BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049754
Article Type:	Original research
Date Submitted by the Author:	19-Feb-2021
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Keywords:	DIABETES & ENDOCRINOLOGY, General diabetes < DIABETES & ENDOCRINOLOGY, Epidemiology < ONCOLOGY

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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 study

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ABSTRACT

Objective: To evaluate the prevalence of diabetes mellitus (DM) and its risk factors among individuals aged 18 years and above.

Study design and methods: A community-based cross sectional study was carried out in Xiaoshan district, Zhejiang Province, China from March 1 to August 31, 2018. A multistage stratified cluster sampling method was applied in this study. Socio-demographic and behavioral characteristics were collected using questionnaire through a combination of centralized surveys and household surveys. Anthropometric parameters were measured using standardized 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. And a standard 2h-75g oral glucose tolerance test (OGTT) was given if FBG results were between 6.1 and 7.0 mmol/L (excluding 7.0 mmol/L). Univariate and multivariate logistic regression analysis were used to assess the associated factors of DM.

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

Conclusion: This study reported high prevalence of DM and prediabetes, especially of UDM amongst the adults. The associated risk factors were also identified. Age,

FHDM, obesity, abdominal obesity, SBP, TG and HDL-C are significantly associated with DM.

Keywords: Diabetes mellitus, Prevalence, Risk factors

Strengths and limitations of this study

The major strength of our study was that FBG and OGTT were done for the diagnosis of DM and prediabetes using venous blood samples instead of capillary blood samples.

This study also had several limitations. Firstly, the study's cross-sectional nature implies that it was not possible to establish a causal relationship between these risk factors and the occurrence of the disease.

Secondly, we would not be able to differentiate between type 1 and type 2 DM on the basis of this survey.

Finally, we only examined the associated factors of DM and the analysis of the associated factors of prediabetes were not undertaken. These issues will be considered in a future study.

INTRODUCTION

Diabetes mellitus (DM) describes a group of metabolic disorders characterized 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 was estimated that these figures were expected to increase to 693 million by 2045 worldwide[7].

The worst scenario is that DM is increasingly encroaching productive population groups[8], within which about 77.3% of people with DM are in the age range of 20-64 years[6], as reported by IDF in 2015. People with DM have an increased risk of developing a number of 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 generalized vascular damage affecting heart, eyes, kidneys and nerves and resulting in various complications[10].

China has experienced rapid economic growth in recent decades, leading to urbanization and significant changes in lifestyle[11]. During this stage, the prevalence of DM has increased significantly in China[12, 13]. In subsequent national surveys conducted in 1994 and 2000-2001, the prevalence of DM was 2.5% and 5.5%, respectively[13, 14]. The national survey in 2007 reported that the prevalence of DM was 9.7%[12]. Another study in China showed that the prevalence of DM was 10.9% among adults in 2013[15]. In addition, one study revealed that the prevalence of prediabetes was estimated to be 50.1%[16]. Although different sampling methods, screening procedures and diagnostic criteria were used in these studies, these data documented a rapid increase in DM in the Chinese population. Therefore, it is urgent to take some intervention measures to prevent and control DM.

In the present study, a community-based cross sectional study was conducted, and we aimed to investigate the prevalence of DM and its associated factors among adults living in Xiaoshan district, China, 2018.

METHODS

Study areas

Xiaoshan district is located in Hangzhou City, the capital of Zhejiang Province. The total area of Xiaoshan district is 1420 square kilometers, with 12 towns and 9 streets in 2018. Xiaoshan district has a superior geographic location, 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 March 1 to August 31, 2018.

The study population was individuals aged 18 years and above permanently living at the study sites. The individuals who were voluntary to participate and sign the study informed consent were our inclusion criteria. Of the total study population, the following participants were excluded: critical patients who were unable to

communicate, pregnant women and individuals <18 years of age to avoid the possible impacts on anthropometric and laboratory measurements.

The sample size was determined using the single population proportion formula by considering 10.64% prevalence of DM among individuals aged 18 years and above in Xiaoshan district, China in 2014[17], with 95% confidence interval (two-tailed) and corresponding u = 1.96, a design effect of 2, 15% allowable error, and 10% of 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 is divided into three areas: east, south and middle according to the geographical location. In the first stage, 2 townships/streets were selected from each area. In the second stage, 2 villages/neighborhoods were selected from each township/street using a simple random sampling method. In the third stage, 150 households were randomly selected from each village/neighborhood. In the final stage, the study participants were all the members aged 18 years and above in the selected households. Taking into account the loss of interviews, refusal, etc., we increased the number of households by 10%.

Questionnaire, anthropometric and biochemical measurement

First, socio-demographic and behavioral characteristics were collected using questionnaire through a combination of centralized surveys and household surveys. Socio-demographic characteristics included age, sex, educational level, marital status, family history of diabetes mellitus (FHDM). Behavioral 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). Dietary habits were classified according to Chinese residents' balanced meal pagoda (2016 edition).

Next, anthropometric parameters were measured for each participant using standardized techniques and calibrated equipment. Height was measured by a stadiometer nearest to 0.1 centimeter when the participants were in an upright standing position on a flat surface without shoes. Weight was measured to the nearest

0.1 kilogram using a person scale when the participants were wearing light clothes and bare feet. Body mass index (BMI) (kg/m^2) was calculated by dividing the weight (kg) by height (m) squared. BMI was classified as < 24.00 kg/m^2 normal, between 24.00 and 28.00 kg/m^2 overweight and ≥ 28.00 kg/m^2 obesity. Waist circumstance (WC) was measured to the nearest 0.1 centimeter in the erect position at the middle of the lowest rib and the superior border of the iliac crest. The WC values of ≥ 90 and ≥ 85 cm for men and women were considered to be abdominal obesity, respectively. Blood pressure (BP) including systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured in sitting position after 15 minutes rest using a mercury sphygmomanometer. The mean of two measurements was taken as the final result of BP. SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg were considered to define as hypertension[18].

Finally, venous blood samples were obtained after at least 8 hours of fasting to determine fasting blood parameters. Fasting blood glucose (FBG) and blood lipids including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) were measured respectively. Afterward, subjects whose FBG results were between 6.1 and 7.0 mmol/L (excluding 7.0 mmol/L), were given a standard 2h-75g oral glucose tolerance test (OGTT). Dyslipidemia was classified as one or more of the following conditions in 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[19].

Diagnostic criteria

DM and prediabetes were diagnosed by Chinese Diabetes Society (CDS) criteria[20]. Those who met one of the following conditions were diagnosed as DM: (1) FBG ≥ 7.0 mmol/L; (2) 2h-75g OGTT ≥ 11.1 mmol/L; (3) Those who have been diagnosed with DM.

