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Original Article

Epidemiology of Adult Diabetes Mellitus and its Correlates in Pars Cohort Study in Southern Iran

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Abstract
Background: The burden of diabetes mellitus (DM) is increasing worldwide, especially in countries such as Iran. Modifiable correlates of the DM may be different across regions. We aimed to estimate the population-based prevalence of DM and its correlates among adults in southern Iran.
Methods: Baseline data of the Pars Cohort Study (PCS) was analyzed. Demographic and socio-economic characteristics, alcohol consumption, opium and tobacco abuse and cigarette smoking, laboratory findings, anthropometric measurements and perceived body shape at 15 and 30 years of age using pictogram were measured and analyzed. The age-standardized prevalence of DM was estimated. Robust Poisson regression was applied to estimate adjusted prevalence ratio (aPR) and 95% robust confidence intervals (CI). A *P* value <0.05 was considered statistically significant.
Results: Out of 9264 individuals, 919 (9.9%; 95% CI: 9.3–10.6) had DM. The prevalence of DM among the males and females was 7.6% (95% CI: 6.8–8.5) and 11.9% (95% CI: 10.9–12.9), respectively. Higher age, female gender, high socioeconomic status and using antihypertensive medication were associated with higher DM prevalence. Also, triglyceride level, physical inactivity, higher body mass index (BMI), pictogram score at 15, and its change from 15 to 30 years of age were significantly associated with DM.
Conclusion: Higher prevalence of modifiable factors such as physical inactivity and obesity among DM patients in the study population highlights the necessity of more effective preventive interventions in such settings, especially in younger ages.
Keywords: Diabetes mellitus, Epidemiology, Iran, Risk factors
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Introduction

Diabetes Mellitus (DM) is a chronic debilitating disease with escalating worldwide prevalence, which is predicted to grow further over the next decades as a result of increased population and life span as well as changes in lifestyle.[1] Low- and middle-income countries will experience the greatest rise in the number of DM cases.[2] The problem is more pronounced in the Eastern Mediterranean Region, which could be explained by a complex array of other contributing factors such as urbanization, inappropriate dietary habits, and low physical activity, along with limited access to health services and inadequate diabetes care.[3] A similar pattern is observed in Iran. In Iran, the prevalence of DM is 11.3-14.6%, while impaired fasting glucose (IFG) is over 14% prevalent.[4,5] This may amplify the burden of DM and its complications in Iran.[6]

The population of Iran is of heterogeneous ethnicity and there are differences in surrounding macro-causes across the country. Social norms and lifestyle in rural areas are different from those in metropolitan areas. This might influence the regional patterns and correlates of DM.[7,8] In spite of heterogeneous population of Iran, there is limited information about prevalence and risk factors of DM in rural population of southern Iran.

The province of Fars, located in southern Iran, has a variety of ethnic groups. Currently, the "Pars Cohort Study" (PCS) is being conducted in a rural population in southern Iran, primarily designed to investigate the burden and major risk factors of non-communicable diseases among adults.[9] Using baseline data from the PCS, we aimed to evaluate the community-based prevalence and correlates of DM and its correlates in the rural population of southern Iran.

Material and Methods

Participants and Settings

The PCS is an ongoing prospective cohort study launched in fall 2012 in Valashahr district of Fars Province, Iran. The population of Valashahr is about 40,000 people. The PCS has been described in details previously.[9] In brief,

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almost all adult population between 40 and 75 years of age were recruited (over 9000 individuals) from 2012 to 2014. Contact information of eligible participants was obtained from 31 health houses and health centers in the region. Via phone calls, the purpose and procedure of the study was clarified by trained native experts and the participants were invited to take part in the study. During individual appointments, history taking, physical examination, and laboratory tests were accomplished.

Data Gathering

The collected demographic variables included age, gender, and ethnicity (categorized as Persian, Turk, and other minorities), the highest level of education attained (categorized into three levels including illiterate, up to 12 years of education, and higher education). The wealth score was based on appliance ownership, using multiple correspondence analysis (MCA). The wealth score was calculated for each participant based on a combination of various variables, which were given different weights. These parameters were ownership of personal car, motorbike, TV, refrigerator, freezer, vacuum cleaner and washing machine. Furthermore, owning a house and its size and structure, as well as occupation were considered in calculation of the wealth score. This method was adapted from a previous paper by Islami et al,[10] who have described the analysis in details. The participants were categorized into quartiles based on their individually calculated wealth score. Participants in quartiles 1, 2, 3, and 4 were labeled as low, low-middle, middle-high, and high socioeconomic status, respectively.

