

Prevalence and Risk Factors of Type 2 Diabetes and Prediabetes Among 53,288 Middle-Aged and Elderly Adults in China: A Cross-Sectional Study

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Background: Diabetes is a metabolic disorder that causes a heavy burden on healthcare systems worldwide. The aim of this study was to determine the prevalence of type 2 diabetes and prediabetes and its associated factors among eight communities in Nanchong, China.

Methods: This was an observational cross-sectional study conducted throughout eight communities in Nanchong, China. The participants were 53,288 individuals aged 45 years or older. The participants' characteristics, comorbidities, health behaviors, family history, and dietary intake were assessed. Multinomial logistic regression models were fitted to identify factors associated with type 2 diabetes and prediabetes.

Results: The prevalence of diabetes and prediabetes was 13.9% (95% confidence interval [CI], 13.6–14.2) and 3.1% (95% CI, 2.9–3.2) of the population, respectively. After adjusting for other risk factors, advanced age, overweight, obesity, abdominal obesity, comorbidities, smoking, a family history of diabetes, and Chinese cooking vegetable intake were associated with an increased risk of type 2 diabetes and prediabetes.

Conclusion: The prevalence of type 2 diabetes in the Chinese population is rising compared with data from the past. The risk factors of type 2 diabetes and prediabetes identified in this study will aid the identification of individuals at a high-risk of diabetes and the implementation of effective health promotion programs and campaigns.

Clinical Trial Registry Number: ChiCTR-HOC-17013200.

Keywords: cross-sectional study, diabetes, prevalence, risk factors

Introduction

The prevalence of diabetes is increasing worldwide. In 2019, more than 463 million people had diabetes, and the incidence is projected to increase to 700 million by 2045.¹ Over 90% of persons with diabetes have type 2 diabetes mellitus (T2DM).² T2DM is associated with numerous complications, including cardiovascular disease (CHD), peripheral neuropathy, stroke, infection, chronic renal failure, and retinopathy. All of these complications significantly contribute to the high mortality, morbidity, and socioeconomic burden associated with diabetes.³ There are no disease-modifying interventions for T2DM and its complications. Therefore, the disease can only be controlled through medication and lifestyle changes,⁴ resulting in a heavy economic burden for patients and healthcare systems.⁵

Diabetes, particularly T2DM, has become a major public health issue in China and has become a relevant socioeconomic burden.² However, although the prevalence and risk factors of diabetes have been studied in China, studies on the risk

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factors and the trend of prediabetes, particularly among middle-aged and elderly adults, are scarce.⁶ China has a vast territory characterized by lifestyle diversity and marked differences in economic and social development endeavors among its regions. Therefore, the diabetes prevalence greatly varies between China's regions.⁷ Nanchong is an important transportation hub and representative city in western China. The population of this city has a recognizable age imbalance, given the high proportion of older people, in line with the country's rapidly aging population. T2DM mainly affects middle-aged and elderly people, accounting for more than 90% of the diabetes cases.⁸ The rapidly aging population, the rapid increase in the incidence of chronic diseases, and epidemiological changes will put significant financial pressure on healthcare systems in the future.⁹ Given that our knowledge of the status of diabetes and prediabetes among the elderly in the urban areas of western China is limited, this study aimed to explore the incidence and risk factors of T2DM and prediabetes in the Nanchong region.

Methods

Study Design and Setting

This observational and cross-sectional study was conducted between November 2012 and December 2017. The participants were recruited from eight communities in the Shunqing District, Nanchong City, China. The communities involved were Xin Jian, Dongnan, Huafeng, Wufeng, Beicheng, Heping Road, Dongcheng, and Zhongcheng. The numbers of households in the eight communities were used as labels, and 1,000 labels were randomly selected from each community via a computer random number generator for questionnaire surveys. The unified quality control plan was formulated by the Center for Disease Control and Prevention of Nanchong and the Center for Comprehensive Management of Chronic Diseases of Nanchong Central Hospital.

Ethical Aspects

This study was approved by the Medical Ethics Committee of Nanchong Central Hospital (2012–65) and registered in the China Clinical Trial Registry (NO: ChiCTR-HOC-17013200). All procedures met the institution's ethical standards and were conducted in compliance with the International Declaration of Helsinki. Written informed consent was obtained from all participants.