They were diagnosed as impaired glucose regulation (prediabetes) 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 revised based on the actual situation of Xiaoshan District combined with the template provided by Zhejiang Provincial Center for Disease Control and Prevention. During the investigation, the investigators conducted face-to-face one-on-one investigations with the respondents. The questionnaires were checked for completeness, consistency, and accuracy at the end of each data collection day. Then, the data was double-entered by two investigators using Epidata version 3.02, and the consistency check was performed.

Anthropometric data was taken twice and in some instances three times to minimize observer bias in the measurement and recording. Furthermore, the blood pressure and weight scale instruments were compared daily for accuracy against a standard calibrated instrument.

After venous blood samples were collected, plasma was separated and placed at −20°C prior to analysis. Instruments were run each day before running samples for tests. The manufacturer's instructions of the machine and the reagents were strictly followed.

Patient and public involvement

It is a community-based epidemiological survey conducted to ascertain the prevalence of people with type 2 DM in China. The results of this survey will help the National and International stakeholders to take appropriate measures for prevention of DM at all levels. With the informed consent, 5387 individuals from Xiaoshan district, China were involved in the survey. The participation of the study subjects was limited to the collection of study data approved by the ethical review committee while the whole survey was performed by the survey team members. The tests involved in the survey were conducted free of cost and the results were communicated to study participants as printed medical reports through local team members. Complimentary medical consultation was provided in case of any abnormal finding. Subjects with newly diagnosed DM and impaired glucose tolerance were referred to the nearest centre for registration and treatment.

Statistical analysis

SPSS version 25.0 was used for statistical analysis. Continuous data were presented as

means and standard deviations (mean±SD), and categorical data were presented as frequencies and percentages (n, %). The χ^2 test was used for categorical data between groups. Univariate and multivariate logistic regression analysis were used to assess the associated factors of DM. Variables that were significant in univariate analysis were then entered in the multivariable logistic regression model. The magnitude of the association was measured using the adjusted odds ratio (a*OR*) and 95% confidence interval (*CI*). A p-value < 0.05 was considered as statistically significant.

RESULTS

Characteristics of the study population

A total of 5387 people successfully completed the survey with the effective response rate of 93.49%. There were 2484 (46.11%) males and 2903 (53.89%) females. The mean age of the study participants was 52.25 ± 15.61 years.

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 ($P < 0.05$) (**Table 1-3**).

Table 1. Socio-demographic characteristics of the participants (n, %).

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

FHDM, family history of diabetes mellitus.

Table 2. Behavioral characteristics of the participants (n, %).

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

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

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

WC, waist circumstance; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Prevalence of DM

There were 672 participants with DM, for a prevalence of 12.47% (672 out of 5387). Among them, nearly half of the participants (327) were not aware that they had DM before the survey, and the proportion of previously undiagnosed DM (UDM) was 48.66% (**Fig. 1**). The prevalence of DM in males and females was 12.40% and 12.54%, respectively (**Table 1**). **Fig. 2** displayed that the prevalence of DM was increased with age. In addition, the prevalence of prediabetes was found to be 10.92% (588 out of 5387).

Factors Associated with DM

Factors associated with DM among participants were 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.

Table 4. Univariate and multivariate logistic regression analysis of factors associated with diabetes mellitus among the participants.

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

OR, odds ratio; a*OR*, adjusted odds ratio; *CI*, confidence interval.

The results presented that the risk of developing DM increased with age.

Participants aged 30-39 (a*OR* = 3.563, 95% *CI*: 1.191-10.652), 40-49 (a*OR* = 9.097, 95% *CI*: 3.187-25.963), 50-59 (a*OR* = 16.328, 95% *CI*: 5.740-46.449) and over 60 years (a*OR* = 22.056, 95% *CI*: 7.677-63.362) were 3, 9, 16 and 22 times more likely to have DM when compared to 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 (a*OR* = 3.304, 95% *CI*: 2.423-4.505).

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

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

DISCUSSION

This present study showed that the overall prevalence of DM was 12.47%. A study from China showed that 11.6% adults had DM[16]. Anjana RM et al.[21] found the prevalence of DM was 13.6% in the INDIAB study. The Chandigarh Urban Diabetes Survey (CUDS) also reported the prevalence of DM was 11.1%[22]. These results were consistent with the present findings.

However, the prevalence of DM in our study was higher than those from other studies done in Bangladesh (9.7%)[23] and in Punjab, North India (8.3%)[24], in Brazil (7.5%)[25] and in Tianjin, China (10%)[11]. On the contrary, one study conducted in Pakistan reported that the prevalence of DM was 26.3%[26], which was much higher than our result. This phenomenon may be related to variation in lifestyle, socio-demographic, genetic factors and sample size. Age group difference of the study population may also be a possible reason. Besides, the prevalence difference might be due to different diagnostic methods of DM.

Our study found that nearly half of the DM cases (48.66%) were previously undiagnosed. The finding was comparable to the IDF Atlas report that nearly half of

all people living with DM (49.7%) were estimated to be undiagnosed[7]. However, 56% of DM were not aware they had the disease in Bangladesh[23]. And the prevalence of previously UDM was 72.5% in Dessie Town, Northeast Ethiopia[27]. In contrast, the proportion of previously UDM cases in our study was higher than the reports from Pakistan (31%)[26], and Hosanna Town, Southern Ethiopia (36%)[28]. The high rate of UDM may be due to a lack of DM awareness and poor screening program in the community and primary health care providers.

The prevalence of prediabetes in our study was found to be 10.92%. Similarly, a study from 15 states of India showed that 10.3% of the participants had prediabetes[29]. Barik A et al.[30] found that the prevalence of prediabetes among adults >18 years was 3.34%. Another study in Koladiba town, northwest Ethiopia indicated that the prevalence of prediabetes was 12%[31]. These figures implied that though the prevalence of prediabetes varied in different settings, it was certainly quite high and warrants immediate attention. This suggested that the prevalence of DM in the study area may increase in the near future as there was a risk of progression of prediabetic condition to diabetic[32].

As expected, the findings in the current study revealed that DM was associated with increasing age. The positive associations we found between age and DM have also been observed previously in Bangladesh[23], China[12] and Brazil[25]. Therefore, it was advisable to design mechanism for health education and promotion to enhance checkup for the disease as age advances.

Our results demonstrated that a positive FHDM was the main risk factor for the prevalence of DM. This finding was in agreement with other studies[25, 26, 31]. It has been known that the lifetime risk of any offspring developing DM was about 40% if one parent was diabetic and 70% if both parents were diabetic[33]. How genetic predisposition causes DM solely was not understood, but the lifestyle and living environments within the families may be the contributing factors[34].