Tobacco (e.g. pipe, hookah, and *Naas*) user or opium (e.g. *Teriak, Heroin, Sukhteh, Shireh*) user was defined as a person with weekly consumption of any kind of tobacco or opium for at least six consecutive months at any point over the life-time. Tobacco users, opium users, and cigarette smokers were classified as never or ever-users.

Physical activity was measured with the International Physical Activity Questionnaire (IPAQ). The Metabolic Equivalent of Task (MET) score was calculated for each participant and categorized into three groups: low, medium, and high intensity.

Anthropometric Measurements

Waist circumference (WC) was classified into normal or high-risk groups (≥102 cm in men and ≥88 cm in women) according to the Adults Treatment Panel (ATP) III criteria.[11] Body mass index (BMI) (measured weight [kg] divided by the square root of measured height [m]) was categorized as underweight (BMI <18.5 kg/m^2), normal (18.5≤BMI<25 kg/m^2), overweight (25≤BMI<30 kg/m^2), and obese (BMI ≥30 kg/m^2) according to the World Health Organization (WHO) recommendation.[12] A pictogram was used to obtain the participants' body perception in early adulthood and adolescence. This tool uses a spectrum of body drawings from lean to obese sizes scored 1-7 for men and 1-9 for women. The use of pictogram has been validated in the Iranian population.[13] Participants selected their perceived body size at 15 and 30 years of age. The difference between pictogram scores at 15 and 30 was calculated and categorized in four groups; no change, decreased, increased ≤2, and increased >2.

Systolic and diastolic blood pressure (BP) were measured in both arms (twice in each arm) in a sitting and standard position and averaged. Participants were considered hypertensive in case of mean systolic BP ≥140 mm Hg or mean diastolic BP ≥90 mm Hg[14] or antihypertensive medication use.

Outcome Measurement

We determined the diabetic patients (type 1 and 2 DM) based on the criteria of fasting blood sugar (FBS) ≥126 mg/dL or already-diagnosed patients using anti-diabetic medications.

Statistical Analysis

The quality of data was investigated and confirmed according to the PCS protocol and recommended statistical procedures.[15] The qualitative and quantitative data were described by frequency (percent) and mean ± standard deviation (SD), respectively.

Age and gender-standardized prevalence proportion and its 95% confidence intervals (CI)was estimated assuming a Poisson distribution and the world 2000 population as standard population.

We used Poisson regression with robust variance estimation to evaluate the association between the covariates of interest and DM. Crude and adjusted prevalence ratios (aPR) and their 95% CI were estimated. Variable selection for multivariable modeling was done according to the assumed conceptual framework of the study, and then a bivariate *P* value of less than 0.25.

Age, gender, ethnicity, education, marital status, alcohol use, wealth score, opium use, tobacco use, smoking, physical activity, hypertension, triglyceride, cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), alanine transaminase, self-reported history of depression, anxiety, antihypertensive medication use, WC, BMI, pictogram score at 15, and change of this score from 15 to 30 years were selected for multivariable analysis.

All statistical analyses were performed using Stata software version 11.2 (Stata Corporation, College Station, TX, USA). A *P* value <0.05 was considered significant under a two-sided alternative.

Results

The mean age of the study population was 52.64 ± 9.69 years. In total, 54% (n = 5003) of the participants were female, 56.3% (n = 5216) were from of Persian ethnicity, and 49% (n = 4539) were illiterate.

Of 9264 individuals, 919 (equal to a prevalence of 9.9%, 95% CI: 9.3, 10.6; and age and gender standardized prevalence of 10.7% with 95% CI of 9.9 to 11.4%) were diagnosed for DM. Prevalence and age standardized prevalence of DM were estimated at 7.6% (95% CI: 6.8-8.5) and 8.2% (95% CI: 7.3–9.1) among males, and 11.9% (95% CI: 10.9–12.9) and 12.7% (95% CI: 11.6–13.6) among females, respectively (Table 1).

In the adjusted model, for every 5-year increase in age, the prevalence of DM increased about 18%. Female gender was associated with prevalence of DM (aPR: 1.12; 95% CI: 0.97, 1.3). Estimated aPR of DM among people within the highest wealth score group (4th quartile) was 1.53 (95% CI: 1.26–1.85) compared with those within the lowest wealth score group (1st quartile). The Turk ethnicity was an independently significant correlate of DM (aPR = 0.75; 95% CI: 0.66, 0.86).

Higher physical activity was independently correlated with DM with a significant aPR of 0.79 (95% CI: 0.66, 0.93) compared to participants with low levels of physical activity. BMI categories representing overweight and obesity were significantly associated with DM (Table 2).

