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Prevalence and associated factors of diabetes mellitus among individuals aged 18 years and above in Xiaoshan District, China, 2018: a community-based cross-sectional study

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ABSTRACT

Objective With the rapid development of the Chinese economy, Xiaoshan District, Zhejiang Province has experienced urbanisation, population ageing and significant lifestyle changes, so diabetes mellitus (DM) has attracted more attention. This study aimed to evaluate the prevalence of DM and its risk factors among individuals aged 18 years and above in the district.

Study design and methods A community-based cross-sectional study was carried out in Xiaoshan, China from 1 March to 31 August 2018. A multistage sampling method was used. Sociodemographic and behavioural characteristics were collected using a combination of centralised surveys and household surveys. Anthropometric parameters were measured with standardised techniques and calibrated equipment. Venous blood samples were obtained after at least 8 hours of fasting to determine the level of fasting blood glucose (FBG) and blood lipids. A standard 2-hour 75 g oral glucose tolerance test was also given if 6.1 mmol/L≤FBG<7.0 mmol/L. Univariate and multivariate logistic regression analyses were used to assess the associated factors of DM.

Results The overall prevalence of DM was 12.47%, and the proportion of previously undiagnosed DM (UDM) was 48.66%. The prevalence of pre-diabetes was 10.92%. Age, family history of DM (FHDM), obesity, abdominal obesity, systolic blood pressure (SBP), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) were significantly associated with DM.

Conclusions This study found a high prevalence of DM and pre-diabetes, especially a high prevalence of UDM among adults. The associated risk factors identified for DM were age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C.

Strengths and limitations of this study

- Proper epidemiological methods with multistage stratified cluster sampling techniques were used to conduct the survey.
- Fasting blood glucose (FBG) and oral glucose tolerance test (OGTT) were administered to diagnose diabetes mellitus (DM) in a sample of over 5000 people.
- Not all participants underwent an OGTT, so the prevalence of DM may have been underestimated.
- We could not be able to differentiate between type 1 and type 2 DM based on this survey.
- Using FBG to diagnose DM may have led to some misdiagnosed cases, since we were not sure of participants' compliance to 8 hours of fasting.

INTRODUCTION

Diabetes mellitus (DM) describes a group of metabolic disorders characterised by high blood glucose levels, and is one of the most common non-communicable diseases. It is the fourth or fifth leading cause of death in most high-income countries.[1] The global prevalence of DM in adults has been increasing alarmingly over recent decades.[2] The International Diabetes Federation (IDF) estimated the global prevalence to be 151 million in 2000,[3] 246 million in 2006,[4] 366 million in 2011[5] and 415 million in 2015.[6] It is estimated that these figures will increase to 693 million worldwide by 2045.[7]

The worst development is that DM is increasingly encroaching on productive population groups,[8] with about 77.3% of people with DM being in the age range of 20–64 years.[6] People with DM have an increased risk of developing many disabling and serious life-threatening health problems, resulting in higher medical-care costs, reduced quality of life and increased mortality.[9] Consistently high blood glucose levels can lead to generalised vascular damage, affecting the heart, eyes, kidneys and nerves, and causing various complications.[10]

In addition, many scholars believe that the shocking increase in DM prevalence in

all populations of the world can be attributed to modifiable risk factors such as advanced age, physical inactivity, overweight and obesity, excessive drinking, hypertension, dyslipidaemia and increased urbanisation.[11–15] However, the majority of such studies were conducted in African and western countries, where people have different racial and demographic characteristics than Asians. In addition, most studies on the prevalence and associated factors of DM in China are national cross-sectional surveys[16–18] and regional studies are few (including some on Tianjin,[19] Xinjiang[20] and Jilin[21]). Due to the rapid development of the Chinese economy, Xiaoshan has experienced urbanisation, population ageing and significant lifestyle changes. DM is receiving more attention due to its higher prevalence. The associated factors of DM and population characteristics vary from region to region. Therefore, it is still necessary to consider the uniqueness of the Xiaoshan population and generalise the findings to other cities in China.

This is a community-based cross-sectional study devoted to investigating the prevalence of DM and its associated factors among adults living in Xiaoshan, China in 2018.

METHODS

Study areas

Xiaoshan District is located in Hangzhou City, the capital of Zhejiang Province. The total area of Xiaoshan is 990 km^2, with 12 towns and 9 streets in 2018.[22] Xiaoshan has a superior geographical location and a developed economy, and the gap between urban and rural areas is gradually narrowing.

Study design, population and sample size

A community-based cross-sectional study was carried out in Xiaoshan District from 1 March to 31 August 2018.

The study population were individuals aged 18 years and above, who had lived at the study sites for 6 months or more, volunteered to participate and signed the informed consent form. Of the total study population, the following participants were excluded to avoid the possible impacts on anthropometric and laboratory measurements: critical patients who were unable to communicate, pregnant women and individuals <18 years old.

