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Prevalence and Ethnic Pattern of Diabetes and Prediabetes in China in 2013

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IMPORTANCE Previous studies have shown increasing prevalence of diabetes in China, which now has the world's largest diabetes epidemic.

OBJECTIVES To estimate the recent prevalence and to investigate the ethnic variation of diabetes and prediabetes in the Chinese adult population.

DESIGN, SETTING, AND PARTICIPANTS A nationally representative cross-sectional survey in 2013 in mainland China, which consisted of 170 287 participants.

EXPOSURES Fasting plasma glucose and hemoglobin A_{1c} levels were measured for all participants. A 2-hour oral glucose tolerance test was conducted for all participants without diagnosed diabetes.

MAIN OUTCOMES AND MEASURES Primary outcomes were total diabetes and prediabetes defined according to the 2010 American Diabetes Association criteria. Awareness and treatment were also evaluated. Hemoglobin A_{1c} concentration of less than 7.0% among treated diabetes patients was considered adequate glycemic control. Minority ethnic groups in China with at least 1000 participants (Tibetan, Zhuang, Manchu, Uyghur, and Muslim) were compared with Han participants.

RESULTS Among the Chinese adult population, the estimated standardized prevalence of total diagnosed and undiagnosed diabetes was 10.9% (95% CI, 10.4%-11.5%); that of diagnosed diabetes, 4.0% (95% CI, 3.6%-4.3%); and that of prediabetes, 35.7% (95% CI, 34.1%-37.4%). Among persons with diabetes, 36.5% (95% CI, 34.3%-38.6%) were aware of their diagnosis and 32.2% (95% CI, 30.1%-34.2%) were treated; 49.2% (95% CI, 46.9%-51.5%) of patients treated had adequate glycemic control. Tibetan and Muslim Chinese had significantly lower crude prevalence of diabetes than Han participants (14.7% [95% CI, 14.6%-14.9%] for Han, 4.3% [95% CI, 3.5%-5.0%] for Tibetan, and 10.6% [95% CI, 9.3%-11.9%] for Muslim; $P < .001$ for Tibetan and Muslim compared with Han). In the multivariable logistic models, the adjusted odds ratios compared with Han participants were 0.42 (95% CI, 0.35-0.50) for diabetes and 0.77 (95% CI, 0.71-0.84) for prediabetes for Tibetan Chinese and 0.73 (95% CI, 0.63-0.85) for diabetes and 0.78 (95% CI, 0.71-0.86) for prediabetes in Muslim Chinese.

CONCLUSIONS AND RELEVANCE Among adults in China, the estimated overall prevalence of diabetes was 10.9%, and that for prediabetes was 35.7%. Differences from previous estimates for 2010 may be due to an alternate method of measuring hemoglobin A_{1c}.

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Supplemental content

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China has the world's largest diabetes epidemic, which continues to increase.[1] The prevalence of diabetes in China was reported to be 0.67% in 1980 and 11.6% in the latest published nationwide estimate in 2010.[2-5] Moreover, according to the 2010 survey, the prevalence of prediabetes was 50.1%, implying that approximately 500 million Chinese adults may have had prediabetes.[5] However, this high estimate for prediabetes raised concern over the possibility of an overestimation.[6,7] As a disorder of glucose metabolism, diabetes mellitus affects multiple organ systems and is associated with a variety of vascular and several nonvascular complications.[8-10] Ongoing reliable estimations are needed to plan effective national prevention and treatment programs for diabetes management.

In addition, although a few epidemiologic studies were available to estimate the prevalence of diabetes among different ethnic groups in China, the data were from different studies conducted at different times.[11-13] Direct comparison under a consistent survey design is therefore of importance for policy making for diabetes management in Chinese minorities.[14]

This study was conducted to provide more recent estimates of the prevalence of diabetes and prediabetes in China and to investigate their ethnic pattern, using a nationally representative survey conducted in 2013.

Key Points

Question What is the prevalence of diabetes and prediabetes in China?

Findings In this nationally representative cross-sectional survey conducted in 2013 in mainland China with 170 287 participants, the estimated overall prevalence of total diabetes was 10.9%; of prediabetes, 35.7%. Tibetan and Muslim Chinese individuals had significantly lower prevalence of diabetes than Han participants.

Meaning The estimated prevalence of diabetes and prediabetes in China differs by ethnic group, and the estimated overall high prevalence may be associated with different methods of measuring hemoglobin A_{1c}.

Methods

The China Chronic Disease and Risk Factors Surveillance study is a nationwide cross-sectional study conducted every 3 years. The study was designed to measure the epidemiology of chronic disease and associated risk factors by selecting a nationally representative sample of the general population.[5,15,16] In the 2013 survey, an integrated national mortality surveillance system was used to provide a nationally and provincially representative survey of the country.[17] This new system increased the number of surveillance points from 161 to 605 to cover major geographic areas of all 31 provinces, autonomous regions, and municipalities in mainland China, and enlarged the surveillance population covered from 6% to 24% of the Chinese population. The first level of sampling was stratified by 31 provinces. Within each province, 8 strata were then generated according to the overall population size (high/low), proportion of urban population (high/low), and mortality rate (high/low). A total of 298 surveillance points were used. The complex multistage sampling design, stringent quality assurance, and quality control program were previously reported.[5,16] Participants (179 347) were enrolled in the survey from 1176 rural townships or urban subdistricts. The overall response rate with the standard definition by the American Association for Public Opinion Research was 93.4% (the cooperation rate was 96.2% and the refusal rate was 2.7%) (eTable 1 in the Supplement).[18] Overall, 6.25% of the sampled families could not be accessed during 3 attempts made on 3 days. These households were replaced by another household with a similar family structure in the same village or residential area (eTable 2 in Supplement). Only persons who had been living in their current residence for at least 6 months within 1 year before the survey and were aged 18 years or older were eligible for the survey. Exclusion criteria were communal residences (eg, university dormitory, military unit, nursing home); patients with severe diseases or having cognitive, language, or mental disorders who could not participate in the interview; and pregnancy. Additionally, we restricted the analytic sample to participants with complete information on major risk factors (ie, age, sex, location, economic development level, body mass index [BMI], and history of diabetes or glycemia markers). This analysis included 170 287 participants (94.9% of those enrolled); 9060 participants were excluded because of missing information on major risk factors.