Study Population

A total of 105,956 individuals older than 45 years were included in the survey. From this population, we excluded 50,294 individuals who were previously diagnosed with type 1 diabetes or other types of diabetes ($n = 344$), and persons who had never taken blood-glucose measurements or were unsure whether they had diabetes ($n = 49,950$). Additionally, 2,374 individuals with missing values in any variables were also excluded. Finally, 53,288 individuals aged between 45 years and 101 years were included in the analysis. Of them, 7,396, 1,643, and 44,249 individuals had T2DM, prediabetes, and no diabetes, respectively (Figure 1). T2DM, prediabetes, and non-diabetes were defined following the World Health Organization criteria.¹⁰

Data Collection

Data on the participants' characteristics were collected from the questionnaire and clinical examination records. Age, sex, education, income, health behaviors, comorbidities, family history of diabetes, and dietary intake were self-reported during face-to-face interviews. Physical examinations included weight, height, and waist circumference. Well-documented fasting serum glucose measurements obtained during the outpatient visit were recorded.

Definitions

Anthropometric variables included height, weight, and waist circumference and were measured by medical staff members. Body mass index (BMI) was classified into normal weight ($< 23.0 \text{ kg/m}^2$), overweight ($23\text{--}27.5 \text{ kg/m}^2$), and obese ($\geq 27.5 \text{ kg/m}^2$) following the WHO classification and BMI recommendations for Asian populations.¹¹ Waist circumference was recorded either as normal ($< 85 \text{ cm}$ in women and $< 90 \text{ cm}$ in men) or indicative of abdominal obesity ($\geq 85 \text{ cm}$ in women and $\geq 90 \text{ cm}$ in men).¹²

The educational categories used in this study were low (primary and lower), middle (middle and high school), and high (college and above). Household income was classified (based on the per capita annual income in China) into poor [$< \text{¥}10,000$ (1496 \$)/year], middle class [$\text{¥}10,000\text{--}20,000$ (1496–2986 \$)/year], well-off [$\text{¥}20,000\text{--}50,000$ (2986–7467 \$)/year], and rich [$> \text{¥}50,000$ (7467 \$)/year].

Hypertension and hyperlipidemia were defined based on a previous diagnosis. CHD was determined based on the presence or absence of coronary atherosclerotic heart