The sample size was determined using a single population proportion formula, based on a 10.64% prevalence of DM among individuals aged 18 years and above in Xiaoshan District in 2014,[23] with a 95% CI (two-tailed) and corresponding u=1.96, a design effect of 2, 15% allowable error and a 10% non-response rate. Thus, the minimum sample size calculated was found to be 3187.

Sampling methods

A multistage stratified cluster sampling method was applied in this study. Xiaoshan District was divided into three areas (East, South and Middle). The east area included five towns/streets, the south area included eight towns/streets and the middle area included eight towns/streets. In the first stage, two towns/streets were randomly selected from each area, and a total of six towns/streets were selected. In the second stage, the numbers of villages/communities of the six selected towns/streets were 18, 23, 24, 21, 28 and 13, respectively. Two villages/communities were randomly selected from each town/street, and a total of 12 villages/communities were selected. In the third stage, 150 households were selected from each village/community. To account for factors like loss of interviews and refusal, we increased the number of households by 10% above the initial 150 households. Based on the geographical location, every 55 households in each village/community were grouped into one cluster, and three clusters were randomly selected from each village/community. Finally, a total of 36 clusters were selected. In the final stage, the study participants were all the members aged 18 years and above in the households selected for the study.

Questionnaires and anthropometric and biochemical measurement

First, we collected information on sociodemographic and behavioural characteristics through a combination of centralised and household surveys. The sociodemographic characteristics included age, sex, educational level, marital status and family history of DM (FHDM). FHDM was only considered for first-degree relatives. The behavioural characteristics included smoking, alcohol consumption, physical activity intensity and dietary habits (including daily staple food intake, daily vegetable intake, daily fruit intake and daily fatty meat intake). Smoking was defined as at least one cigarette per day, continuously or cumulatively for 6 months. Drinking was defined as at least one alcoholic drink per week. Physical activity intensity was divided into sedentary, moderate and vigorous. 'Sedentary' denoted having no work, or sitting or standing 75% of the time at work, and standing 25% of the time for activities such as office, hotel attendant or attending lectures. 'Moderate' denoted sitting or standing 40% of the time at work, and 60% of the time for special occupational activities, for example, students, drivers or electricians. 'Vigorous' denoted sitting or standing 25% of the time at work, and 75% of the time for special occupational activities such as agricultural labour, steelmaking, sports, loading and unloading, and mining. Dietary habits were classified according to Chinese residents' balanced meal pagoda (2016 edition).

Next, we measured anthropometric parameters for each participant using standardised techniques and calibrated equipment. Height was measured with a stadiometer to the nearest 0.1 cm when the participants were in an upright standing position on a flat surface without shoes. Weight was measured to the nearest 0.1 kg using a body weight scale when the participants were wearing light clothes and no shoes. Body mass index (BMI) (kg/m^2) was calculated by dividing weight (kg) by height (m) squared. BMI was classified as normal if <24.00 kg/m^2, overweight between 24.00 and 28.00 kg/m^2, and obese if

≥28.00 kg/m^2.[24] Waist circumference (WC) was measured to the nearest 0.1 cm at the middle of the lowest rib and the superior border of the iliac crest in an erect position. WC values ≥90 or ≥85 cm (for men and women, respectively) were considered to be abdominal obesity. Blood pressure (BP), including systolic BP (SBP) and diastolic BP (DBP), was measured in a sitting position after 15-minute rest, using a mercury sphygmomanometer. The mean of two measurements was taken as the final BP result. SBP ≥140 mm Hg and/or DBP ≥90 mm Hg were defined as hypertension.[25]

Finally, venous blood samples were obtained after participants had fasted for at least 8 hours, to determine fasting blood parameters. Fasting blood glucose (FBG) and blood lipids including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured. Afterward, a standard 2-hour 75 g oral glucose tolerance test (OGTT) was given if 6.1 mmol/L≤FBG<7.0 mmol/L. Dyslipidaemia was classified as one or more of the following conditions in a fasting state: TC ≥6.2 mmol/L, TG ≥2.3 mmol/L, HDL-C <1.0 mmol/L and LDL-C ≥4.1 mmol/L.[26]

Diagnostic criteria

DM and pre-diabetes were diagnosed by the Chinese Diabetes Society criteria.[27] Those who met one of the following conditions were diagnosed with DM: (1) FBG ≥7.0 mmol/L; (2) OGTT ≥11.1 mmol/L or (3) previous diagnosis of DM. The latter was included in their questionnaires.

Participants were diagnosed with impaired glucose regulation (pre-diabetes) if the results met the following conditions: 6.1 mmol/L≤FBG<7.0 mmol/L and/or 7.8 mmol/L≤OGTT<11.1 mmol/L.

Data quality assurance

The questionnaire was based on the template provided by Zhejiang Provincial Center for Disease Control and Prevention and revised to fit the actual situation of Xiaoshan District. During the investigation, the investigators conducted face-to-face interviews with the respondents. The questionnaires were checked for completeness, consistency and accuracy at the end of each data collection day. Then, the data were double-entered by two investigators using Epidata V.3.02, and a consistency check was performed.

