Prevalence of diabetes recorded in mainland China using 2018 diagnostic criteria from the American Diabetes Association: national cross sectional study

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Additional material is published online only. To view please visit the journal online.

Cite this as: *BMJ* 2020;369:m997
http://dx.doi.org/10.1136 bmj.m997

Accepted: 3 March 2020

ABSTRACT

OBJECTIVE

To assess the prevalence of diabetes and its risk factors.

DESIGN

Population based, cross sectional study.

SETTING

31 provinces in mainland China with nationally representative cross sectional data from 2015 to 2017.

PARTICIPANTS

75 880 participants aged 18 and older—a nationally representative sample of the mainland Chinese population.

MAIN OUTCOME MEASURES

Prevalence of diabetes among adults living in China, and the prevalence by sex, regions, and ethnic groups, estimated by the 2018 American Diabetes Association (ADA) and the World Health Organization diagnostic criteria. Demographic characteristics, lifestyle, and history of disease were recorded by participants on a questionnaire. Anthropometric and clinical assessments were made of serum concentrations of fasting plasma glucose (one measurement), two hour plasma glucose, and glycated haemoglobin (HbA_{1c}).

RESULTS

The weighted prevalence of total diabetes (n=9772), self-reported diabetes (n=4464), newly diagnosed diabetes (n=5308), and prediabetes (n=27 230) diagnosed by the ADA criteria were 12.8% (95% confidence interval 12.0% to 13.6%), 6.0% (5.4% to 6.7%), 6.8% (6.1% to 7.4%), and 35.2% (33.5% to 37.0%), respectively, among adults living in China. The weighted prevalence of total diabetes was higher among adults aged 50 and older and among men. The prevalence of total diabetes in 31 provinces ranged from 6.2% in Guizhou to 19.9% in Inner Mongolia. Han ethnicity had the highest prevalence of diabetes (12.8%) and Hui ethnicity had the lowest (6.3%) among five investigated ethnicities. The weighted prevalence of total diabetes (n=8385) using the WHO criteria was 11.2% (95% confidence interval 10.5% to 11.9%).

CONCLUSION

The prevalence of diabetes has increased slightly from 2007 to 2017 among adults living in China. The findings indicate that diabetes is an important public health problem in China.

WHAT IS ALREADY KNOWN ON THIS TOPIC

The previous national survey of diabetes in China, conducted in 2013, found a diabetes prevalence of 10.9% and a prediabetes prevalence of 35.7% using the American Diabetes Association (ADA) diagnostic criteria

In 2013, China implemented major healthcare reform and several government prevention, screening, and management programmes for non-communicable diseases, which provided useful data to show whether these changes have affected the prevalence of diabetes

Such surveys generally use a single reading of glucose or HbA_{1c}, rather than repeat readings which are typical in clinical practice, where clinical diagnosis is based also on patient symptoms

WHAT THIS STUDY ADDS

This nationally representative epidemiological survey indicated that the overall prevalence of diabetes in mainland China in 2017 was 12.8% using the ADA diagnostic criteria and 11.2% using World Health Organization criteria

The prevalence of diabetes in 2017 in China is higher than that found by previous national surveys in 2007, 2010, and 2013 using the same WHO diagnostic criteria

The findings suggest that diabetes is an important health problem in China

Introduction

Diabetes is a metabolic disorder caused by genetic and environmental factors, which results in insulin insensitivity, insulin deficiency, and impaired biological function. The disease has become a critical health concern worldwide owing to its high prevalence and related disability and mortality.[1 2] The prevalence and number of adults with diabetes has increased at a greater rate in low and middle income countries than in high income countries. This rise in prevalence has been compounded by a growing and ageing population, nearly quadrupling the number of adults with diabetes from 1980 to 2014 worldwide.[3] The increase in prevalence could also be partially attributable to the new diagnostic criteria, with reduced cut-off points for blood glucose and the addition of glycated haemoglobin (HbA_{1c}). The American Diabetes Association (ADA) criteria and World Health Organization (WHO) criteria are shown in table 1. The main difference between them is the inclusion of HbA_{1c} in the ADA criteria.[4 5]

Rapid economic development in the past three decades has led to a change in lifestyle among the Chinese population, with more sedentary behaviour and a high energy/high fat diet.[6] This change has resulted in more people who are overweight.[7] The prevalence of diabetes in adults living in China increased from 0.67% using the WHO criteria in 1980 to 10.9% using the ADA criteria in 2013.[8-14] Although different sampling methods and screening procedures were used between 1980 and 2013, these data show a remarkable increase. According to the diabetes atlas of the International Diabetes Federation, China has the largest number of patients with diabetes in the world. Estimates suggest that there are 113.9 million adults with diabetes living in China, accounting for 24% globally of patients with diabetes.[15] Additionally, the healthcare cost associated with diabetes in China is 110 billion international dollars (purchasing power parity) in 2017.[15]

China implemented healthcare reforms in 2013.[16] As a result, patients with non-communicable diseases, including diabetes, could have easier access to clinical resources, thus improving the control of diabetes. Some areas have carried out a whole population project with prevention, screening, diagnosis, and management of diabetes and other non-communicable diseases. Prevention and treatment of diabetes has moved from large general hospitals to community health service centres, from simple clinical treatment to tertiary prevention of diabetes, and from simple control of blood glucose to control of weight, blood glucose, blood pressure, and blood lipids.

Our objective was to perform a cross sectional study of the prevalence of diabetes and prediabetes in mainland China, and to evaluate awareness, treatment, and control of diabetes by geographical location and subpopulation.

Methods

Sampling and study population

This epidemiological study, the Thyroid disorders, Iodine status and Diabetes Epidemiological survey (TIDE study), included all 31 provinces of mainland China with a sample of 75 880 people according to the age and sex composition of each community and the urban-rural ratio using the latest national census data.[17] The study was conducted between 2015 and 2017.

We used a multistage, stratified sampling method to select a nationally representative sample of people aged 18 and older in the general population. The study was conducted through four stages of random sampling in urban and rural locations in parallel (supplementary fig 1). Developed, developing, and underdeveloped cities were defined based on gross domestic product per capita, concentration of commercial resources, the extent to which a city serves as a commercial hub, vitality of residents, diversity of lifestyle, and future growth potential. Six tiers of cities were categorised from developed to underdeveloped cities, each two tiers being defined as a rank and thus three ranks in all. The cities with tier 1 and new tier 1 were classified as developed cities, tiers 2 and 3 as developing cities, and tiers 4 and tier 5 as underdeveloped cities (supplementary table 1).

For urban locations, at the first stage, one city was selected from each province from all 31 provinces of China. These 31 cities were classified as 10 developed, 13 developing, and 8 underdeveloped cities. At the second stage, one district was randomly selected from each city. At the third stage, two residential communities were randomly selected from each district. At the final stage, eligible people who met the inclusion criteria and were registered as local residents were randomly selected and stratified by age and sex. The composition of age and sex of each community and urban-rural ratio were decided based on China's 2010 national census data.[17] Parallel random sampling was performed in rural locations (supplementary fig 1).

For adult respondents, the inclusion criteria were age 18 or older, living in the selected community for at least five years, and not pregnant. At least 1000 people from each ethnic minority were recruited in four autonomous regions. Finally, Tibetan, Uyghur, Hui, and Zhuang ethnic groups were analysed. A total of 80 937 participants completed the survey and the overall response rate was 92.1%. Our analysis included 75 880 participants after excluding 5057 people with missing information on sex, age, plasma glucose, or HbA_{1c} (supplementary fig 1). Research protocols were approved by the medical ethics committee of China Medical University. All participants provided written informed consent after receiving a thorough explanation of the research procedures.