Generalized obesity and abdominal obesity were independently associated with DM, which was similar to the results in most other studies[21, 30, 35]. Obesity may lead to increased production of adipokines/cytokines which contributed to insulin

resistance and reduced levels of adiponectin which works as an insulin sensitizer[36].

Observations indicated that the link between high SBP and DM was positive and significant in our study. Individuals with high SBP had a higher risk of DM than those with normal SBP. This finding was supported by other studies[25, 26, 37]. The pathophysiological mechanisms that explain the association between hypertension and DM are not clear. However, high BP was shown to induce microvascular and endothelial dysfunction, which may contribute to insulin resistance[38].

In addition, dyslipidemia including TG and HDL-C was found to be the 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 was corroborated by the results in Mizan-Aman Town, Southwest Ethiopia[32] and in Brazil[25]. This was in line with the explanation that individuals with elevated levels of total TG as well as raised LDL-C levels were at high risk of developing DM and other cardiovascular diseases[39]. Such associations were consequent of the resistance to insulin and were worrisome, because they considerably increased the risk of cardiovascular complications[25].

CONCLUSION

This study reported high prevalence of DM and prediabetes, especially of UDM amongst the adults. The associated risk factors were also identified. Age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C are significantly associated with DM. Urgent action is needed to counter the rise in DM through better detection, awareness, prevention and treatment.

Acknowledgements The authors greatly appreciate all participants included in this study and their families, and greatly thank the investigators for their cooperation and efforts.

Contributors YRL, JYL and FJW conceived and designed the project. YYJ and JYL collected the data. DFW and CLW analysed the data. YRL and FJW were involved in drafting the manuscript or revising it critically for important intellectual content; all authors gave final approval of the version to be published.

Funding: This study was supported by the project of National Chronic Disease Comprehensive Prevention and Control Demonstration Zone.

Competing interests None declared.

Patient consent Obtained.

Ethical approval Ethics Committee of Xiaoshan District Center for Disease Control and Prevention (No. XSCDC201801).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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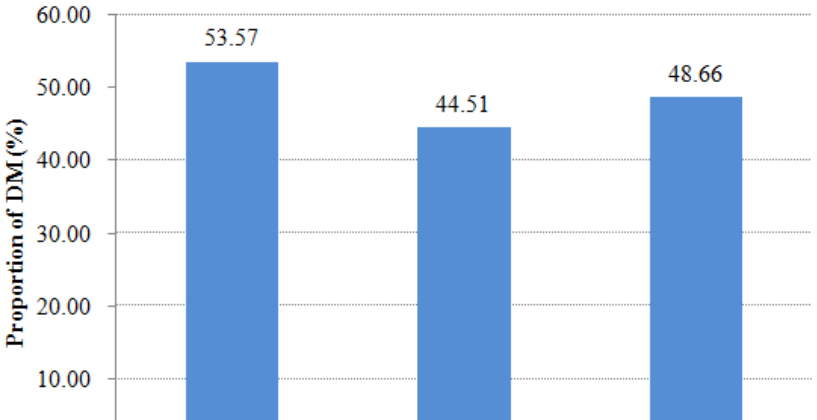

Figure 1. Diabetics who were not aware of their condition in male, female and total patients.

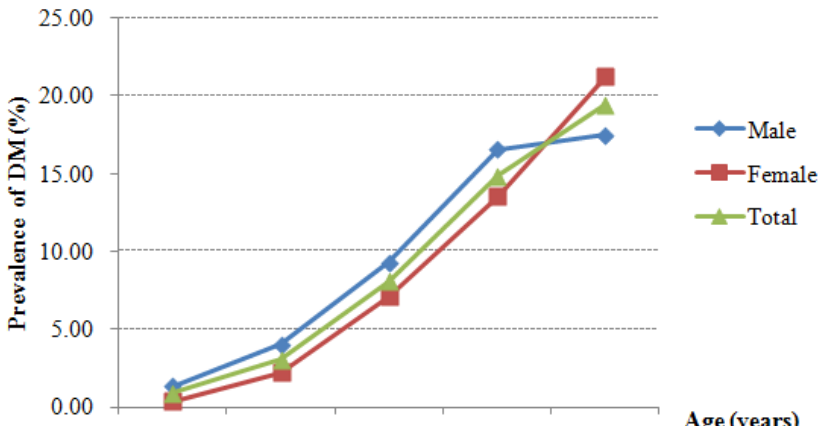

Figure 2. Prevalence of DM in male, female and total participants in various age groups.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3-4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-6*
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	3-4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	4
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049754.R1
Article Type:	Original research
Date Submitted by the Author:	07-Sep-2021
Complete List of Authors:	Li, Yu-rong; Xiaoshan District Center for Disease Control and Prevention Jiang, Yuan-yuan; Xiaoshan District Center for Disease Control and Prevention Lin, Jun-ying; Xiaoshan District Center for Disease Control and Prevention Wang, Dong-fei; Xiaoshan District Center for Disease Control and Prevention Wang, Chun-li; Xiaoshan District Center for Disease Control and Prevention Wang, Fen-juan; Xiaoshan District Center for Disease Control and Prevention
Primary Subject Heading:	Diabetes and endocrinology
Secondary Subject Heading:	Diabetes and endocrinology, Epidemiology
Keywords:	DIABETES & ENDOCRINOLOGY, General diabetes < DIABETES & ENDOCRINOLOGY, Epidemiology < ONCOLOGY

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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 economy, Xiaoshan District, Zhejiang Province, China has experienced urbanization, population aging and significant lifestyle changes, so diabetes mellitus (DM) has attracted more attention. Therefore, this study aimed to evaluate the prevalence of DM and its risk factors among individuals aged 18 years and above.

Study design and methods: A community-based cross-sectional study was carried out in Xiaoshan, China from March 1 to August 31, 2018. A multistage sampling method was applied in this study. Socio-demographic and behavioral characteristics were collected using questionnaires through a combination of centralized surveys and household surveys. Anthropometric parameters were measured using standardized 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. And a standard 2h-75g oral glucose tolerance test (OGTT) was 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%, of which, the proportion of previously undiagnosed DM (UDM) was 48.66%. The prevalence of prediabetes was 10.92%. Age, family history of diabetes mellitus (FHDM), obesity, abdominal obesity, systolic blood pressure (SBP), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) were significantly associated with DM.

Conclusion: This study reported a high prevalence of DM and prediabetes, especially a high prevalence of UDM amongst adults. The identified associated risk factors of DM were age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C.

Keywords: Diabetes mellitus, Prevalence, Risk factors

Strengths and limitations of this study

Proper epidemiological methods with multistage stratified cluster sampling techniques were used to conduct the survey.

FBG and OGTT were done for the diagnosis of DM for a sample of over 5 000 people.

Not all participants underwent an OGTT, which may underestimate the prevalence of DM.

