 (19.41, 26.21)	21.28 (18.25, 24.66)	
Residential area				0.026
- **Rural**	57.58 (53.49, 61.57)	11.56 (9.27, 14.34)	30.86 (27.14, 34.84)	
- **Urban**	62.92 (59.89, 65.85)	12.39 (10.52, 14.54)	24.69 (22.13, 27.45)	
Years of schooling (years)				0.413
- **0**	62.74 (58.60, 66.70)	9.24 (6.94, 12.18)	28.02 (24.45, 31.91)	
- **1–6**	60.50 (56.17, 64.67)	13.14 (10.50, 16.34)	26.36 (22.89, 30.15)	
- **7–11**	60.38 (53.83, 66.58)	12.21 (8.81, 16.68)	27.41 (21.91, 33.70)	
- **≥ 12**	63.47 (57.70, 68.88)	13.56 (10.17, 17.84)	22.97 (18.21, 28.54)	
Marital status				0.146

Variables	Never-smoker [a] (N = 1908)	Current smoker [b] (N = 367)	Passive smoker [c] (N = 803)	P-value
- **Single living**	60.75 (57.93, 63.49)	12.73 (10.96, 14.73)	26.53 (24.11, 29.10)	
- **Married**	67.15 (61.08, 72.69)	9.69 (6.65, 13.91)	23.16 (18.25, 28.93)	
BMI (kg/m2)				< 0.001
- **< 25**	60.05 (53.97, 65.83)	17.62 (13.18, 23.15)	22.33 (18.06, 27.28)	
- **25-29.9**	65.23 (61.45, 68.82)	12.23 (9.88, 15.04)	22.55 (19.50, 25.91)	
- **≥ 30**	59.65 (55.53, 63.63)	9.70 (7.74, 12.09)	30.65 (26.92, 34.66)	
Employment status				< 0.001
- **Unemployed**	64.51 (61.56, 67.34)	9.17 (7.54, 11.12)	26.32 (23.77, 29.05)	
- **Employed**	53.08 (48.05, 58.04)	22.13 (18.36, 26.44)	24.79 (20.73, 29.35)	
Physical activity, min/week				0.586
- **< 150**	62.86 (59.47, 66.12)	11.95 (9.84, 14.44)	25.19 (22.36, 28.26)	
- **≥ 150**	60.24 (56.38, 63.98)	12.63 (10.43, 15.21)	27.13 (23.77, 30.78)	

* Presented as percent (95% CI) for categorical variables and mean (95% CI) for continuous variables.

CI: confidence interval; BMI: Body Mass Index.

a Never-smoker.

b Current smoker.

c Passive smoker.

The p-value was calculated using the chi-square test for categorical variables and one-way ANOVA for continuous variables.

The reported percentages represent row-wise prevalence.

Data have been weighted based on the age, sex, and area stratifications at the province level from the 2016 Iranian census.

Table 1. **Prevalence of smoking status in patients with diabetes*: STEPS 2021**

The distribution of cardiometabolic risk factors across smoking groups is presented in Table 2. Mean fasting blood glucose and HbA1c did not differ significantly by smoking status ($p = 0.411$ and $p = 0.439$, respectively). The proportion of participants with undiagnosed diabetes was higher, although not significantly, among current smokers (57.06%, 95% CI: 49.61–64.21) compared with never-smokers (50.65%, 95% CI: 47.32–53.97) and passive smokers (51.80%, 95% CI: 46.77–56.80).

Table 2
Cardio-metabolic risk factors status based on smoking status in patients with diabetes*: STEPS 2021