The study protocol was approved by the ethical review committee of the Chinese Center for Disease Control and Prevention and other participating institutes. Written informed consent was obtained from all study participants.

Data Collection for the Nationwide Cross-sectional Study

A comprehensive questionnaire including information on demographic characteristics, medical history, and lifestyle risk factors was administered by trained interviewers. Staff at local health stations or community clinics in the participants' residential area were trained according to a standard protocol. Information on the ethnic groups of participants was self-reported but cross-checked with participants' national identification. There are 56 ethnic groups in China. The 10 largest ones were listed in the questionnaire and others were collected by open-ended questions. Analyses by ethnic groups were restricted to those with at least 1000 participants, resulting in inclusion of Tibetan (Zang), Zhuang, Manchu (Man), Uyghur (Wei), and Muslim (Hui) ethnic groups. Each surveillance point was categorized into underdeveloped, intermediately developed, or developed according to the region's gross domestic product per capita in 2013. Blood samples were collected for all participants after an overnight fast of at least 10 hours. Serum samples and measurements of fasting plasma glucose level and 2-hour plasma glucose level after 75 g glucose were managed under the same procedure used in the 2010 survey, as reported previously.[5] In contrast, to overcome limitations in the calculated level of venous hemoglobin A_{1c} (HbA_{1c}) used previously, HbA_{1c} was directly measured from venous blood samples in the 2013 survey in a single laboratory using quantitative high-performance liquid chromatography and the boronate affinity method (Bio-Rad D-10 Hemoglobin Analyzer). Venous blood samples were stored at -80°C until HbA_{1c} was measured within 1 month, which is within the range of stability according to the

Table 1. General Characteristics of the Chinese Adult Population in 2013 (Weighted Data)

	Overall (N = 170 287)	Sex		Age Groups, in Years			Economic Levels[a]		
		Women (n = 97 551)	Men (n = 72 736)	<40 (n = 35 466)	40-59 (n = 85 279)	≥60 (n = 49 542)	Underdeveloped (n = 47 683)	Intermediately Developed (n = 48 111)	Developed (n = 74 493)
Age at survey, mean (SD), y	43.5 (16.2)	43.7 (16.3)	43.3 (16.0)	29.2 (6.4)	49.0 (5.7)	69.7 (7.1)	42.6 (15.7)	43.6 (16.0)	43.8 (16.4)
Smoker, No. (%) [95% CI]	41 515 (27.5) [26.7-28.2]	2906 (2.3) [1.9-2.6]	38 609 (52.2) [50.8-53.5]	8584 (25.9) [24.8-27.0]	21 302 (30.5) [29.8-31.2]	11 629 (24.7) [23.6-25.8]	11 683 (28.9) [27.6-30.2]	12 189 (28.7) [27.0-30.3]	17 643 (26.3) [25.4-27.2]
Systolic blood pressure, mean (SD), mm Hg	127.85 (20.00)	125.78 (21.37)	129.89 (18.33)	120.53 (15.93)	130.22 (19.18)	142.14 (22.38)	127.18 (19.95)	127.05 (20.07)	128.51 (19.96)
BMI, mean (SD)	24.0 (3.72)	24.0 (3.79)	24.1 (3.65)	23.5 (3.84)	24.7 (3.49)	23.9 (3.65)	23.8 (3.71)	23.8 (3.64)	24.2 (3.75)
Obese (BMI ≥30), No. (%) [95% CI]	11 430 (6.4) [6.0-6.7]	7195 (6.1) [5.7-6.6]	4235 (6.6) [6.2-7.0]	2221 (6.0) [5.5-6.5]	6292 (7.3) [6.9-7.6]	2917 (5.5) [5.0-6.0]	2889 (5.8) [5.2-6.5]	2739 (5.4) [4.9-5.9]	5802 (7.1) [6.5-7.6]
Education, junior high school or higher, No. (%) [95% CI]	88 034 (63.7) [61.8-65.6]	44 357 (56.7) [54.5-59.0]	43 677 (70.4) [68.8-72.1]	26 854 (81.9) [80.3-83.6]	47 027 (58.7) [56.7-60.8]	14 153 (25.7) [23.1-28.4]	22 053 (57.8) [54.5-61.2]	24 434 (62.1) [59.0-65.2]	41 547 (66.5) [63.6-69.4]
Physical activity, mean (SD) MET min/wk	5711 (6887)	4877 (5527)	6529 (7916)	5308 (6627)	6786 (7588)	4420 (5465)	6475 (7269)	5784 (6645)	5405 (6853)
Nondrinker (alcohol), No. (%) [95% CI]	115 147 (62.7) [60.9-65.6]	83 004 (84.4) [82.7-86.0]	32 143 (41.3) [39.4-43.2]	22 426 (60.8) [58.3-63.3]	56 441 (60.8) [59.5-62.2]	36 280 (71.6) [70.5-72.8]	32 075 (64.9) [62.0-67.7]	32 235 (61.9) [59.5-64.2]	50 837 (62.3) [59.5-65.1]
Dietary intake, median (IQR), g/d									
Meat	85.7 (38.8-159.5)	68.7 (51.2-185.7)	104.8 (29.7-133.4)	101.9 (50.0-178.6)	84.8 (38.0-157.1)	55.0 (21.3-113.3)	73.4 (30.0-150.0)	91.8 (43.8-164.3)	86.0 (39.9-160.5)
Vegetables	300 (200-500)	300 (200-500)	300 (200-450)	300 (200-450)	300 (200-500)	300 (200-450)	300 (200-450)	300 (200-500)	300 (200-500)
Fruit	57.1 (16.7-150.0)	71.4 (14.3-114.3)	50.0 (21.4-150.0)	85.7 (28.6-150.0)	50.0 (14.3-142.9)	28.6 (6.7- 100.0)	50.0 (14.3-114.3)	50.0 (14.3- 142.9)	64.3 (21.4-150.0)
Laboratory findings, mean (SD)									
Total cholesterol, mg/dL	181.6 (39.1)	181.1 (39.4)	182.1 (38.9)	172.7 (37.5)	187.7 (38.5)	192.0 (39.4)	176.3 (39.0)	180.4 (38.6)	184.1 (39.2)
HDL cholesterol, mg/dL	52.3 (14.9)	54.5 (14.4)	50.0 (15.0)	51.5 (14.0)	52.2 (15.2)	54.5 (16.0)	51.2 (14.7)	52.0 (14.8)	52.8 (14.9)
Fasting plasma glucose, mg/dL	100.5 (26.1)	99.8 (25.0)	101.4 (27.0)	96.2 (21.1)	103.2 (28.8)	106.3 (29.4)	98.9 (26.3)	100.5 (25.9)	101.3 (25.9)
2-h Plasma glucose, mg/dL	114.2 (44.0)	115.5 (42.2)	113.0 (45.6)	106.7 (36.2)	116.6 (46.8)	130.1 (51.7)	109.4 (42.5)	115.5 (43.8)	115.1 (44.3)
HbA_{1c}, %	5.38 (0.83)	5.38 (0.83)	5.38 (0.84)	5.19 (0.66)	5.47 (0.90)	5.68 (0.96)	5.36 (0.81)	5.35 (0.82)	5.40 (0.85)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); HbA_{1c}, hemoglobin A_{1c}; HDL, high-density lipoprotein; IQR, interquartile range (25th-75th percentiles); MET, metabolic equivalent.