We would not be able to differentiate between type 1 and type 2 DM based on this survey.

Using FBG to diagnose DM may lead to some misdiagnosed cases, since it was not sure of participants' compliance to 8 hours of fasting.

INTRODUCTION

Diabetes mellitus (DM) describes a group of metabolic disorders characterized 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 was estimated that these figures were expected to increase to 693 million by 2045 worldwide[7].

The worst scenario is that DM is increasingly encroaching on productive population groups[8], within which about 77.3% of people with DM are in the age range of 20-64 years[6], as reported by IDF in 2015. 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 generalized vascular

damage, affecting the heart, eyes, kidneys and nerves, and cause various complications[10].

In addition, many scholars believe that the shocking increase in DM prevalence in all populations of the world could be attributed to amenable risk factors such as advanced age, physical inactivity, increasing proportion of overweight and obese people, excessive drinking, hypertension, dyslipidemia and increased urbanization[11-15]. However, the majority of such studies were conducted in African and western countries, where people have different racial and demographic characteristics compared with those from Asian countries. Besides, most studies on the prevalence and associated factors of DM in China are nationally cross-sectional surveys[16-18], and regional studies are few, which only involving Tianjin[19], Xinjiang[20] and Jilin[21]. With the rapid development of the economy, Xiaoshan has experienced urbanization, population aging and significant lifestyle changes, so DM has attracted more attention. The associated factors of DM and population characteristics vary from region to region. Therefore, it is still necessary to express the uniqueness of Xiaoshan region and generalize the findings to other cities of China.

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

METHODS

Study areas

Xiaoshan District is located in Hangzhou City, the capital of Zhejiang Province. The total area of Xiaoshan is 990 square kilometers, with 12 towns and 9 streets in 2018[22]. Xiaoshan has a superior geographic location, 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 March 1 to August 31, 2018.

The study population were individuals aged 18 years and above, who lived in the study sites for 6 months or more, volunteered to participate, and signed the study

informed consent. Of the total study population, the following participants were excluded: critical patients who were unable to communicate, pregnant women and individuals <18 years old to avoid the possible impacts on anthropometric and laboratory measurements.

The sample size was determined using the single population proportion formula by considering 10.64% prevalence of DM among individuals aged 18 years and above in Xiaoshan District, China in 2014[23], with 95% confidence interval (two-tailed) and corresponding u = 1.96, a design effect of 2, 15% allowable error, and 10% of 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 is divided into three areas: east, south and middle area according to the geographical location. The east area includes 5 towns/streets, south area includes 8 towns/streets, and middle area includes 8 towns/streets. In the first stage, 2 towns/streets were randomly selected from each area, and a total of 6 towns/streets were selected. In the second stage, the number of villages/communities of the 6 selected towns/streets are 18, 23, 24, 21, 28 and 13, respectively. 2 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. Taking into account the loss of interviews, refusal, etc., we increased the number of households by 10% of the initial 150 households. According to the geographical location, every 55 households in each village/community were divided into one cluster, and 3 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 selected households.

A questionnaire, anthropometric and biochemical measurement

First, socio-demographic and behavioral characteristics were collected using questionnaires through a combination of centralized surveys and household surveys. Socio-demographic characteristics included age, sex, educational level, marital status

and family history of diabetes mellitus (FHDM). FHDM referred to first-degree relatives. Behavioral 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 1 cigarette per day, continuous or cumulative for 6 months. Drinking was defined as at least once a week. Physical activity intensity was divided into sedentary, moderate and vigorous. Sedentary denoted having no work, or sitting or standing for 75% of the time at work, and standing for 25% of the time for activities, such as office, hotel attendant, lectures, etc. Moderate denoted sitting or standing for 40% of the time at work, and 60% of the time for special occupational activities, such as students, drivers, electricians, etc. Vigorous denoted sitting or standing for 25% of the time at work, and 75% of the time for special occupational activities, such as agricultural labor, steelmaking, sports, loading and unloading, and mining. Dietary habits were classified according to Chinese residents' balanced meal pagoda (2016 edition).

Next, anthropometric parameters were measured for each participant using standardized techniques and calibrated equipment. Height was measured by a stadiometer nearest to 0.1 centimeters when the participants were in an upright standing position on a flat surface without shoes. Weight was measured to the nearest 0.1 kilograms using a person scale when the participants were wearing light clothes and bare feet. Body mass index (BMI) (kg/m^2) was calculated by dividing the weight (kg) by height (m) squared. BMI was classified as < 24.00 kg/m^2 normal, between 24.00 and 28.00 kg/m^2 overweight and ≥ 28.00 kg/m^2 obesity[24]. Waist circumference (WC) was measured to the nearest 0.1 centimeters in the erect position at the middle of the lowest rib and the superior border of the iliac crest. The WC values of ≥ 90 and ≥ 85 cm for men and women were considered to be abdominal obesity, respectively. Blood pressure (BP) including systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured in a sitting position after 15 minutes rest using a mercury sphygmomanometer. The mean of two measurements was taken as the final result of BP. SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg were considered to be defined as hypertension[25].

Finally, venous blood samples were obtained after fasting 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 respectively. Afterward, a standard 2h-75g oral glucose tolerance test (OGTT) was given if 6.1 mmol/L ≤ FBG < 7.0 mmol/L. Dyslipidemia was classified as one or more of the following conditions in 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 prediabetes were diagnosed by the Chinese Diabetes Society (CDS) criteria[27]. Those who met one of the following conditions were diagnosed as DM: (1) FBG ≥ 7.0 mmol/L; (2) OGTT ≥ 11.1 mmol/L; (3) Those who have been diagnosed with DM. It was included in their questionnaires.

They were diagnosed as impaired glucose regulation (prediabetes) 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 revised based on the actual situation of Xiaoshan District combined with the template provided by Zhejiang Provincial Center for Disease Control and Prevention. During the investigation, the investigators conducted face-to-face investigations 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 version 3.02, and the consistency check was performed.

Anthropometric data were taken twice and in some instances three times to minimize observer bias during measurement and recording. Furthermore, the blood pressure and weight scale instruments were compared daily for accuracy against a standard calibrated instrument.

After venous blood samples were collected, plasma was separated and placed at −20°C before analysis. The instrument, C16000 chemistry analyzer, was run each day

before running samples for tests. The manufacturer's instructions (Yapei) of the machine and the reagents were strictly followed.

Patient and public involvement

It is a community-based epidemiological survey conducted to ascertain the prevalence of people with type 2 DM in China. The results of this survey will help the 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 the study subjects was limited to the collection of study data approved by the ethical review committee, while the whole survey was performed by the survey team members. The tests involved in the survey were conducted free of cost and the results were communicated to study participants as printed medical reports through local team members. Complimentary medical consultation was provided in case of any abnormal findings. Subjects with newly diagnosed DM and impaired glucose tolerance were referred to the nearest center for registration and treatment.

