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Prevalence, awareness, treatment and control of type 2 diabetes and its determinants among Mongolians in China: a cross-sectional analysis of IMAGINS 2015–2020

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ABSTRACT

Objectives This study aims to estimate the prevalence, awareness, treatment and control rates of type 2 diabetes (T2D) and pre-diabetes as well as to identify its associated factors among Mongolians living in the Inner Mongolia Autonomous Region, China.

Design Cross-sectional study.

Setting and participants This sample included 11 361 Mongolian participants from the Inner Mongolian Healthy Aging Intervention Study, a population-based screening project consisting of 141 255 adults aged above 35 years in Inner Mongolia from 2015 to 31 December 2020.

Outcome measures The prevalence and 95% CIs of T2D and pre-diabetes were calculated. Factors associated with the prevalence, awareness, treatment and control of T2D were explored by a binomial logistic regression.

Results A total of 17.2% (95% CI 16.5% to 17.9%) of the sample had T2D, of whom 34.0% (95% CI 31.9% to 36.1%) were aware of their diagnosis, 24.7% (95% CI 22.8% to 26.6%) were taking prescribed antidiabetic medications, 6.7% (95% CI 5.6% to 7.8%) had achieved control and 27.5% (95 % CI 26.7% to 28.3%) had pre-diabetes. The prevalence of T2D increased with increasing age, male, lower education level, smoking, obesity and a history of hypertension or dyslipidaemia (all p<0.05).

Conclusions T2D is highly prevalent, with suboptimal awareness, treatment and control rates, and an escalating health challenge among the Mongolian population. Broad-based strategies, including diabetes prevention education, better screening and affordable treatment, should be implemented to raise awareness, treatment and control rates of T2D in Inner Mongolia.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The largest investigation to estimate the prevalence of type 2 diabetes (T2D) and pre-diabetes, together with the rates of awareness, treatment and control among the Mongolian population.
⇒ Representative analysis of Mongolian population living in Inner Mongolia, China.
⇒ Diagnosis of diabetes and pre-diabetes, based on fasting plasma glucose individually, might underestimate the prevalence of T2D and pre-diabetes.

INTRODUCTION

During the past 20 years, type 2 diabetes (T2D) has become a serious global health concern due to its high prevalence, related disability and mortality.[1] The worldwide prevalence of diabetes was reported to be 10.5% in 2021.[2] According to the diabetes atlas 10th edition of the International Diabetes Federation, China has the world's largest absolute diabetes burden and relatively high prevalence, which continues to increase with rapid socioeconomic development in past decades.[2 3] Estimates suggest that there are close to 141 million patients (20–79 years) with diabetes in China in 2021, accounting for 26% worldwide of diabetics.[2] The prevalence of diabetes was 0.67% in 1980 and 12.8% in the latest published nationwide estimate in 2017, according to the six national studies in China.[4–9] Diabetes-related health expenditure in China is approximately 110 billion international dollars in 2017.[2] Therefore, ongoing reliable estimations are needed to plan concerted efforts and implement national prevention, management and surveillance programmes for diabetes.

The burden of diabetes and its risk factors is not uniform across China. It is important to make a comparison of the prevalence of diabetes among ethnic groups and regions. The Inner Mongolia Autonomous Region stretches across northeast, north and northwest China and borders eight provinces, including Heilongjiang, Jilin, Liaoning, Hebei, Shanxi, Shaanxi, Ningxia and Gansu, as well as Russia and Mongolia. According to China's Seventh National Census, there were

approximately 24 million permanent residents, of which 17.66% were Mongolians.[10] Great disparities in geographical location, dietary patterns and genetic characteristics were reported between the Mongolian and other ethnic groups.[11] The Mongolians tended to consume more milk foods, oil, salt, beef and mutton and fewer vegetables and fruits.[11–13] And the 'wine culture' in Inner Mongolia cannot be ignored, especially. Therefore, Mongolians drink significantly more alcohol than the general Chinese population. Zhang *et al* reported that the prevalence of diabetes in Inner Mongolia was 3.7% in 2002.[14] The Thyroid disorders, Iodine status and Diabetes Epidemiological survey (TIDE) study reported that the prevalence of diabetes among Mongolians was 19.9%.[9] Although some large cross-sectional surveys have reported the prevalence, awareness, treatment and control rates of diabetes among different ethnic groups and areas of China,[8 15–18] there remains a wide gap around the prevalence of T2D and pre-diabetes and awareness, treatment and control rates of diabetes among the Mongolian population in Inner Mongolia, China.

RESEARCH DESIGN AND METHODS

Study participants

The Inner Mongolian Healthy Aging Intervention Study (IMAGINS) was part of the China Patient-Centered Evaluative Assessment of Cardiac Events Million Persons Project.[15] A multistage stratified cluster sampling method was used to recruit study samples during 2015–2020. The detailed sampling process of IMAGINS has been described previously.[16] This is a community-based longitudinal study in the Inner Mongolian Autonomous Region, China. The flow chart of this study is shown in figure 1.

Six sites (including Hohhot, Ordos, Wuhai, Xingan League, Chifeng and Hulun Buir) of the Inner Mongolia Autonomous Region according to the age, sex and economic development composition of eastern, central and western Inner Mongolia were included in this study, which was conducted from 2015 to 31 December 2020. Participants aged above 35 years, living in the selected community for at least 6 months, and not pregnant were enrolled, and those with a history of cardiovascular diseases (including self-reported myocardial infarction, stroke and coronary heart disease) were excluded. Our analysis included 11 361 Mongolian participants after excluding 145 subjects with missing information on sex, fasting plasma glucose (FPG), waist circumference (WC), triglycerides (TG), high-density lipoprotein (HDL), self-reported diabetes or hypertension, and 78 subjects with blood pressure or blood glucose outliers (systolic blood pressure (SBP) >200 mm Hg, diastolic blood pressure (DBP) <130 mm Hg or FPG <2.3 mmol/L).