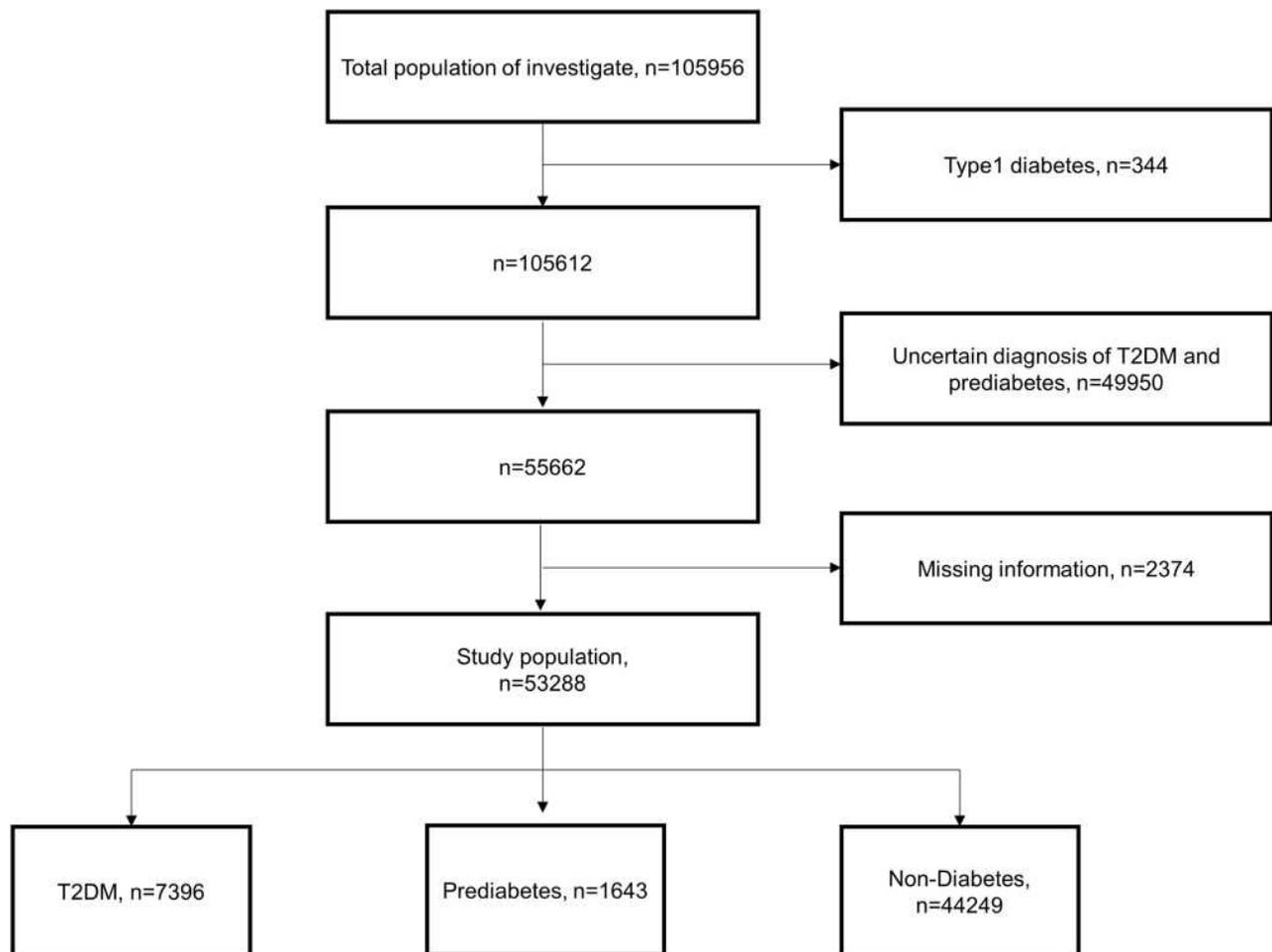


Figure 1 Flow chart documenting inclusion criteria, exclusion criteria, and the number of individuals included in the study population.

disease. Stroke was defined as having a recorded diagnosis of cerebral hemorrhage, cerebral infarction, or other cerebrovascular diseases. A family history of diabetes was determined as having a relative within three generations or multiple family members being diagnosed with diabetes.

Smoking status was classified into smokers (at least one cigarette per day), ex-smokers (people who quit smoking > 1 year ago at the time of the study), and non-smokers (those who never smoked).¹³ Alcohol intake was categorized into non-drinkers (0 g alcohol/day), light (1–14.99 g/day), moderate (15–29.99 g/day), and heavy drinkers (≥ 30 g/day).^{14,15}

We used a questionnaire similar to the International Physical Activity Questionnaire¹⁶ and collected the cumulative hours per day spent at work, transportation, household, and leisure physical activity in the past seven days. The physical activity level, based on metabolic equivalents of task score (METs), was divided into low, medium, and high, following international physical activity standards.¹⁷

Sleep was assessed using the Pittsburgh Sleep Quality Index Scale.¹⁸ Sleep status was divided into three categories: ≤ 5 h, 6–9 h, and > 9 h.¹⁹ Considering the actual status of the Chinese community diet, the participants' current dietary intake was evaluated as follows: meat or poultry intake, < 100 g/day or > 100 g/day; vegetable intake, 100 g/day or > 100 g/day; added fish consumption, yes or no; soy, yes or no; dairy product, yes or no; and fruits, yes or no.

Statistical Analyses

The overall prevalence of T2DM and its associated factors were determined and recorded using the descriptive and inferential method of data analysis. Descriptive statistics were used to summarize the characteristics of study participants. Continuous variables (age, BMI, waist circumference, sleep, and MET) were expressed as the mean \pm standard deviation (SD) and compared using an ANOVA when variables were normally distributed. For variables that did not follow

a normal distribution, a Kruskal–Wallis test was used. Descriptive statistics of categorical variables were presented as frequency and percentage and analyzed using the Chi-squared test. Multivariate logistic analysis was used to assess the association between the explanatory variables and the outcome variable to control the effect of confounding and the independent effect of each variable on diabetes and prediabetes. These data are presented as odds ratios (ORs) and a 95% confidence interval (CI). All statistical analyses were performed using the IBM SPSS Version 20.0 (IBM Corp, Armonk, NY, USA). A *p*-value of < 0.05 was considered statistically significant.

Results

The average age of the study population was 63.7 ± 10.0 (mean \pm SD) years and was similar in three groups. The mean BMI of the overall study population was 24.2 ± 3.2 kg/m², and the average WC was 82.6 ± 8.6 cm. The average sleep duration was 7.0 ± 1.1 hours (Table 1). In total, 13.9% (95% CI, 13.6–14.2) and 3.1% (95% CI, 2.9–3.2) had T2DM and prediabetes, respectively. In all three groups, the majority of the participants were female, had moderate-level income, and had primary and middle-level education. Most of the participants in the T2DM group were older than 65 years. Nearly 30% of the participants had comorbidities, and most participants had hypertension and hyperlipidemia. More than 10% of the participants were either smokers or drinkers, or both. More than 90% of the participants had moderate physical activity levels, and few had high physical activity levels. There were no significant differences in this regard between the three groups. Furthermore, the three groups also showed similar sleep habits, with most of the participants having a sleep duration of 6–9 h, few slept ≤ 6 h, and very few slept > 9 h. Dietary habits were similar in the three groups and showed a trend of low intake of protein-rich foods such as fish, meat/poultry, and soybeans. Over 90% of the

participants hardly consumed fish, soybeans, and meat (< 100 g per day).

