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 11361 Mongolian participants from the Inner Mongolian Healthy Aging Intervention Study, a population-based screening project consisting of 141255 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.

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. The worldwide prevalence of diabetes was reported to be 10.5% in 2021. 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. 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. 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. Diabetes-related health expenditure in China is approximately 110 billion international dollars in 2017. 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. Great disparities in geographical location, dietary patterns and genetic characteristics were reported between the Mongolian and other ethnic groups. The Mongolians tended to consume more milk foods, oil, salt, beef and mutton and fewer vegetables and fruits. 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. The Thyroid disorders, Iodine status and Diabetes Epidemiological survey (TIDE) study reported that the prevalence of diabetes among Mongolians was 19.9%. 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, 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. 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. This is a community-based longitudinal study in the Inner Mongolia Autonomous Region, China. The flow chart of this study is shown in figure 1.

Six sites (including Hohhot, Ordos, Wuhai, Xinggan 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/m²), normal weight (18.5 kg/m²<BMI<24 kg/m²), overweight (24 kg/m²<BMI<28 kg/m²) and obese (BMI≥28 kg/m²). 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.

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, 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.
Pre-diabetes was defined as FPG 6.1 mmol/L-6.9 mmol/L without diabetes. 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.
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.

**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 χ² 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. 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%.

**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.

**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 inversely correlated with education. In the logistic models, male sex, older age, being obese, smoking, low education level, living in rural areas and increased TG, heart rate, TG levels, decreased HDL and...
## Table 1  General characteristics of the Mongolian population living in Inner Mongolia

| Variables | Total (n=11361) | Male (n=4603) | Female (n=6758) | P value | Age group | 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 (%) | | | | | | | | | | |
| Married/cohabiting | 10550 (94.4) | 4357 (95.9) | 6193 (93.4) | 2262 (97.0) | 3896 (96.3) | 3187 (93.6) | 1205 (86.4) | | <0.001 |
| 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) | | <0.001 |
| Education level, n (%) | | | | | | | | | | |
| Less than high school | 7437 (73.9) | 2866 (71.2) | 4571 (75.7) | 1336 (63.3) | 2618 (71.5) | 2337 (77.9) | 946 (66.9) | | <0.001 |
| High school and above | 2632 (26.1) | 1162 (28.8) | 1470 (24.3) | 775 (36.7) | 664 (22.1) | 664 (22.1) | 664 (22.1) | | <0.001 |
| Employment, n (%) | | | | | | | | | | |
| Employed | 8839 (79.8) | 3811 (84.6) | 5028 (76.6) | 2193 (94.9) | 3607 (90.0) | 2244 (66.5) | 795 (57.6) | | <0.001 |
| Unemployed | 2234 (20.2) | 695 (15.4) | 1539 (23.4) | 118 (5.1) | 400 (10.0) | 1130 (33.5) | 586 (42.4) | | <0.001 |
| Registered residence, n (%) | | | | | | | | | | |
| Rural | 8234 (72.5) | 3376 (73.3) | 4858 (71.9) | 1655 (70.2) | 3088 (75.0) | 2545 (73.3) | 946 (66.9) | | 0.088 |
| Urban | 3127 (27.5) | 1227 (26.7) | 1900 (28.1) | 704 (29.8) | 1031 (25.0) | 925 (26.7) | 467 (33.1) | | <0.001 |
| Smoker, n (%) | 2871 (25.3) | 2091 (45.4) | 780 (11.5) | 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) | 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) | 666 (16.0) | 413 (12.0) | 130 (9.2) | | <0.001 |
| Habitual drinker | 989 (8.8) | 897 (19.6) | 92 (1.4) | 174 (7.4) | 363 (8.9) | 323 (9.4) | 129 (9.2) | | <0.001 |
| 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 | <0.001 |
| Obesity (BMI ≥28), n (%) | 3140 (27.6) | 1325 (28.8) | 1815 (26.9) | 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 | 141.7±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±0.6 | 1.7±0.6 | 1.6±0.9 | 0.112 | 1.8±0.6 | 1.7±0.6 | 1.7±0.6 | 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 Patients (n) | Percentage (95% CI) | Pre-diabetes Patients (n) | Percentage (95% CI) | Awareness Patients (n) | Percentage (95% CI) | Treatment Patients (n) | Percentage (95% CI) | Control 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                  | 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                | 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    | 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 | 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 | 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  | 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 <0.001 <0.001 0.004 0.042

| Registered residence            | Rural                 | 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                 | 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             | 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            | 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 <0.001