SI Conversions: To convert cholesterol, multiply values by 0.0259; to convert glucose, multiply by 0.0555.

[a] Economic levels were categorized into underdeveloped, intermediately developed, or developed according to the surveillance point regions' gross domestic product per capita in 2013.

Table 2. Weighted Prevalence of Diabetes and Prediabetes Among Chinese Adults in 2013[a]

		% (95% CI)				
	No. of Participants	Total Diabetes	Diagnosed Diabetes	Undiagnosed Diabetes Based on FPG, 2-Hour PG, and HbA_{1c}	Diabetes Based on Information With Diagnosed Diabetes, FPG, and PG	Prediabetes
Overall	170 287	10.9 (10.4-11.5)	4.0 (3.6-4.3)	6.9 (6.7-7.2)	10.4 (9.8-10.9)	35.7 (34.1-37.4)
Age groups, y						
<40	35 466	5.9 (5.1-6.6)	1.3 (1.0-1.7)	4.5 (4.1-4.9)	5.4 (4.7-6.0)	28.8 (26.8-30.9)
40-59	85 279	12.9 (12.3-13.5)	5.0 (4.7-5.4)	7.8 (7.5-8.1)	12.3 (11.7-12.9)	39.5 (37.8-41.2)
≥60	49 542	20.2 (19.1-21.2)	8.8 (8.0-9.5)	11.4 (10.8-12.0)	19.4 (18.3-20.4)	45.8 (44.3-47.2)
Sex						
Women	97 551	10.2 (9.7-10.7)	4.1 (3.7-4.4)	6.1 (5.9-6.4)	9.6 (9.1-10.1)	35.0 (33.4-36.7)
Men	72 736	11.7 (10.9-12.4)	3.9 (3.5-4.3)	7.7 (7.4-8.1)	11.1 (10.4-11.7)	36.4 (34.6-38.2)
Location						
Urban	78 317	12.6 (11.7-13.6)	5.4 (4.8-6.1)	7.1 (6.8-7.5)	12.0 (11.1-13.0)	34.3 (32.3-36.3)
Rural	91 970	9.5 (9.0-10.1)	2.8 (2.5-3.0)	6.8 (6.4-7.1)	8.9 (8.4-9.5)	37.0 (35.0-38.9)
Economic development						
Underdeveloped	47 683	9.6 (8.3-10.8)	3.2 (2.6-3.8)	6.3 (5.9-6.8)	9.0 (7.7-10.3)	34.3 (31.1-37.5)
Intermediately developed	48 111	10.2 (9.4-10.9)	3.5 (3.0-3.9)	6.7 (6.3-7.1)	9.7 (8.9-10.5)	36.2 (33.1-39.3)
Developed	74 493	11.8 (11.0-12.7)	4.5 (4.0-5.1)	7.3 (6.9-7.6)	11.2 (10.4-12.0)	36.0 (33.7-38.3)
BMI						
<25 (Normal)	103 072	7.8 (7.3-8.4)	2.8 (2.5-3.1)	5.0 (4.8-5.3)	7.4 (6.9-7.9)	32.6 (30.8-34.4)
25-<30 (Overweight)	55 785	15.4 (14.6-16.2)	5.8 (5.3-6.3)	9.5 (9.0-10.0)	14.7 (13.9-15.4)	40.7 (38.9-42.4)
≥30 (Obese)	11 430	21.1 (19.5-22.7)	7.2 (6.0-8.3)	13.9 (12.8-15.0)	19.6 (18.0-21.2)	43.6 (41.5-45.6)
BMI (Asian-specific cutoffs)						
<23 (Normal)	65 829	6.4 (5.8-7.0)	2.3 (1.9-2.6)	4.1 (3.7-4.6)	6.0 (5.5-6.6)	30.7 (28.7-32.7)
23-<25 (Overweight)	37 243	10.8 (10.1-11.5)	3.9 (3.6-4.3)	6.8 (6.2-7.4)	10.2 (9.5-10.8)	36.5 (34.8-38.3)
≥25 (Obese)	67 215	16.4 (15.5-17.2)	6.1 (5.5-6.6)	10.3 (9.7-10.8)	15.5 (14.7-16.3)	41.2 (39.5-42.8)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); FPG, fasting plasma glucose; HbA_{1c}, hemoglobin A_{1c}; PG, plasma glucose.