Demographic and behavioural assessment

For each participant, a trained interviewer used a detailed questionnaire to collect information about demographic variables, behavioural factors, family history of chronic diseases, and personal medical history. Current smoking was defined as having smoked at least 100 cigarettes in one's life and currently smoking cigarettes. Occasional smokers were defined as currently smoking fewer than 20 cigarettes a day. Regular smokers were defined as currently smoking more than 20 cigarettes a day.

Anthropometric and clinical assessment

Body weight, height, waist circumference, and blood pressure were measured by trained health workers according to standard protocols. Body mass index was calculated by dividing body weight in kg by the square of height in metres. Blood pressure was measured by an electronic blood pressure monitor (Omron HEM-7430, Omron Corporation) on the non-dominant arm twice consecutively with a 10 minute interval between measurements and with the participant in a seated position after five minutes of rest. We defined central obesity as a waist circumference of 90 cm or greater for men and 80 cm or greater for women. We defined generalised overweight as a body mass index of 25 to less than 30, and defined obesity as a body mass index

Table 1 | Diagnostic criteria for diabetes related disorders

Disorders	ADA diagnostic criteria	WHO diagnostic criteria
Self-reported diabetes	A self-reported diagnosis that was determined previously by a healthcare professional	A self-reported diagnosis that was determined previously by a healthcare professional
Newly diagnosed diabetes	Among participants without self-reported diabetes: fasting plasma glucose ≥126 mg/dL (7.0 mmol/L), or oral glucose tolerance test: two hour plasma glucose ≥200 mg/dL (11.1 mmol/L), or HbA_{1c} ≥6.5%	Among participants without self-reported diabetes: fasting plasma glucose ≥126 mg/dL (7.0 mmol/L) or oral glucose tolerance test: two hour plasma glucose ≥200 mg/dL (11.1 mmol/L)
Total diabetes	Sum of the number of patients with self-reported diabetes and the number of patients with newly diagnosed diabetes	Sum of the number of patients with self-reported diabetes and the number of patients with newly diagnosed diabetes
Impaired fasting glucose	Among participants without diabetes: fasting plasma glucose 100 mg/dL (5.6 mmol/L) to 125 mg/dL (6.9 mmol/L)	Among participants without diabetes: fasting plasma glucose 110 mg/dL (6.1 mmol/L) to 125 mg/dL (6.9 mmol/L), and oral glucose tolerance test: two hour plasma glucose <140 mg/dL (7.8 mmol/L)
Impaired glucose tolerance	Among participants without diabetes: oral glucose tolerance test: two hour plasma glucose 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L)	Among participants without diabetes: fasting plasma glucose <126 mg/dL (7.0 mmol/L), and oral glucose tolerance test: two hour plasma glucose 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L)
Prediabetes	Among participants without diabetes: fasting plasma glucose 100 mg/dL (5.6 mmol/L) to 125 mg/dL (6.9 mmol/L), or oral glucose tolerance test: two hour plasma glucose 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L), or HbA_{1c} 5.7-6.4%	Among participants without diabetes: fasting plasma glucose 110 mg/dL (6.1 mmol/L) to 125 mg/dL (6.9 mmol/L), and oral glucose tolerance test: two hour plasma glucose <140 mg/dL (7.8 mmol/L), or fasting plasma glucose <126 mg/dL (7.0 mmol/L), and oral glucose tolerance test: two hour plasma glucose 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L)

ADA=American Diabetes Association; HbA_{1c}=glycated haemoglobin; WHO=World Health Organization.

of 30 or higher for both men and women.[18] Detailed information for the anthropometric and clinical methods and quality control is given in supplementary appendix 1.

Biochemical assessment

Blood samples were collected from all participants after an overnight fast of at least 10 hours. Serum samples were used for the measurements of fasting plasma glucose levels and two hour plasma glucose levels after carrying out an oral 75 g glucose tolerance test. HbA_{1c} was measured in venous blood samples by high performance liquid chromatography (Bio-Rad VARIANT II Haemoglobin Analyzer). In people with self-reported diabetes, only fasting plasma glucose and HbA_{1c} were measured. Fasting plasma glucose, two hour plasma glucose levels, serum total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol, and triglycerides were measured using an automatic biochemical analyser (Mindray BS-180 Analyzer).

This biochemical assessment of diabetes differs from the testing strategy used in practice. In the absence of unequivocal hyperglycaemia or symptoms, assessment should be confirmed by repeat testing. We carried out only one reading on measured glucose or HbA_{1c}, but this approach has been widely used by previous national epidemiologic surveys.[8-13]

Outcome assessment

Diagnostic criteria for diabetes related disorders are presented in table 1. Treatment was defined as the proportion of individuals taking drugs for diabetes among those diagnosed with the disease. Control was defined as the proportion of individuals with an HbA_{1c} concentration of less than 7.0% among patients with diabetes who were taking medication.

Statistical analysis

To account for the complex sampling design of this study, we used SUDAAN software (Research Triangle Institute) to obtain estimates of prevalence and the standard errors according to the Taylor linearisation method. Estimates were weighted to reflect age, sex, and urban-rural, distribution of provinces of the adults living in China. Weighting coefficients were derived from the 2010 Chinese population census data, and the sampling scheme of our survey was to obtain a national estimate. Briefly, the weighting coefficient was the inverse of the adjusted probability of obtaining the data for the respondent; each individual case in the analysis was assigned a certain coefficient (individual weight), by which it was multiplied to represent the actual population with the same characteristics of sex, age, province, and location. Standard errors were calculated with appropriate statistical techniques with data from the complex survey design. Categorical data are presented as percentages and 95% confidence intervals and were analysed by a χ^2 test or Fisher's exact test, as appropriate. Continuous data are described with means and 95% CIs. A binomial logit regression was used to examine the association of risk factors with the odds of total diabetes and prediabetes. A P value less than 0.05 was considered statistically significant. All statistical analyses were conducted using the SAS system, version 9.3 (SAS Institute Inc, Cary, NC) and SUDAAN software, version 10.0 (Research Triangle Institute).

Patient and public involvement

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Results

The general characteristics and metabolic risk factors of the study population are presented in table 2 and supplementary figure 2. The overall standardised prevalence of total diabetes, self-reported diabetes,

and newly diagnosed diabetes using the ADA criteria were 12.8% (95% confidence interval 12.0% to 13.6%), 6.0% (5.4% to 6.7%), and 6.8% (6.1% to 7.4%), respectively, in Chinese adults. The prevalence of total diabetes was higher in men than in women. The standardised prevalence of prediabetes was 35.2% (33.5% to 37.0%) in Chinese adults, diagnosed by the ADA criteria (table 3 and supplementary table 2). No significant differences in the prevalence of diabetes and prediabetes were found between urban and rural residents. The weighted prevalence of total diabetes diagnosed by the WHO criteria was 11.2% in 2017. The prevalence of diabetes varied with different diagnostic criteria.