Data collection and examination

Demographic and behavioural assessment by questionnaires

Trained interviewers administered a standardised questionnaire to all participants. Information about demographic and socioeconomic status, including gender, age, marital status, education level, occupation and registered residence, was collected. Age was classified as follows: 35–44, 45–54, 55–64 and 65–76 years. Marital status was classified as married/cohabiting versus widowed/single/divorced/separation. Education level was classified into two groups: less than high school versus high school and above. Occupation was categorised as employed and unemployed. Registered residence was categorised as rural and urban. In addition, behavioural lifestyle data, including smoking status (yes or no), alcohol consumption (non-drinker, non-habitual drinker, habitual drinker), history of common chronic diseases including diabetes (yes or no), hypertension (yes or no), dyslipidaemia (yes or no) and personal medical history (yes or no), were collected.

Anthropometric assessment and biochemical assessment

Height and weight were measured in light clothing using standardised stadiometers and scales, respectively. Body mass index (BMI) was calculated as the weight in kilograms divided by the height in metres squared. Based on the standards of the WHO, BMI values were divided into four groups: low weight (BMI<18.5 kg/m^2), normal weight (18.5 kg/m^2 ≤BMI < 24 kg/m^2), overweight (24 kg/m^2≤BMI<28 kg/m^2) and obese (BMI ≥28 kg/m^2).[17] WC was measured using a measuring tape. We defined central obesity as a WC of 90 cm or greater for men and 85 cm or greater for women.[18]

Blood pressure and heart ratio were measured in electronic sphygmomanometer arm (Omron HEM-7430; Omron Corporation, Kyoto, Japan) on the right arm three times consecutively with a 10 min interval between measurements and with the participant in a seated position after resting for 15 min. Three readings of SBP, DBP and heart ratio were taken to calculate the mean value as the final value. Blood samples were collected from all participants after an overnight fast of at least 10 hours. Serum samples were used for the measurements of FPG levels. Blood glucose was measured by a glucose analyzer (BeneCheck PD-G001-2, Taiwan, China and CardioChek PA Analyzer, Polymer Technology Systems, Indianapolis, Indiana, USA) at the laboratory of the Inner Mongolia Autonomous Region Comprehensive Center of Disease Control and Prevention. Serum total cholesterol (TC), low-density lipoprotein cholesterol, HDL cholesterol (HDL-C) and TG were measured by a rapid lipid analyser (CardioChek PA Analyser; Polymer Technology Systems, Indianapolis, Indiana, USA). Blood samples were stored for biospecimen banking (−80°C) after on-site processing and centrifugation.

Definitions

According to the American Diabetes Association (ADA) 2022 criteria,[19] participants were defined as T2D if one of the following three conditions was met: (1) self-reported diagnosis of T2D, (2) FPG ≥7.0 mmol/L or (3) having received any drug treatment for diabetes regularly.