Variables	Never-smoker [a] (N = 1908)	Current smoker [b] (N = 367)	Passive smoker [c] (N = 803)	P-value
T2DM				
FBG, mg/dl	149.44 (146.27, 152.60)	151.19 (142.60, 159.78)	152.86 (147.26, 158.46)	0.411
HbA1c, %	7.79 (7.71, 7.86)	7.90 (7.72, 8.08)	7.85 (7.72, 7.97)	0.439
Undiagnosed T2DM	50.65 (47.32, 53.97)	57.06 (49.61, 64.21)	51.80 (46.77, 56.80)	0.250
Uncontrolled Diagnosed T2DM	34.78 (31.79, 37.90)	33.89 (26.94, 41.60)	35.61 (30.89, 40.63)	
Controlled Diagnosed T2DM	14.57 (12.54, 16.86)	9.05 (6.24, 12.95)	12.59 (9.79, 16.04)	
Hypertension				
SBP, mmHg	137.52 (136.62, 138.42)	134.69 (132.66, 136.71)	136.20 (134.85, 137.55)	0.026
DBP, mmHg	81.59 (81.07, 82.11)	81.30 (80.11, 82.49)	81.75 (80.94, 82.55)	0.826
Total HTN	64.41 (61.18, 67.52)	54.53 (47.28, 61.59)	64.19 (59.41, 68.70)	0.035
Undiagnosed HTN	3. 01 (1.96, 4.60)	2.87 (1.01, 7.86)	1.40 (0.62, 3.11)	0.648
Uncontrolled Diagnosed HTN	57.68 (53.36, 61.89)	54.43 (40.60, 67.61)	55.93 (49.00, 62.65)	
Controlled Diagnosed HTN	39.31 (35.15, 43.62)	42.70 (29.87, 56.60)	42.66 (35.99, 49.62)	
Lipid profile				
TC mg/dl	178.20 (173.91, 182.49)	194.64 (182.67, 206.62)	182.49 (175.98, 189.00)	0.012
TG, mg/dl	171.43 (169.43, 173.44	166.85 (162.60, 171.10)	173.52 (170.61, 176.44)	0.053
HDL-C, mg/dl	41.45 (40.99, 41.91)	37.24 (36.28, 38.20)	40.49 (39.82, 41.16)	< 0.001

Variables	Never-smoker [a] (N = 1908)	Current smoker [b] (N = 367)	Passive smoker [c] (N = 803)	P-value
LDL-C, mg/dl	94.45 (92.73, 96.17)	90.68 (87.19, 94.17)	96.54 (94.07, 99.00	0.044
Total dyslipidemia	54.65 (51.34, 57.92)	42.25 (35.40, 49.40)	50.10 (49.35, 54.54)	0.007
Hypercholesterolemia				
Total Hypercholesterolemia				
Undiagnosed Hypercholesterolemia	29.96 (26.76, 33.38)	34.32 (27.21, 42.20)	30.95 (25.81, 36.61)	0.534
Uncontrolled Diagnosed Hypercholesterolemia	24.30 (20.70, 28.29)	18.38 (13.40, 24.68)	25.40 (21.07, 30.27)	
Controlled Diagnosed Hypercholesterolemia	45.74 (42.01, 49.52)	47.30 (39.29, 55.47)	43.66 (38.28, 49.19)	
Comorbidities				
- **0**	26.97 (24.11, 30.04)	27.54 (21.95, 33.93)	27.10 (23.09, 31.52)	0.432
- **1**	38.69 (35.62, 41.86)	39.72 (33.01, 46.84)	43.35 (38.35, 48.49)	
- **≥ 2**	34.34 (31.07, 37.76)	32.74 (25.71, 40.64)	29.55 (25.28, 34.21)	

* Presented as percent (95% CI) for categorical variables and mean (95% CI) for continuous variables.

a Never-smoker (reference group).

b Current smoker.

c Passive smoker.

T2DM: Type 2 Diabetes Mellitus; FBG: Fasting Blood Glucose; HbA1c: Hemoglobin A1c; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HTN: Hypertension; TC: Total Cholesterol; TG: Triglycerides; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol.

The reported percentages for T2DM, HTN, Hypercholesterolemia, and Comorbidities represent column-wise prevalence.

Comorbidity is defined as a positive history of CVD, cancer, hypertension, or CKD in patients with diabetes.

Data have been weighted based on the age, sex, and area stratifications at the province level from the 2016 Iranian census.

Regarding blood pressure, current smokers had a significantly lower mean systolic blood pressure (134.69 mmHg, 95% CI: 132.66–136.71) compared with never-smokers (137.52 mmHg, 95% CI: 136.62–138.42) and passive smokers (136.20 mmHg, 95% CI: 134.85–137.55) (p = 0.026). Diastolic blood pressure did not differ significantly between groups (p = 0.826). The prevalence of total hypertension was lower among current smokers (54.53%, 95% CI: 47.28–61.59) relative to never-smokers (64.41%, 95% CI: 61.18–67.52) and passive smokers (64.19%, 95% CI: 59.41–68.70) (p = 0.035). No significant differences were observed across groups in the prevalence of undiagnosed, controlled, or uncontrolled hypertension.