In all three groups, the proportion of participants with T2DM significantly differed according to age; sex; BMI; abdominal obesity; education; income; comorbidities like hypertension, hyperlipidemia, CHD and stroke; smoking; drinking; sleep; family history of diabetes; and dietary intake of fish, vegetables, soy, dairy product, and fruits (Table 2).

Age, sex, education, income, comorbidities, smoking, drinking, sleep duration, family history of diabetes, BMI, and abdominal obesity were included in the multivariate regression analysis. After adjusting for other factors, the result showed that compared with people younger than 65 years, participants aged 65–80 years ($p < 0.001$) and older than 80 ($p < 0.001$) had higher odds of having diabetes and prediabetes ($p = 0.044$, $p < 0.001$, respectively). Individuals who were overweight and obese also had higher odds of T2DM and prediabetes than those with normal BMI ($p < 0.001$). Furthermore, abdominally obese people had higher odds of diabetes and prediabetes ($p < 0.001$) than persons with normal abdominal girth (Table 3).

The risk of T2DM was significantly higher in individuals with lower education, comorbidities like hypertension and hyperlipidemia, CHD and stroke, who were smokers, with short sleep duration, a family history of diabetes, consumed dairy products, had a vegetable intake ≥ 100 g, and had no soy and fruit intake. The significant findings in the prediabetes group were also observed in the diabetes group. However, smoking, short sleep, drinking, and comorbidities did not increase the risk of prediabetes, unlike higher education, which increased the risk of prediabetes. (Table 3).

Discussion

Data on diabetes and prediabetes among middle-aged and elderly adults in the urban areas of western China are

Table 1 The Continuous Variables of Participants. (Mean \pm SD)

Variables	Total	T2DM	Prediabetes	Non-Diabetes
Age	63.7 \pm 10.0	67.2 \pm 9.3	63.9 \pm 9.9	63.7 \pm 10.0
BMI (kg/m ²)	24.2 \pm 3.2	24.6 \pm 3.4	24.6 \pm 3.1	24.1 \pm 3.2
Waist circumference (cm)	82.6 \pm 8.6	84.6 \pm 10.0	83.5 \pm 8.3	82.2 \pm 8.3
Sleep duration (hour)	7.0 \pm 1.1	6.9 \pm 1.2	7.1 \pm 1.1	7.0 \pm 1.0
METs	1500.1 \pm 571.5	1475.4 \pm 568.8	1484.6 \pm 572.4	1504.8 \pm 571.8

Abbreviations: BMI, body mass index; METs, metabolic equivalent of task score.

Table 2 Characteristics of the 53,288 Respondents Included in This Study

Characteristics	Total	Frequency (%)			
		T2DM	Prediabetes	Non-Diabetes	P value
Age (Year)					
< 65	29,102 (54.6)	2880 (38.9)	854 (52.0)	25,368 (57.3)	< 0.001
65–80	20,517 (38.5)	3758 (50.8)	694 (42.2)	16,065 (36.3)	
≥ 80	3669 (6.9)	758 (10.2)	95 (5.8)	2816 (6.4)	
Gender					
Male	20,024 (37.6)	3081 (41.7)	656 (39.9)	16,287 (36.8)	< 0.001
Female	33,264 (62.4)	4315 (58.3)	987 (60.1)	27,962 (63.2)	
BMI					
< 23	19,308 (36.2)	2322 (31.4)	482 (29.3)	16,504 (37.3)	< 0.001
23–27.5	26,877 (50.4)	3862 (52.2)	906 (55.1)	22,109 (50.0)	
≥ 27.5	7103 (13.3)	1212 (16.4)	255 (15.5)	5636 (12.7)	
Waist circumference†					
Normal	38,674 (72.6)	4672 (63.2)	1130 (68.8)	32,872 (74.3)	< 0.001
Abdominal obesity	14,614 (27.4)	2724 (36.8)	513 (31.2)	11,377 (25.7)	
Education					
Primary/under	23,877 (44.8)	3804 (51.4)	574 (34.9)	19,499 (44.1)	< 0.001
Middle and High	26,077 (48.9)	3094 (41.8)	941 (57.3)	22,042 (49.8)	
College/above	3334 (6.3)	498 (6.7)	128 (7.8)	2708 (6.1)	
Household income					
Poor	290 (0.5)	48 (0.6)	12 (0.7)	230 (0.5)	0.024
Moderate	47,269 (88.7)	6618 (89.5)	1449 (88.2)	39,202 (88.6)	
Well-off	5663 (10.6)	723 (9.8)	182 (11.1)	4758 (10.8)	
Rich	66 (0.1)	7 (0.1)	0 (0) ‡	59 (0.1)	
Comorbidities					
Hypertension					
No	37,816 (71.0)	4506 (60.9)	1127 (68.6)	32,183 (72.7)	< 0.001
Yes	15,472 (29.0)	2890 (39.1)	516 (31.4)	12,066 (27.3)	
Hyperlipidemia					
No	49,694 (93.3)	6337 (85.7)	1367 (83.2)	41,990 (94.9)	< 0.001
Yes	3594 (6.7)	1059 (14.3)	276 (16.8)	2259 (5.1)	
CHD					
No	52,606 (98.7)	7194 (97.3)	1617 (98.4)	43,795 (99.0)	< 0.001
Yes	682 (1.3)	202 (2.7)	26 (1.6)	454 (1.0)	
Stroke					
No	52,643 (98.8)	7189 (97.2)	1624 (98.8)	43,830 (99.1)	< 0.001
Yes	645 (1.2)	207 (2.8)	19 (1.2)	419 (0.9)	
Health behaviors					
Smoking					
Non-smoker	46,851 (87.9)	6396 (86.4)	1431 (87.1)	39,024 (88.2)	0.001
Ex-smoker	1075 (2.0)	161 (2.2)	37 (2.3)	877 (2.0)	
Smoker	5362 (10.1)	839 (11.3)	175 (10.7)	4348 (9.8)	

