Electronic Physician (ISSN: 2008-5842) http://www.ephysician.ir
Year: 2015, Volume: 7, Issue: 1, Pages: 998-1004, DOI: 10.14661/2015.998-1004

High prevalence of type 2 diabetes and pre-diabetes in adult Zoroastrians in Yazd, Iran: a cross-sectional study

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Type of article: Original

Abstract

Background: The prevalence of type 2 diabetes mellitus (T2DM) varies among ethnic groups. We aimed to estimate the prevalence of diagnosed and undiagnosed diabetes mellitus, impaired fasting glucose (IFG), and impaired glucose tolerance (IGT) for the first time in an ethnic population, specifically Zoroastrian citizens in Yazd, Iran whose ages were 30 or older.

Methods: In a cross-sectional study, participants aged≥30 years were selected using systematic random sampling. An inventory, including socio-demographic data, was completed. Weight, height, body mass index (BMI), and blood pressure (BP) were measured using standard methods. Also, blood levels of glucose, triglycerides (TG), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), urea, creatinine (Cr), and uric acid were measured. The latest criteria established by the American Diabetes Association (ADA) were used to diagnose DM.

Results: The mean age of the participants (n=403) was 56.9±12.8 years. The total prevalence of diabetes, including previously diagnosed and undiagnosed diabetes, IFG, and IGT was 26.1%, 18.6%, 7.5%, 34.7% and 25.8%, respectively. Participants with diabetes had higher fasting blood sugar (FBS) (P<0.001), oral glucose tolerance test (OGTT) (P<0.001), urea (P=0.019), BMI (P=0.001), systolic blood pressures (P<0.001), TG (P=0.007) and lower HDL (P=0.034) than patients with IFG, IGT, and normoglycemic subjects.

Conclusions: The current study showed a high prevalence of T2DM in the Zoroastrian population of Yazd, Iran. One-third of the total cases with diabetes were undiagnosed.

Keywords: type 2 diabetes, ethnic group, prevalence, pre-diabetes

1. Introduction

1.1. Background

The prevalence and incidence of type 2 diabetes mellitus (T2DM) are high in the Middle Eastern countries (1), and it has been estimated that these countries will have the largest increases in the prevalence of diabetes by 2030 (2).The prevalence of T2DM was determined to be 14.52% in Yazd, Iran (3). Environmental factors, including urbanization and a westernized lifestyle, as well as genetic susceptibility, can be considered as possible etiologies of the T2DM epidemic in Asia (4).

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Received: December 05, 2014, Accepted: January 20, 2015, Published: March 01, 2015

1.2. Statement of the problem and objectives

The prevalence of T2DM exhibits variations among ethnic groups (5). Pima Indian adolescents (15 to 19 years of age) have the highest reported prevalence of T2DM among youth in the United States (6). A lot of people with T2DM remain unidentified (7). It has been reported that undiagnosed T2DM and impaired glucose regulation are very important clinically since they increase the risk of cardiovascular morbidity and mortality (8-11). In addition, due to the fact that the subjects remain untreated and at risk for complications, undiagnosed diabetes can have significant public health implications (7). Although it is feasible to screen for undiagnosed diabetes within a general practice by measuring fasting blood glucose, it would be better to target individuals with multiple risk factors for diabetes (12). Although Iranian people are mostly Muslims, there is an ethno-religious minority in Iran that practices Zoroastrianism, representing approximately 0.02-0.05% of the population. Zoroastrianism originated between the ninth and sixth centuries BC and was introduced by Sassanid as the official religion during the last pre-Islamic Persian Empire (13). In the last millennium, Zoroastrians have lived in a high level of isolation as well as endogamy, and this condition has been maintained vigorously to date. This enabled the survival of most of the mtDNA of their indigenous Iranian ancestors since there were no foreign contributions to their gene pool in the recent past (14). This provides an outstanding opportunity to study risk factors associated with T2DM in a setting in which genetic variability is limited. Most of this population is distributed throughout the Tehran, Kerman, and Yazd Provinces. We evaluated the prevalence of T2DM, impaired fasting glucose (IFG), and impaired glucose tolerance (IGT) for the first time in this ethnic population in Yazd, Iran, among people whose ages ranged from 30 to 88.