Table 1 Sociodemographic characteristics of participants (n, %)

Variable	Total (n=5387)	DM		χ^2	P value
		No (n=4715)	Yes (n=672)		
Age (years)				**228.685**	**0.000**
18–29	566 (10.51)	561 (11.90)	5 (0.74)		
30–39	588 (10.92)	570 (12.09)	18 (2.68)		
40–49	1018 (18.90)	936 (19.85)	82 (12.20)		
50–59	1253 (23.26)	1067 (22.63)	186 (27.68)		
≥60	1962 (36.42)	1581 (33.53)	381 (56.70)		
Sex				0.024	0.877
Male	2484 (46.11)	2176 (46.15)	308 (45.83)		
Female	2903 (53.89)	2539 (53.85)	364 (54.17)		
Educational level				**137.441**	**0.000**
Illiterate	1174 (21.79)	955 (20.25)	219 (32.59)		
Primary school	1649 (30.61)	1394 (29.57)	255 (37.95)		
Middle school	1260 (23.39)	1117 (23.69)	143 (21.28)		
High school and above	1304 (24.21)	1249 (26.49)	55 (8.18)		
Marital status				**56.896**	**0.000**
Married	4547 (84.41)	3975 (84.31)	572 (85.12)		
Single	402 (7.46)	390 (8.27)	12 (1.79)		
Divorced	36 (0.67)	30 (0.64)	6 (0.89)		
Widowed	402 (7.46)	320 (6.79)	82 (12.20)		
FHDM				**48.060**	**0.000**
No	5103 (94.73)	4504 (95.52)	599 (89.14)		
Yes	284 (5.27)	211 (4.48)	73 (10.86)		

p- value of <0.05 considered statistically significant are in bold.
DM, diabetes mellitus; FHDM, family history of DM.

Table 2 Behavioural characteristics of participants (n, %)

Variable	Total (n=5387)	DM		χ^2	P value
		No (n=4715)	Yes (n=672)		
Smoking				0.025	0.875
No	4204 (78.04)	3678 (78.01)	526 (78.27)		
Yes	1183 (21.96)	1037 (21.99)	146 (21.73)		
Alcohol consumption				**9.042**	**0.003**
No	3794 (70.43)	3354 (71.13)	440 (65.48)		
Yes	1593 (29.57)	1361 (28.87)	232 (34.52)		
Physical activity intensity				5.109	0.078
Sedentary	3809 (70.71)	3314 (70.29)	495 (73.66)		
Moderate	1150 (21.35)	1029 (21.82)	121 (18.01)		
Vigorous	428 (7.95)	372 (7.89)	56 (8.33)		
Daily staple food intake (g)				**8.158**	**0.004**
50–150	627 (11.64)	571 (12.11)	56 (8.33)		
>150	4760 (88.36)	4144 (87.89)	616 (91.67)		
Daily vegetable intake (g)				0.564	0.754
<300	2953 (54.82)	2592 (54.97)	361 (53.72)		
300–500	1807 (33.54)	1573 (33.36)	234 (34.82)		
>500	627 (11.64)	550 (11.66)	77 (11.46)		
Daily fruit intake (g)				3.012	0.222
<200	4906 (91.07)	4282 (90.82)	624 (92.86)		
200–350	381 (7.07)	343 (7.27)	38 (5.65)		
>350	100 (1.86)	90 (1.91)	10 (1.49)		
Daily fatty meat intake (g)				5.321	0.070
<40	1905 (35.36)	1671 (35.44)	234 (34.82)		
40–75	1455 (27.01)	1250 (26.51)	205 (30.51)		
>75	2027 (37.63)	1794 (38.05)	233 (34.67)		

p- value of <0.05 considered statistically significant are in bold.
DM, diabetes mellitus.

Anthropometric measurements were taken twice, and in some instances three times, to minimise observer bias during measurement and recording. Furthermore, the BP and weight scale instruments were calibrated daily against a standard calibrated instrument for accuracy.

After venous blood samples were collected, plasma was separated and kept at −20°C before analysis. The instrument, a C16000 chemistry analyser, was warmed up each day before running tests on samples. The manufacturer's instructions for the machine (Yapei) and the reagents were strictly followed.

Patient and public involvement

This was a community-based epidemiological survey conducted to ascertain the prevalence of people with type 2 DM in China. The results will help national and international stakeholders to take appropriate measures to prevent DM at all levels. With informed consent, 5387 individuals from Xiaoshan, China were involved in the survey. The participation of study subjects was limited to the collection of study data approved by the ethical review committee, and the entire survey was performed by the survey team members. The tests involved in the survey were conducted free of charge and the results were communicated to study participants through printed medical reports given to them by local team members. Complimentary medical consultation was provided if there were any abnormal findings. Subjects with newly diagnosed DM and impaired glucose tolerance were referred to the nearest medical centre for registration and treatment.