In many subpopulations, the prevalence of total diabetes and prediabetes was higher among men, among people with a low education level and low family income, among those who were overweight and obese, and among those who reported a family history of diabetes. Han ethnic participants had the highest prevalence of total diabetes in comparison with Uyghur, Zhuang, Tibetan, and Hui participants. The prevalence of total diabetes and prediabetes increased with age in both men and women and increased more sharply after age 50 (table 3 and fig 1).

Regional variations in the prevalence of total diabetes were found, with the highest prevalence in the north, followed by the southwest, northeast, south, central, east, and northwest (table 3). Supplementary figure 3 illustrates the geographical variation in the prevalence of total diabetes and prediabetes at the provincial level, stratified into quintiles. The prevalence of total diabetes varied from 6.2% in Guizhou to 19.9% in Inner Mongolia (supplementary table 3).

Awareness, treatment, and control of diabetes and risk factors in adults living in China, standardised for age and sex, are presented in table 4. The proportion of patients who were aware of their diabetes and were treated was higher in the older population, and the rate of awareness of diabetes was significantly higher in urban than in rural residents (table 4 and fig 1). The proportion of patients who controlled their HbA_{1c} levels well was higher in younger patients and in urban residents.

Table 2 | General characteristics of adults living in mainland China. Data are percentage (95% confidence interval) unless indicated otherwise

		Sex		Urbanisation	
Characteristics	Overall (n=75 880)	Men (n=36 819)	Women (n=39 061)	Urban (n=40 560)	Rural (n=35 320)
Mean age at survey (95% CI)	42.8 (41.9 to 43.7)	42.6 (41.8 to 43.5)	43.0 (42.1 to 43.9)	41.4 (40.5 to 42.4)	44.3 (43.5 to 45.1)
Ethnicity:					
Han	95.4 (93.5 to 96.8)	95.3 (93.4 to 96.7)	95.6 (93.6 to 97.0)	96.7 (86.9 to 99.2)	94.0 (78.7 to 98.5)
Tibetan	0.2 (0.1 to 0.5)	0.2 (0.1 to 0.5)	0.2 (0.1 to 0.5)	0.1 (0.01 to 0.7)	0.3 (0.04 to 2.3)
Uyghur	1.3 (1.1 to 1.6)	1.4 (1.1 to 1.7)	1.3 (1.1 to 1.5)	1.2 (0.2 to 8.7)	1.5 (0.2 to 10.9)
Hui	0.3 (0.1 to 1.3)	0.3 (0.04 to 1.4)	0.3 (0.1 to 1.3)	0.04 (0.01 to 0.3)	0.5 (0.1 to 3.7)
Zhuang	2.8 (1.6 to 4.8)	2.9 (1.7 to 4.8)	2.7 (1.6 to 4.8)	2.0 (0.3 to 13.9)	3.7 (0.5 to 23.7)
Income per year (¥):					
≤30 000	44.8 (38.2 to 51.7)	41.3 (35.1 to 47.9)	48.4 (41.3 to 55.6)	31.0 (26.4 to 35.9)	59.7 (53.9 to 65.3)
>30 000	55.2 (48.3 to 61.8)	58.7 (52.2 to 64.9)	51.6 (44.4 to 58.7)	69.1 (64.1 to 73.6)	40.3 (34.7 to 46.1)
Education:					
Less than high school	43.7 (36.5 to 51.2)	40.4 (33.6 to 47.6)	47.1 (39.3 to 55.0)	28.2 (23.2 to 33.8)	60.5 (56.2 to 64.7)
High school and above	56.3 (48.8 to 63.5)	59.6 (52.4 to 66.4)	52.9 (45.1 to 60.7)	71.8 (66.2 to 76.8)	39.5 (35.3 to 43.8)
Cigarette smoking:					
Current non-smoker	73.6 (72.3 to 74.8)	50.0 (47.5 to 52.5)	97.5 (96.8 to 98.1)	75.5 (73.7 to 77.2)	71.5 (69.3 to 73.6)
Occasional smoker	4.0 (3.6 to 4.4)	7.0 (6.3 to 7.7)	0.9 (0.7 to 1.2)	4.3 (3.6 to 5.1)	3.6 (3.0 to 4.3)
Regular smoker	22.5 (21.2 to 23.8)	43.1 (40.4 to 45.8)	1.6 (1.1 to 2.2)	20.3 (18.5 to 22.2)	24.9 (22.5 to 27.4)
Family history of diabetes	16.4 (13.9 to 19.3)	15.5 (13.2 to 18.1)	17.4 (14.6 to 20.6)	22.0 (19.1 to 25.1)	10.4 (8.8 to 12.3)
Physical examination:					
Mean body mass index (95% CI)	24.0 (23.9 to 24.1)	24.6 (24.4 to 24.8)	23.4 (23.2 to 23.6)	23.9 (23.6 to 24.3)	24.1 (23.8 to 24.4)
Body mass index <25	62.9 (61.5 to 64.2)	56.1 (54.2 to 58.0)	69.7 (67.8 to 71.6)	63.9 (60.2 to 67.3)	61.8 (58.5 to 65.0)
Body mass index 25 to <30	30.9 (29.8 to 32.0)	36.3 (34.8 to 37.9)	25.3 (23.7 to 27.0)	30.0 (27.6 to 32.6)	31.8 (29.5 to 34.2)
Body mass index ≥30	6.3 (5.9 to 6.6)	7.6 (7.0 to 8.2)	4.9 (4.6 to 5.3)	6.1 (5.1 to 7.4)	6.4 (5.4 to 7.5)
Mean waist circumference (95% CI; cm)	83.2 (82.4 to 84.0)	86.6 (85.8 to 87.5)	79.7 (78.8 to 80.6)	82.7 (81.6 to 83.8)	83.7 (82.1 to 85.3)
Mean heart rate (95% CI; counts per min	79.8 (79.2 to 80.5)	78.9 (78.2 to 79.6)	80.8 (80.1 to 81.5)	80.0 (78.7 to 81.4)	79.6 (78.5 to 80.8)
Mean systolic blood pressure (95% CI; mm Hg)	126.3 (124.9 to 127.7)	129.9 (128.8 to 131.0)	122.7 (120.9 to 124.4)	124.1 (122.8 to 125.5)	128.7 (126.9 to 130.5)
Mean diastolic blood pressure 95% CI; mm Hg)	78.3 (77.2 to 79.5)	80.7 (79.3 to 82.1)	76.0 (74.9 to 77.0)	77.3 (76.0 to 78.6)	79.5 (77.4 to 81.5)
Laboratory tests (mean (95% CI)):					
Cholesterol (mmol/L)	4.8 (4.7 to 4.8)	4.8 (4.8 to 4.9)	4.8 (4.7 to 4.8)	4.8 (4.7 to 4.9)	4.7 (4.6 to 4.9)
Low density lipoprotein (mmol/L)	2.8 (2.8 to 2.9)	2.9 (2.8 to 3.0)	2.8 (2.7 to 2.8)	2.8 (2.7 to 2.9)	2.8 (2.7 to 3.0)
High density lipoprotein (mmol/L)	1.5 (1.5 to 1.5)	1.4 (1.4 to 1.4)	1.6 (1.5 to 1.6)	1.5 (1.4 to 1.5)	1.5 (1.4 to 1.5)
Triglycerides (mmol/L)	1.6 (1.5 to 1.6)	1.8 (1.7 to 1.8)	1.4 (1.3 to 1.4)	1.5 (1.5 to 1.6)	1.6 (1.5 to 1.7)
Fasting plasma glucose (mmol/L)	5.4 (5.4 to 5.5)	5.5 (5.4 to 5.6)	5.3 (5.3 to 5.4)	5.4 (5.3 to 5.5)	5.5 (5.3 to 5.6)
Two hour plasma glucose (mmol/L)	6.5 (6.4 to 6.6)	6.5 (6.4 to 6.6)	6.5 (6.4 to 6.6)	6.5 (6.4 to 6.7)	6.5 (6.3 to 6.7)
HbA_{1c}	5.6 (5.4 to 5.7)	5.6 (5.5 to 5.7)	5.5 (5.4 to 5.6)	5.5 (5.3 to 5.7)	5.6 (5.6 to 5.7)

¥ 100=£12; €13; $14.