2. Materials and Methods

2.1. Study setting and selection criteria

In a community-based, cross-sectional study of inhabitant Zoroastrians of Yazd, Iran, a number of people aged between 30 and 88 years using systematic random sampling was selected from 14 locations representative of the distribution of the Zoroastrians population in Yazd. A letter was sent with all necessary information to those identified, requesting their collaboration and including eating requirements for the 3 days prior to the test and the need for fasting for at least 12-14 hours before the test. Of 410 letters sent, 408 were received, and 406 people took part in the study. Comparing sex and age distribution of those who did not respond and of those who took part in the study, we found there was no significant difference. The study was concluded in July 2013. Individuals were excluded from the analysis if they had a missing fasting (n=2) or 2-hours glucose value (n=1). Finally, 403 participants whose ages were ≥30 were included in the current data analysis.

2.2. Ethical consideration

The study's protocol was approved by the Medical Ethics Committee of Yazd Islamic Azad University of Medical Sciences. The ethical committee of the research institute for endocrine sciences of Shahid Sadoughi University approved design of the study. Written informed consent forms were collected from all participants. The subjects were invited to the Yazd Diabetes Research Center.

2.3. Data Collection

An inventory was completed for all the subjects by a trained examiner. The inventory included age; gender; job; education; and history of hypertension, hyperlipidemia, alcohol consumption, and family history of diabetes mellitus (DM). The subjects' weights were measured to the nearest 0.1 kg using a calibrated scale (Seca 220, Seca GmbH & Co. KG., Hamburg, Germany) with the subjects wearing light clothing and standing in an upright position. The subjects' heights were measured to the nearest 0.5 cm using a standard stadiometer (Seca 220, Seca GmbH & Co. KG., Hamburg, Germany) while the subjects were not wearing shoes. Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m2). After a 10-minute rest, the subjects' blood pressure (BP) was measured twice (on a single occasion) by a standard mercury sphygmomanometer. The measurements were made to an accuracy of the nearest 2 mmHg while the subjects were in a seated position.

After 12-14 hours of overnight fasting, venous blood samples were taken from the subjects and analyzed in the laboratory of the Yazd Diabetes Research Center. An oral glucose tolerance test (OGTT) was conducted using 75-gm oral glucose powder. Blood levels of glucose, triglycerides (TG), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), urea, creatinine (Cr), and uric acid were measured by an autoanalyzer (AMS Autolab, Italy) using pertinent Pars Azmun kits (Pars Azmun Co, Tehran, Iran), i.e., GOD-PAP for glucose, CHOD-PAP for TC, GPO-PAP for TG, ENZYMATIC for LDL, and PERCIPITANT for HDL. The latest criteria established by the American Diabetes Association (ADA) were used for the diagnosis of DM in the subjects (15).

2.4. Statistical Analysis

After entry, the data were analyzed using SPSS software, version 17 (SPSS Inc., Chicago, IL). Descriptive quantitative methods (measures of central tendency and dispersion) as well as ANOVA and chi-squared tests were used, where appropriate. Fisher's exact test was employed for measure relationship between age and prevalence of different glucose intolerance categories. P values ≤ 0.05 were considered to be statistically significant.