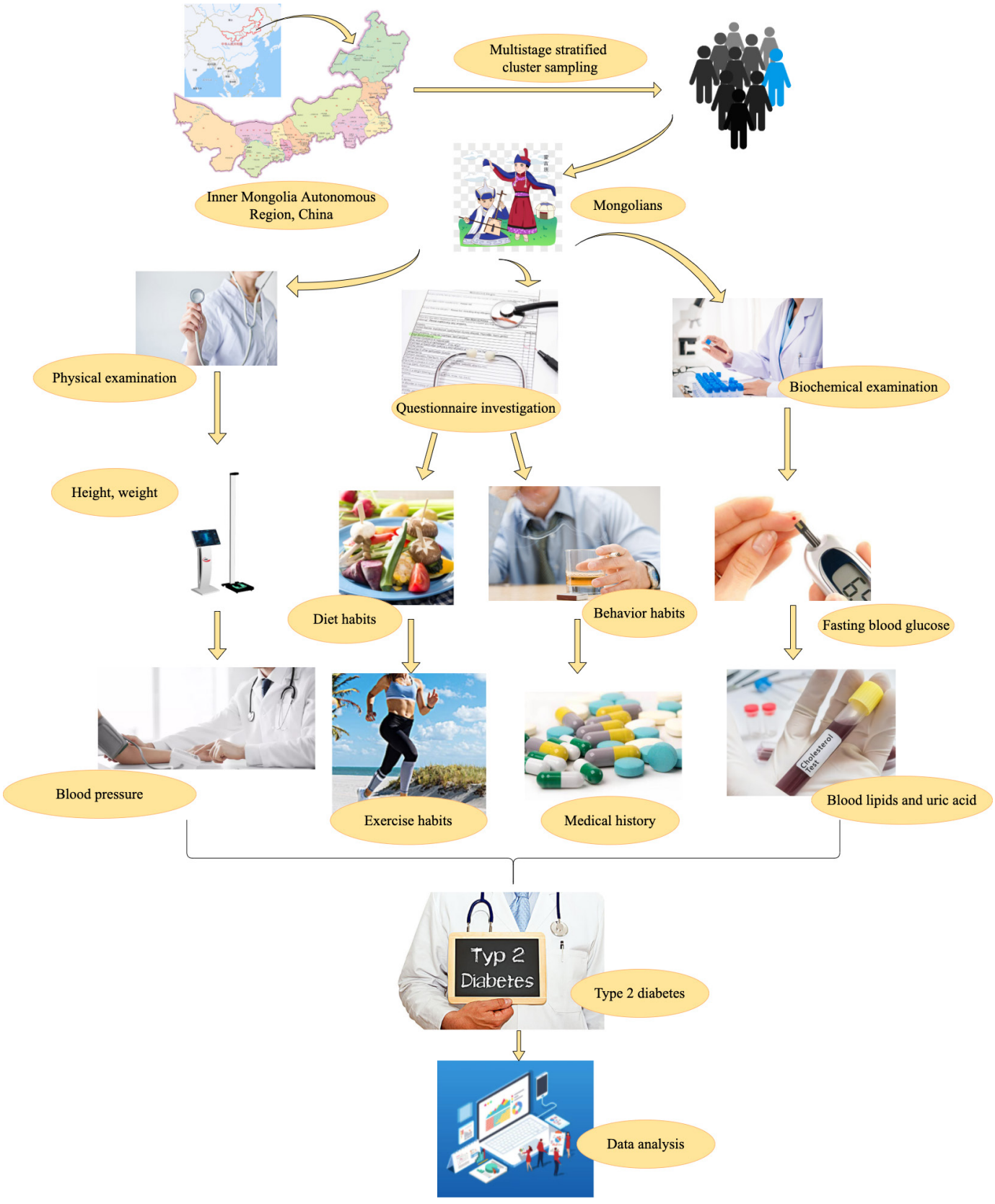

Figure 1 The flow chart of the study.

Pre-diabetes was defined as FPG 6.1 mmol/L-6.9 mmol/L without diabetes.[19] Consistent with the US Joint National Committee and Chinese definitions, hypertension was defined as SBP≥140 mm Hg and/or DBP≥90 mm Hg and/or the use of antihypertensive medicines and/or previously diagnosed as hypertension by a physician.[20]

Diabetes awareness was defined as those who were aware of diabetes among those with diabetes. Diabetes treatment was defined as those who had taken any antidiabetic medication or were injected with insulin. Diabetes control was defined as those whose FPG level was less than 7.0 mmol/L.[3 7]

Quality control

To ensure the accuracy and validity of research data, strict quality evaluation and control procedures were implemented. The members of the research team received training on the protocol and the use of instruments in data collection. The research group used unified tools and laboratory testing methods.

Patient and public involvement

No patient nor public were involved in the design, conduct, choice of outcome or recruitment to the study.

Statistical analysis

Continuous variables were described as the mean (SD) or median (IQR) and frequencies (percentage) for categorical variables. A t-test (for continuous variables) and χ^2 test (for categorical variables) were applied to analyse the differences in demographic variables and risk factors between groups. The prevalence of diabetes and pre-diabetes and the awareness, treatment and control rates of diabetes were calculated. Age-standardised prevalence of diabetes and pre-diabetes, as well as age-standardised rates of awareness, treatment and control of diabetes, was calculated using a direct method of standardisation, based on the standard population from the 2010 Chinese census.[21] A binomial logistic regression was performed to identify the risk factors by using ORs and 95% CIs. A two-tailed p<0.05 was considered statistically significant. SAS V.9.4 (SAS Institute) was used for all statistical analyses.

RESULTS

General characteristics of the participants

The baseline characteristics of the Mongolian population are shown in table 1. Data were available for 11 361 participants aged 35–76 years. The mean age (SD) of the study group was 52.9 (9.4) years. There were 6758 female subjects (59.5%). The 45–54 age group had the largest number of study participants, accounting for 36.3%. The mean FPG level (SD) was 6.2 (1.6) mmol/L, and the mean BMI (SD) was 26.0 (3.6) kg/m^2. Compared with the females, the males had the following characteristics: higher education level, WC, SBP, DBP and FPG; a lower percentage of worse marital status; and higher ratios of smoking, drinking, obesity and employment (p<0.05 for each).

Prevalence of T2D and pre-diabetes in different subgroups

Table 2 presents the prevalence of T2D and pre-diabetes. The overall prevalence of T2D among the Mongolian population was estimated to be 17.2% (95% CI 16.5% to 17.9%), 20.2% (95% CI, 19.0% to 21.3%) in men and 15.2% (95% CI 14.3% to 16.0%) in women. Meanwhile, the overall prevalence of pre-diabetes was estimated as 27.5% (95% CI 26.7% to 28.3%), 28.3% (95% CI 27.0% to 29.6%) in men and 27.0% (95% CI 25.9% to 28.0%) in women. In addition, figure 2 also shows the prevalence of T2D and pre-diabetes in different age and sex groups. The age-standardised prevalence rates of T2D and pre-diabetes were 15.9% (95% CI 15.2% to 16.7%) and 27.1% (95% CI 26.1% to 28.2%), respectively. The prevalence of T2D increased with age in both men and women, and increased more sharply after age 55. In many subpopulations, the prevalence of T2D was higher among older people, men and habitual drinkers, among people with a low education level and rural residents, among those who were overweight and obese, and among those who had a higher WC and faster heart rate (table 2).

Awareness, treatment and control of T2D in different subgroups

The awareness, treatment and control rates of T2D among the Mongolian population are presented in table 2 and online supplemental figure S1. Among 1942 subjects with T2D (12 subjects missing awareness, treatment and control information were excluded), 660 (34.0% (95% CI 31.9% to 36.1%)) were aware of their condition. The proportion of women who were aware of their diabetes condition was 34.8% (95% CI 31.9% to 37.7%) and that of men was 33.1% (95% CI 30.1% to 36.2%). A total of 480 patients (24.7% (95% CI 22.8% to 26.6%)) took any antidiabetic medication or were injected with insulin. Only 130 (6.7% (95% CI 5.6% to 7.8%)) patients had their FPG level controlled. The age-standardised awareness, treatment and control of T2D were 29.7% (95% CI 27.0% to 32.5%), 20.2% (95% CI 18.9% to 23.5%) and 5.6% (95% CI 4.5% to 6.8%), respectively. The proportion of patients with T2D who were aware of their condition and treated for T2D was higher in the older population, higher education level, unemployed, non-habitual drinker, obesity, higher WC and urban residents. The proportion of patients who controlled their FPG level well was higher in older individuals, higher education level, unemployed and living in urban areas, but broadly similar across sex, BMI categories and marital status. There were increasing trends in awareness, treatment and control of T2D with age (table 2).