Statistical analysis

SPSS version 25.0 was used for statistical analysis. Continuous data were presented as means and standard deviations (mean±SD), and categorical data were presented as frequencies and percentages (n, %). The χ^2 test was used for categorical data between groups. Univariate and multivariate logistic regression analyses were used to assess the associated factors of DM. Variables that were significant in the univariate analysis were then entered in the multivariable logistic regression model. The magnitude of the association was measured using the adjusted odds ratio (A*OR*) and 95% confidence interval (*CI*). A p-value < 0.05 was considered statistically significant.

RESULTS

Characteristics of the study population

Initially, 5762 questionnaires were collected. However, during clearance of data for missing and unexpected values, 375 questionnaires had unrepairable missing and/or unexpected values and were excluded from the analysis. Therefore, a total of 5387 participants successfully completed the survey, and the effective response rate was

93.49%. There were 2484 (46.11%) males and 2903 (53.89%) females. The mean age of the study participants was 52.25 ± 15.61 years, including 51.97 ± 15.99 years for males and 52.50 ± 15.27 years for females.

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 ($P < 0.05$) (**Table 1-3**).

Table 1. Socio-demographic characteristics of the participants (n, %).

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

FHDM, family history of diabetes mellitus.

Table 2. Behavioral characteristics of the participants (n, %).

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

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

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Prevalence of DM

There were 482 participants administered the 2h-75g OGTT, and 44 of them 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, 5 participants fell into the prediabetes class after being administered the 2h-75g OGTT, and finally, the prevalence of prediabetes was 10.92% (588 out of 5387). Among the participants with DM, nearly half of them (327) were not aware that they had DM before the survey, and the proportion of previously undiagnosed DM (UDM) was 48.66% (**Fig. 1**). The prevalence of DM in males and females were 12.40% and 12.54%, respectively (**Table 1**). **Fig. 2** displayed that the prevalence of DM increased with age.

Factors Associated with DM

Factors associated with DM among participants were 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.

Table 4. Univariate and multivariate logistic regression analysis of factors associated with diabetes mellitus among the participants.

Variable	*OR* (95%*CI*)	*P*	A*OR* (95%*CI*)	*P*
Age (years) (ref. 18-29)				
30-39	**3.543 (1.307-9.609)**	**0.013**	**3.563 (1.191-10.652)**	**0.023**
40-49	**9.829 (3.961-24.393)**	**0.000**	**9.097 (3.187-25.963)**	**0.000**
50-59	**19.559 (7.999-47.823)**	**0.000**	**16.328 (5.740-46.449)**	**0.000**
≥60	**27.039 (11.131-65.678)**	**0.000**	**22.056 (7.677-63.362)**	**0.000**
Educational level (ref. illiterate)				
Primary school	**0.798 (0.654-0.973)**	**0.026**	1.006 (0.810-1.248)	0.960
Middle school	**0.558 (0.445-0.701)**	**0.000**	1.094 (0.826-1.449)	0.530

High school and above	**0.192 (0.141-0.261)**	**0.000**	0.902 (0.611-1.332)	0.604
Marital status (ref. married)				
Single	**0.214 (0.120-0.382)**	**0.000**	1.428 (0.699-2.918)	0.328
Divorced	1.390 (0.576-3.354)	0.464	1.426 (0.556-3.655)	0.460
Widowed	**1.781 (1.376-2.305)**	**0.000**	1.106 (0.833-1.469)	0.485
FHDM (ref. no)				
Yes	**2.601 (1.967-3.440)**	**0.000**	**3.304 (2.423-4.505)**	**0.000**
Alcohol consumption (ref. no)				
Yes	**1.299 (1.095-1.542)**	**0.003**	1.033 (0.857-1.245)	0.735
Physical activity intensity (ref. sedentary)				
Moderate	**0.787 (0.638-0.972)**	**0.026**	0.840 (0.668-1.055)	0.134
Vigorous	1.008 (0.749-1.356)	0.959	0.820 (0.598-1.124)	0.217
Daily staple food intake (g) (ref. 50-150)				
>150	**1.516 (1.137-2.020)**	**0.005**	1.259 (0.929-1.705)	0.137
BMI (kg/m^2) (ref. normal)				
Overweight	**1.844 (1.537-2.211)**	**0.000**	1.194 (0.960-1.484)	0.111
Obesity	**3.014 (2.402-3.782)**	**0.000**	**1.520 (1.125-2.053)**	**0.006**
WC (ref. normal)				
High	**2.807 (2.382-3.308)**	**0.000**	**1.607 (1.292-1.998)**	**0.000**
SBP (ref. normal)				
High	**3.100 (2.595-3.703)**	**0.000**	**1.807 (1.442-2.265)**	**0.000**
DBP (ref. normal)				
High	**2.156 (1.753-2.652)**	**0.000**	0.921 (0.711-1.194)	0.536
TC (ref. normal)				
High	**1.870 (1.434-2.439)**	**0.000**	1.293 (0.969-1.726)	0.081
TG (ref. normal)				
High	**2.328 (1.904-2.846)**	**0.000**	**1.657 (1.310-2.096)**	**0.000**
HDL-C (ref. normal)				
High	**1.676 (1.352-2.077)**	**0.000**	**1.336 (1.040-1.717)**	**0.023**

OR, odds ratio; A*OR*, adjusted odds ratio; *CI*, confidence interval.

The results presented that the risk of developing DM increased with age. Participants aged 30-39 (A*OR* = 3.563, 95% *CI*: 1.191-10.652), 40-49 (A*OR* = 9.097, 95% *CI*: 3.187-25.963), 50-59 (A*OR* = 16.328, 95% *CI*: 5.740-46.449) and over 60 years (A*OR* = 22.056, 95% *CI*: 7.677-63.362) were 3, 9, 16 and 22 times more likely to have DM when compared to 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 (A*OR* = 3.304, 95% *CI*: 2.423-4.505).

Obese participants were 1.5 times at more risk of being DM positive than those

with normal BMI (A*OR* = 1.520, 95% *CI*: 1.125-2.053). Similarly, participants with high WC were 1.6 times more likely to be DM positive compared to those whose WC was normal (A*OR* = 1.607, 95% *CI*: 1.292-1.998). Additionally, individuals with high SBP were 1.8 times more likely to have DM in comparison with normal SBP individuals (A*OR* = 1.807, 95% *CI*: 1.442-2.265).

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

DISCUSSION

This present study showed that the overall prevalence of DM was 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 the Indian study. The Chandigarh Urban Diabetes Survey (CUDS) also reported the prevalence of DM was 11.1%[29]. These results were consistent with the present findings.