3. Results

3.1 Demographic findings

After applying the inclusion and exclusion criteria, 403 subjects were enrolled in the study. One hundred and fifty-three (38%) were male, and 250 (62%) were female. The mean age of the subjects was 56.9±12.8 years (range: 30-88 years). Abnormal glucose tolerance was more common in subject who married than in subjects who were single and widow, but there was no significant difference between marital status and abnormal glucose tolerance (P=0.062). There were significant difference between type of job, educational level and abnormal glucose tolerance, in while subject who were homemaker and have diploma, abnormal glucose tolerance was more common (P=0.022 and P<0.001, respectively). Subject who consume alcohol have less prevalent abnormal glucose tolerance than who do not (P=0.959) (Table 1). Among the married and widowed subjects, 152 (37.5%) were endogamous and 239 (59.3%) exogamous. Family histories of DM were found in 43.2% of the subjects. Histories of hypertension and/or taking anti-hypertensive drugs were found in 125 (31%) subjects. Histories of hyperlipidemia and/or taking anti-hyperlipidemic agents were found in 111 (27.5%) of the subjects.

Table 1. Association of demographic finding and abnormal glucose tolerance

Demographic factors		Total	Abnormal glucose tolerance n (%)	P
Marital status	Single	14	5 (35.7)	0.062
	Married	349	136 (39)	
	Widow	40	8 (20)	
Job	Office worker	40	22 (55)	0.022
	Worker	16	10 (62.5)	
	Homemaker	178	60 (33.7)	
	Farmer	10	3 (30)	
	Retired	113	35 (31)	
	Self-employed	46	19 (41.3)	
Education	Illiterate	22	5 (22.7)	<0.001
	Primary school	86	15 (17.4)	
	Guidance school and High school	21	8 (38.1)	
	Diploma	207	78 (37.7)	
	Associates degree or higher	67	43 (64.2)	
Alcohol consumption	Yes	144	53 (36.8)	0.959
	No	259	96 (37.1)	

Diabetes was found in 105 (26.1%) of the subjects. The prevalence of diabetes was higher in women (28%) than in men (22.9%), but the difference was not significant (P=0.255). The greatest total number of diabetic subjects was among those who were older than 50, and the peak prevalence was observed among individuals in the age range of 60-69 (37%). Also, it was found that 140 (34.7%) and 104 (25.8%) had IFG and IGT, respectively. Pearson's correlation coefficient for test showed that the correlation between age and prevalence of previously diagnosed diabetes was 0.230 (P<0.001), between age and prevalence of undiagnosed diabetes was 0.174 (P<0.001), and between age and total prevalence of diabetes was 0.281 (P<0.001).There were no significant differences in the prevalence of diabetes (P=0.255), IFG (P=0.728), or IGT (P=0.296) by gender (Table 2).

3.2. Anthropometric and metabolic characteristics by glucose tolerance categories

We evaluated association of anthropometric and metabolic characteristics between subjects with NFG/NGT and subjects who had DM, IFG and IGT. In the subjects, all anthropometric and metabolic characteristics (except for TC, HDL-cholesterol, and LDL-cholesterol) were higher among those who had any glucose abnormality than among

those who had normal glucose tolerance (NGT) (Table 3). Overall, the subjects with diabetes had higher cardiovascular disease risk profiles than did the NGT subjects or the subjects with IFG and IGT.

Table 2. Age and gender prevalence of different glucose intolerance categories among Zoroastrian adults

		Previously diagnosed n (%)	Newly diagnosed (undiagnosed) n (%)	Total prevalence n (%)	IFG n (%)	IGT n (%)
Gender	Male	23 (15)	12 (7.9)	35 (22.9)	58 (37.9)	38 (24.8)
	Female	52 (20.8)	18 (7.2)	70 (28)	82 (32.8)	66 (26.4)
	Total	75 (18.6)	30 (7.5)	105 (26.1)	140 (34.7)	104 (25.8)
Age (year)	30-39	0 (0)	1 (3.1)	1 (3.1)	8 (25)	4 (12.5)
	40-49	7 (7.1)	5 (5)	12 (12.1)	28 (28.3)	13 (3.1)
	50-59	19 (19.4)	6 (6.1)	25 (25.5)	36 (36.7)	30 (30.6)
	60-69	29 (31.5)	5 (5.5)	34 (37)	41 (44.6)	31 (33.7)
	70-89	20 (24.4)	13 (15.8)	33 (40.2)	27 (32.9)	26 (31.7)

n: number of sample, IFG: impaired fasting glucose, IGT: impaired glucose tolerance