(Continued)

Table 2 (Continued).

Characteristics	Total	Frequency (%)			
		T2DM	Prediabetes	Non-Diabetes	P value
Drinking					
Non-drinkers	14,893 (27.9)	2104 (28.4)	445 (27.1)	12,344 (28.0)	0.012
Light	17,964 (33.7)	2525 (34.1)	531 (32.3)	14,908 (33.7)	
Moderate	13,192 (24.7)	1807 (24.4)	394 (24.0)	10,991 (24.8)	
Heavy	7239 (13.6)	960 (13.0)	273 (16.6)	6006 (13.6)	
METS§					
Low	2308 (4.3)	346 (4.7)	51 (3.1)	1911 (4.3)	0.060
Medium	50,598 (95.0)	7002 (94.7)	1582 (96.3)	42,014 (94.9)	
High	382 (0.7)	48 (0.6)	10 (0.6)	324 (0.7)	
Sleep duration (Hour)					
≤ 5	3538 (6.6)	682 (9.2)	129 (7.9)	2727 (6.2)	< 0.001
6–9	49,294 (92.5)	6622 (89.5)	1499 (91.2)	41,173 (93.0)	
> 9	456 (0.9)	92 (1.2)	15 (0.9)	349 (0.8)	
Family history					
Diabetes					
No	50,218 (94.2)	6319 (85.4)	1471 (89.5)	42,428 (95.9)	< 0.001
Yes	3070 (5.8)	1077 (14.6)	172 (10.5)	1821 (4.1)	
Dietary intake					
Fish					
No	51,368 (96.4)	7184 (97.1)	1606 (97.7)	42,578 (96.2)	< 0.001
Yes	1920 (3.6)	212 (2.9)	37 (2.3)	1671 (3.8)	
Meat/Poultry (g)					
< 100	49,184 (92.3)	6859 (92.7)	1517 (92.3)	40,808 (92.2)	0.305
≥ 100	4104 (7.7)	537 (7.3)	126 (7.7)	3441 (7.8)	
Vegetables (g)					
< 100	26,030 (48.9)	3503 (47.3)	660 (40.2)	21,867 (49.4)	< 0.001
≥ 100	27,258 (51.2)	3893 (52.6)	983 (59.8)	22,382 (50.6)	
Soy					
No	49,037 (92.0)	6941 (93.8)	1561 (95.0)	40,535 (91.6)	< 0.001
Yes	4251 (8.0)	455 (6.2)	82 (5.0)	3714 (8.4)	
Dairy Product					
No	38,831 (72.9)	5110 (69.1)	1273 (77.5)	32,448 (73.3)	< 0.001
Yes	14,457 (27.1)	2286 (30.9)	370 (22.5)	11,801 (26.7)	
Fruits					
No	23,569 (44.2)	3929 (53.1)	913 (55.6)	18,727 (42.3)	< 0.001
Yes	29,719 (55.8)	3467 (46.9)	730 (44.4)	25,522 (57.7)	

Notes: †Abdominal obesity: waist circumference ≥ 90 cm for men and ≥ 85 cm for women. ‡The number of people in this group is zero and cannot be brought into the formula to calculate the percentage.