Statistical analysis

SPSS V.25.0 was used for statistical analysis. Continuous data are presented as means and SDs (mean±SD), and categorical data were presented as frequencies and percentages (n, %). The χ^2 test was used for comparison of categorical data between groups. Univariate and multivariate logistic regression analyses were used to assess the associated factors of DM and variables that were significant in the univariate analysis were entered in the multivariable logistic regression model. The magnitude of the association was measured using the adjusted OR (AOR), with a 95% CI. A p value of <0.05 was considered statistically significant.

Table 3 Anthropometric and biochemical measurement characteristics of participants (n, %)

Variable	Total (n=5387)	DM		χ^2	P value
		No (n=4715)	Yes (n=672)		
BMI (kg/m^2)				**104.118**	**0.000**
Normal	2850 (52.91)	2603 (55.21)	247 (36.76)		
Overweight	1894 (35.16)	1612 (34.19)	282 (41.96)		
Obesity	643 (11.94)	500 (10.60)	143 (21.28)		
WC				**160.947**	**0.000**
Normal	3626 (67.31)	3318 (70.37)	308 (45.83)		
High	1761 (32.69)	1397 (29.63)	364 (54.17)		
SBP				**167.535**	**0.000**
Normal	4455 (82.70)	4018 (85.22)	437 (65.03)		
High	932 (17.30)	697 (14.78)	235 (34.97)		
DBP				**55.041**	**0.000**
Normal	4729 (87.79)	4198 (89.03)	531 (79.02)		
High	658 (12.21)	517 (10.97)	141 (20.98)		
TC				**21.925**	**0.000**
Normal	5010 (93.00)	4414 (93.62)	596 (88.69)		
High	377 (7.00)	301 (6.38)	76 (11.31)		
TG				**70.934**	**0.000**
Normal	4699 (87.23)	4181 (88.67)	518 (77.08)		
High	688 (12.77)	534 (11.33)	154 (22.92)		
HDL-C				**22.638**	**0.000**
Normal	4708 (87.40)	4159 (88.21)	549 (81.70)		
High	679 (12.60)	556 (11.79)	123 (18.30)		
LDL-C				0.373	0.541
Normal	5320 (98.76)	4658 (98.79)	662 (98.51)		
High	67 (1.24)	57 (1.21)	10 (1.49)		

p- value of <0.05 considered statistically significant are in bold.
BMI, body mass index; DBP, diastolic blood pressure; DM, diabetes mellitus; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; WC, waist circumference.

RESULTS

Characteristics of the study population

Initially, we collected 5762 questionnaires. However, during a check of data for missing and unexpected values, we found that 375 questionnaires had missing and/or unexpected values that could not be repaired, and thus needed to be excluded from the analysis. Ultimately, a total of 5387 participants successfully completed the survey, and the effective response rate was 93.49%. There were 2484 (46.11%) men and 2903 (53.89%) women. The mean age of study participants was 52.25±15.61 years: 51.97±15.99 years for men and 52.50±15.27 years for women.

The distribution differences between age, educational level, marital status, FHDM, alcohol consumption, daily staple food intake, BMI, WC, SBP, DBP, TC, TG, and HDL-C between the DM and non-DM groups were statistically significant (p<0.05) (tables 1–3).

Prevalence of DM

The 2-hour 75 g OGTT was administered to 482 participants, 44 of whom fell into the DM class. Therefore, a total of 672 participants had DM, with a prevalence of 12.47% (672 out of 5387). In addition, five participants fell into the pre-diabetes class after being administered the 2-hour 75 g OGTT, leading to a total pre-diabetes prevalence of 10.92% (588 out of 5387). Among the participants with DM, nearly half (327) were not aware that they had DM before the survey, and the proportion of previously undiagnosed DM (UDM) was 48.66% (figure 1). The prevalence rates of DM in men and women were 12.40% and 12.54%, respectively (table 1). Figure 2 illustrates that prevalence of DM increased with age.

Factors associated with DM

Factors associated with DM among participants are reported in table 4. The multivariate logistic regression analysis showed that age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C were independently associated with DM.

The results made it clear that the risk of developing DM increased with age. Participants aged 30–39 years (AOR=3.563, 95% CI: 1.191 to 10.652), 40–49 years (AOR=9.097, 95% CI: 3.187 to 25.963), 50–59 years (AOR=16.328, 95% CI: 5.740 to 46.449), and over 60