Table 3. Anthropometric and metabolic characteristics of participants by glucose tolerance categories

Variables	NGT/NFG		DM		IFG		IGT	
	Mean±SD	P *	Mean±SD	P †	Mean±SD	P ‡	Mean±SD	P §
FBS (mg/dl)	89.3±6.4	< 0.001	145.5±52.4	< 0.001	108.8±6.9	0.806	110.1±21.6	0.816
OGTT (mg/dl)	100.6±20.4	< 0.001	223.9±58.1	< 0.001	148.3±46.2	0.845	166.2±17.2	< 0.001
TG (mg/dl)	166.6±67.4	0.019	195.2±83.5	0.007	181±71.3	0.571	168.4±69.1	0.627
TC (mg/dl)	201.8±37.4	0.471	197.7±37.6	0.453	198.1±36.7	0.450	197.7±36	0.463
LDL (mg/dl)	126.7±24.9	0.059	119.1±23.1	0.027	121.8±25.2	0.258	121.6±25.6	0.307
HDL (mg/dl)	41.3±9.3	0.065	38.6±9	0.034	40.2±9	0.961	39.8±9	0.627
Urea (mg/dl)	32.9±9.9	0.021	36.4±12.2	0.019	35.4±9.5	0.169	34.4±8.7	0.996
Cr (mg/dl)	0.98±0.30	0.952	0.99±0.22	0.77	0.98±0.20	0.936	0.96±0.19	0.224
UA (mg/dl)	5.1±1.3	0.193	5.31±1.21	0.326	5.33±1.15	0.148	5.11±1.24	0.363
BMI (kg/m^2)	25.5±3.6	0.012	27.2±3.9	0.001	26.4±3.5	0.220	26±3.5	0.858
SBP (mmHg)	122.06±16.3	< 0.001	134.4±18.2	< 0.001	129.6±15.2	0.142	129.6±14.9	0.231
DBP (mmHg)	78.09±11.09	0.001	80.9±10.3	0.566	82.6±10.5	0.002	81.1±9.8	0.460

* Compare variables mean between four glucose tolerance categories; † Compare variables mean between NGT and DM; ‡ Compare variables mean between NGT and IFG; § Compare variables mean between NGT and IGT

4. Discussion

In a population-based study of Zoroastrians living in Yazd, Iran, we reported the prevalence of previously diagnosed diabetes, undiagnosed (or newly diagnosed) diabetes, IFG, and IGT. We found that more than two-thirds of Zoroastrian adults whose ages were ≥30 were affected by some degree of hyperglycemia. Approximately 26.1% of all participants were known to have diabetes, of whom about one-third were undiagnosed (or newly diagnosed). The reported prevalence of diabetes in the current study was more than four times the rate predicted by King et al. for Iranians in 2000. The prevalence of diabetes was estimated to be 5.5 and 5.7% in 1995 and 2000, respectively, and it

has been projected to be 9.8% in 2025. As acknowledged, such studies are flawed by old data, the scarcity of data, and the assumptions used to make estimates (16).

4.1 Association of demographic factors and abnormal glucose tolerance

In our study, although the prevalence of T2DM was higher in subjects aged 70 and above compared to 30-39 years old group, it was lower than subjects aged 60-69 years. This may be related to malnutrition, insufficient care, higher mortality rate, and socioeconomic status of these subjects. T2DM was lower in subjects who consume alcohol than those who do not, but this was not statistically significant. Some studies have shown different results (17) that may be associated with age, sex, and amount of alcohol intake. Wakabayashi et al. showed that light drinking is associated with a lower risk of DM in Japanese men and women, while very heavy drinking is thought to increase the risk of DM in Japanese men (18).