Table 3 | Age and sex standardised prevalence of diabetes, prediabetes, and risk factors among adults living in mainland China

Characteristics	No of participants	Percentage estimated prevalence (95% confidence interval)				
		Self-reported diabetes	Self-reported diabetes or fasting plasma glucose ≥7 mmol/L	Self-reported diabetes, fasting plasma glucose ≥7 mmol/L, or two hour plasma glucose ≥11.1 mmol/L	Self-reported diabetes, fasting plasma glucose ≥7 mmol/L, two hour plasma glucose ≥11.1 mmol/L, or HbA_{1c} ≥6.5%	Prediabetes
Overall	75 880	6.0 (5.4 to 6.7)	8.7 (8.1 to 9.3)	11.2 (10.5 to 11.9)	12.8 (12.0 to 13.6)	35.2 (33.5 to 37.0)
Sex:						
Men	36 819	6.4 (5.6 to 7.2)	9.7 (8.9 to 10.5)	12.1 (11.3 to 13.0)	13.7 (12.8 to 14.7)	37.0 (35.2 to 38.9)
Women	39 061	5.6 (5.1 to 6.2)	7.7 (7.1 to 8.3)	10.3 (9.5 to 11.1)	11.8 (10.9 to 12.7)	33.4 (31.6 to 35.3)
P for difference	—	0.01	<0.001	<0.001	<0.001	<0.001
Urbanisation:						
Urban	40 560	7.1 (6.6 to 7.7)	9.6 (9.0 to 10.3)	12.2 (11.4 to 13.1)	13.7 (12.7 to 14.7)	34.6 (31.6 to 37.7)
Rural	35 320	5.0 (4.3 to 5.9)	7.9 (7.0 to 8.9)	10.3 (9.2 to 11.6)	12.0 (10.7 to 13.3)	35.8 (32.2 to 39.6)
P for difference	—	0.08	0.49	0.76	0.92	0.29
Age group:						
18-29	17 873	0.8 (0.5 to 1.2)	1.3 (0.9 to 1.8)	1.5 (1.0 to 2.1)	2.0 (1.5 to 2.7)	20.2 (18.2 to 22.40)
30-39	15 082	2.6 (2.1 to 3.2)	4.2 (3.6 to 4.8)	5.4 (4.6 to 6.3)	6.3 (5.4 to 7.3)	29.9 (27.4 to 32.5)
40-49	16 686	4.8 (4.1 to 5.7)	8.2 (7.4 to 9.1)	10.6 (9.6 to 11.6)	12.1 (11.1 to 13.3)	40.0 (38.0 to 41.9)
50-59	12 736	10.6 (9.6 to 11.7)	15.0 (14.1 to 16.1)	18.9 (17.8 to 20.1)	21.1 (19.8 to 22.6)	47.1 (44.9 to 49.4)
60-69	8205	14.9 (12.8 to 17.3)	19.7 (17.6 to 22.0)	25.5 (23.3 to 27.9)	28.8 (26.5 to 31.3)	47.8 (45.0 to 50.6)
≥70	5298	16.5 (13.8 to 19.5)	21.4 (18.6 to 24.4)	28.8 (25.7 to 32.1)	31.8 (28.8 to 35.1)	47.6 (44.3 to 51.0)
P for trend	—	<0.001	<0.001	<0.001	<0.001	<0.001
Ethnicity:						
Han	68 064	6.1 (5.5 to 6.8)	8.8 (8.2 to 9.5)	11.3 (10.6 to 12.0)	12.8 (12.0 to 13.7)	35.4 (33.6 to 37.3)
Tibetan	2034	1.5 (0.6 to 3.3)	1.9 (0.7 to 5.0)	4.2 (3.8 to 4.6)	6.5 (6.1 to 6.9)	34.4 (26.3 to 43.6)
Uyghur	2159	4.6 (4.2 to 5.0)	7.8 (6.4 to 9.5)	9.1 (7.4 to 11.0)	11.5 (9.6 to 13.6)	20.2 (12.6 to 30.7)
Hui	1661	1.8 (0.5 to 7.0)	4.4 (2.6 to 7.3)	5.4 (3.6 to 8.1)	6.3 (3.9 to 9.9)	36.2 (31.3 to 41.4)
Zhuang	1962	3.8 (1.5 to 9.1)	5.6 (2.5 to 12.3)	10.0 (6.6 to 14.7)	11.4 (7.7 to 16.5)	35.5 (34.6 to 36.4)
P for difference	—	<0.001	<0.001	<0.001	<0.001	0.005
Region:						
South	6882	5.8 (3.0 to 10.7)	8.3 (5.3 to 12.7)	11.6 (8.2 to 16.1)	12.8 (9.5 to 16.9)	35.1 (32.7 to 37.1)
North	12 112	6.6 (5.2 to 8.4)	9.2 (7.7 to 10.9)	11.4 (9.7 to 13.4)	14.2 (12.5 to 16.2)	37.4 (33.0 to 42.0)
East	17 206	5.9 (5.1 to 6.7)	8.2 (7.5 to 9.1)	10.7 (9.9 to 11.5)	12.2 (10.9 to 13.5)	33.7 (30.1 to 37.5)
Central	7823	6.6 (5.5 to 7.9)	8.7 (7.8 to 9.6)	10.5 (9.8 to 11.2)	12.3 (11.7 to 12.8)	38.0 (35.4 to 40.7)
Southwest	11 347	4.7 (3.7 to 6.1)	8.8 (7.5 to 10.4)	11.9 (10.0 to 14.2)	13.3 (10.8 to 16.3)	37.7 (31.8 to 44.1)
Northwest	13 147	5.7 (4.4 to 7.4)	8.2 (7.0 to 9.6)	10.7 (9.6 to 12.0)	12.1 (10.9 to 13.6)	31.7 (28.3 to 35.3)
Northeast	7363	6.8 (4.8 to 9.6)	10.0 (7.7 to 12.8)	12.7 (10.2 to 15.6)	12.9 (10.5 to 15.8)	31.3 (24.7 to 38.7)
P for difference	—	0.25	0.27	0.33	0.10	0.04
Income per year (¥):						
≤30 000	32 339	5.9 (5.2 to 6.6)	8.7 (7.9 to 9.5)	11.3 (10.4 to 12.3)	12.9 (11.9 to 14.0)	35.7 (33.8 to 37.7)
>30 000	42 552	6.3 (5.7 to 7.0)	8.9 (8.3 to 9.6)	11.4 (10.7 to 12.1)	12.9 (12.0 to 13.8)	35.0 (32.9 to 37.1)
P for difference	—	<0.001	<0.001	<0.001	0.001	0.01
Education:						
Less than high school	34 856	5.8 (5.1 to 6.7)	8.8 (7.9 to 9.8)	11.3 (10.3 to 12.5)	12.9 (11.8 to 14.1)	36.9 (34.2 to 39.7)
High school and above	40 729	6.6 (6.1 to 7.3)	9.0 (8.4 to 9.6)	11.5 (10.8 to 12.2)	13.2 (12.5 to 14.0)	34.6 (32.7 to 36.5)
P for difference	—	<0.001	<0.001	<0.001	<0.001	<0.001
Cigarette smoking:						
Current non-smoker	55 958	6.2 (5.5 to 6.9)	8.7 (8.1 to 9.4)	11.4 (10.7 to 12.1)	12.9 (12.1 to 13.7)	35.0 (33.2 to 36.9)
Occasional smoker	2626	6.2 (4.6 to 8.3)	9.9 (8.6 to 11.2)	12.0 (10.9 to 13.3)	13.5 (12.2 to 14.9)	35.2 (31.5 to 39.0)
Regular smoker	17 246	6.7 (5.7 to 7.9)	10.0 (8.7 to 11.5)	11.9 (10.4 to 13.6)	13.6 (11.9 to 15.4)	34.2 (31.4 to 37.1)
P for trend	—	0.38	0.08	0.42	0.33	0.50
Family history of diabetes:						
Yes	12 348	15.3 (14.1 to 16.5)	18.6 (17.4 to 19.9)	21.6 (20.2 to 23.2)	23.3 (21.8 to 25.0)	33.2 (30.9 to 35.4)
No	63 503	4.5 (4.1 to 5.0)	7.1 (6.6 to 7.6)	9.5 (8.9 to 10.1)	11.0 (10.3 to 11.7)	35.4 (33.6 to 37.2)
P for difference	—	<0.001	<0.001	<0.001	<0.001	<0.001
Body mass index:						
<25	47 749	5.0 (4.4 to 5.7)	6.8 (6.2 to 7.5)	8.8 (8.0 to 9.6)	10.0 (9.2 to 10.9)	33.0 (31.1 to 35.0)
25 to <30	23 178	7.4 (6.7 to 8.2)	10.8 (10.0 to 11.7)	13.8 (13.0 to 14.7)	15.6 (14.7 to 16.6)	38.9 (36.6 to 41.4)
≥30	4786	9.8 (8.8 to 10.9)	15.3 (14.4 to 16.2)	20.1 (18.9 to 21.5)	23.0 (21.8 to 24.2)	43.1 (40.3 to 46.0)
P for trend	—	<0.001	<0.001	<0.001	0.03	<0.001
Waist circumference (cm):						
Men ≥90, women ≥80	41 736	7.4 (6.7 to 8.3)	11.1 (10.3 to 11.9)	14.2 (13.4 to 15.2)	16.2 (15.2 to 17.1)	38.9 (36.9 to 40.9)
Men <90, women <80	33 827	4.4 (3.8 to 5.1)	6.2 (5.5 to 7.0)	8.0 (7.2 to 8.9)	9.3 (8.3 to 10.3)	33.1 (31.2 to 35.1)
P for difference	—	<0.001	<0.001	<0.001	<0.001	<0.001