[a] Weighted prevalence to be representative of the Chinese population was calculated. Diagnosed diabetes was defined as a self-reported previous diagnosis by health care professionals. Total diabetes included persons with diagnosed and undiagnosed diabetes. Undiagnosed diabetes was defined according to the American Diabetes Association 2010 criteria, which included diagnosis of diabetes with an FPG level of 126 mg/dL or greater, 2-hour PG level of 200 mg/dL or greater (after 75 g glucose), or HbA_{1c} level of 6.5% or higher. Diabetes based on information with diagnosed diabetes, FPG level, and 2-hour PG level corresponded to the 1999 World Health Organization criteria. Prediabetes was defined as any participants who did not have diabetes but who had an HbA_{1c} level of 5.7% to 6.4%, FPG level of 100 to 125 mg/dL, or 2-hour PG level of 140 to 199 mg/dL. Economic levels were categorized into underdeveloped, intermediately developed, or developed according to the surveillance point regions' gross domestic product per capita in 2013.

manufacturer's instructions. Detailed information related to the HbA_{1c} assay method and quality control is described in the eAppendix in the Supplement.

Outcomes

Diagnosed diabetes was defined as a self-reported diagnosis that was determined previously by a health care professional. Undiagnosed diabetes was defined according to the American Diabetes Association 2010 criteria, which included fasting plasma glucose level of 126 mg/dL or greater, 2-hour plasma glucose level of 200 mg/dL or greater (after 75 g glucose), or HbA_{1c} level of 6.5% or higher. Total diabetes was the sum of the number of patients who received a diagnosis of diabetes and the number of patients with undiagnosed diabetes. Prediabetes was defined as any participants who did not have diabetes but who had an HbA_{1c} level of 5.7% to 6.4%, fasting plasma glucose level of 100 to 125 mg/dL, or 2-hour plasma glucose level of 140 to 199 mg/dL. Awareness was defined as the proportion of individuals with physician-diagnosed diabetes among all patients with diabetes. Treatment was defined as the proportion of individuals receiving diabetes medications among all patients with diabetes. 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

Standardized prevalence was estimated in the overall population and in subgroups of sex, age, location (urban/rural), stages of economic development, and categories of BMI in the Chinese adult population. The subgroup variables were selected before the analyses were conducted. Standardized prevalence was calculated unless stated otherwise, using the weight coefficients to represent the overall Chinese adult population aged 18 years or older. Weight coefficients accommodated the sampling scheme for unequal probabilities of sample selection, as well as the poststratification weights, which harmonized the sample structure of the survey with that of the 2010 Chinese population census. For the analyses of ethnic variation, unweighted estimations are presented because ethnicity was not considered in the multistage sampling design. The χ^2 test was used to compare crude prevalences. A number of participants (9060) were excluded from the analyses

Table 3. Weighted Awareness, Treatment, and Control of Diabetes Among Chinese Adults in 2013[a]

	Awareness of Diabetes		Treatment of Diabetes		Control of Diabetes	
	No. of Cases/ Participants	% (95% CI)	No. of Cases/ Participants	% (95% CI)	No. of Cases/ Participants	% (95% CI)
Overall	10 216/24 174	36.5 (34.3-38.6)	9048/24 174	32.2 (30.1-34.2)	4515/8995	49.2 (46.9-51.5)
Age groups, y						
<40	497/2013	22.8 (18.6-26.9)	430/2013	20.0 (16.4-23.5)	219/426	56.0 (48.7-63.3)
40-59	4683/11 403	39.0 (37.2-40.9)	4145/11 403	34.5 (32.7-36.4)	1977/4123	47.0 (44.3-49.6)
≥60	5036/10 758	43.5 (41.1-45.9)	4473/10 758	38.4 (36.0-40.8)	2319/4446	49.3 (46.4-52.1)
Sex						
Women	6083/13 430	39.8 (37.5-42.2)	5369/13 430	35.3 (33.0-37.6)	2552/5338	48.5 (45.7-51.3)
Men	4133/10 744	33.5 (31.2-35.9)	3679/10 744	29.5 (27.4-31.6)	1863/3657	49.9 (47.1-52.7)
Location						
Urban	6483/13 441	43.1 (40.3-45.8)	5867/13 441	38.4 (35.8-41.0)	3143/5835	53.3 (50.3-56.2)
Rural	3733/10 733	29.1 (26.9-31.3)	3181/10 733	25.2 (23.3-27.1)	1372/3160	42.3 (39.3-45.3)
Economic development						
Underdeveloped	2196/5436	33.5 (28.4-38.5)	1926/5436	29.3 (25.1-33.6)	933/1906	47.9 (42.5-53.3)
Intermediately developed	2581/6518	34.1 (30.5-37.6)	2340/6518	31.0 (27.6-34.4)	1139/2323	47.6 (44.2-50.9)
Developed	5439/12 220	38.4 (35.3-41.4)	4782/12 220	33.5 (30.6-36.4)	2443/4766	50.2 (46.9-53.4)
BMI						
<25 (Normal)	4523/10 827	35.8 (33.1-38.6)	3988/10 827	31.3 (28.9-33.7)	2012/3962	49.7 (46.7-52.7)
25-<30 (Overweight)	4546/10 434	37.8 (35.6-40.0)	4052/10 434	33.8 (31.6-36.0)	2019/4030	49.1 (46.4-51.8)
≥30 (Obese)	1147/2913	34.0 (30.3-37.8)	1008/2913	29.8 (26.3-33.4)	484/1003	47.5 (41.6-53.4)
BMI (Asian-specific cutoffs)						
<23 (Normal)	2332/5867	35.4 (31.6-39.1)	2043/5867	30.5 (27.4-33.5)	1028/2026	50.6 (46.2-55.0)
23-<25 (Overweight)	2191/4960	36.5 (33.6-39.3)	1945/4960	32.3 (29.6-35.1)	984/1936	49.3 (46.0-52.7)
≥25 (Obese)	5693/13 347	37.0 (34.7-39.2)	5060/13 347	32.9 (30.7-35.0)	2503/5033	49.0 (46.4-51.6)