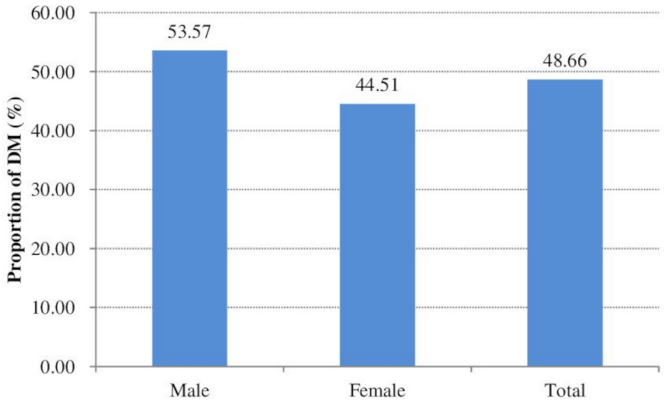

Figure 1 Diabetics who were not aware of their condition among male, female and total patients. DM, diabetes mellitus.

years (AOR=22.056, 95% CI: 7.677 to 63.362) were 3, 9, 16, and 22 times more likely to have DM compared with those aged 18–29 years, respectively. Respondents with a positive FHDM were found to be 3.3 times more likely to have DM than those without FHDM (AOR=3.304, 95% CI: 2.423 to 4.505).

Obese participants were 1.5 times more at risk of being DM positive than those with normal BMI (AOR=1.520, 95% CI: 1.125 to 2.053). Similarly, participants with high WC were 1.6 times more likely to be DM positive compared with those whose WC was normal (AOR=1.607, 95% CI: 1.292 to 1.998). Additionally, individuals with high SBP were 1.8 times more likely to have DM than normal SBP individuals (AOR=1.807, 95% CI: 1.442 to 2.265).

Furthermore, high TG (AOR=1.657, 95% CI: 1.310 to 2.096) and HDL-C (AOR=1.336, 95% CI: 1.040 to 1.717) also proved to be significantly associated with DM.

DISCUSSION

This present study shows an overall DM prevalence of 12.47%. A study from China showed that 11.6% of adults had DM.[17] Anjana *et al*[28] found the prevalence of DM was 13.6% in an Indian study. The Chandigarh Urban Diabetes Survey also reported a DM prevalence of 11.1%.[29] These results were consistent with the present findings.

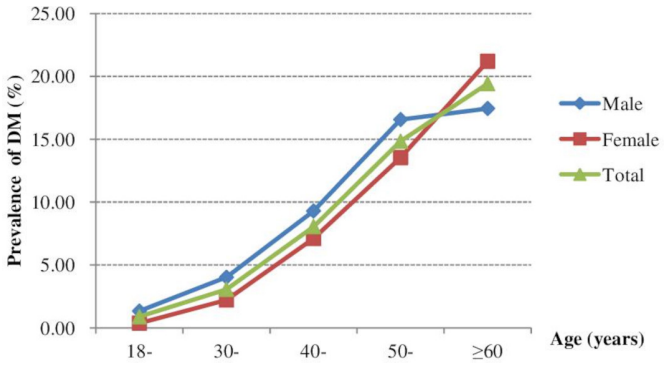

Figure 2 Prevalence of diabetes mellitus (DM) in male, female and total participants in various age groups

However, the prevalence of DM in our study was higher than that in other studies done in Bangladesh (9.7%),[30] Punjab, North India (8.3%),[31] Brazil (7.5%),[32] and Tianjin, China (10%).[19] Meanwhile, one study conducted in Pakistan reported that the prevalence of DM was 26.3%,[12] higher than our result. This lack of congruency may be related to variations in lifestyle, sociodemographic and genetic factors, or sample size. Age group differences in the study populations may also be a cause of discrepancies. In addition, the differences might be due to different diagnostic methods for DM.

Our study found that nearly half of DM cases (48.66%) were previously undiagnosed. This finding was comparable with the IDF Atlas report that nearly half of all people living with DM (49.7%) were undiagnosed.[7] However, a much higher percentage of participants with DM (56%) were not aware that they had the disease in a Bangladeshi study,[30] and the prevalence of previously UDM was 72.5% in Dessie Town, Northeast Ethiopia.[33] In contrast, the proportion of previously UDM cases in our study was higher than in reports from Pakistan (31%)[12] and Hosanna Town, Southern Ethiopia (36%).[34] The widespread high rates of UDM may be due to a lack of DM awareness and poor screening programmes in the community and among primary healthcare providers.

The prevalence of pre-diabetes in our study was found to be 10.92%. A study from 15 states in India showed a similar rate (10.3%).[35] Barik *et al*[36] found that the prevalence of pre-diabetes among adults >18 years was 3.34%. Another study in Koladiba Town, Northwest Ethiopia, indicated a pre-diabetes prevalence of 12%.[37] These figures make it evident that though the prevalence of pre-diabetes varies in different settings, it is generally quite high and warrants immediate attention. They also suggest that the prevalence of DM in the study area may increase shortly as there is obviously a risk of progression from pre-diabetes to diabetes.[38]

As expected, our findings reveal that DM is associated with increasing age. The positive associations we found between age and DM have also been observed previously in Bangladesh,[30] China,[18] and Brazil.[32] Therefore, it is advisable to design a mechanism for health education and promotion to enhance check-ups for the disease as patients advance in age.