Lipid profiles differed across smoking categories. Current smokers had the highest mean total cholesterol (194.64 mg/dL, 95% CI: 182.67–206.62) and the lowest mean HDL-C (37.24 mg/dL, 95% CI: 36.28–38.20). However, the prevalence of total dyslipidemia was lower among current smokers (42.25%, 95% CI: 35.40–49.40) than among never-smokers (54.65%, 95% CI: 51.34–57.92), although this finding should be interpreted with caution given the cross-sectional design and potential confounding. The prevalence of cardiometabolic comorbidities, including CVD, cancer, hypertension, and CKD, did not vary significantly by smoking status (p = 0.432). Approximately one-third of participants in each group had two or more comorbidities.

Table 2. **Cardio-metabolic risk factors status based on smoking status in patients with diabetes*: STEPS 2021**

Multivariable logistic regression identified several demographic and clinical predictors of tobacco exposure (Table 3). Male sex was the strongest predictor of current smoking (OR: 4.69, 95% CI: 3.65–6.01). Older adults (≥ 60 years) had lower odds of both current smoking (OR: 0.61, 95% CI: 0.48–0.77) and passive exposure (OR: 0.67, 95% CI: 0.53–0.86). CKD was associated with higher odds of current smoking (OR: 1.35, 95% CI: 1.05–1.75). Full adjusted models are presented in Table 3.

Table 3
Stepwise Logistic Regression of Factors for Passive and Active Smoking in patients with diabetes: STEPS 2021

	Current smoker [a]		Passive smoker [b]	
	OR (95% CI)	**P-value**	**OR (95% CI)**	**P-value**
Age (years)				
- **< 60**	Reference		Reference	
- **≥ 60**	0.61 (0.48, 0.77)	< 0.001	0.67 (0.53, 0.86)	0.001
Sex				
- **Female**	Reference		Reference	
- **Male**	4.69 (3.65, 6.01)	< 0.001	0.67 (0.52, 0.85)	0.001
Residential area				
- **Rural**	-	-	Reference	
- **Urban**	-	-	0.76 (0.61, 0.96)	0.02
BMI (kg/m^2)				
- **< 25**	Reference			
- **25-29.9**	0.61 (0.46, 0.81)	0.001	-	-
- **≥ 30**	0.60 (0.44, 0.80)	0.001	-	-
CKD				
- **No**	Reference		-	-
- **Yes**	1.35 (1.05, 1.75)	0.02	-	-

CKD: Chronic Kidney Disease; BMI: Body Mass Index; OR: Odds Ratio; CI: Confidence Interval.

a Current smoker.

b Passive smoker.

- Variable was not selected for the final model by the stepwise selection process (entry p-value < 0.2, retention p-value < 0.05).

Data have been weighted based on the age, sex, and area stratifications at the province level from the 2016 Iranian census.

Table 3. **Stepwise Logistic Regression of Factors for Passive and Active Smoking in patients with diabetes: STEPS 2021**

Supplementary analyses among individuals with previously diagnosed diabetes explored associations between tobacco exposure and glycemic control (Table S1). Although descriptive and not adjusted for confounders, these patterns showed that current smoking was more common among individuals with uncontrolled diabetes (79.57%, 95% CI: 71.09–86.05) than among those with controlled diabetes. (20.43%, 95% CI: 13.95–28.91) Passive exposure, whether occurring at home, at the workplace, or in both environments, was also more frequent among individuals with uncontrolled diabetes. Among current smokers, poorer glycemic control clustered in those with higher smoking intensity and greater cumulative exposure. While these findings suggest a consistent pattern of less favorable glycemic control among those with greater active or passive exposure to tobacco smoke, they remain observational and exploratory and therefore should not be interpreted as evidence of causal relationships.

Discussion

This nationally representative study provides an updated understanding of active and passive smoking among Iranian adults living with diabetes and illustrates how demographic, clinical, and sociocultural factors shape tobacco exposure in this population. Smoking patterns differed markedly across sex and age groups, reflecting well-documented global disparities. While 22.6% of males with diabetes reported current smoking, only 4.7% of females did so; in contrast, nearly one-third of females experienced passive household or workplace exposure, consistent with prior regional evidence[10, 11, 32, 33]. A meta-analysis of diabetic populations reporting a smoking prevalence of 20.8%, with males five times more likely to smoke, further supports these sex-related patterns [34]. Although the prevalence of active smoking was low (4.7%) among females with diabetes in our sample, nearly one-third (29.4%) were exposed to passive smoke.