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] Awareness was defined as the proportion of individuals with a self-reported history of physician-diagnosed diabetes among all patients with total diabetes. Treatment was defined as the proportion of individuals receiving diabetes medications among all patients with diabetes. The analytic sample for awareness and treatment was all patients with diabetes (ie, column 3 in Table 2). Control was defined as the proportion of individuals with an HbA_{1c} concentration of less than 7.0% among patients with diabetes who were treated. The analytic sample for control was all patients with diabetes who were treated (ie, column 4) minus 53 patients with diabetes under treatment who had missing information on HbA_{1c} and therefore were excluded for the calculation of control of diabetes.

because of missing important information. Multivariable logistic regression was used to examine the association of ethnic groups with the odds of diabetes and prediabetes. Five models with progressively increased adjustment of risk factors were applied. All *P* values were 2-tailed and were adjusted for multiple testing, and 95% CI was used. $P < .05$ was the threshold for statistical significance. All statistical analyses were conducted with SAS version 9.4 and Stata version 14.1.

Results

Prevalence and Control of Diabetes in Chinese Adults

Data were available for 170 287 participants aged 18 years or older (**Table 1**). The basic characteristics of participants included and excluded in the analyses are presented in eTable 3 in the Supplement, which demonstrate similar age, sex, and BMI, with a higher prevalence of lower educational status and a higher activity level in the included group. The mean age at baseline was 43.5 years (SD 16.2), BMI was 24.0, and 57% were women. The mean fasting plasma glucose level was 100.5 mg/dL, and the 2-hour plasma glucose level was 114.2 mg/dL, similar to those in the 2010 China Chronic Disease and Risk Factors Surveillance study, whereas the mean HbA_{1c} levels decreased from 5.8% in 2010 to 5.38% in 2013 ($P < .001$). The overall standardized prevalence of total diabetes in Chinese adults was estimated as 10.9% (95% CI, 10.4%-11.5%), with 10.2% (95% CI, 9.7%-10.7%) in women and 11.7% (95% CI, 10.9%-12.4%) in men (**Table 2**). Four percent (95% CI, 3.6%-4.3%) of Chinese adults had previously received a diagnosis of diabetes; 6.9% (95% CI, 6.7%-7.2%) of the population had received a new diagnosis by glycemic biomarkers (ie, fasting plasma glucose, 2-hour plasma glucose, and HbA_{1c} levels). Hemoglobin A_{1c} concentration added an additional 0.5% to the total diabetes group beyond those previously receiving a diagnosis of diabetes or through traditional glycemic biomarkers. The prevalence of diabetes was higher in the older population ($P < .001$), men ($P < .001$), urban residents ($P < .001$), participants living in economically developed areas ($P = .003$), and overweight and obese participants ($P < .001$). Prevalence estimates were also higher in overweight and obese participants when Asian-specific BMI cutoffs were used ($P < .001$) (Table 2).

The estimated prevalence of prediabetes was 35.7% (95% CI, 34.1%-37.4%) in the overall population, 35.0% (95% CI, 33.4%-36.7%) in women and 36.4% (95% CI, 34.6%-38.2%) in men. The prevalence of prediabetes was higher in the older population ($P < .001$; men, $P = .008$) and overweight and obese participants ($P < .001$), particularly with Asian-specific cutoffs ($P < .001$). Prediabetes was more prevalent in rural residents than in urban residents ($P = .02$) (Table 2).