Our results demonstrate that a positive FHDM is the main risk factor for a diagnosis of DM. This finding is in agreement with other studies.[12 32 37] It is already known that the lifetime risk of any offspring developing DM is about 40% if one parent is diabetic and 70% if both parents are diabetic.[39] How genetic predisposition causes DM in the absence of other risk factors is not understood, but the lifestyle and living environment within families may be the contributing factors.[40]

Generalised obesity and abdominal obesity are independently associated with DM, which is similar to the results in most other studies.[28 36 41] Obesity may lead

Table 4 Univariate and multivariate logistic regression analyses of factors associated with diabetes mellitus among participants

Variable	OR (95% CI)	P value	AOR (95% CI)	P value
Age (years) (ref. 18–29)				
30–39	**3.543 (1.307 to 9.609)**	**0.013**	**3.563 (1.191 to 10.652)**	**0.023**
40–49	**9.829 (3.961 to 24.393)**	**0.000**	**9.097 (3.187 to 25.963)**	**0.000**
50–59	**19.559 (7.999 to 47.823)**	**0.000**	**16.328 (5.740 to 46.449)**	**0.000**
≥60	**27.039 (11.131 to 65.678)**	**0.000**	**22.056 (7.677 to 63.362)**	**0.000**
Educational level (ref. illiterate)				
Primary school	**0.798 (0.654 to 0.973)**	**0.026**	1.006 (0.810 to 1.248)	0.960
Middle school	**0.558 (0.445 to 0.701)**	**0.000**	1.094 (0.826 to 1.449)	0.530
High school and above	**0.192 (0.141 to 0.261)**	**0.000**	0.902 (0.611 to 1.332)	0.604
Marital status (ref. married)				
Single	**0.214 (0.120 to 0.382)**	**0.000**	1.428 (0.699 to 2.918)	0.328
Divorced	1.390 (0.576 to 3.354)	0.464	1.426 (0.556 to 3.655)	0.460
Widowed	**1.781 (1.376 to 2.305)**	**0.000**	1.106 (0.833 to 1.469)	0.485
FHDM (ref. no)				
Yes	**2.601 (1.967 to 3.440)**	**0.000**	**3.304 (2.423 to 4.505)**	**0.000**
Alcohol consumption (ref. no)				
Yes	**1.299 (1.095 to 1.542)**	**0.003**	1.033 (0.857 to 1.245)	0.735
Physical activity intensity (ref. sedentary)				
Moderate	**0.787 (0.638 to 0.972)**	**0.026**	0.840 (0.668 to 1.055)	0.134
Vigorous	1.008 (0.749 to 1.356)	0.959	0.820 (0.598 to 1.124)	0.217
Daily staple food intake (g) (ref. 50–150)				
>150	**1.516 (1.137 to 2.020)**	**0.005**	1.259 (0.929 to 1.705)	0.137
BMI (kg/m^2) (ref. normal)				
Overweight	**1.844 (1.537 to 2.211)**	**0.000**	1.194 (0.960 to 1.484)	0.111
Obesity	**3.014 (2.402 to 3.782)**	**0.000**	**1.520 (1.125 to 2.053)**	**0.006**
WC (ref. normal)				
High	**2.807 (2.382 to 3.308)**	**0.000**	**1.607 (1.292 to 1.998)**	**0.000**
SBP (ref. normal)				
High	**3.100 (2.595 to 3.703)**	**0.000**	**1.807 (1.442 to 2.265)**	**0.000**
DBP (ref. normal)				
High	**2.156 (1.753 to 2.652)**	**0.000**	0.921 (0.711 to 1.194)	0.536
TC (ref. normal)				
High	**1.870 (1.434 to 2.439)**	**0.000**	1.293 (0.969 to 1.726)	0.081
TG (ref. normal)				
High	**2.328 (1.904 to 2.846)**	**0.000**	**1.657 (1.310 to 2.096)**	**0.000**
HDL-C (ref. normal)				
High	**1.676 (1.352 to 2.077)**	**0.000**	**1.336 (1.040 to 1.717)**	**0.023**

p- value of <0.05 considered statistically significant are in bold.
AOR, adjusted OR; BMI, body mass index; DBP, diastolic blood pressure; FHDM, family history of diabetes mellitus; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; WC, waist circumference.

to increased production of adipokines/cytokines, resulting in insulin resistance and reduced levels of adiponectin which works as an insulin sensitiser.[42]

Our observations indicate that the link between high SBP and DM is positive and significant. Individuals with high SBP had a higher risk of DM than those with normal SBP. This finding is supported by other studies.[12 15 32] The pathophysiological mechanism of the relationship between hypertension and DM is not clear. However, high BP has been shown to induce microvascular and endothelial dysfunction, which may contribute to insulin resistance.[43]