However, the prevalence of DM in our study was higher than those from other studies done in Bangladesh (9.7%)[30], Punjab, North India (8.3%)[31], Brazil (7.5%)[32] and Tianjin, China (10%)[19]. On the contrary, one study conducted in Pakistan reported that the prevalence of DM was 26.3%[12], which was much higher than our result. This phenomenon may be related to variation in lifestyle, socio-demographic, genetic factors and sample size. Age group difference of the study population may also be a possible reason. Besides, the prevalence difference might be due to different diagnostic methods of DM.

Our study found that nearly half of the DM cases (48.66%) were previously undiagnosed. The finding was comparable to the IDF Atlas report that nearly half of all people living with DM (49.7%) were undiagnosed[7]. However, 56% of DM were not aware that they had the disease in Bangladesh[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 the reports from Pakistan (31%)[12] and Hosanna Town, Southern Ethiopia (36%)[34]. The high rate of UDM may be due to a lack of DM awareness and poor screening programs in the community and primary health care providers.

The prevalence of prediabetes in our study was found to be 10.92%. Similarly, a study from 15 states of India showed that 10.3% of the participants had prediabetes[35]. Barik et al.[36] found that the prevalence of prediabetes among adults >18 years was 3.34%. Another study in Koladiba town, northwest Ethiopia indicated that the prevalence of prediabetes was 12%[37]. These figures implied that though the prevalence of prediabetes varied in different settings, it was certainly quite high and warrants immediate attention. This suggested that the prevalence of DM in the study area may increase shortly as there was a risk of progression of prediabetic condition to diabetic[38].

As expected, the findings in the current study revealed that DM was 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 was advisable to design a mechanism for health education and promotion to enhance checkups for the disease as age advances.

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

Generalized obesity and abdominal obesity were independently associated with DM, which was similar to the results in most other studies[28, 36, 41]. Obesity may lead to increased production of adipokines/cytokines, resulting in insulin resistance and reduced levels of adiponectin which works as an insulin sensitizer[42].

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

In addition, dyslipidemia, including TG and HDL-C, was found to be the 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 was corroborated by the results in Mizan-Aman Town, Southwest Ethiopia[38] and Brazil[32]. This was in line with the explanation that individuals with elevated levels of total TG as well as raised LDL-C levels were at high risk of developing DM and other cardiovascular diseases[44]. Such associations were consequent of the resistance to insulin and were worrisome because they considerably increased the risk of cardiovascular complications[32].

Strengths and limitations

The present study has some strengths. The sample size was large. FBG and OGTT were done for the diagnosis of DM and prediabetes using venous blood samples instead of capillary blood samples. Nevertheless, there were some limitations. First, the study's cross-sectional nature implies that it was not possible to establish a causal relationship between these risk factors and the occurrence of the disease. Second, not all participants underwent an OGTT, which may underestimate the prevalence of DM. Third, we would not be able to differentiate between type 1 and type 2 DM based on this survey. Fourth, we only examined the associated factors of DM, while the analysis of the associated factors of prediabetes was not undertaken. Finally, using FBG to diagnose DM may lead to some misdiagnosed cases, since it was not sure of participants' compliance to 8 hours of fasting. These issues will be considered in a future study.

CONCLUSION

This study reported a high prevalence of DM and prediabetes, especially a high prevalence of UDM amongst adults. The identified associated risk factors of DM were age, FHDM, obesity, abdominal obesity, SBP, TG and HDL-C.

Acknowledgements The authors greatly appreciate all participants included in this study and their families, and greatly thank the investigators for their cooperation and efforts.

Contributors YRL, JYL and FJW conceived and designed the project. YYJ and JYL collected the data. DFW and CLW analyzed the data. YRL and FJW were involved in drafting the manuscript or revising it critically for important intellectual content; all authors gave final approval of the version to be published.

Funding This study was supported by the project of National Chronic Disease Comprehensive Prevention and Control Demonstration Zone (Award/grant number: N/A).

Competing interests None declared.

Participant consent Obtained written consent.

Ethical approval Ethics Committee of Xiaoshan District Center for Disease Control and Prevention (No. XSCDC201801).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legends/captions

Figure 1. Diabetics who were not aware of their condition in male, female and total patients.

Figure 2. Prevalence of DM in male, female and total participants in various age groups.

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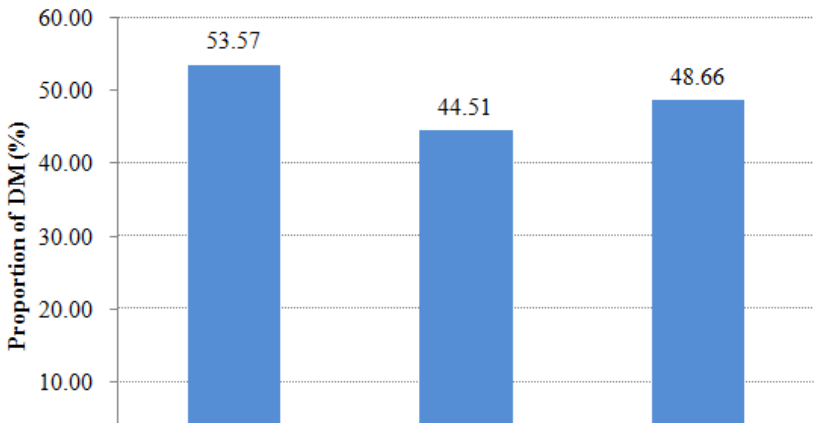

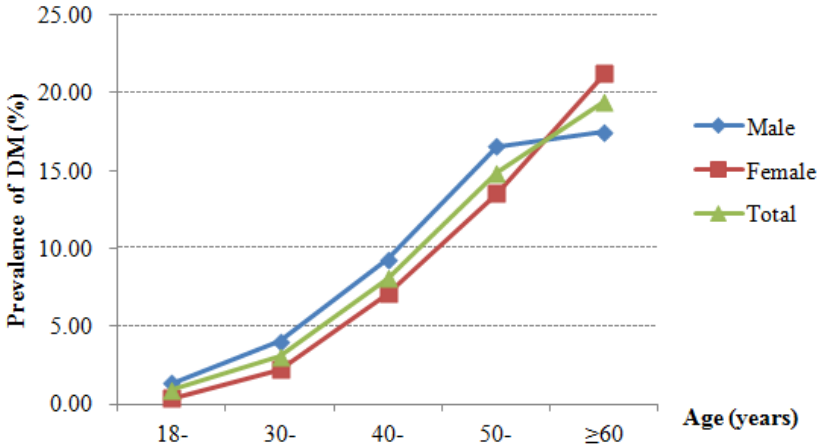

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3-4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-7*
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	3-4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	4
		(*e*) Describe any sensitivity analyses	Not Applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7-8
		(b) Give reasons for non-participation at each stage	7-8
		(c) Consider use of a flow diagram	Not Applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7