¥ 100=£12; €13; $14. Some values were missing in the total population: 989 for income, 295 for education, 50 for cigarette smoking, 29 for family history of diabetes, 167 for body mass index, and 317 for waist circumference.

In the multivariable logit models, male sex; older age; family history of diabetes; overweight and obesity; central obesity; each 10 mm Hg increase in systolic blood pressure; each 10 beats/min in heart rate; and raised total cholesterol, low density lipoprotein, and triglycerides levels were significantly associated with increased risks of total diabetes and prediabetes (table 5). Hui ethnic participants had a lower risk of total diabetes than ethnic Han participants.

Discussion

This large national survey indicated that 11.2% of adults (according to WHO criteria) or 12.8% of adults (ADA criteria including the addition of HbA_{1c}) aged 18 and older living in China had diabetes in 2017. Thus the total number of patients with diabetes in mainland China is estimated to be 129.8 million (70.4 million men and 59.4 million women).

The prevalence of diabetes continues to increase worldwide. The Non-Communicable Disease Risk Factor Collaboration reported that the age standardised prevalence of adult diabetes is 10% in men and 8.8% in women.[3] Between 1980 and 2014, the global prevalence of diabetes increased from 4.3% to 9.0% in men and from 5.0% to 7.9% in women.[3] For the increase in the number of adults with diabetes, 28.5% was attributed to the increased prevalence, 39.7% to population growth and ageing, and 31.8% to both.[3]

The trend in the prevalence of diabetes in China is the same as that worldwide. The weighted prevalence of total diabetes diagnosed by the WHO criteria has been increasing from 9.7% in 2007 and 2010, to 10.4% in 2013, and to 11.2% in this study in 2017 (supplementary table 4).[11-13] The prevalence of prediabetes was 35.2%, which was similar to the 35.7% reported in 2013 with the same ADA diagnostic criteria.[11] In this study, a venous blood was used to test for HbA_{1c}, and this method was accepted by most laboratories. These findings suggest that the prevalence of total diabetes in China maintains a trend of continuing growth without any plateau or inflection point.

Awareness, treatment, and control of diabetes

Although a continuing increase in self-reported diabetes was found, a decrease in the prevalence of newly diagnosed diabetes was noted under the same WHO diagnostic criteria (supplementary table 4), suggesting better awareness of diabetes than found in previous studies.[11-13] This improved awareness could be attributed to the concerted effort of the China National Plan for Non-Communicable Diseases Prevention and Treatment in 2013-15 and the Chinese Diabetes Society's Diabetes Prevention and Management Program (Bluelight Action) from 2010.[19] The percentage control of diabetes in the 2017 survey was improved in comparison with the 2010 survey but remained the same as in the 2013 survey, which indicates that the healthcare system needs further strengthening and improvement. Thus systematically trained community physicians with the requisite skills and expertise in diagnosis, management, and treatment of diabetes are needed to improve its control.

Age and age specific difference in the prevalence of diabetes

The prevalence of total diabetes and prediabetes was extremely high in people over 50, as was found in previous studies using the same ADA