We observed that current smokers had less favorable lipid profiles, including lower HDL-C and higher triglyceride levels, which aligns with extensive evidence linking smoking to dyslipidemia [35–37]. Mechanistically, smoke-induced oxidative stress and inflammation may impair HDL function, while nicotine suppresses lipoprotein lipase activity and increases triglycerides [38, 39]. These associations support the biological plausibility of the lipid differences observed across smoking groups.

In contrast, findings related to blood pressure were counterintuitive. Current smokers had significantly lower mean systolic blood pressure and lower hypertension prevalence than never-smokers, contrary to established evidence showing that smoking increases sympathetic activity, arterial stiffness, and hypertension risk [36, 40–42]. Several explanations may account for this discrepancy. Lower BMI among current smokers may partially reduce blood pressure levels, and smokers may be less likely to receive hypertension screening, contributing to underdiagnosis. Reverse causality, whereby individuals diagnosed with hypertension quit smoking and adhere more closely to treatment, may also contribute. Additionally, conditioning analyses on individuals with diabetes may introduce collider bias that distorts associations between smoking and blood pressure. Similar findings have been observed in other large

samples of diabetic patients, suggesting that diabetes itself may be a more dominant determinant of blood pressure regulation [43].

Sociocultural factors in Iran likely reinforce the patterns documented in this study. Indoor smoking remains relatively common, contributing to the high prevalence of passive exposure among females [9–11]. Hookah use, a culturally embedded practice especially among young males, further complicates tobacco control. Regional evidence from the Eastern Mediterranean shows hookah prevalence rates between 20% and 30%, with health risks comparable to cigarette smoking[12]. Daily hookah use reported among young males in Iranian coffee houses underscores its role in shaping tobacco exposure patterns[12]. The cultural embeddedness of hookah smoking highlights the need for public health interventions that address both cigarettes and waterpipe tobacco[12].

Although primary analyses did not reveal statistically significant differences in HbA1c across smoking groups, current smokers showed slightly higher mean HbA1c values (7.90% vs. 7.79% in never-smokers), consistent with longitudinal evidence indicating that smoking is associated with modest increases in HbA1c among individuals with diabetes [44]. Lack of statistical significance in our findings may reflect heterogeneity in treatment, medication adherence, and diabetes duration, which were not fully captured in the survey. Exploratory analyses also suggested that uncontrolled diabetes was more frequent among active and passive smokers, particularly those with higher smoking intensity or cumulative exposure, aligning with prior research showing dose-dependent associations between smoking and impaired glycemic control [45–47].

Our study also found that younger adults, individuals with lower BMI, and employed participants were more likely to smoke, consistent with previous evidence linking occupational stressors and sociodemographic factors to smoking behavior [48, 49]. The inverse association between BMI and smoking is widely documented and may reflect nicotine’s appetite-suppressing properties, though its relationship with central obesity and metabolic dysfunction is more complex [48].

Additionally, CKD was more common among smokers, aligning with evidence linking tobacco exposure to renal dysfunction through oxidative stress, inflammation, and renal vasoconstriction [50–52]. However, given the cross-sectional design, these associations cannot be interpreted directionally, and it is plausible that individuals with chronic illness may continue smoking as a coping mechanism.

Strengths and limitations

This study has several notable strengths. It draws on data from the nationally representative WHO STEPS 2021 survey, which achieved a very high response rate (97.73%) and used standardized protocols for sampling, data collection, and biochemical assessments. The application of complex survey weighting further enhances the representativeness of the findings for Iranian adults with diabetes.

Despite these strengths, several limitations should be acknowledged. First, the cross-sectional design precludes any determination of temporal or causal relationships, and all observed associations must be

interpreted cautiously. Second, smoking status and passive exposure were self-reported without biochemical verification, which may introduce recall, reporting, or interviewer bias. The measurement of passive smoking as a binary indicator of “regular exposure” without information on duration, frequency, or intensity further limits the ability to assess dose–response relationships. Third, several unexpected or null findings, such as lower systolic blood pressure and lower hypertension prevalence among current smokers, and the absence of significant differences in HbA1c, may reflect residual confounding, behavioral changes following diagnosis, or misclassification rather than true physiological associations. Collider bias arising from restricting the sample to individuals with diabetes may also have influenced some associations.