| Smoker                          | Yes                   | 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                    | 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           | 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  | 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
| Variable                        | Diabetes (%) | Pre-diabetes (%) | Awareness (%) | Treatment (%) | Control (%) |
|--------------------------------|--------------|------------------|---------------|---------------|-------------|
| Habitual drinker               | 23.8 (21.1 to 26.4) | 32.4 (29.4 to 35.3) | 20.2 (15.0 to 25.3) | 11.6 (7.5 to 15.8) | 9 (3.9 to 6.3) |
| P for trend                    | <0.001       | <0.001           | <0.001        | <0.001        | <0.001      |
| BMI < 18.5                     | 14.0 (8.7 to 19.3) | 23.8 (17.3 to 30.3) | 26.9 (8.1 to 44.0) | 21.7 (4.9 to 38.6) | 1 (4.0 to 12.7) |
| 18.5 ≤ BMI < 24                | 12.1 (11.0 to 13.2) | 24.3 (22.8 to 25.8) | 27.8 (23.4 to 32.2) | 18.6 (14.7 to 22.4) | 29 (7.4 to 9.8) |
| 24 ≤ BMI < 28                  | 15.9 (14.9 to 17.0) | 28.9 (27.6 to 30.2) | 35.4 (32.0 to 38.9) | 26.3 (23.2 to 29.5) | 50 (6.7 to 8.5) |
| ≥ 28                           | 24.8 (23.2 to 26.3) | 29.0 (27.4 to 30.5) | 36.0 (32.6 to 39.4) | 26.5 (23.4 to 29.6) | 50 (6.5 to 8.2) |
| P for trend                    | <0.001       | <0.001           | 0.023         | 0.015         | 0.001       |
| Waist circumference (cm)       | 12.4 (11.6 to 13.3) | 26.4 (25.3 to 27.5) | 29.8 (26.5 to 33.1) | 20.8 (17.9 to 23.7) | 54 (7.3 to 9.2) |
| Men < 90, women < 85           | 22.5 (21.4 to 23.6) | 28.7 (27.5 to 29.9) | 36.6 (33.9 to 39.3) | 27.1 (24.6 to 29.6) | 76 (6.4 to 7.7) |
| P for difference               | <0.001       | 0.006            | 0.002         | 0.002         | 0.376       |
| Heart rate (beat/min)          | 10.5 (7.6 to 13.4) | 26.3 (22.1 to 30.4) | 39.1 (25.0 to 53.2) | 32.6 (19.1 to 46.2) | 19.6 (8.1 to 31.0) |
| < 60                           | 17.3 (16.5 to 18.0) | 27.6 (26.8 to 28.5) | 33.7 (31.5 to 35.9) | 24.3 (22.4 to 26.3) | 120 (6.5 to 7.6) |
| 60 ≤ HR ≤ 100                  | 30.7 (23.9 to 37.5) | 39.6 (26.5 to 52.8) | 32.1 (19.5 to 44.6) | 1 (1.9 to 5.6)     |             |
| > 100                          | 30.7 (23.9 to 37.5) | 40 (27.7 to 39.5)  | 21 (18.9 to 44.6)  | 17 (1.9 to 5.6)    |             |

Note: Boldface indicates statistical significance (p < 0.05).
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 $\leq 54$ years than age $\geq 55$ 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 awareness and treatment rates and urban participants have higher control rates.
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%), Uygur (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 ethnicities, 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 ethnic 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 32 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. 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. 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, access of healthcare is relatively difficult, and low economic level of participants in the Inner Mongolia. 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 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. 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. Third, only FPG, without 2-hour oral glucose tolerance testing (OGTT) or glycosylated hemoglobin (HbA1c), was used to diagnose diabetes and pre-diabetes, 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. 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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REFERENCES

1. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990-2016: a systematic analysis for the global burden of disease study 2016. *Lancet* 2017;390:1211–59.

2. International Diabetes Federation. *IDF diabetes atlas*. 10th ed. Brussels, Belgium: International Diabetes Federation, www.diabetesatlas.org.

3. Yue J, Mao X, Xu K, et al. Prevalence, awareness, treatment and control of diabetes mellitus in a Chinese population. *PLoS One* 2016;11:e0153791.

4. National Diabetes Research Group. [A mass survey of diabetes mellitus in a population of 300,000 in 14 provinces and municipalities in China (author’s transl)]. *Zhonghua Nei Ke Za Zhi* 1981;20:678–83.

5. Pan XR, Yang WY, Li GW, et al. Prevalence of diabetes and its risk factors in China, 1994. National diabetes prevention and control cooperative group. *Diabetes Care* 1997;20:1664–9.

6. Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. *N Engl J Med* 2010;362:1090–101.

7. Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA* 2013;310:948–59.

8. Wang L, Gao P, Zhang M, et al. Prevalence and ethnic pattern of diabetes and prediabetes in China in 2013. *JAMA* 2017;317:2515–23.

9. Li Y, Teng D, Shi X, et al. Prevalence of diabetes recorded in mainland China using 2018 diagnostic criteria from the American diabetes association: national cross sectional study. *BMJ* 2020;369:m997.

10. Inner Mongolia autonomous region Bureau of statistics, 2021. Available: http://tj.rmg.gov.cn/ztl/dqccqkpc/202105/20210526..1596852.html.

11. Wang X, Liu A, Du M, et al. Diet quality is associated with reduced risk of hypertension among inner Mongolia adults in northern China. *Public Health Nutr* 2020;23:1543–54.