§Three levels of METs: low (any of the following two criteria: a. No activity reported; b. Some activities were reported, but they did not meet the medium criteria), medium (any of the following three criteria: a. Satisfy various high-intensity physical activities for at least 20 minutes per day, total ≥ 3 d; b. Satisfy all kinds of medium-intensity or walking activities for at least 30 minutes every day, total ≥ 15 d; c. Total physical activity of 3 intensities ≥ 5 d, and total physical activity level of each week ≥ 600 MET-min/w), high (any of the following two criteria: a. various types of high-intensity physical activity total ≥ 3 d, and the total weekly physical activity level ≥ 1500 MET-min/w; b. three types of physical activity total ≥ 7 d, and the weekly total physical activity level ≥ 3000 MET-min/w).

Abbreviations: BMI, body mass index; METs, metabolic equivalent of task score; CHD, cardiovascular disease.

Table 3 Participants Characteristics with or without Diabetes

Variables	Crude OR (95% CI); P value				Adjusted OR† (95% CI); P value			
	T2DM	P	Prediabetes	P	T2DM	P	Prediabetes	P
Age (Year)								
< 65	Ref		Ref		Ref		Ref	
65–80	2.06 (1.96–2.17)	< 0.001	1.28 (1.16–1.42)	< 0.001	1.88 (1.78–1.99)	< 0.001	1.26 (1.01–1.57)	0.044
≥ 80	2.37 (2.17–2.59)	< 0.001	1.00 (0.81–1.24)	0.990	2.16 (1.96–2.37)	< 0.001	1.38(1.24–1.54)	< 0.001
Gender								
Male	1.23 (1.17–1.29)	< 0.001	1.14 (1.03–1.26)	0.010	1.06 (0.99–1.13)	0.074	0.97 (0.85–1.10)	0.594
Female	Ref		Ref		Ref		Ref	
BMI								
< 23	Ref		Ref		Ref		Ref	
23–27.5	1.24 (1.18–1.31)	< 0.001	1.40 (1.25–1.57)	< 0.001	1.59 (1.47–1.72)	< 0.001	1.55 (1.33–1.81)	< 0.001
≥ 27.5	1.53 (1.42–1.65)	< 0.001	1.55 (1.33–1.81)	< 0.001	1.28 (1.21–1.36)	< 0.001	1.40 (1.25–1.57)	< 0.001
Waist circumference								
Normal	Ref		Ref		Ref		Ref	
Abdominal obesity	1.69 (1.60–1.77)	< 0.001	1.31 (1.18–1.46)	< 0.001	1.64 (1.55–1.73)	< 0.001	1.28 (1.14–1.44)	< 0.001
Education								
Primary/under	Ref		Ref		Ref		Ref	
Middle and High	0.72 (0.68–0.76)	< 0.001	1.45 (1.32–1.95)	< 0.001	0.82 (0.78–0.87)	< 0.001	1.53 (1.38–1.71)	< 0.001
College/above	0.94 (0.85–1.04)	0.260	1.61 (1.32–1.96)	< 0.001	0.97 (0.87–1.08)	0.561	1.64 (1.34–2.00)	< 0.001
Household income								
Poor	Ref		Ref		Ref		Ref	
Moderate	0.81 (0.59–1.11)	0.183	0.71 (0.40–1.27)	0.246	0.84 (0.61–1.15)	0.274	0.71 (0.40–1.28)	0.258
Well-off	0.73 (0.53–1.00)	0.052	0.73 (0.40–1.33)	0.310	0.78 (0.57–1.08)	0.139	0.75 (0.41–1.36)	0.336
Rich	0.57 (0.25–1.32)	0.189	–‡	–‡	0.61 (0.26–1.43)	0.254	–‡	–‡
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.71 (1.63–1.80)	< 0.001	1.22 (1.10–1.36)	< 0.001	1.54 (1.47–1.62)	< 0.001	1.18 (1.06–1.32)	0.002
Hyperlipidemia								
No	Ref		Ref		Ref		Ref	
Yes	3.11 (2.87–3.36)	< 0.001	3.75 (3.28–4.30)	< 0.001	3.02 (2.79–3.27)	< 0.001	3.70 (3.23–4.24)	< 0.001
CHD								
No	Ref		Ref		Ref		Ref	
Yes	2.71 (2.29–3.20)	< 0.001	1.55 (1.04–2.31)	0.031	2.23 (1.88–2.64)	< 0.001	1.48 (1.00–2.21)	0.053
Stroke								
No	Ref		Ref		Ref		Ref	
Yes	3.01 (2.55–3.56)	< 0.001	1.22 (0.77–1.94)	0.392	2.49 (2.10–2.96)	< 0.001	1.16 (0.73–1.84)	0.534
Smoking								
Non-smoker	Ref		Ref		Ref		Ref	
Ex-smoker	1.20 (0.95–1.33)	0.191	1.15(0.83–1.61)	0.409	1.14 (0.95–1.37)	0.169	0.98(0.69–1.39)	0.887
Smoker	1.18 (1.09–1.27)	< 0.001	1.10 (0.94–1.29)	0.254	1.13 (1.03–1.24)	0.010	0.91 (0.75–1.09)	0.307
Drinking								
Non-drinkers	Ref		Ref		Ref		Ref	
Light	0.99(0.93–1.06)	0.843	0.99(0.87–1.12)	0.854	1.00 (0.94–1.07)	0.937	0.98(0.86–1.12)	0.777
Moderate	0.97 (0.91–1.03)	0.298	0.99(0.87–1.14)	0.936	0.97(0.90–1.03)	0.296	0.99 (0.86–1.14)	0.912
Heavy	0.94 (0.86–1.02)	0.126	1.26(1.11–1.47)	0.003	0.73 (0.66–0.80)	< 0.001	1.08 (0.91–1.29)	0.379