Table 4. Unweighted Prevalence of Diabetes by Ethnic Group

	Overall	*P* Value vs Han Ethnicity	Age Groups, in Years			Sex	
			<40	40-59	≥60	Men	Women
Chinese Han							
No. of cases/ participants	22 220/150 766		1767/29 785	10 398/75 618	10 055/45 363	9758/64 012	12 462/86 754
Prevalence, % (95% CI)	14.7 (14.6-14.9)		5.9 (5.7-6.2)	13.8 (13.5-14.0)	22.2 (21.8-22.5)	15.2 (15.0-15.5)[a]	14.4 (14.1-14.6)
Tibetan (Zang)							
No. of cases/ participants	132/3103		22/1151	95/1652	15/300	62/1328	70/1775
Prevalence, % (95% CI)	4.3 (3.5-5.0)	<.001	1.9 (1.1-2.7)[b]	5.8 (4.6-6.9)[b]	5.0 (2.5-7.5)[b]	4.7 (3.5-5.8)	3.9 (3.0-4.8)
Zhuang							
No. of cases/ participants	250/2081		24/368	115/1038	111/675	117/798	133/1283
Prevalence, % (95% CI)	12.0 (10.6-13.4)	<.001	6.5 (4.0-9.1)	11.1 (9.2-13.0)[b]	16.4 (13.6-19.2)[b]	14.7 (12.2-17.1)[a]	10.4 (8.7-12.0)
Manchu (Man)							
No. of cases/ participants	315/2106		33/429	179/1211	103/466	141/893	174/1213
Prevalence, % (95% CI)	15.0 (13.4-16.5)	.78	7.7 (5.2-10.2)	14.8 (12.8-16.8)	22.1 (18.3-25.9)	15.8 (13.4-18.2)	14.3 (12.4-16.3)
Uyghur (Wei)							
No. of cases/ participants	236/1929		37/743	109/779	90/407	119/1029	117/900
Prevalence, % (95% CI)	12.2 (10.8-13.7)	.002	5.0 (3.4-6.5)	14.0 (11.6-16.4)	22.1 (18.1-26.2)	11.6 (9.6-13.5)	13.0 (10.8-15.2)
Muslim (Hui)							
No. of cases/ participants	221/2085		16/620	112/981	93/484	106/990	115/1095
Prevalence, % (95% CI)	10.6 (9.3-11.9)	<.001	2.6 (1.3-3.8)[b]	11.4 (9.4-13.4)[b]	19.2 (15.7-22.7)	10.7 (8.8-12.6)	10.5 (8.7-12.3)

[a] *P* < .001 in Chinese Han; *P* = .003 in Zhuang.

[b] *P* < .001 for Tibetan vs Han in those aged < 40, 40-60, ≥60 years; *P* = .01 and <.001 for Zhuang vs Han in those aged 40-60 and ≥60 years, respectively; *P* < .001 and .03 for Muslim vs Han in those aged < 40 and 40-60 years, respectively.

The overall proportion of patients who were aware of their diabetes condition was 36.5% (95% CI, 34.3%-38.6%) (**Table 3**). The proportion of women who were aware of their diabetes condition was 39.8% (95% CI, 37.5%-42.2%), and of men it was 33.5% (95% CI, 31.2%-35.9%); 32.2% (95% CI, 30.1%-34.2%) of all patients with diabetes were receiving antidiabetic medication. Among patients treated, 49.2% (95% CI, 46.9%-51.5%) had HbA_{1c} levels controlled to a concentration of less than 7.0%.

The proportion of patients who were aware of their diabetes and treated for it was higher in the older population (*P* < .001 for both), women (*P* < .001 for both), and urban residents (*P* < .001 for both). The proportion of patients who controlled their HbA_{1c} levels well was higher in younger individuals (*P* = .03) and in urban residents (*P* < .001), but broadly similar across sex, BMI categories, and economic development conditions. The characteristics of treated diabetes patients with and without adequate glycemic control were also compared (eTable 4 in the Supplement). Of patients without adequate glycemic control, a higher percentage received insulin treatment.

Ethnic Variation

Compared with Han participants, whose crude diabetes prevalence was 14.7% (95% CI, 14.6%-14.9%), the crude prevalence of total diabetes was lower among major minority ethnic groups, except for Manchu participants (**Table 4**). Tibetan and Muslim adults had the lowest and second lowest prevalence of total diabetes (4.3% [95% CI, 3.5%-5.0%] vs 10.6% [95% CI, 9.3%-11.9%]; both *P* < .001 compared with Han participants).

For prediabetes, Tibetan and Muslim adults had a similar crude prevalence that was significantly lower than that of Han participants (31.3% [95% CI, 29.7%-32.9%] for Tibetan, 31.9% [95% CI, 29.9%-33.9%] for Muslim, and 38.8% [95% CI, 38.5%-39.0%] for Han; Tibetan and Muslim *P* < .001 compared with Han) (**Table 5**). Manchu participants had a significantly higher prevalence of prediabetes than did Chinese Han (43.4% [95% CI, 41.3%-45.5%]; *P* < .001).

In the multivariable logistic models for diabetes, the age- and sex-adjusted odds ratio for Tibetan Chinese was 0.34 (95% CI, 0.29-0.41); for Muslim Chinese, 0.76 (95% CI, 0.66-0.88) (**Table 6**). In the fully adjusted multivariable logistic models, the adjusted odds ratios compared with Han participants were 0.42 (95% CI, 0.35-0.50) for diabetes and 0.77 (95% CI, 0.71-0.84) for prediabetes for Tibetan Chinese and 0.73 (95% CI, 0.63-0.85) for diabetes and 0.78 (95% CI, 0.71-0.86) for prediabetes for Muslim Chinese.

Discussion

In this large, nationally representative survey of Chinese adults in 2013, it was estimated that 10.9% of Chinese adults have