12. Dugee O, Khor GL, Lye M-S, et al. Association of major dietary patterns with obesity risk among Mongolian men and women. *Asia Pac J Clin Nutr* 2009;18:433–40.

13. Jia L, Lu H, Wu J, et al. Association between diet quality and obesity indicators among the working-age adults in inner Mongolia, Northern China: a cross-sectional study. *BMC Public Health* 2020;20:1165.

14. Zhang S, Tong W, Xu T, et al. Diabetes and impaired fasting glucose in Mongolian population, inner Mongolia, China. *Diabetes Res Clin Pract* 2009;86:124–9.

15. Lu J, Xuan S, Downing NS, et al. Protocol for the China peace (patient-centered evaluative assessment of cardiac events) million persons project pilot. *BMJ Open* 2016;6:e010200.

16. Xi Y, Tian Q, Na B, et al. Protocol of the inner Mongolian healthy aging study (IMAGINS): a longitudinal cohort study. *BMC Public Health* 2022;22:115.

17. Society CD. Guidelines for the prevention and treatment of type 2 diabetes mellitus in China (2020 edition). *Chinese Journal of Practical Internal Medicine* 2021;37.

18. Zhang L, Wang Z, Wang X, et al. Prevalence of abdominal obesity in China: results from a cross-sectional study of nearly half a million participants. *Obesity* 2019;27:1898–905.

19. American Diabetes Association Professional Practice Committee. 2. classification and diagnosis of diabetes: standards of medical care in diabetes-2022. *Diabetes Care* 2022;45:S17–38.

20. Hypertension CGroup. 2018 Chinese guidelines for the management of hypertension. *China J Hypertens Med* 2018;36:1596–852.

21. National Bureau of Statistics of China. Population Census of People's Republic of China, 2010. Available: http://www.stats.gov.cn/tjsj/pcsj/rkpc6/rkpc6indexx.htm [Accessed 01 Oct 2021].

22. Smil V. China’s great famine: 40 years later. *BMJ* 1999;319:1619–21.

23. Wang J, Li Y, Han X, et al. Exposure to the Chinese famine in childhood increases type 2 diabetes risk in adults. *J Nutr* 2016;146:2289–95.

24. Newsome CA, Shiell AW, Fall CHD, et al. Is birth weight related to later glucose and insulin metabolism?–A systematic review. *Diabet Med* 2011;28:781–87.

25. Whincup PH, Kaye SJ, Owen CG, et al. Birth weight and risk of type 2 diabetes: a systematic review. *JAMA* 2008;300:2886–97.

26. Tao Y, Mao X, Xie Z, et al. The prevalence of type 2 diabetes and hypertension in Uyghur and Kazak populations. *Cardiovasc Toxicol* 2008;8:155–9.

27. Yang Y-N, Xie X, Ma Y-T, et al. Type 2 diabetes in Xinjiang Uyghur autonomous region, China. *PLoS One* 2012;7:e35270.

28. Gao Y, Xie X, Wang S-X, et al. Effects of sedentary occupations on type 2 diabetes and hypertension in different ethnic groups in North West China. *Diab Vasc Dis Res* 2017;14:372–5.

29. Hu D, Fu P, Xie J, et al. Increasing prevalence and low awareness, treatment and control of diabetes mellitus among Chinese adults: the InterAsia study. *Diabetes Res Clin Pract* 2008;81:250–7.

30. Jiao X, JCN, Malik V, et al. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA* 2009;301:2129–40.

31. Wu J, Cheng X, Qiu L, et al. Prevalence and clustering of major cardiovascular risk factors in China: a recent cross-sectional survey. *Medicine* 2016;95:e2712.

32. Izraelov Y, Rubinstein A, Bazzano L, et al. Prevalence, awareness, treatment and control of diabetes and impaired fasting glucose in the southern cone of Latin America. *PLoS One* 2017;12:e0183953.

33. Li M-Z, Su L, Liang B-Y, et al. Trends in prevalence, awareness, treatment, and control of diabetes mellitus in mainland China from 1979 to 2013. *Int J Endocrinol* 2013;2013:753150.

34. Kaiser A, Vollenweider P, Waeger G, et al. Prevalence, awareness and treatment of type 2 diabetes mellitus in Switzerland: the CoLaus study. *Diabet Med* 2012;29:190–7.

35. McDonald M, Hertz RP, et al. Birth weight and risk of type 2 diabetes mellitus in Switzerland: the CoLaus study. *Diabet Med* 2012;29:190–7.

36. Wang C, Yu Y, Zhang X, et al. Awareness, treatment, control of diabetes mellitus and the risk factors: survey results from Northeast China. *PLoS One* 2014;9:e103594.

37. Gong Q, Zhang P, Wang J, et al. Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the Da Qing diabetes prevention outcome study. *Lancet Diabetes Endocrinol* 2019;7:452–61.

38. WHO. Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia. Geneva: World Health Organization, 2006.