(Continued)

Table 3 (Continued).

Variables	Crude OR (95% CI); P value				Adjusted OR† (95% CI); P value			
	T2DM	P	Prediabetes	P	T2DM	P	Prediabetes	P
Sleep duration (Hour)								
≤ 5	1.55(1.42–1.70)	< 0.001	1.30 (1.08–1.56)	0.005	1.44 (1.32–1.58)	< 0.001	1.29 (1.07–1.55)	0.007
6–9	Ref		Ref		Ref		Ref	
> 9	1.64(1.30–2.07)	< 0.001	1.18 (0.70–1.98)	0.531	1.46 (1.15–1.84)	0.002	1.15 (0.68–1.93)	0.603
Family diabetes								
No	Ref		Ref		Ref		Ref	
Yes	3.97(3.67–4.30)	< 0.001	2.72 (2.31–3.21)	< 0.001	4.68 (4.31–5.08)	< 0.001	2.85 (2.41–3.36)	< 0.001
Fish								
No	Ref		Ref		Ref		Ref	
Yes	0.75(0.65–0.87)	< 0.001	0.59 (0.42–0.82)	< 0.001	0.77 (0.67–0.90)	0.001	0.59 (0.43–0.83)	0.002
Vegetables								
< 100	Ref		Ref		Ref		Ref	
≥ 100	1.09(1.03–1.14)	0.001	1.46 (1.32–1.61)	< 0.001	1.10 (1.05–1.16)	< 0.001	1.46 (1.32–1.61)	< 0.001
Soy								
No	Ref		Ref		Ref		Ref	
Yes	0.72(0.65–0.79)	< 0.001	0.57 (0.46–0.72)	< 0.001	0.73 (0.66–0.80)	< 0.001	0.58 (0.46–0.72)	< 0.001
Dairy Product								
No	Ref		Ref		Ref		Ref	
Yes	1.23 (1.17–1.30)	< 0.001	0.80 (0.71–0.90)	< 0.001	1.17 (1.11–1.24)	< 0.001	0.79 (0.71–0.89)	< 0.001
Fruit								
No	Ref		Ref		Ref		Ref	
Yes	0.65 (0.62–0.68)	< 0.001	0.59 (0.53–0.65)	< 0.001	0.66 (0.63–0.70)	< 0.001	0.59 (0.54–0.65)	< 0.001

Notes: † OR were adjusted for their factors; ‡ The number of people in this group is 0 and cannot be brought into the formula to calculate the percentage.

Abbreviation: OR, odds ratios.

limited to date. In this investigation focusing on the Nanchong region, the overall prevalence of T2DM was 13.9%. To the best of our knowledge, this is the first large-scale diabetes survey conducted for middle-aged and elderly adults in a third-tier city in western China. The T2DM prevalence in this study was higher than that in previous studies carried out in China.^{20,21} The higher prevalence in this region may be related to the ongoing urbanization and unique nutritional habits among the different provinces of China.²² Moreover, the higher average age of our study's target population, compared to other studies, might have been a critical factor underlying our results. Our findings highlight that age is an independent risk factor of T2DM in China.²³ Interestingly, the health habits and dietary patterns of middle-aged and elderly people are better than those of young people, thereby reducing the incidence of diseases. In the current study, the incidence of prediabetes was only 3.7%, which was lower than that previously reported in China.^{24–26}

Since prediabetes was predominantly asymptomatic, people largely ignored routine blood glucose testing. This may be related to low awareness of prediabetes and insufficient attention to blood glucose in older adults.^{24–26} This part of the population was not included in our study due to the lack of blood glucose data. However, we will address this group and report on the prevalence of T2DM and prediabetes in this sector of the population in future work. It is noteworthy to mention that it is imperative to raise awareness on diabetes and stress the relevance of blood glucose testing, especially among middle-aged and older adults in western China, where the medical system requires improvements.