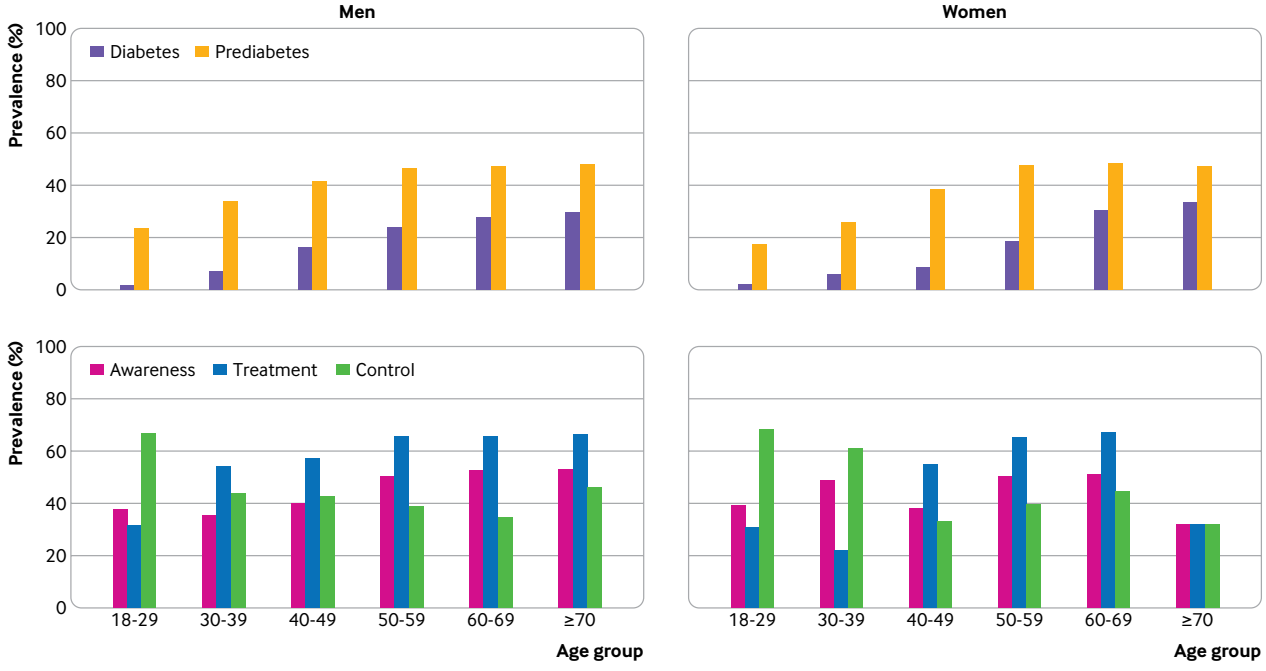

Fig 1 | Prevalence, awareness, treatment, and control of diabetes diagnosed by the American Diabetes Association criteria among study participants

diagnostic criteria.[12 13] Compared with previous data, the prevalence of total diabetes in the younger population was relatively low and decreasing, which is inconsistent with the concept that diabetes has a tendency to be greater among the young in Asia.[20] Increases in the prevalence of total diabetes, diagnosed by the WHO criteria, have resulted from an increased prevalence in those aged 40 and older, especially the

Table 4 | Age and sex standardised awareness, treatment, and control of diabetes and risk factors among adults living in mainland China

	Awareness of diabetes		Treatment of diabetes		Control of diabetes	
Variables	No of participants	% (95% CI)	No of participants	% (95% CI)	No of participants	% (95% CI)
Overall	9772	43.3 (39.2 to 47.5)	4464	49.0 (44.5 to 53.4)	2792	49.4 (39.4 to 59.4)
Sex:						
Men	5093	42.0 (35.6 to 48.7)	2316	52.6 (47.5 to 57.5)	1503	48.0 (37.1 to 59.1)
Women	4679	44.5 (41.5 to 47.6)	2148	45.3 (38.8 to 51.9)	1289	50.9 (38.8 to 62.8)
P for difference	—	0.25	—	0.10	—	0.36
Urbanisation:						
Urban	5561	47.5 (42.9 to 52.0)	2751	51.6 (46.9 to 56.2)	1746	53.9 (41.9 to 65.5)
Rural	4211	38.0 (33.1 to 43.2)	1713	45.5 (38.6 to 52.7)	1046	47.4 (42.6 to 52.2)
P for difference	—	0.02	—	0.90	—	0.003
Age group:						
18-29	344	38.4 (28.7 to 49.1)	118	31.0 (20.5 to 43.9)	38	67.7 (32.3 to 90.2)
30-39	903	41.6 (37.0 to 46.5)	355	38.1 (31.9 to 44.7)	139	52.2 (42.5 to 61.7)
40-49	1916	39.2 (34.2 to 44.4)	768	55.9 (49.1 to 62.6)	441	37.9 (31.2 to 45.0)
50-59	2549	50.1 (46.3 to 53.8)	1167	65.5 (62.4 to 68.5)	771	39.2 (34.2 to 44.6)
60-69	2317	51.8 (45.5 to 57.9)	1171	66.3 (60.6 to 71.6)	794	39.7 (36.1 to 43.4)
≥70	1743	51.8 (46.8 to 56.7)	885	64.9 (57.3 to 71.7)	609	45.5 (40.3 to 50.8)
P for trend	—	<0.001	—	0.003	—	0.03
Ethnicity:						
Han	9076	44.0 (39.8 to 48.2)	4210	49.1 (44.6 to 53.6)	2647	49.5 (39.5 to 59.6)
Tibetan	129	28.3 (14.9 to 47.2)	48	43.4 (29.4 to 58.6)	22	24.3 (24.3 to 24.3)
Uyghur	233	34.2 (28.8 to 40.1)	92	32.5 (10.3 to 66.9)	45	36.9 (32.2 to 41.8)
Hui	112	36.7 (23.7 to 51.9)	36	66.7 (53.0 to 78.0)	23	43.9 (40.9 to 47.0)
Zhuang	222	27.1 (8.5 to 59.6)	78	60.6 (40.6 to 77.6)	55	40.8 (36.4 to 45.3)
P for difference	—	0.047	—	0.86	—	0.12
Region:						
South	1003	45.4 (31.8 to 59.8)	448	46.9 (39.3 to 54.7)	219	67.0 (51.4 to 79.6)
North	1820	39.0 (33.9 to 44.5)	836	50.7 (37.6 to 63.7)	548	51.3 (44.7 to 57.8)
East	2216	41.8 (36.8 to 46.9)	1012	39.8 (33.4 to 46.5)	580	43.0 (32.3 to 54.4)
Central	952	48.6 (42.2 to 55.1)	529	49.0 (40.3 to 57.7)	355	41.3 (40.7 to 41.9)
Southwest	1374	33.2 (26.1 to 41.2)	528	46.8 (37.7 to 56.2)	355	53.3 (43.1 to 63.3)
Northwest	1451	43.8 (35.6 to 52.3)	612	58.0 (50.4 to 65.3)	408	41.0 (31.7 to 51.0)
Northeast	956	47.9 (40.3 to 55.6)	499	61.4 (49.2 to 72.3)	327	40.8 (30.9 to 51.5)
P for difference	—	0.42	—	0.29	—	0.02
Income per year (¥):						
≤30 000	4652	43.1 (38.4 to 47.9)	2089	50.7 (42.2 to 59.1)	1301	51.7 (47.6 to 55.8)
>30 000	5012	43.1 (38.4 to 47.9)	2325	49.6 (42.9 to 56.4)	1473	45.5 (37.3 to 53.9)
P for difference	—	0.59	—	0.69	—	0.12
Education:						
Less than high school	5708	44.3 (39.4 to 49.3)	2562	46.6 (42.0 to 51.2)	1669	44.7 (37.0 to 52.7)
High school and above	4018	43.9 (39.3 to 48.6)	1880	50.9 (45.8 to 56.0)	1119	54.6 (44.1 to 64.8)
P for difference	—	0.34	—	0.02	—	0.045
Cigarette smoking:						
Current non-smoker	6791	44.4 (39.6 to 49.3)	3216	51.0 (45.4 to 56.7)	2004	50.9 (39.8 to 62.0)
Occasional smoker	304	38.5 (30.8 to 46.7)	135	44.7 (37.7 to 52.1)	84	29.5 (20.5 to 40.5)
Regular smoker	2487	44.5 (34.9 to 54.5)	1105	40.4 (35.6 to 45.3)	704	42.9 (32.2 to 54.4)
P for trend	—	0.98	—	<0.001	—	0.01
Family history of diabetes:						
Yes	2623	59.3 (55.8 to 62.8)	1640	56.4 (47.9 to 64.5)	1080	49.2 (38.1 to 60.4)
No	7138	36.7 (32.6 to 41.0)	2815	43.6 (38.7 to 48.6)	1709	46.8 (39.6 to 54.1)
P for difference	—	<0.001	—	0.23	—	0.9
Body mass index:						
<25	4310	43.1 (38.0 to 48.3)	2078	51.6 (42.6 to 60.5)	1243	57.4 (51.8 to 62.9)
25 to <30	4289	45.8 (39.5 to 52.3)	1911	46.9 (40.2 to 53.8)	1245	39.7 (30.6 to 49.5)
≥30	1142	41.2 (36.8 to 45.7)	462	51.0 (43.9 to 58.1)	298	49.2 (39.7 to 58.8)
P for trend	—	0.40	—	0.93	—	0.004
Waist circumference (cm)						
Men ≥90, women ≥80	6466	44.1 (39.8 to 48.5)	2924	48.8 (42.3 to 55.3)	1869	42.3 (33.5 to 51.7)
Men <90, women <80	3250	42.3 (36.8 to 48.0)	1505	50.0 (41.3 to 58.6)	905	57.4 (49.4 to 65.0)
P for difference	—	0.54	—	0.14	—	0.44