Outcome data	15*	Report numbers of outcome events or summary measures	7-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12
		(*b*) Report category boundaries when continuous variables were categorized	8-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not Applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049754.R2
Article Type:	Original research
Date Submitted by the Author:	11-Feb-2022
Complete List of Authors:	Li, Yu-rong; Xiaoshan District Center for Disease Control and Prevention Jiang, Yuan-yuan; Xiaoshan District Center for Disease Control and Prevention Lin, Jun-ying; Xiaoshan District Center for Disease Control and Prevention Wang, Dong-fei; Xiaoshan District Center for Disease Control and Prevention Wang, Chun-li; Xiaoshan District Center for Disease Control and Prevention Wang, Fen-juan; Xiaoshan District Center for Disease Control and Prevention
Primary Subject Heading:	Diabetes and endocrinology
Secondary Subject Heading:	Diabetes and endocrinology, Epidemiology
Keywords:	DIABETES & ENDOCRINOLOGY, General diabetes < DIABETES & ENDOCRINOLOGY, Epidemiology < ONCOLOGY

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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 urbanization, population aging, 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 March 1 to August 31, 2018. A multistage sampling method was used. Socio-demographic and behavioral characteristics were collected using a combination of centralized surveys and household surveys. Anthropometric parameters were measured with standardized 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 2h-75g oral glucose tolerance test (OGTT) 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 prediabetes was 10.92%. Age, family history of diabetes mellitus (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 prediabetes, especially a high prevalence of UDM amongst adults. The associated risk factors identified for DM were age, FHDM, obesity, abdominal obesity, SBP, TG, and HDL-C.

Keywords: Diabetes mellitus, Prevalence, Risk factors

Strengths and limitations of this study

Proper epidemiological methods with multistage stratified cluster sampling techniques were used to conduct the survey.

FBG and OGTT were administered to diagnose DM in a sample of over 5, 000 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 characterized 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 by 2045 worldwide[7].

The worst scenario 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 generalized 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 amenable risk factors such as advanced age, physical inactivity, overweight and obesity, excessive drinking, hypertension, dyslipidemia, and increased urbanization[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 urbanization, population aging, 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 generalize 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 square kilometers, with 12 towns and 9 streets in 2018[22]. Xiaoshan has a superior geographic 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 March 1 to August 31, 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% confidence interval (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 5 towns/streets, the south area included 8 towns/streets, and the middle area included 8 towns/streets. In the first stage, 2 towns/streets were randomly selected from each area, and a total of 6 towns/streets were selected. In the second stage, the number of villages/communities of the 6 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 socio-demographic and behavioral through a combination of centralized and household surveys. The socio-demographic characteristics included age, sex, educational level, marital status, and family history of diabetes mellitus (FHDM). FHDM was only considered for first-degree relatives. The behavioral 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 1 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 labor, 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 standardized techniques and calibrated equipment. Height was measured with a stadiometer to the nearest 0.1 centimeters when the participants were in an upright standing position on a flat surface without shoes. Weight was measured to the nearest 0.1 kilograms 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 centimeters 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 blood pressure (SBP) and diastolic blood pressure (DBP), was measured in a sitting position after 15 minutes rest, using a mercury sphygmomanometer. The mean of two measurements was taken as the final BP result. SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg 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 2h-75g oral glucose tolerance test (OGTT) was given if 6.1 mmol/L ≤ FBG < 7.0 mmol/L. Dyslipidemia 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 prediabetes were diagnosed by the Chinese Diabetes Society (CDS) 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 (prediabetes) 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 version 3.02, and a consistency check was performed.

Anthropometric measurements were taken twice, and in some instances three times, to minimize observer bias during measurement and recording. Furthermore, the blood pressure 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 analyzer, 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 center for registration and treatment.

Statistical analysis

SPSS version 25.0 was used for statistical analysis. Continuous data are presented as means and standard deviations (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 odds ratio (A*OR*), with a 95% confidence interval (*CI*). A p-value < 0.05 was considered statistically significant.

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%) males and 2903 (53.89%) females. The mean age of study participants was 52.25 ± 15.61 years: 51.97 ± 15.99 years for males and 52.50 ± 15.27 years for females.

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 ($P < 0.05$) (**Table 1-3**).

Table 1. Socio-demographic characteristics of participants (n, %).

Variable	Total (n=5387)	DM		χ^2	P
		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)		

FHDM, family history of diabetes mellitus.

Table 2. Behavioral characteristics of participants (n, %).

Variable	Total (n=5387)	DM		χ^2	P
		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)		

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

Variable	Total (n=5387)	DM		χ^2	*P*
		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)		

WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Prevalence of DM

The 2h-75g 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, 5 participants fell into the prediabetes class after being administered the 2h-75g OGTT, leading to a total prediabetes 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% (**Fig. 1**). The prevalence rates of DM in males and females were 12.40% and 12.54%, respectively (**Table 1**). **Fig. 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.

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

Variable	*OR* (95%*CI*)	*P*	A*OR* (95%*CI*)	*P*
Age (years) (ref. 18-29)				
30-39	**3.543 (1.307-9.609)**	**0.013**	**3.563 (1.191-10.652)**	**0.023**
40-49	**9.829 (3.961-24.393)**	**0.000**	**9.097 (3.187-25.963)**	**0.000**
50-59	**19.559 (7.999-47.823)**	**0.000**	**16.328 (5.740-46.449)**	**0.000**
≥60	**27.039 (11.131-65.678)**	**0.000**	**22.056 (7.677-63.362)**	**0.000**
Educational level (ref. illiterate)				
Primary school	**0.798 (0.654-0.973)**	**0.026**	1.006 (0.810-1.248)	0.960
Middle school	**0.558 (0.445-0.701)**	**0.000**	1.094 (0.826-1.449)	0.530