Table 5. Unweighted Prevalence of Prediabetes by Ethnic Group

	Overall	P Value vs Han Ethnicity	Age Groups, in Years			Sex	
			<40	40-59	≥60	Men	Women
Chinese Han							
No. of cases/ participants	58 468/150 766		8700/29 785	29 604/75 618	20 164/45 363	25 005/64 012	33 463/86 754
Prevalence, % (95% CI)	38.8 (38.5-39.0)		29.2 (28.7-29.7)	39.1 (38.8-39.5)	44.5 (44.0-44.9)	39.1 (38.7-39.4)[a]	38.6 (38.2-38.9)
Tibetan (Zang)							
No. of cases/ participants	971/3103		232/1151	584/1652	155/300	422/1328	549/1775
Prevalence, % (95% CI)	31.3 (29.7-32.9)	<.001	20.2 (17.8-22.5)[b]	35.4 (33.0-37.7)[b]	51.7 (46.0-57.4)[b]	31.8 (29.3-34.3)	30.9 (28.8-33.1)
Zhuang							
No. of cases/ participants	877/2081		124/368	444/1038	309/675	353/798	524/1283
Prevalence, % (95% CI)	42.1 (40.0-44.3)	.002	33.7 (28.8-38.5)	42.8 (39.8-45.8)[b]	45.8 (42.0-49.5)	44.2 (40.8-47.7)	40.8 (38.1-43.5)
Manchu (Man)							
No. of cases/ participants	914/2106		148/429	546/1211	220/466	391/893	523/1213
Prevalence, % (95% CI)	43.4 (41.3-45.5)	<.001	34.5 (30.0-39.0)[b]	45.1 (42.3-47.9)[b]	47.2 (42.7-51.8)	43.8 (40.5-47.0)	43.1 (40.3-45.9)
Uyghur (Wei)							
No. of cases/ participants	760/1929		231/743	351/779	178/407	384/1029	376/900
Prevalence, % (95% CI)	39.4 (37.2-41.6)	.58	31.1 (27.8-34.4)	45.1 (41.6-48.6)[b]	43.7 (38.9-48.6)	37.3 (34.4-40.3)[a]	41.8 (38.5-45.0)
Muslim (Hui)							
No. of cases/ participants	665/2085		141/620	312/981	212/484	313/990	352/1095
Prevalence, % (95% CI)	31.9 (29.9-33.9)	<.001	22.7 (19.4-26.1)[b]	31.8 (28.9-34.7)[b]	43.8 (39.4-48.2)	31.6 (28.7-34.5)	32.1 (29.4-34.9)

[a] $P = .049$ in Chinese Han and $P = .046$ in Uyghur.

[b] $P < .001$, .002, .01 for Tibetan vs Han in people aged <40, 40-60, and ≥60 years, respectively; $P = .02$ for Zhuang vs Han in people aged 40-60 years; $P = .02$ and <.001 for Manchu vs Han in people aged <40 and 40-60 years, respectively; $P = .001$ for Uyghur vs Han in people aged 40-60 years; both $P < .001$ for Muslim vs Han in people aged <40 and 40-60 years, respectively.

diabetes. The study has yielded several findings about the prevalence and ethnic variation of diabetes among the major minorities in China.

The prevalence of diabetes, at 10.9%, was only slightly lower than the prevalence of total diabetes in the US population (12%-14%) in 2011-2012, although the mean BMI was still much lower than that of the US population (24.0 vs 28.7).[19] The prevalence of diabetes was much higher in overweight BMI categories in this study than in the US population (15.4% vs 8%-9%). This was consistent with the finding that Asians may have a higher risk of developing diabetes at a given BMI. However, when the Asian-specific BMI cutoffs were applied, the prevalence of diabetes for overweight persons was more comparable with that of the US population (Table 2).

The updated prevalence of prediabetes in 2013 was significantly lower than that in 2010 (35.7% vs 50.1%). With approximately 1.09 billion adults in total in mainland China, it is projected that 388.1 million Chinese adults (200.4 million men and 187.7 million women) may have had prediabetes in 2013, considerably reduced from the projected number of 493.4 million individuals in 2010.[5] Projections were calculated with the overall Chinese population aged 18 years and older in 2013 multiplied by the estimated prevalence based on the sampling weight. Sex-specific projections used sex-specific estimations of the prevalence. The 2010 and 2013 surveys were conducted under the same study protocol and followed identical, strict strategies for quality control within the serial cross-sectional China Chronic Disease and Risk Factors Surveillance study. The most likely reason for the discrepancy in prediabetes prevalence was a difference in HbA_{1c} measurement between the 2 surveys. Hemoglobin A_{1c} level was calculated in 2010 by converting capillary HbA_{1c} with a formula derived from an internal validation study, whereas HbA_{1c} was directly measured from venous blood samples stored at −80°C in the 2013 survey, which is a more reliable method. The estimated prevalence of prediabetes in the United States was 36.5% in 2011-2012,[19] similar to that in the 2013 Chinese survey. Overall, 47% of the Chinese adult population was estimated to have either diabetes or prediabetes, slightly lower than the 49% to 52% estimate in the US population.

China has 56 ethnic groups, with Chinese Han the majority. There are substantial differences in genetic background, culture, socioeconomic levels, climate and geographic features of the residential area, lifestyle, and dietary pattern among certain ethnic groups. In the 2010 census, the populations of Tibetan, Zhuang, Manchu, Uyghur, and Muslim were 6.3, 16.9, 10.4, 10.1, and 10.6 million, respectively. Variants of 2 genes involved in oxygen processing were found in most Tibetan highlanders, who thrive at altitudes greater than 4400 m.[20] Significant variation in dietary patterns among different ethnic groups also has been reported.[21] The relatively large sample size of the

Table 6. Odds Ratios of Ethnic Groups for Diabetes and Prediabetes[a]