There was a significant stepwise increase in DM prevalence with increasing 15-year-old pictogram scores. Increase in body size from 15 to 30 years was associated with an increase in the odds of DM; the estimated aPR of DM among those with one or two, and those with more than two units of pictogram increase were 1.47 (95% CI:

Table 1. Baseline Characteristics of the Pars Cohort Study Participants with and without Diabetes Mellitus

Variables	Diabetes, No. (%) 919 (9.9)	No diabetes, No. (%) 8345 (90.1)	*P* Value
Age, mean (SD)	55.95±9.34	52.28±9.66	<0.001
Sex			
Male	325 (7.6)	3951 (92.4)	<0.001
Female	594 (11.9)	4394 (88.1)	
Ethnicity, No. (%)			
Persian	603 (11.6)	4614 (88.4)	
Turk	279 (77.6)	3317 (22.4)	<0.001
Others	37 (8.2)	414 (97.8)	
Education, No. (%)			
Illiterate	503 (11.1)	4035 (88.9)	
Up to high school	393 (8.9)	4045 (91.1)	0.006
Higher education	22 (7.8)	259 (92.2)	
Wealth score, No. (%)			
Low	161 (7.3)	2053 (92.7)	
Low-medium	238 (10.0)	2148 (90.0)	<0.001
Medium high	241 (10.7)	2020 (89.3)	
High	279 (11.6)	2124 (88.4)	
Tobacco use, No. (%)			
Never-user	496 (8.7)	5214 (91.3)	<0.001
Ever-user	421 (11.9)	3116 (88.1)	
Smoking, No. (%)			
Never-user	764 (10.4)	6582 (89.6)	0.002
Ever-user	155 (8.1)	1763 (91.9)	
Opium user, No. (%)			
Never-user	861 (10.1)	7629 (89.9)	0.018
Ever-user	58 (7.5)	716 92.5)	
Hypertension, No. (%)			
Normotensive	735 (9.4)	7090 (90.6)	<0.001
Hypertensive (mean DBP≥90 and/or mean SBP≥140)	184 (12.8)	1248 (87.2)	
Physical activity, No. (%)			
Low	419 (13.5)	2686 (86.5)	
Medium	303 9.9)	2764 90.1)	<0.001
High	197 (6.4)	2889 (93.6)	

Table 1. Continued

Variables	Diabetes, No. (%) 919 (9.9)	No diabetes, No. (%) 8345 (90.1)	*P* Value
BMI, No. (%)			
Underweight (BMI<18.5)	11 (2.9)	371 (97.1)	
Normal (BMI 18.5-24.9)	205 (5.5)	3505 (94.5)	<0.001
Overweight (BMI 25.0-29.9)	429 (12.4)	3021 (87.6)	
Obese (BMI ≥30)	265 (15.8)	1410 (84.2)	
Men waist circumference, No. (%)			
Quintile 1 (<78)	20 (2.3)	851 (97.7)	
Quintile 2 (78-84)	39 (5.0)	744 (95.0)	
Quintile 3 (85-90)	53 (6.3)	791 (93.7)	<0.001
Quintile 4 (91-97)	75 (8.5)	806 (91.5)	
Quintile 5 (≥98)	136 (15.5)	741 (84.5)	
Women waist circumference, No. (%)			
Quintile 1 (<83)	46 (4.4)	996 (95.6)	
Quintile 2 (83-90)	79 (8.1)	902 (91.9)	
Quintile 3 (90.5-95)	124 (1.3)	847 (98.7)	<0.001
Quintile 4 (96-102)	150 (14.7)	872 (85.3)	
Quintile 5 (≥103)	188 (19.9)	758 (80.1)	
TG			
Normal	360 (6.41)	5261 (93.59)	
Borderline	198 (11.82)	1477 (88.18)	<0.001
High	333 (17.98)	1519 (82.02)	
Very High	28 (24.56)	86 (75.44)	
Antihypertensive medication	294 (19.0)	1250 (81.0)	
HDL			
Less than 40	71 (13.2)	467 (86.8)	0.009
40 and more	848 (9.7)	7878 (90.3)	
Self-reported history of depression			
No	1557 (18.66)	6788 (81.34)	<0.001
Yes	238 (25.9)	681 (74.1)	

SD, standard deviation; BMI, body mass index; TG, triglyceride.