In addition, dyslipidaemia, including TG and HDL-C, was found to be a risk factor significantly associated with DM. The prevalence of DM was higher among participants with a high level of TG or HDL-C. This finding is corroborated by results from Mizan-Aman Town, Southwest Ethiopia[38] and Brazil.[32] This is in line with the explanation that individuals with elevated levels of total TG, as well as raised LDL-C levels, are at high risk of developing DM and other cardiovascular diseases.[44] Such associations are a consequence of insulin resistance and are worrisome because they considerably increase the risk of cardiovascular complications.[32]

STRENGTHS AND LIMITATIONS

The present study has some strengths. The sample size was large, and the FBG and OGTT carried out to diagnose DM and pre-diabetes used venous instead of capillary blood samples. Nevertheless, there were several limitations. First, the study's cross-sectional nature meant that it was not possible to establish a causal relationship between the risk factors and occurrence of the disease. Second, not all participants underwent an OGTT, which may have led to underestimation of the prevalence of DM. Third, it was not possible to differentiate between type 1 and type 2 DM based on this survey. Fourth, we only examined the associated factors of DM, not those of pre-diabetes. Finally, using FBG to diagnose DM may have led to some misdiagnosed cases, since we could not be sure of participants' compliance to 8 hours of fasting. These issues will be considered in a future study.

CONCLUSIONS

This study found a high prevalence of DM and pre-diabetes, especially a high prevalence of UDM, among adults in Xiaoshan District, China. The associated risk factors identified for DM were age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C.

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Ethics approval This study involves human participants and was approved by Xiaoshan District Center for Disease Control and Prevention Ethics Committee (number/ID of the approval: XSCDC201801). Participants gave informed consent to participate in the study before taking part.

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REFERENCES

1 IDF. *IDF diabetes atlas*. 6. Brussels, Belgium: International Diabetes Federation, 2013.
2 Ogurtsova K, da Rocha Fernandes JD, Huang Y, *et al*. IDF diabetes atlas: global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Pract* 2017;128:40–50.
3 IDF. *IDF diabetes atlas*. 1. Brussels, Belgium: International Diabetes Federation, 2000.
4 IDF. *IDF diabetes atlas*. 3. Brussels, Belgium: International Diabetes Federation, 2006.
5 IDF, Brussels. *IDF diabetes atlas*. 5. Brussels, Belgium: International Diabetes Federation, 2011.
6 IDF. *IDF diabetes atlas*. 7. Brussels, Belgium: International Diabetes Federation, 2015.
7 Cho NH, Shaw JE, Karuranga S, *et al*. IDF diabetes atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract* 2018;138:271–81.
8 Zimmet PZ, Magliano DJ, Herman WH, *et al*. Diabetes: a 21st century challenge. *Lancet Diabetes Endocrinol* 2014;2:56–64.
9 Baena-Díez JM, Peñafiel J, Subirana I, *et al*. Risk of cause-specific death in individuals with diabetes: a competing risks analysis. *Diabetes Care* 2016;39:1987–95.
10 WHO. Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: Switzerland; 2009. *World Health Organization* 2013.
11 Abebe SM, Berhane Y, Worku A, *et al*. Diabetes mellitus in North West Ethiopia: a community based study. *BMC Public Health* 2014;14:97–104.
12 Basit A, Fawwad A, Qureshi H, *et al*. Prevalence of diabetes, pre-diabetes and associated risk factors: second national diabetes survey of Pakistan (NDSP), 2016-2017. *BMJ Open* 2018;8:e020961.
13 Regmi D, Al-Shamsi S, Govender RD, *et al*. Incidence and risk factors of type 2 diabetes mellitus in an overweight and obese population: a long-term retrospective cohort study from a Gulf state. *BMJ Open* 2020;10:e035813.
14 Tino S, Mayanja BN, Mubiru MC, *et al*. Prevalence and factors associated with overweight and obesity among patients with type 2 diabetes mellitus in Uganda-a descriptive retrospective study. *BMJ Open* 2020;10:e039258.
15 Zekewos A, Loha E, Egeno T, *et al*. Prevalence of diabetes mellitus and associated factors in southern Ethiopia: a community based study. *Ethiop J Health Sci* 2018;28:451–60.
16 Wang L, Gao P, Zhang M, *et al*. Prevalence and ethnic pattern of diabetes and prediabetes in China in 2013. *JAMA* 2017;317:2515–23.
17 Xu Y, Wang L, He J, *et al*. Prevalence and control of diabetes in Chinese adults. *JAMA* 2013;310:948–59.
18 Yang W, Lu J, Weng J, *et al*. Prevalence of diabetes among men and women in China. *N Engl J Med Overseas Ed* 2010;362:1090–101.
19 Zhang H, Xu W, Dahl AK, *et al*. Relation of socio-economic status to impaired fasting glucose and type 2 diabetes: findings based on a large population-based cross-sectional study in Tianjin, China. *Diabet Med* 2013;30:e157–62.
20 Li S, Guo S, He F, *et al*. Prevalence of diabetes mellitus and impaired fasting glucose, associated with risk factors in rural Kazakh adults in Xinjiang, China. *Int J Environ Res Public Health* 2015;12:554–65.
21 He H, Zhen Q, Li Y, *et al*. Prevalence of high Non-high-density lipoprotein cholesterol and associated risk factors in patients with diabetes mellitus in Jilin Province, China: a cross-sectional study. *Biomed Environ Sci* 2016;29:534–8.
22 Xiaoshan statistical Yearbook editorial Committee. *Xiaoshan District Statistical Yearbook* 2018.
23 Lin JY, Jiang YY, Ge Y. Prevalence of diabetes mellitus and its risk factors in residents aged 18 years and above in Xiaoshan district, Hangzhou City, 2014 (in Chinese). *Pract Prev Med* 2017;24:141–4.
24 National Health and Family Planning Commission. *WS/T 428-2013 criteria of weight for adults (in Chinese)*. Beijing: Standards Press of China, 2013.
25 Guidelines for the prevention and treatment of hypertension in China revision Committee. *Guidelines for the prevention and treatment of hypertension in China* 2018.
26 Guidelines for the prevention and treatment of dyslipidemia in Chinese adults revision Committee. Guidelines for the prevention