	Overall	Tibetan vs Han	Zhuang vs Han	Manchu vs Han	Uyghur vs Han	Muslim vs Han
Diabetes						
Model 1[b]						
No. of participants	170 211	3103	2081	2016	1929	2085
OR (95% CI)		0.26 (0.22-0.31)	0.79 (0.69-0.90)	1.02 (0.90-1.15)	0.81 (0.70-0.93)	0.68 (0.60-0.79)
Model 2[c]						
No. of participants	170 211	3103	2081	2016	1929	2085
OR (95% CI)		0.34 (0.29-0.41)	0.76 (0.66-0.87)	1.09 (0.96-1.23)	1.00 (0.87-1.15)	0.76 (0.66-0.88)
Model 3[d]						
No. of participants	169 933	3063	2078	2103	1924	2804
OR (95% CI)		0.37 (0.31-0.45)	0.91 (0.80-1.05)	1.12 (0.99-1.27)	1.12 (0.97-1.29)	0.74 (0.64-0.86)
Model 4[e]						
No. of participants	155 917	2804	1911	1859	1677	1957
OR (95% CI)		0.41 (0.34-0.49)	0.93 (0.80-1.07)	1.09 (0.95-1.24)	1.15 (0.99-1.34)	0.75 (0.64-0.87)
Model 5[f]						
No. of participants	155 844	2803	1911	1858	1676	1954
OR (95% CI)		0.42 (0.35-0.50)	0.91 (0.78-1.05)	1.09 (0.95-1.25)	1.08 (0.93-1.27)	0.73 (0.63-0.85)
Prediabetes						
Model 1[b]						
No. of participants	170 211	3103	2081	2016	1929	2085
OR (95% CI)		0.72 (0.67-0.78)	1.15 (1.05-1.26)	1.21 (1.11-1.32)	1.03 (0.94-1.13)	0.74 (0.67-0.81)
Model 2[c]						
No. of participants	170 211	3103	2081	2016	1929	2085
OR (95% CI)		0.82 (0.76-0.88)	1.13 (1.03-1.23)	1.24 (1.14-1.36)	1.16 (1.05-1.27)	0.78 (0.71-0.86)
Model 3[d]						
No. of participants	169 933	3063	2078	2103	1924	2804
OR (95% CI)		0.82 (0.75-0.88)	1.17 (1.07-1.28)	1.19 (1.09-1.30)	1.14 (1.04-1.25)	0.77 (0.70-0.85)
Model 4[e]						
No. of participants	155 917	2804	1911	1859	1677	1957
OR (95% CI)		0.77 (0.71-0.84)	1.16 (1.06-1.27)	1.15 (1.04-1.26)	1.20 (1.08-1.33)	0.77 (0.70-0.84)
Model 5[f]						
No. of participants	155 844	2803	1911	1858	1676	1954
OR (95% CI)		0.77 (0.71-0.84)	1.14 (1.04-1.25)	1.14 (1.04-1.25)	1.23 (1.11-1.36)	0.78 (0.71-0.86)

[a] Odds ratios (ORs) of minority ethnic groups were calculated with multivariable logistic regression. Ethnic group was defined as a 7-category variable in the model. Seven categories were defined as Chinese Han (reference), Tibetan, Zhuang, Manchu, Uyghur, Muslim, and others. Numbers of participants were the total number of participants used in the logistic regression, including all 7 categories of the participants. Seventy-six participants were removed from the total 170 287 participants for model 1 because of missing information on the ethnic group; 8141 of 170 211 participants belonging to other minority ethnic groups were included in the model, but the ORs are not listed in the Table. Data for participants with missing information on the relative risk factors were removed. Sensitivity analysis using the study set with complete information on all risk factors in model 5 is shown in eTable 6 in the Supplement.

[b] Model 1: unadjusted.

[c] Model 2: adjusted for age and sex.

[d] Model 3: adjusted for age, sex, smoking status, systolic blood pressure, body mass index, and location.

[e] Model 4: adjusted for age, sex, smoking status, systolic blood pressure, body mass index, location, education, and physical activity.

[f] Model 5: adjusted for age, sex, smoking status, systolic blood pressure, body mass index, location, education, physical activity, total cholesterol level, and high-density lipoprotein cholesterol level.

survey provided enough participants enrolled in major Chinese minority groups. Compared with Han participants, Tibetan adults had a significantly lower prevalence of both total diabetes and prediabetes. They had generally low BMIs (eTable 5 in the Supplement), which might be attributed to multiple factors, including economic development and lifestyle factors. According to the survey, Tibetans may have higher levels of physical activity, which is to be expected because of their nomadic way of life. They consume more meat and fewer vegetables or fruits (eTable 5). It has also been reported that Tibetans have a specialized diet, customarily drinking copious tea with salt and butter.[21] Moreover, persons dwelling at high altitudes have been reported to have lower diabetes prevalence than those living at low altitudes.[22] These data are all consistent with findings from this study. It was also previously shown that Tibetan highlanders have accelerated vulnerability to diabetes with lifestyle change or aging.[23] However, reasons for the ethnic variation in diabetes prevalence are difficult to determine from the cross-sectional surveillance data. Further investigation is required to confirm and find the causes.

This study has several strengths. The survey was conducted in a large nationally representative sample of the general population in China, following a strict quality assurance and control program to ensure data validity and reliability. Compared with the 2010 survey, the 2013 survey recruited 70% more individuals and had nearly double the number of study sites, covering

more areas within each province and resulting in better representation of the Chinese population. The large sample size of this study provided, to our knowledge, the first direct comparison of diabetes prevalence among major minority groups in China within 1 survey, using the latest diabetes diagnosis criteria.

This study also has several limitations. First, we did not distinguish between type 1 and type 2 diabetes. Limited information is available in regard to the prevalence of type 1 diabetes in China. According to the Chinese clinical guideline for preventing diabetes, less than 5% of patients with diabetes have type 1 diabetes.[24] Second, all the glycemic markers in the survey were measured only once for each participant, although the guideline for diagnosing diabetes required confirmation by repeated testing. Third, nonresidents such as college students and migrant workers were not included in the study because of the sampling design. These groups were more likely to be healthy and young, with a lower incidence of diabetes, which could lead to the overestimation of diabetes in the population. Fourth, because of missing data on important information, 9060 participants (5% of the total sample) were excluded from analysis. Although the characteristics of excluded participants were similar (eTable 3), their exclusion could have affected the estimates.

Conclusions

Among adults in China in 2013, the estimated overall prevalence of diabetes was 10.9% and that of prediabetes was 35.7%. Differences from previous estimates for 2010 may be due to an alternate method of measuring HbA_{1c}.

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