This study showed the association of BMI with T2DM and prediabetes. High BMI has been reported to be one of the strongest determinants of T2DM.²⁷ Compared with other European and American nations, Chinese participants had a higher comparative risk of T2DM than participants of other ethnic groups, despite having the same

BMI.²⁸ The present study found that hypertension, hyperlipidemia, CHD, and stroke were positively related to T2DM, consistent with previous studies.^{29–31} Hyperlipidemia was also associated with prediabetes. Unfortunately, we were unable to determine whether the comorbidity was the cause or consequence of T2DM and prediabetes. However, it is worth noting that individuals with hypertension, hyperlipidemia, or CHD were at a higher risk of T2DM. Individuals with prediabetes and T2DM are at a higher risk of developing macrovascular complications, including hypertension, CHD, and stroke,³² and more than 60% of older adults with T2DM have at least one comorbidity.³³ Therefore, T2DM of middle-aged and elderly people is a significant public health concern receiving widespread attention given its substantial morbidity, mortality, and economic burden.

Our data showed that compared with low-level education, persons with middle-level education had a lower risk of T2DM. A previous study showed that higher education was significantly related to better management of diabetes among older adults in China.³⁴ Furthermore, higher education was positively associated with awareness and control of diabetes among the American elderly.³⁵ This pattern could be explained because higher education is associated with better access and understanding of diabetes.

We found that current smokers have a significantly higher risk of developing T2DM than ex-smokers and nonsmokers. Helmut et al demonstrated that exposure to smoke and second-hand smoke strongly affects the risk of T2DM and the probability of its complications.³⁶ Furthermore, given that more women than men smoke, a higher incidence of smoking-related diabetes in females is expected in the future.³⁷ Our results show that drinking alcohol reduced the risk of T2DM, as alcohol intake ≥ 30 g/day lowered the risk of T2DM after adjusting for other factors in the analysis. This is consistent with previous results showing that moderate alcohol consumption is associated with a lower risk of T2DM. Interestingly, for current non-drinkers and never-drinkers, those with alcohol intake < 63 g/day had a lower risk of T2DM, while the risk increased with higher alcohol amounts.³⁸ However, this benefit might be limited to women only since men tended to have higher risks of T2DM even at very low levels of alcohol consumption.³⁹

Some dietary factors, such as the intake of soy and fruit, were protective against T2DM and prediabetes, in line with previous research.^{40–43} In this study, eating dairy products was protective against prediabetes. However, it

also increased the risk of T2DM, suggesting an inconclusive relationship between dairy products and diabetes. Our data support that the physiologic response to dairy products may differ according to the type of dairy product, the fat content, and the individual's age and health status.⁴⁴ Thus, it cannot be simply concluded that dairy products, in general, reduce the risk of diabetes.^{45–47}

Our results contrast with evidence supporting a beneficial effect of vegetable intake in preventing T2DM.^{42,48} In Chinese cuisine, vegetables are mainly stir-fried in oil.⁴⁹ In contrast, Europeans and Americans consume vegetables primarily in salads, boiled or steamed.⁵⁰ Stir-frying involves a greater amount of oil than salads and boiled dishes, with the average amount of oil being 12 g per 100 g of vegetables.⁴⁹ This excessive oil in vegetable-based dishes is known to increase the risk of developing diabetes.⁵¹

This cross-sectional study is representative of the middle-aged population not only because it was conducted in eight communities of Nanchong but also because of its large sample size. Nevertheless, this study also has some limitations. First, the results were specific to the urban population. Future research should examine individuals from rural areas to confirm the results obtained in the present study. Second, although we also investigated the risk factors of prediabetes, the findings should be interpreted with caution, as a large number of individuals in this group had incomplete information and were excluded. The prevalence of T2DM and prediabetes in the excluded population should be investigated to further confirm our findings. Moreover, individual awareness of prediabetes needs to be assessed in future studies. Finally, we did not collect data on diabetes treatment and glycated hemoglobin levels and did not assess the impact of these factors on diabetes and prediabetes.

Conclusion

The prevalence of T2DM and prediabetes was 13.9% and 3.1%, respectively, among middle-aged and older adults in Nanchong. Advanced age, high BMI, abdominal obesity, a family history of diabetes, hyperlipidemia, and smoking increased the risk of T2DM and prediabetes. Soy and fruit intake was beneficial in preventing T2DM and prediabetes, whereas vegetable intake increased the risk, mainly due to the large amount of oil used in the Chinese cooking method. These findings can assist the early identification of persons at high risk of T2DM and prediabetes and the implementation of timely lifestyle interventions to prevent these conditions.

Data Sharing Statement

After publication, the authors intend to share individual de-identified participant data and all the clinical data collected from the patients. Besides, the statistical results and ethical approval consent are available for one year upon request through an e-mail: xishengx@126.com.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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