Risk factors and ORs of prevalence, awareness, treatment and control rate of T2D

T2D and pre-diabetes

A binomial logistic regression identified risk factors for the prevalence, treatment and control of diabetes. Figure 3 presents the risk factors for the prevalence of diabetes and pre-diabetes among the Mongolian population. The risk of diabetes was directly associated with sex and age and was reversely correlated with education. In the logistic models, male sex, older age, being obese, smoking, low education level, living in rural areas and increased TC, heart rate, TG levels, decreased HDL and

Table 1 General characteristics of the Mongolian population living in Inner Mongolia

Variables	Total (n=11 361)	Gender			Age group				
		Male (n=4603)	Female (n=6758)	P value	35–44 (n=2359)	45–54 (n=4119)	55–64 (n=3470)	65–75 (n=1413)	P value
Age (years)	52.9±9.4	53.1±9.6	52.8±9.2	0.106	40.2±2.7	49.6±2.8	59.1±2.8	68.5±3.0	**<0.001**
Marital status, n (%)				**<0.001**					**<0.001**
Married/cohabiting	10 550 (94.4)	4357 (95.9)	6193 (93.4)		2262 (97.0)	3896 (96.3)	3187 (93.6)	1205 (86.4)	
Widowed/single/divorced/separation	624 (5.6)	185 (4.1)	439 (6.6)		69 (3.0)	148 (3.7)	218 (6.4)	189 (13.6)	
Education level, n (%)				**<0.001**					**<0.001**
Less than high school	7437 (73.9)	2866 (71.2)	4571 (75.7)		1336 (63.3)	2618 (71.5)	2337 (77.9)	1146 (88.4)	
High school and above	2632 (26.1)	1162 (28.8)	1470 (24.3)		775 (36.7)	1043 (28.5)	664 (22.1)	150 (11.6)	
Employment, n (%)				**<0.001**					**<0.001**
Employed	8839 (79.8)	3811 (84.6)	5028 (76.6)		2193 (94.9)	3607 (90.0)	2244 (66.5)	795 (57.6)	
Unemployed	2234 (20.2)	695 (15.4)	1539 (23.4)		118 (5.1)	400 (10.0)	1130 (33.5)	586 (42.4)	
Registered residence, n (%)				0.088					**< 0.001**
Rural	8234 (72.5)	3376 (73.3)	4858 (71.9)		1655 (70.2)	3088 (75.0)	2545 (73.3)	946 (66.9)	
Urban	3127 (27.5)	1227 (26.7)	1900 (28.1)		704 (29.8)	1031 (25.0)	925 (26.7)	467 (33.1)	
Smoker, n (%)	2871 (25.3)	2091 (45.4)	780 (11.5)	**<0.001**	567 (24.0)	983 (23.9)	924 (26.6)	397 (28.1)	**0.001**
Drinker, n (%)									
Non-drinker	8685 (76.9)	2506 (54.7)	6179 (92.0)	**<0.001**	1755 (74.7)	3077 (75.1)	2706 (78.6)	1147 (81.6)	**<0.001**
Non-habitual drinker	1619 (14.3)	1175 (25.7)	444 (6.6)		420 (17.9)	656 (16.0)	413 (12.0)	130 (9.2)	
Habitual drinker	989 (8.8)	897 (19.6)	92 (1.4)		174 (7.4)	363 (8.9)	323 (9.4)	129 (9.2)	
BMI	26.0±3.6	26.1±3.5	25.9±3.7	0.109	25.7±3.6	26.1±3.6	26.2±3.7	25.7±3.7	**<0.001**
Obesity (BMI ≥28), n (%)	3140 (27.6)	1325 (28.8)	1815 (26.9)	**0.024**	612 (25.9)	1130 (27.4)	1017 (29.3)	381 (27.0)	**0.035**
Waist circumference(cm)	86.4±10.3	89.7±10.0	84.2±9.9	**<0.001**	84.7±10.4	85.9±10.3	87.7±10.4	87.5±9.5	**<0.001**
SBP (mm Hg)	138.7±19.9	141.1±19.2	137.1±20.2	**<0.001**	129.7±17.4	137.0±19.3	143.5±19.6	146.8±19.7	**<0.001**
DBP (mm Hg)	84.4±11.3	87.2±11.0	82.5±11.0	**<0.001**	81.8±11.1	84.8±11.4	85.6±11.0	84.7±10.9	**<0.001**
Fasting plasma glucose (mmol/L)	6.2±1.6	6.3±1.6	6.1±1.5	**<0.001**	6.0±1.2	6.2±1.5	6.4±1.7	6.4±1.8	**<0.001**
TG (mmol/L)	1.7±1.0	1.7±1.0	1.6±0.9	0.112	1.6±1.0	1.7±1.0	1.7±1.0	1.7±0.9	**<0.001**
HDL cholesterol (mmol/L)	1.4±0.4	1.3±0.4	1.5±0.4	**<0.001**	1.4±0.4	1.4±0.4	1.4±0.4	1.4±0.4	**0.0061**

Note: Boldface indicates statistical significance ($p<0.05$).
BMI, body mass index; DBP, diastolic blood pressure; HDL, high-density lipoprotein; SBP, systolic blood pressure; TG, triglycerides.