Recently, the national prevalence of T2DM among Iranian citizens, aged 25 to 64, was reported to be 7.7%; of this percentage, half had undiagnosed diabetes (19). It seems that the prevalence of diabetes and prediabetic states among Iranian adults is the same as those reported by neighboring countries (20, 21). In Iran, abnormalities in glucose tolerance might be increased by the high prevalence of obesity and metabolic syndrome (22-25). It has been reported that undiagnosed diabetes is as prevalent as, or even more prevalent than, diagnosed diabetes (26-27). The proportion of undiagnosed diabetics to the total number of diabetics has been estimated to be 70% in Denmark (28), 60.6% in India (29), and 47% in Australia (30). The proportion reported in this study is in agreement with the results of a study of the U.S. population (31). In spite of the fact that improvements have been made in education and access to medical care in Iran that have increased the population's awareness of diabetes, the percentage of undiagnosed cases has not decreased. Several studies have focused on the association between diabetes and gender, but the results have not been consistent (32-35). In our study, it was found that the total prevalence of T2DM in women was higher than in men (28 vs. 22.9%). This finding was confirmed by a national survey of diabetes in Iran (8.3% in women vs. 7.1% in men) (19), but the data were different from the data of the U.S (36) and Australia (30). The underlying cause of this difference could be the high prevalence of metabolic syndrome in Iranian women (22-23).

4.2 Association of Anthropometric and metabolic characteristics of participants and glucose tolerance categories

In this study, participants with no glucose abnormality showed lower HDL than those with NGT. This may be attributed to low mean of HDL in Iranians (37), which might be, in turn, due to industrialization, unhealthy diets, lifestyle changes, obesity, and smoking (38). However, some studies have shown that the 40-60% variations in plasma levels of HDL in different individuals are related to gene polymorphism (39). In the current study, IGT was more prevalent among women, whereas IFG was more prevalent among men. Furthermore, the data from a national survey on diabetes in Iran (19) and in the U.S. (36) both represented the higher prevalence of IFG in the male population. It was previously shown that IGT was more prevalent in women whereas IFG was more prevalent in men (32). Several studies have reported that the prevalence of diabetes increases with age (32-34). The current study showed that the prevalence of diagnosed and undiagnosed diabetes, IGT, and IFG in both genders increased with age. It was found that the cardiovascular risk profile of subjects with diabetes was higher than that of NGT subjects, as well as subjects with IFG and IGT. In a review study, Harris et al. stated that patients with undiagnosed diabetes are not as hyperglycemic as those with diagnosed diabetes, but they have substantial rates of risk factors for complications (40). First, according to the increasing prevalence of obesity (25) and diabetes (41) in our population, the reported figures in this study seem to be underestimated. Second, it is impossible to make causal inferences about the relationship between risk factors and undiagnosed T2DM in a cross-sectional study. Strength of the study is that, to the best of our knowledge, this is the first population-based study in Zoroastrians who live in Yazd, Iran, in which the prevalence of T2DM was estimated using both fasting blood sugar (FBS) and OGTT for determining of undiagnosed diabetes.

5. Conclusions

This study found that there is a high prevalence of T2DM and pre-diabetes in the adult Zoroastrian population of Yazd, Iran. The most concerning finding to emerge from this study was that about one-third of patients with diabetes were newly diagnosed. We found that the cardiovascular risk profiles of the subjects with diabetes were higher than NGT subjects and subjects who had IFG and IGT. Further studies on different ethnic groups around the world using the cohort methodology could be a good direction for future research on this issue.

Acknowledgments
The authors are sincerely grateful for all participants in the study. Special thanks to Mohammad Hossein Ahmadieh of Department of Epidemiology of Shahid Sadoughi University of Medical Sciences for his perfect assistance in statistical analysis.

Conflict of Interest:
There is no conflict of interest to be declared.

Authors' contribution:
All of authors read and approved the final manuscript, and contributed in the research and manuscript preparation. M.A. was the principal investigator, contributed to the study design and researched data. S.K., wrote the manuscript, gathered data, reviewed, and edited it. M.A-A is the guarantor of this works and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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