Fourth, diabetes status was defined using both laboratory values and self-reported physician diagnosis, and misclassification remains possible because clinical records were not available for verification. Fifth, important confounding factors not captured in the STEPS dataset, such as psychosocial stress, sleep quality, medication adherence, or substance use, may have influenced the observed patterns. Sixth, although the GPAQ used in STEPS followed WHO translation and piloting procedures, a formal psychometric validation of the Persian version has not been published. This limitation may contribute to non-differential misclassification of physical activity and should be addressed in future studies. Finally, although stepwise regression was used to improve model parsimony, this approach has known limitations, including potential model instability and omitted-variable bias.

Implications for policy and clinical practice

The findings underscore the importance of addressing tobacco exposure, both active smoking and involuntary household exposure, within diabetes care pathways in Iran. Routine screening for smoking and passive exposure during clinical visits, combined with integration of tobacco indicators into electronic health records, may facilitate systematic identification and counseling. Given the pronounced gender differences in exposure patterns, cessation programs should be designed with gender-specific needs in mind: males require targeted behavioral support for cessation, while females may benefit from interventions aimed at reducing involuntary household exposure. Strengthening enforcement of indoor smoke-free policies, particularly in homes and social settings where passive exposure is most common, could substantially reduce risk among non-smokers. Public health communication strategies should also address misconceptions regarding the perceived relative safety of hookah use, emphasizing its documented cardiometabolic risks. Integrating culturally tailored tobacco-cessation interventions into diabetes management programs may enhance glycemic control and reduce long-term complications.

Conclusion

This nationally representative study highlights substantial levels of active and passive smoking among Iranian adults living with diabetes and reveals significant demographic, clinical, and sociocultural patterns of tobacco exposure. While the cross-sectional nature of the data precludes causal inference, the associations observed underscore tobacco exposure—particularly passive smoking among females—as a meaningful factor within the broader context of diabetes management. These findings support the

need for culturally informed, gender-responsive strategies that address both cigarette and hookah use, strengthen smoke-free environments, and integrate systematic tobacco assessment and cessation support into routine diabetes care. Longitudinal studies are needed to clarify temporal relationships and evaluate the impact of reducing tobacco exposure on glycemic control and cardiometabolic outcomes in this high-risk population.

Declarations

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Authors' contributions

Conceptualization: S.AK, S.AS; Data Curation: SS; Formal Analysis: SS; Investigation: A.SK, NR; Methodology: S.AK, S.AS, SS; Project Administration: S.AK, NR; Supervision: S.AK, S.AS, NR; Validation: NB, SS, S.AK, S.AS, OT, SM, NR; Writing, Original Draft Preparation: NB; Writing, Review and Editing: NB, SS, S.AK, S.AS, OT, SM, NR; All authors reviewed the manuscript, critically commented on the draft, and provided their approval for the submission.

Data sharing statement:

The datasets used and/or analyzed during this study are not publicly available due to contractual agreements with the funding agency, the National Institute of Health Research of the I.R. Iran. However, data access can be requested from the corresponding author under reasonable conditions. All data inquiries should be directed to the corresponding author.

Ethics approval and consent to participate

All participants were fully informed about the study's aims and procedures, and participation was voluntary. Written informed consent was obtained from every participant. To protect confidentiality, the final dataset used for analysis was anonymized, with access limited to the primary investigator and database manager. Ethical approval was granted by the Ethics Committee of the Endocrine & Metabolism Research Institute at Tehran University of Medical Sciences (ID: IR.TUMS.EMRI.REC.1403.103).

Trial Registration:

Not applicable (secondary analysis of the nationally conducted WHO STEPS 2021 survey).

Consent for publication

This is not applicable as the manuscript does not include identifiable personal data or images of

individual participants.

Competing interests

The authors declare that they have no competing interests.