and treatment of dyslipidemia in Chinese adults (2016 edition) (in Chinese). *Chin J Cardiol* 2016;44:833–53.
27 CDS. Guidelines for the prevention and treatment of type 2 diabetes in China (2017 edition) (in Chinese). *Chin J Diabetes Mellitus* 2018;10:4–67.
28 Anjana RM, Pradeepa R, Deepa M, *et al*. Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in urban and rural India: phase I results of the Indian Council of medical Research-INdia diabetes (ICMR-INDIAB) study. *Diabetologia* 2011;54:3022–7.
29 Ravikumar P, Bhansali A, Ravikiran M, *et al*. Prevalence and risk factors of diabetes in a community-based study in North India: the Chandigarh urban diabetes study (CUDS). *Diabetes Metab* 2011;37:216–21.
30 Akter S, Rahman MM, Abe SK, *et al*. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ* 2014;92:204–13.
31 Tripathy JP, Thakur JS, Jeet G, *et al*. Prevalence and risk factors of diabetes in a large community-based study in North India: results from a steps survey in Punjab, India. *Diabetol Metab Syndr* 2017;9:8.
32 Flor LS, Campos MR. The prevalence of diabetes mellitus and its associated factors in the Brazilian adult population: evidence from a population-based survey. *Rev Bras Epidemiol* 2017;20:16–29.
33 Endris T, Worede A, Asmelash D. Prevalence of diabetes mellitus, prediabetes and its associated factors in Dessie town, northeast Ethiopia: a community-based study. *Diabetes Metab Syndr Obes* 2019;12:2799–809.
34 Dereje N, Earsido A, Temam L, *et al*. Prevalence and associated factors of diabetes mellitus in Hosanna town, southern Ethiopia. *Ann Glob Health* 2020;86:18.
35 Anjana RM, Deepa M, Pradeepa R, *et al*. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR-INDIAB population-based cross-sectional study. *Lancet Diabetes Endocrinol* 2017;5:585–96.
36 Barik A, Mazumdar S, Chowdhury A, *et al*. Physiological and behavioral risk factors of type 2 diabetes mellitus in rural India. *BMJ Open Diabetes Res Care* 2016;4:e000255.
37 Worede A, Alemu S, Gelaw YA, *et al*. The prevalence of impaired fasting glucose and undiagnosed diabetes mellitus and associated risk factors among adults living in a rural Koladiba town, Northwest Ethiopia. *BMC Res Notes* 2017;10:251.
38 Aynalem SB, Zeleke AJ. Prevalence of diabetes mellitus and its risk factors among individuals aged 15 years and above in Mizan-Aman town, Southwest Ethiopia, 2016: a cross sectional study. *Int J Endocrinol* 2018;2018:9317987.
39 InterAct Consortium, Scott RA, Langenberg C, *et al*. The link between family history and risk of type 2 diabetes is not explained by anthropometric, lifestyle or genetic risk factors: the EPIC-InterAct study. *Diabetologia* 2013;56:60–9 http://www.ncbi.nlm.nih.gov/pubmed/23052052
40 Ferrannini E, Gastaldelli A, Iozzo P. Pathophysiology of prediabetes. *Med Clin North Am* 2011;95:327–39.
41 Little M, Humphries S, Patel K, *et al*. Factors associated with glucose tolerance, pre-diabetes, and type 2 diabetes in a rural community of South India: a cross-sectional study. *Diabetol Metab Syndr* 2016;8:21.
42 Deng Y, Scherer PE. Adipokines as novel biomarkers and regulators of the metabolic syndrome. *Ann N Y Acad Sci* 2010;1212:E1–19.
43 Kim M-J, Lim N-K, Choi S-J, *et al*. Hypertension is an independent risk factor for type 2 diabetes: the Korean genome and epidemiology study. *Hypertens Res* 2015;38:783–9.
44 Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* 2006;23:469–80.