Table 2 Prevalence of diabetes and pre-diabetes, awareness, treatment and control of diabetes among the Mongolian population

Variable	Diabetes		Pre-diabetes		Awareness		Treatment		Control	
	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)
Overall	1954	17.2 (16.5 to 17.9)	3122	27.5 (26.7 to 28.3)	660	34.0 (31.9 to 36.1)	480	24.7 (22.8 to 26.6)	130	6.7 (5.6 to 7.8)
Age										
35–44	253	10.7 (9.5 to 12.0)	617	26.2 (24.4 to 27.9)	52	20.7 (15.7 to 25.7)	35	13.9 (9.7 to 18.2)	8	3.2 (1.0 to 5.4)
45–54	638	15.5 (14.4 to 16.6)	1141	27.7 (26.3 to 29.1)	182	28.8 (25.2 to 32.3)	116	18.3 (15.3 to 21.3)	38	6.0 (4.2 to 7.9)
55–64	756	21.8 (20.4 to 23.2)	1000	28.8 (27.3 to 30.3)	308	41.0 (37.4 to 44.5)	230	30.6 (27.3 to 33.9)	62	8.2 (6.3 to 10.2)
65–76	307	21.7 (19.6 to 23.9)	364	25.8 (23.5 to 28.0)	118	38.6 (33.1 to 44.0)	99	32.4 (27.1 to 37.6)	22	7.2 (4.3 to 10.1)
P for trend		**<0.001**		**0.016**		**<0.001**		**<0.001**		**0.038**
Gender										
Male	929	20.2 (19.0 to 21.3)	1301	28.3 (27.0 to 29.6)	306	33.1 (30.1 to 36.2)	220	23.8 (21.1 to 26.6)	62	6.7 (5.1 to 8.3)
Female	1025	15.2 (14.3 to 16.0)	1821	27.0 (25.9 to 28.0)	354	34.8 (31.9 to 37.7)	260	25.5 (22.9 to 28.2)	68	6.7 (5.2 to 8.2)
P for difference		**<0.001**		0.122		0.441		0.377		0.979
Marital status										
Married/cohabiting	1812	17.2 (16.5 to 17.9)	2902	27.5 (26.7 to 28.4)	607	33.7 (31.5 to 35.9)	448	24.9 (22.9 to 26.9)	119	6.6 (5.5 to 7.8)
Widowed/single /divorced/separation	106	17.0 (14.0 to 19.9)	164	26.3 (22.8 to 29.7)	44	41.5 (32.1 to 50.9)	27	25.5 (17.2 to 33.8)	9	8.5 (3.2 to 13.8)
P for difference		0.904		0.505		0.100		0.890		0.452
Education level										
Less than high school	1329	17.9 (17.0 to 18.7)	2151	28.9 (27.9 to 30.0)	410	31.1 (28.6 to 33.6)	303	23.0 (20.7 to 25.2)	79	6.0 (4.7 to 7.3)
High school and above	409	15.5 (14.2 to 16.9)	618	23.5 (21.9 to 25.1)	175	43.1 (38.3 to 47.9)	122	30.1 (25.6 to 34.5)	36	8.9 (6.1 to 11.6)
P for difference		**0.007**		**<0.001**		**<0.001**		**0.004**		**0.042**
Registered residence										
Rural	1535	18.6 (17.8 to 19.5)	2507	30.5 (29.5 to 31.4)	484	31.7 (29.4 to 34.1)	334	21.9 (19.8 to 24.0)	82	5.4 (4.2 to 6.5)
Urban	419	13.4 (12.2 to 14.6)	615	19.7 (18.3 to 21.1)	176	42.2 (37.5 to 47.0)	146	35.0 (30.4 to 39.6)	48	11.5 (8.5 to 14.6)
P for difference		**<0.001**		**<0.001**		**<0.001**		**<0.001**		**<0.001**
Employment										
Employed	1480	16.7 (16.0 to 17.5)	2506	28.4 (27.4 to 29.3)	432	29.4 (27.0 to 31.7)	304	20.7 (18.6 to 22.8)	81	5.5 (4.4 to 6.7)
Unemployed	422	18.9 (17.3 to 20.5)	528	23.6 (21.9 to 25.4)	211	50.1 (45.3 to 54.9)	168	39.9 (35.2 to 44.6)	44	10.5 (7.5 to 13.4)
P for difference		**0.016**		**<0.001**		**<0.001**		**<0.001**		**0.000**
Smoker										
Yes	529	18.4 (17.0 to 19.8)	763	26.6 (25.0 to 28.2)	176	33.5 (29.5 to 37.6)	130	24.8 (21.1 to 28.5)	32	6.1 (4.1 to 8.1)
No	1425	16.8 (16.0 to 17.6)	2359	27.8 (26.8 to 28.7)	484	34.2 (31.7 to 36.6)	350	24.7 (22.5 to 27.0)	98	6.9 (5.6 to 8.2)
P for difference		**0.044**		0.210		0.794		0.978		0.520
Drinker										
Non-drinker	1400	16.1 (15.4 to 16.9)	2341	27.0 (26.0 to 27.9)	511	36.7 (34.2 to 39.2)	381	27.4 (25.0 to 29.8)	100	7.2 (5.8 to 8.5)
Non-habitual drinker	308	19.0 (17.1 to 20.9)	431	26.2 (24.5 to 28.8)	99	32.4 (27.1 to 37.6)	70	22.9 (18.2 to 27.6)	21	6.9 (4.0 to 9.7)