Patient and Public Involvement Statement:

Patients and members of the public were not involved in the design, conduct, reporting, or dissemination plans of this secondary data analysis. The study used anonymized data from the nationally representative WHO STEPS 2021 survey. However, the original STEPS survey was developed to inform national health policy and prevention strategies addressing non-communicable diseases in the general population. Results of the present study will be disseminated through peer-reviewed publication and may inform public health and clinical strategies aimed at improving diabetes care and tobacco-control interventions in Iran.

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Figures

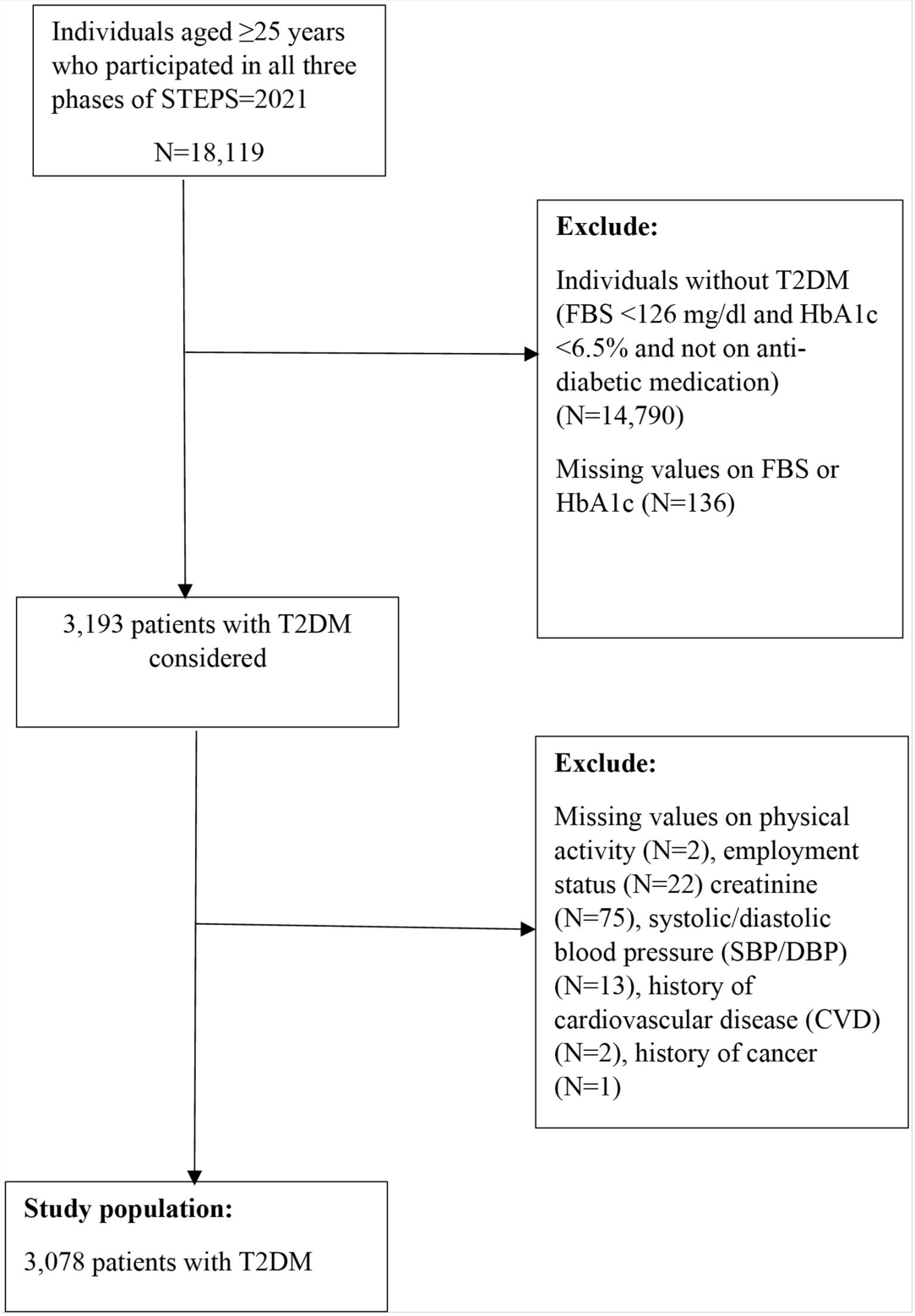


Figure 1

Flow diagram of participant selection for the study of smoking status among Iranian adults with diabetes.

Supplementary Files

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- TableS1.docx