High school and above	**0.192 (0.141-0.261)**	**0.000**	0.902 (0.611-1.332)	0.604
Marital status (ref. married)				
Single	**0.214 (0.120-0.382)**	**0.000**	1.428 (0.699-2.918)	0.328
Divorced	1.390 (0.576-3.354)	0.464	1.426 (0.556-3.655)	0.460
Widowed	**1.781 (1.376-2.305)**	**0.000**	1.106 (0.833-1.469)	0.485
FHDM (ref. no)				
Yes	**2.601 (1.967-3.440)**	**0.000**	**3.304 (2.423-4.505)**	**0.000**
Alcohol consumption (ref. no)				
Yes	**1.299 (1.095-1.542)**	**0.003**	1.033 (0.857-1.245)	0.735
Physical activity intensity (ref. sedentary)				
Moderate	**0.787 (0.638-0.972)**	**0.026**	0.840 (0.668-1.055)	0.134
Vigorous	1.008 (0.749-1.356)	0.959	0.820 (0.598-1.124)	0.217
Daily staple food intake (g) (ref. 50-150)				
>150	**1.516 (1.137-2.020)**	**0.005**	1.259 (0.929-1.705)	0.137
BMI (kg/m^2) (ref. normal)				
Overweight	**1.844 (1.537-2.211)**	**0.000**	1.194 (0.960-1.484)	0.111
Obesity	**3.014 (2.402-3.782)**	**0.000**	**1.520 (1.125-2.053)**	**0.006**
WC (ref. normal)				
High	**2.807 (2.382-3.308)**	**0.000**	**1.607 (1.292-1.998)**	**0.000**
SBP (ref. normal)				
High	**3.100 (2.595-3.703)**	**0.000**	**1.807 (1.442-2.265)**	**0.000**
DBP (ref. normal)				
High	**2.156 (1.753-2.652)**	**0.000**	0.921 (0.711-1.194)	0.536
TC (ref. normal)				
High	**1.870 (1.434-2.439)**	**0.000**	1.293 (0.969-1.726)	0.081
TG (ref. normal)				
High	**2.328 (1.904-2.846)**	**0.000**	**1.657 (1.310-2.096)**	**0.000**
HDL-C (ref. normal)				
High	**1.676 (1.352-2.077)**	**0.000**	**1.336 (1.040-1.717)**	**0.023**

OR, odds ratio; A*OR*, adjusted odds ratio; *CI*, confidence interval.

The results made it clear that the risk of developing DM increased with age. Participants aged 30-39 (A*OR* = 3.563, 95% *CI*: 1.191-10.652), 40-49 (A*OR* = 9.097, 95% *CI*: 3.187-25.963), 50-59 (A*OR* = 16.328, 95% *CI*: 5.740-46.449), and over 60 years (A*OR* = 22.056, 95% *CI*: 7.677-63.362) were 3, 9, 16, and 22 times more likely to have DM compared to 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 (A*OR* = 3.304, 95% *CI*: 2.423-4.505).

Obese participants were 1.5 times more at risk of being DM positive than those

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

Furthermore, high TG (A*OR* = 1.657, 95% *CI*: 1.310-2.096) and HDL-C (A*OR* = 1.336, 95% *CI*: 1.040-1.717) 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 (CUDS) also reported a DM prevalence of 11.1%[29]. These results were consistent with the present findings.

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, socio-demographic 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 to 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 programs in the community and among primary

health-care providers.

The prevalence of prediabetes 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 prediabetes among adults >18 years was 3.34%. Another study in Koladiba Town, northwest Ethiopia, indicated a prediabetes prevalence of 12%[37]. These figures make it evident that though the prevalence of prediabetes 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 prediabetes 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 checkups 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].

Generalized 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 to increased production of adipokines/cytokines, resulting in insulin resistance and reduced levels of adiponectin which works as an insulin sensitizer[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, dyslipidemia, 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 prediabetes 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 prediabetes. 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 prediabetes, 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.

Acknowledgements The authors greatly appreciate all participants included in this study and their families, and greatly thank the investigators for their cooperation and efforts.

Contributors YRL, JYL and FJW conceived and designed the project. YYJ and JYL

collected the data. DFW and CLW analyzed the data. YRL and FJW were involved in drafting the manuscript or revising it critically for important intellectual content; all authors gave final approval of the version to be published.

Funding This study was supported by the project of National Chronic Disease Comprehensive Prevention and Control Demonstration Zone (Award/grant number: N/A).

Competing interests None declared.

Participant consent Obtained written consent.

Ethical approval Ethics Committee of Xiaoshan District Center for Disease Control and Prevention (No. XSCDC201801).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legends/captions

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

Figure 2. Prevalence of DM in male, female and total participants in various age groups.

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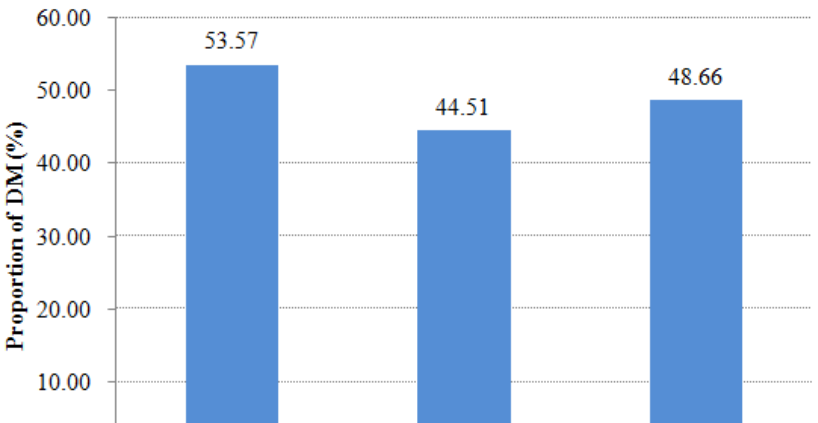

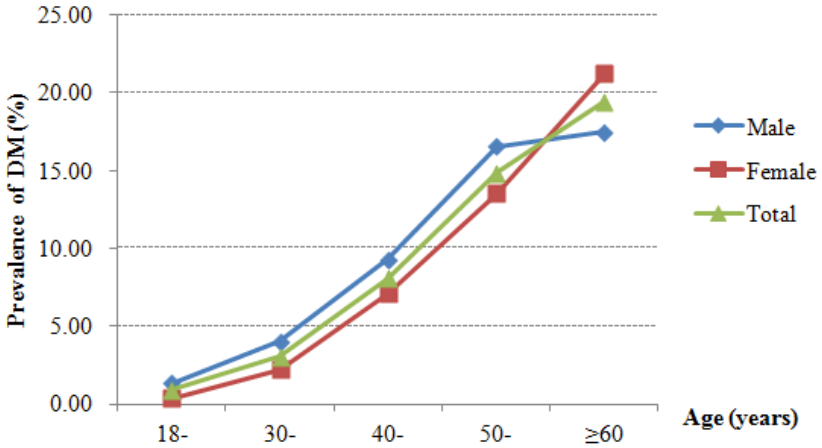

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3-4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-7*
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	3-4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	4
		(*e*) Describe any sensitivity analyses	Not Applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7-8
		(b) Give reasons for non-participation at each stage	7-8
		(c) Consider use of a flow diagram	Not Applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7

Outcome data	15*	Report numbers of outcome events or summary measures	7-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12
		(*b*) Report category boundaries when continuous variables were categorized	8-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not Applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.