Table 2. Correlates of Diabetes Mellitus in the PARS Cohort Study According To Multivariable Poisson Regression Analysis

Variables	No. (%)	Crude PR	Adjusted PR 95% CI
Age (per 5-year increase), mean (SD)	9264	1.17 (1.14, 1.20)	1.18 (1.14, 1.21)
Sex			
Male	4276 (46.2)	Ref.	Ref.
Female	4988 (53.8)	1.57 (1.38, 1.78)	1.12 (0.97, 1.3)
Ethnicity, No. (%)			
Non-Persian	3596 (38.8)	Ref.	Ref.
Persian	5668 (61.2)	0.69 (0.6, 0.79)	0.75 (0.66, 0.86)
HDL			
40 and more	8726 (94.2)	Ref.	Ref.
Less than 40	538 (5.8)	0.94 (0.92, 0.96)	0.97 (0.95, 0 .1)
History of depression			
No	7469 (80.62)	Ref.	Ref.
Yes	1795 (19.38)	1.45 (1.27, 1.67)	1.27 (1.1, 1.46)
Wealth score, No. (%)			
Low	2214 (23.9)	Ref.	Ref.
Low-medium	2386 (25.8)	1.37 (1.13, 1.66)	1.33 (1.1, 1.6)
Medium high	2264 (24.4)	1.47 (1.21, 1.77)	1.5 (1.24, 1.81)
High	2403 (25.9)	1.6 (1.33, 1.92)	1.53 (1.26, 1.85)
Physical activity, No. (%)			
Low	3105 (33.5)	Ref.	Ref.
Medium	3067 (33.1)	0.73 (0.64,.84)	0.93 (0.81, 1.07)
High	3086 (33.3)	0.47(0.4,.56)	0.79 (0.66, 0.93)
Body Mass Index (BMI), No. (%)			
Underweight (BMI<18.5)	382 (4.1)	Ref.	Ref.
Normal (BMI 18.5-24.9)	3710 (40.3)	0.52 (.29,.95)	0.76 (0.42, 1.37)
Overweight (BMI 25.0-29.9)	3450 (37.2)	2.25 (1.92,2.64)	1.58 (1.33, 1.87)
Obese (BMI ≥30)	1675 (18.1)	2.86 (2.41,3.4)	1.6 (1.32, 1.94)
Pictogram at age 15, No. (%)			
1	2566 (27.8)	Ref.	Ref.
2	2814 (30.4)	0.84 (0.71, 0.92)	1.04 (0.88, 1.21)
3	1954 (21.1)	0.83 (0.69, 0.99)	1.16 (0.97, 1.39)
4	918 (9.9)	0.84 (0.67, 1.06)	1.42 (1.12, 1.80)
5	592 (6.4)	0.85 (0.64, 1.11)	1.53 (1.14, 2.05)
6	259 (2.8)	1.15 (0.82, 1.6)	2.29 (1.59, 3.29)
7	93 (1.0)	1.42 (0.85, 2.37)	3.61 (2.19, 5.96)
8	36 (0.4)	1.39 (0.69, 2.75)	2.86 (1.36, 6.00)
Change in pictogram from 15 to 30, No. (%)			
No change	1510 (16.3)	Ref.	Ref.
Decrease	1443 (15.6)	0.99 (0.74, 1.33)	0.64 (0.47, 0.87)
Increase ≤2	5256 (56.7)	1.79 (1.44, 2.23)	1.47 (1.17, 1.85)
Increase >2	1055 (11.4)	3.49 (2.76, 4.43)	2.46 (1.88, 3.22)
TG			
Normal	5621(60.69)	Ref.	Ref.
Borderline	1675(18.09)	1.84 (1.56, 2.17)	1.51 (1.28, 1.79)
High	1852(19.99)	2.8 (2.44, 3.22)	2.09 (1.79, 2.44)
Very High	114(1.23)	3.83 (2.74, 5.37)	3.55 (2.52, 4.98)
Anti-hypertensive medication use			
No	1544 (16.7)	2.35 (2.07, 2.67)	1.46 (1.26, 1.68)
Yes	7720 (83.3)	Ref.	Ref.

SD, standard deviation; BMI, body mass index; TG, triglyceride; PR, prevalence ratio.
Variables included in the model; age, sex, ethnicity, wealth score, physical activity, BMI, pictogram score at age 15, change of pictogram score from age 15 to 30, TG, use of anti-hypertensive medication.

1.17, 1.85) and 2.46 (95% CI: 1.88, 3.22), respectively. Also, those participants with decreased pictogram scores had an aPR of DM equal to 0.64 (95% CI: 0.47, 0.87).

Discussion

Our findings showed an overall DM prevalence of 9.9% in the population of the PCS. The prevalence was higher in women (11.9%) than men (7.6%). Other correlates of DM were age, ethnicity, wealth score, anti-hypertensive medications use, alanine aminotransferase and triglyceride serum level, physical activity, BMI, body shape at age 15 years, and its change between 15 and 30 years.