¥ 100=£12; €13; $14. Some values were missing in the total population: 989 for income, 295 for education, 50 for cigarette smoking, 29 for family history of diabetes, 167 for body mass index, and 317 for waist circumference.

population older than 50 (supplementary table 5, supplementary fig 4).[11-13] The age specific difference might partially explain the phenomenon. Many patients with prediabetes in the younger population have more social and family responsibilities but poorer health awareness. As a result, effective lifestyle modification or medical treatments are lacking in this population. Additionally, people who remain free from diabetes and prediabetes after the age of 50 might have some advantages due to genetic, socioeconomic, and lifestyle factors, and will continue to be healthier with ageing. One study showed that prenatal exposure to famine markedly increased the risk of hyperglycaemia in two consecutive generations of adults living in China.[21] Given that the Chinese famine of 1959–61 was among the most severe on record, the affected population comprises those with a current age of 50 and older, who showed a higher prevalence of diabetes and prediabetes.[22] Whether or not prenatal exposure to famine affects diabetes remains controversial, and this needs to be investigated in future studies.[23]

Being overweight and obese

Obesity and being overweight are two important risk factors for diabetes, and changes in these factors could contribute to the changes in the prevalence of total diabetes.[24] The prevalence of obesity increased from 5.7% in the 2010 survey to 6.3% in the 2017 survey.[12] Waist circumference also increased significantly from 80.2 cm to 80.7 cm in the 2007 and 2010 surveys to 83.2 cm in the 2017 survey (no published data on the 2013 survey for waist circumference are yet available).[11 12] An increase in mean values of waist circumference, and prevalence in general overweight and obesity, and central obesity from 2007 to 2017 could contribute to an increase in the prevalence of diabetes, although we found no changes in body mass index between the 2013 and 2017 surveys (supplementary table 4). Nevertheless, obesity is still an important risk factor for diabetes.

Table 5 | Risk factors for total diabetes and prediabetes diagnosed by the American Diabetes Association criteria among adults living in mainland China. Data are odds ratio (95% confidence interval)

Variable	Total diabetes	Prediabetes
Men	1.29 (1.14 to 1.45)	1.18 (1.08 to 1.28)
Age, per 10 year increment	2.20 (2.05 to 2.36)	1.54 (1.46 to 1.61)
Urban residence	1.19 (0.87 to 1.62)	1.03 (0.75 to 1.42)
Ethnicity (reference: Han):		
Tibetan	0.58 (0.14 to 2.37)	0.93 (0.34 to 2.52)
Uyghur	0.58 (0.26 to 1.30)	0.31 (0.09 to 1.06)
Hui	0.64 (0.45 to 0.90)	1.13 (0.76 to 1.68)
Zhuang	1.37 (0.78 to 2.39)	1.19 (1.02 to 1.39)
Region (reference: South):		
North	1.24 (0.77 to 2.01)	1.31 (1.03 to 1.66)
East	1.06 (0.64 to 1.76)	1.06 (0.82 to 1.37)
Central	1.06 (0.67 to 1.69)	1.25 (1.04 to 1.50)
Southwest	1.48 (0.79 to 2.78)	1.41 (0.98 to 2.02)
Northwest	1.14 (0.72 to 1.80)	1.14 (0.91 to 1.43)
Northeast	0.74 (0.47 to 1.18)	0.83 (0.57 to 1.19)
Family history of diabetes	3.06 (2.74 to 3.42)	1.27 (1.16 to 1.39)
Less than high school education	1.11 (0.99 to 1.23)	1.08 (0.96 to 1.21)
Income ≤¥30 000 RMB a year	1.13 (1.01 to 1.27)	1.03 (0.97 to 1.10)
Current smoking	0.94 (0.85 to 1.05)	0.97 (0.90 to 1.05)
Weight:		
Overweight	1.46 (1.26 to 1.69)	1.25 (1.13 to 1.38)
Obesity	2.62 (2.30 to 2.98)	1.79 (1.56 to 2.06)
Central obesity	1.49 (1.32 to 1.69)	1.22 (1.11 to 1.35)
Systolic blood pressure per 10 mm Hg increase	1.12 (1.10 to 1.15)	1.05 (1.02 to 1.07)
Cholesterol		
Total per 1 mmol/L	1.19 (1.07 to 1.34)	1.15 (1.05 to 1.25)
Low density lipoprotein per mmol/L	1.12 (1.00 to 1.25)	1.16 (1.06 to 1.27)
High density lipoprotein per mmol/L	0.64 (0.53 to 0.78)	0.89 (0.78 to 1.01)
Triglycerides per mmol/L	1.16 (1.10 to 1.22)	1.05 (1.00 to 1.11)
Heart rate, per increase of 10 beats/min	1.21 (1.15 to 1.28)	1.13 (1.09 to 1.16)

¥ 100=£12; €13; $14.

Genetic background and geography

It is generally accepted that genetic factors significantly influence the risk of developing diabetes. Substantial differences in genetic background are present among certain ethnic groups in mainland China. This study found that the prevalence of total diabetes and prediabetes in four ethnic groups was significantly different from that in the Han ethnic group. Compared with the Han ethnic group, the Tibetan ethnic group had a significantly lower prevalence of diabetes, which was consistent with the findings of a previous study.[13] The difference might be associated with dietary patterns, altitude, economic development, and genetic factors.[25 26] A wide variation in the prevalence of diabetes and prediabetes between the Hui and Uyghur ethnic groups was found in this study. The difference might be explained by factors such as genetic variation, although the two minority groups in northwest China lived among Muslims and shared similar lifestyles.[27 28]

Among the 31 provinces of mainland China, a large variation in the prevalence of diabetes and prediabetes was found. In Inner Mongolia, the prevalence of total diabetes was three times higher than that in Guizhou province. For prediabetes, Yunnan province had the highest prevalence, being three times higher than the lowest prevalence in Anhui province. Although few differences in the prevalence of total diabetes existed between regions, a considerable variation in awareness, treatment, and control of the disease was found. This difference might be associated with genetic factors, environmental factors, dietary patterns, level of medical care, lifestyle, and economic development levels. Therefore, appropriate allocation of medical resources should be a key priority for policymakers.