Continued

Table 2 Continued

Variable	Diabetes		Pre-diabetes		Awareness		Treatment		Control	
	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)	Patients (n)	Percentage (95% CI)
Habitual drinker	235	23.8 (21.1 to 26.4)	320	32.4 (29.4 to 35.3)	47	20.2 (15.0 to 25.3)	27	11.6 (7.5 to 15.8)	9	3.9 (1.4 to 6.3)
P for trend		**<0.001**		**<0.001**		**<0.001**		**<0.001**		**<0.001**
BMI										
<18.5	23	14.0 (8.7 to 19.3)	39	23.8 (17.3 to 30.3)	6	26.9 (8.1 to 44.0)	5	21.7 (4.9 to 38.6)	1	4.4 (0.0 to 12.7)
18.5≤BMI<24	402	12.1 (11.0 to 13.2)	809	24.3 (22.8 to 25.8)	111	27.8 (23.4 to 32.2)	74	18.6 (14.7 to 22.4)	29	7.3 (4.7 to 9.8)
24≤BMI<28	752	15.9 (14.9 to 17.0)	1365	28.9 (27.6 to 30.2)	264	35.4 (32.0 to 38.9)	196	26.3 (23.2 to 29.5)	50	6.7 (4.9 to 8.5)
≥28	777	24.8 (23.2 to 26.3)	909	29.0 (27.4 to 30.5)	279	36.0 (32.6 to 39.4)	205	26.5 (23.4 to 29.6)	50	6.5 (4.7 to 8.2)
P for trend		**<0.001**		**<0.001**		**0.023**		**0.015**		0.922
Waist circumference(cm)										
Men<90, women <85	745	12.4 (11.6 to 13.3)	1581	26.4 (25.3 to 27.5)	219	29.8 (26.5 to 33.1)	153	20.8 (17.9 to 23.7)	54	7.3 (5.5 to 9.2)
Men≥90, women ≥85	1209	22.5 (21.4 to 23.6)	1541	28.7 (27.5 to 29.9)	441	36.6 (33.9 to 39.3)	327	27.1 (24.6 to 29.6)	76	6.3 (4.9 to 7.7)
P for difference		**<0.001**		**0.006**		**0.002**		**0.002**		0.376
Heart rate (beat/min)										
<60	46	10.5 (7.6 to 13.4)	115	26.3 (22.1 to 30.4)	18	39.1 (25.0 to 53.2)	15	32.6 (19.1 to 46.2)	9	19.6 (8.1 to 31.0)
60≤HR≤100	1854	17.3 (16.5 to 18.0)	2967	27.6 (26.8 to 28.5)	621	33.7 (31.5 to 35.9)	448	24.3 (22.4 to 26.3)	120	6.5 (5.4 to 7.6)
>100	54	30.7 (23.9 to 37.5)	40	22.7 (16.5 to 28.9)	21	39.6 (26.5 to 52.8)	17	32.1 (19.5 to 44.6)	1	1.9 (0.0 to 5.6)
P for trend		**<0.001**		0.299		0.506		0.197		**0.001**

Note: Boldface indicates statistical significance ($p<0.05$).

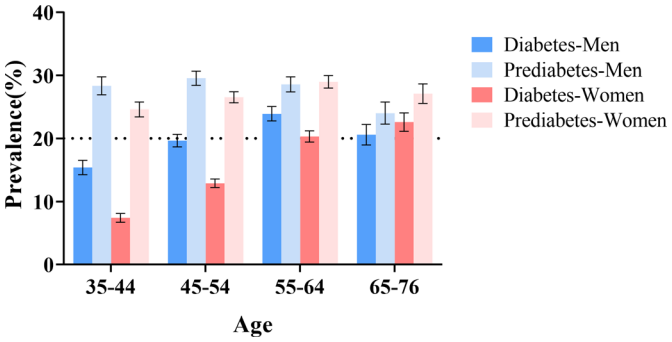

Figure 2 Prevalence of diabetes and pre-diabetes among Mongolian participants by gender and age group.

coexisting conditions (hypertension or dyslipidaemia) were significantly associated with increased risks of diabetes. Meanwhile, participants who were urban residents, had a high education level, had increased HDL and were not current smokers were more likely to have a lower risk of pre-diabetes. In addition, age was found to be a significant determinant of diabetes, and respondents older than 55 years were significantly more likely to have diabetes than those aged 35–54 years (figure 3).

Awareness, treatment, control of diabetes

Higher awareness and treatment rates were observed in the old, high education level subjects, unemployed, non-habitual drinkers and people who suffered from hypertension or dyslipidaemia (online supplemental figure S2). A higher control rate was observed in urban residents. The results of the multivariable regression model showed that awareness was close to two times higher in the unemployed than in the employees. In addition, habitual drinkers were less likely to be aware of their conditions. Participants who suffered from hypertension or dyslipidaemia and had a high education level showed higher awareness of diabetes. The probability of receiving treatments was lower in age ≤54 years than age ≥55 years participants. It was approximately two times higher in non-habitual drinkers than habitual drinkers. Compared with less than high education subjects, more than high school people were associated with a higher