The estimated prevalence of DM in our study was slightly lower than previous reports on the prevalence of DM in Iran, ranging from 11% to 14%, while it is less than the global estimates, reported at 8.5%.[5,16,17] In this regard, our findings may be more accurate than studies which rely on self-reported DM status. Self-reported measures may not yield highly accurate information,[18] especially in the case of DM, as cases which are probably not previously confirmed, may be unaware of their condition, or have a misconception about DM. This may exert a stronger effect in rural areas, where the tendency to seek medical care and routine checkups is lower and poor levels of literacy lead to false beliefs about the DM. However, it is worth mentioning that Iran has established a near perfect coverage of health services and even in the most remote areas, primary health care network is available; nonetheless, the quality disparities are undeniable.[19,20]

Female gender was associated with a higher prevalence of the DM in our study. In line with our findings, the WHO reported DM to be more prevalent among women (11.1%) compared to men (9.6%) in 2014.[5] However, there are reports with different results on the relationship between gender and the prevalence of DM.[7,21]

A higher wealth score was associated with DM prevalence. An extensive body of literature suggests that lower income level renders the individuals prone to diabetes and its complications, as well as higher mortality.[22-25] In contrast, the economically underprivileged subgroup of our population was less prone to developing DM. The difference in financial status in our study is only relative. While the higher group in our study may be financially capable of consuming high-carbohydrate and high-fat food products more often, the other group may not. Both of them are, nonetheless, unaware of healthy lifestyle habits. As we studied in a rural area in a middle-income country, it could be interpreted that our higher-income group almost matches lower-income groups in developed countries.

DM was more common among participants with Persian ethnicity compared to others. The ethnical differences in blood sugar level have been shown in other studies. This difference could be due to genetic or lifestyle differences.[26]

Low level of physical activity, in the adjusted model, was associated with a 38% increase in the odds of DM compared to high level of physical activity, which is supported by previous literature.[27, 28] The acute and prolonged effects of physical activity or resistance exercise manifest in enhancing insulin action for glucose uptake in muscles, along with increasing muscular capillary density, lipid metabolism, oxidative capacity, and insulin signaling proteins even without weight loss.[29] In addition to prevention of type 2 diabetes, physical activity helps control other underlying factors of further diabetes-related complications.[30]

Similar to previous reports, we noticed a positive association between higher BMI and increased DM prevalence.[31-33] This finding was internally validated by findings from investigation of pictogram scores, as higher scores were associated with a significant increase in the prevalence of DM. Our findings regarding pictogram scores are similar to previous reports.[34]

In our population, the prevalence of antihypertensive medications was twice among diabetic people. In spite of the positive correlation between diabetes and consuming anti-hypertensive medication, no correlation was found for being hypertensive in our study. Hypertension is more common among diabetic patients compared to the general population and antihypertensive medications have an important role in reducing cardiovascular event among these patients.[35] On the other hand, some of the antihypertensive medications such as beta-blockers and calcium channel blockers have been shown to cause new-onset DM.[36]

The large number and relative diversity and heterogeneity of the study population are the strengths of this study. Another point of strength is that we defined DM based on FBS higher than 126 in addition to anti-DM medication use. As we analyzed the baseline data from the PCS, we had the opportunity to investigate the confounding effects of a huge number of potential confounders which were measured in a highly qualified equipment and study setting.

The major limitation of the present study is its cross-sectional nature. As our participants were limited to people over 40 years of age, the results may be generalizable to a similar population.

Modifiable correlates of DM including low socio-economic status, tobacco abuse, and obesity emphasize the importance of improving general living and effective preventive interventions, which should also be targeted at very young age groups. We recommend focus on educational policy about proper lifestyle. Also, health promotion regarding prevention of DM may be an effective intervention in this setting.

Authors' Contribution

AK, initiated the first revision of the manuscript; AS, proposed the idea; HMV, analysed the data and revised the manuscript; HP, proposed the idea and supervised the data collection; AG, managed the data collection at field; MRF, supervised the study; RM, designed and conducted the PCS, supervised the data collection and preparation and proposed the idea. All authors read the manuscript and agree to publication.

Conflict of Interest Disclosures

None.

Ethical Statement

The study protocol was approved by the Ethics Committees of Shiraz University of Medical Sciences and Tehran University of Medical Sciences. The purpose of the study was described to the participants and they were invited to visit the PCS center. Written informed consents were obtained from the participants.

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