Urban-rural disparity

Variations based on urbanisation were found in the prevalence of total diabetes and prediabetes, and in awareness, treatment, and control of diabetes. Although the prevalence of total diabetes continues to be higher in urban than in rural areas, without a significant difference, the gap showed a decreasing trend compared with previous data.[11-13] Compared with the national study conducted in 2013, the current prevalence of diabetes increased by 1% in urban areas but by 2.5% in rural areas under the same ADA diagnostic criteria. China has a large rural population, and sanitation is lacking, thus an increased prevalence of diabetes in rural areas will lead to increased

diabetic complications. Given the higher prevalence of prediabetes, and lower awareness, treatment, and control of diabetes, in rural populations, a large number of people are at risk of developing diabetes without the implementation of effective preventive measures.

Strengths of the study

This study had several strengths. Firstly, this nationally representative epidemiological survey provided reliable data on the prevalence of total diabetes and prediabetes in mainland China by following a strict quality assurance and control protocol. We estimated the prevalence not only by using statistical methods to weight the results but also by recruiting individuals according to the composition by age and sex of each community and the urban-rural ratio, referring to the latest national census data, which may have provided more accurate results. Secondly, a similar study design and statistical methods to those used previously make our findings more comparable with historical data. Although lacking a high quality national cohort to estimate the incidence of diabetes, our findings could add value to the assessment of diabetes epidemics in mainland China. Lastly, our study also provides provincial and regional data on prevalence using the latest diagnostic criteria for diabetes.

Limitations of the study

Our study also had some limitations. Firstly, we did not obtain information about the physical activity, dietary patterns, or alcohol consumption of participants, which reduced our ability to explore some risk factors. Secondly, using levels of 6.5% for HbA_{1c} to diagnose diabetes could be controversial since that level was set for the US population. Although geographic disparities might exist in HbA_{1c} levels, a consistent threshold was preferred across the study to enable comparison. Thirdly, owing to our study design, we could not distinguish between type 1 and type 2 diabetes. Fourthly, we did not carry out repeat testing in people with abnormal glucose values over time. We categorised one reading as being synonymous with diabetes, which may overestimate the prevalence, compared with clinical practice.[29] Lastly, non-residents, such as internal migrant workers, who account for more than a sixth of the nation's total population in China and who were more likely to have a lower prevalence of diabetes, were not included in the study owing to the study design.[30 31] These limitations could lead to an overestimation of diabetes in the population.

Conclusions and policy implications

In conclusion, the estimated prevalence of total diabetes and prediabetes diagnosed by the ADA criteria was 12.8% and 35.2%, respectively, among the Chinese population aged 18 and older between 2015 and 2017. The prevalence of total diabetes defined by the WHO criteria increased from 9.7% in 2007 to 11.2% in 2017 among adults living in China. Our findings indicate that diabetes is an important health problem in China. Continuing surveillance and effective control are needed to reduce its burden.

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We thank Gang Hu (Pennington Biomedical Research Centre) for his careful revision and guidance of this manuscript; the participants of this study. For continuous support, assistance, and cooperation, we thank Jiang He and Chung-Shiuan Chen (Tulane University); Wei Gong, Chenling Fan, Hong Wang, Hongmei Zhang, Shuangning Ding, Xiaochen Xie and Tingting Liu (First Hospital of China Medical University); Caiping Li and Jian Huangfu (Affiliated Hospital of Inner Mongolia University); Nan Jin (Chinese PLA General Hospital); Wuquan Deng, Fang Deng (Third Military Medical University); Haicheng Zhou (First Affiliated Hospital of Dalian Medical University); Qingling Lu (Cardiovascular and Cerebrovascular Disease Hospital of Ningxia Medical University); Yunfeng Shen (Second Affiliated Hospital of Nanchang University); Guodong Liu (First Affiliated Hospital of Harbin Medical University); Junxiu Hou and Zhiqiang Zhang (Affiliated Hospital of Inner Mongolia Medical University); Hong Zhang (Second Xiangya Hospital); Xiaodong Mao, Qifeng Wang and Kun Wang (Nanjing University of Chinese Medicine); Yanping Wang (Fujian Medical University Union Hospital); Xiaojun Ma (First Affiliated Hospital of Zhengzhou University); Liheng Meng (First Affiliated Hospital of Guangxi Medical University); Weihua Linle and Tuanyu Fang (Hainan General Hospital); Xingjun Liu and Yanru Zhao (First Affiliated Hospital of Xi'an Jiaotong University); Lulu Chen, Jiaoyue Zhang and Hanyu Wang (Huazhong University of Science and Technology); Jingfang Liu and Songbo Fu (First Hospital of Lanzhou University); Qingguo Lv (West China Hospital); Chenglin Sun (First Hospital of Jilin University); Qiuming Yao and Ronghua Song (Shanghai University of Medicine and Health Science Affiliated Zhoupu Hospital); Tingting Chen (First Hospital of An Hui Medical University); Ben Niu (First People's Hospital of Yunnan province); Mingtong Xu and Feng Li (Sun Yat-sen Memorial Hospital); Lizhen Lan (First Hospital of Shanxi Medical University); Jun Yue and Jia Song (People's Hospital of Tibet Autonomous Region); Yanan Li and Wei Luo (Qinghai Provincial People's Hospital); Xiaoming Lou and Zhe Mo (Zhejiang Provincial Centre for Disease Control and Prevention); Nianchun Peng and Lixin Shi (Affiliated Hospital of Guiyang Medical University); Mian Wang, Qiuxiao Zhu and Lingling Yuan (Second Hospital of Hebei Medical University); Haiqing Zhang (Shandong Provincial Hospital affiliated with Shandong University); Yong Fan (First Affiliated Hospital of Xinjiang Medical University); Hongyan Wei (Tianjin Medical University General Hospital).

Contributors: YZL, DT, XS, GQ, YQ, HQ, BS, and HS contributed equally to the paper. ZS and WT are joint corresponding authors. ZS, WT, YZL, GQ, YQ, HQ, BS, HS, DT, and XS conceived and designed the study. ZS and WT supervised the study. ZS, WT, and YZL performed the statistical analysis. YZL, DT, XS, GQ, YQ, HQ, BS, HS, JB, BC, JD, LH, XL, YBL, HC, EL, CL, LL, XT, NT, GW, JAZ, YW, YX, LY, JY, LHY, YY, ZY, QZ, LZ, JZ, MZ, JJZ, GN, and YM conducted the epidemiological survey. All authors contributed to acquisition, analysis, or interpretation of data. ZS, WT and YZL drafted the manuscript. All authors revised the report and approved the final version before submission. ZS and WT are the guarantors and attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Funding: This work is supported by the Clinical Research Fund of the Chinese Medical Association (grant No 15010010589). The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or the writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: funding for the project through a grant (15010010589) from the Chinese Medical Association; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: This study was approved by the medical ethics committee of China Medical University (2014-103-2).

Patient consent: All participants provided written informed consent after a thorough explanation of the research procedures.

Data sharing: No additional data available.

The lead authors (ZS and WT) affirm that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Dissemination to participants and related patient and public communities: The results of this research were reported in newsletters for study participants, and public lectures about disease prevention have been provided based on the results.

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Web appendix: Supplementary appendix