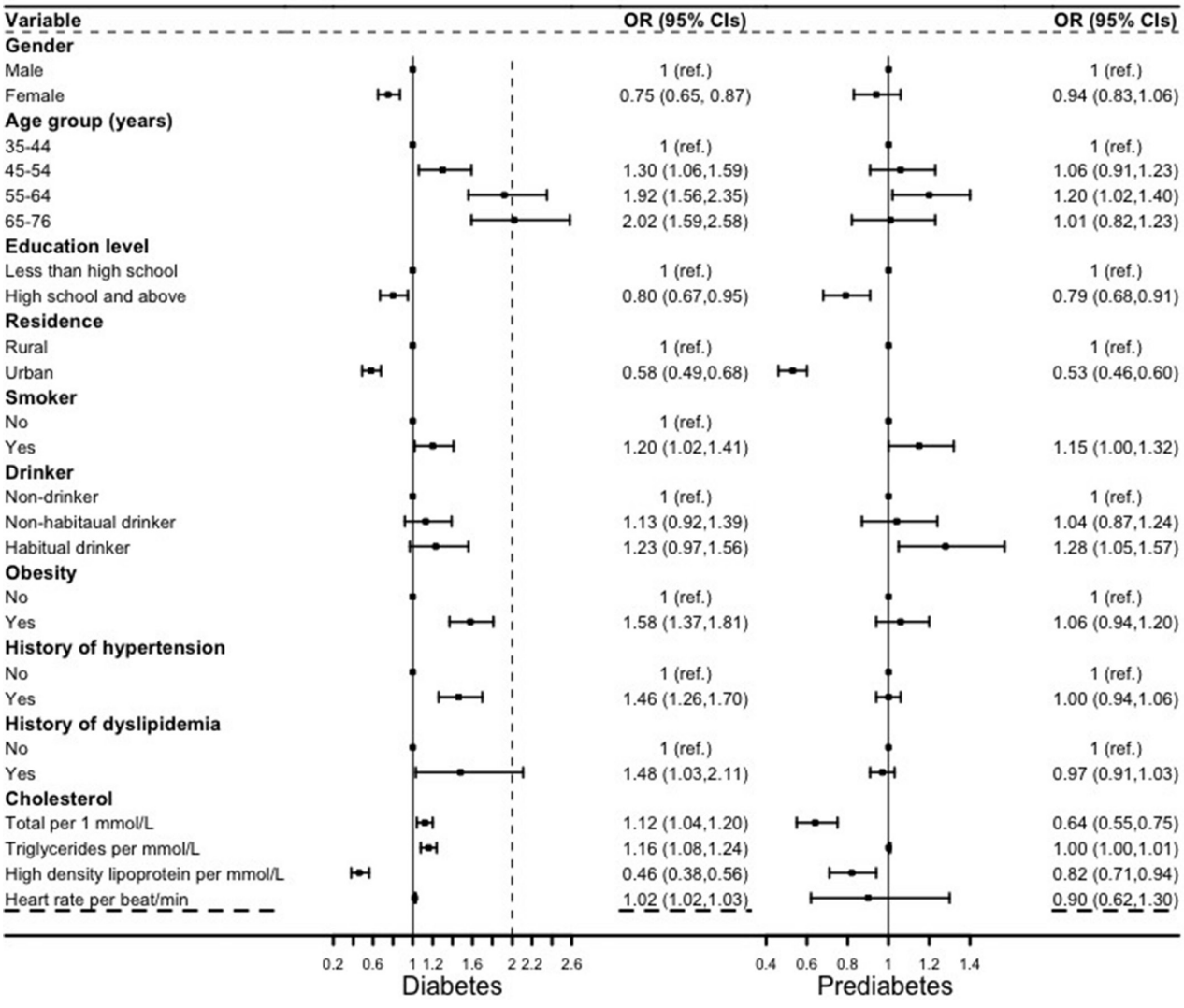

Figure 3 OR for characteristics associated with the prevalence of diabetes and pre-diabetes among Mongolian participants.

chance of plasma glucose being treated. Moreover, based on the results, participants suffering from dyslipidaemia were more likely to be treated than those with no comorbidities. Urban residents were more likely to have their plasma glucose controlled than rural residents (online supplemental figure S2).

DISCUSSION

This is the first representative study to estimate the burden of T2D and pre-diabetes and the rates of awareness, treatment and control among the Mongolian population living in Inner Mongolia, China. We further explored risk factors associated with T2D, pre-diabetes, awareness, treatment and control. The prevalence rates of T2D and pre-diabetes were 17.2% and 27.5% among the 11 361 Mongolian population. Beyond that, among patients with T2D, 34.0% were aware of their diagnosis, 24.7% received treatment and 6.7% had adequately controlled FPG. It revealed that among the Mongolian population, T2D was highly prevalent but remained underaware, undertreated and uncontrolled.

Our results showed an obvious discrepancy with Zhang *et al*'s study, which reported that the prevalence of diabetes and IFG in subjects aged 18 years and older in Inner Mongolia was 3.7% (males 3.9%; females 3.5%) and 18.5% (males 17.7%; females 19.0%), respectively, 20 years ago.[14] The reason for the vital difference in the prevalence of T2D could be attributed to China's rapid economic development and urbanisation over the past two decades, which were strongly associated with changes in lifestyle and a nutritional transition. Given that the largest Chinese famine on record took place during 1959–1961, the affected people comprise those with a current age of 55 years and older, who have a higher prevalence of diabetes.[22] Wang *et al* reported that famine exposure in childhood was related to a higher risk of diabetes in adulthood.[23] Systematic reviews have suggested that birth weight is inversely related to diabetes risk.[24 25]

In our study, the prevalence of T2D among the Mongolian population was above the previous national level, while the prevalence of pre-diabetes was below. A national study reported that 10.9% and 35.7% of participants in China suffered from overall diabetes and pre-diabetes in 2013, respectively.[8] At the same time, this study also compared the prevalence of diabetes among the Han population (14.7%) with other major minority ethnicities, including Tibetan (4.3%), Hui (10.6%), Zhuang (12.0%), Uyghur (12.2%) and Manchu (15.0%).[8] However, this study mainly recruited the Chinese Han population. The prevalence of diabetes and pre-diabetes among minority ethnicities is rarely investigated in China, especially among the Mongolian population. Recently, the TIDE study estimated that the latest prevalence of total diabetes and pre-diabetes diagnosed by the ADA criteria was 12.8% and 35.2%, respectively, among the Chinese population aged 18 and older. In addition, this study reported several major minority ethnics, including the Mongolian population (19.9%), which is slightly higher than the prevalence of diabetes reported in this study.[9] The TIDE study included 75 880 participants from all 31 provinces of mainland China, but fewer than 100 participants were Mongolian.[9] Therefore, the Mongolians participants in this study may not represent the whole Mongolian population living in Inner Mongolia due to the small sample.

Due to the unique ethnic culture, climate and geographical location, most Mongolian populations have unique diets and lifestyles, such as consuming more meat and engaging fewer vegetables and fruit.[11–13] Mongolians are more comparable the Kazak and Uygur people, who also like to eat beef, mutton and dairy products. Tao *et al* found that the prevalence of diabetes was 1.47% in Kazak and 8.16% in the Uygur population in 2008.[26] Subsequently, the data from the Cardiovascular Risk Survey study provide a more comprehensive update to Tao *et al*'s results. This study reported that 3.65% of Kazak and 6.23% of Uygur people 35 years of age had diabetes in 2012.[27] A recent study revealed that diabetes was found in 8.5% of the Uygur and 7.4% of the Kazak in 2017.[28] Overall, the Mongolian population had a higher prevalence of diabetes. The significant difference in prevalence of diabetes and pre-diabetes between Mongolians and other two ethic groups could be explained by the fact that Mongolians are fatter,[29 30] consume more alcohol or are genetically specific.

Consistent with the results of previous studies,[6 8 9 30 31] we found that obesity and being overweight were two significant determinants of T2D, and the prevalence of diabetes increased with BMI and was higher among individuals with obesity than among those with normal weight. According to Wu *et al*'s research, the Mongolian population is the heaviest among ethnic groups according to the Chinese Physiological Constant and Health Condition survey, with an overweight rate of 44.7%.[30] Similar to other studies,[6–8] we found that the prevalence of T2D was higher among men than women and increased with age. It is interesting in our study that, contrary to other studies,[6–8] the prevalence of diabetes was lower in the urban population than in rural populations among the Mongolian population. Reasonable explanations for this included the lower education level of rural residents, the changes in lifestyle associated with rural living, and the existence of widespread risk factors such as harmful use of cigarettes, alcohol use, universal opportunities for unhealthy diets. The risk of diabetes was higher in those suffering from concurrent hypertension or dyslipidaemia. Our results showed a consistency with a previous similar study based on the Southern Corn of the Latin American population.[32]

In this study, approximately 34.0% of patients with T2D were aware of their condition, 24.7% received drug treatment and 6.7% controlled their glucose level well. The management situation of T2D showed no optimism, especially the control rate. Issues concerning the prevalence, awareness, treatment, control and related risk factors for diabetes have not received sufficient attention. A

meta-analysis considered that the pooled awareness, treatment and control rates of diabetes were 45.81%, 42.54% and 20.87%, respectively, for the general population in mainland China from 1979 to 2012.[33] Data from mainland China from a national cross-sectional study from 2015 to 2017 showed that the awareness, treatment and control rates were 43.3%, 49.0% and 49.4%, respectively.[9] The awareness, treatment and control rates of Mongolians in the Inner Mongolia are significantly lower than that of China as a whole. There are some potential reasons for this huge difference, such as low education level,[10] access of healthcare is relatively difficult, and low economic level of participants in the Inner Mongolia.[7] In the risk factor analysis, we noticed an interesting phenomenon that the relationship between unemployed and paradoxically better results of awareness, treatment and control. Compared with the employed, a greater proportion of the unemployed are female and the older in our study. Several studies[34 35] suggested that women were more likely than men to aware diabetes, take antidiabetic medications and achieve control. We also found that the awareness, treatment and control of T2D increased concomitantly with age, which is in line with prior studies.[36] This may be due to the long course of diabetes, as it gives the older more time to focus on their health and accumulate diabetes knowledge.

This is one of the few studies, that researched the prevalence and associated risk factors for T2D among the Mongolian population in Inner Mongolia. There were also several potential limitations. First, our study did not adopt representative sampling because that would be impossible in such a rapid and large-scale recruitment. Second, we did not conduct laboratory examinations to distinguish the type of diabetes strictly in the IMAGINS. However, T2D is the predominant form of diabetes in adults.[7] Third, only FPG, without 2-hour oral glucose tolerance testing (OGTT) or glycosylated hemoglobin (HbA1c),[37] was used to diagnose diabetes and prediabetes, and people with a history of cardiovascular disease were excluded. It was not practicable to conduct OGTT and HbA1c in the background of this large survey because of logistic and financial obstacles. Consequently, we may have underestimated the true diabetes prevalence. However, all participants with diabetes were diagnosed by a physician or had a history of taking medication. For epidemiological purposes, the WHO considers that a single FPG estimation is acceptable.[38] Finally, we did not capture non-pharmacological treatment patterns, such as dietary modification or physical therapy, which might generate an underestimation of diabetes treatment but would not affect assessments of awareness and control. Despite these limitations, we have shown a high prevalence of diabetes and relatively low awareness, treatment and control of diabetes among the Mongolian population in Inner Mongolia.

CONCLUSIONS

The results highlight the need for effective measures for diabetes control, such as prevention, surveillance and treatment. The study will be a useful tool in developing intervention programmes aimed at the early detection of T2D among the Mongolian population in Inner Mongolia. Since the exposure factors and disease in the cross-sectional study were obtained at the same time, it can only provide etiological clues for the analytical study but cannot obtain the causal association. Therefore, we will further conduct a cohort study to examine the correlation between the prevalence, the rate of awareness, treatment and control of T2D and risk factors among the Mongolian population.

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Contributors YW, DZ, XZ and WW conceived the study protocol. YX contributed population data resources. YW and MD participated in the study design and coordination and helped draft the manuscript. MD and YX participated in the study design, performed the statistical analysis and wrote the original draft. YX, QT, BN and KH collected the samples and performed the data clearance. YW reviewed and edited the manuscript. YW guaranted for the overall content. All authors read and approved the final manuscript.

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Patient consent for publication Not applicable.

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