# Epidemiology of Diabetes in adults in GanSu province of northwest China

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# Abstract

**Background:** The purpose of this study was to study the characteristics and distribution of adult diabetes and prediabetes in Gansu province, northwest China.

**Methods:** We conducted a population-based, cross-sectional survey in GanSu province of northwest China. A representative sample of 31417 adults, aged 20-74 years, from 14 regions participated in the study. After an overnight fast, a 2-hour oral glucose tolerance test (OGTT) 75 g glucose load was conducted among participants without a self-reported history of diagnosed diabetes. Questionnaire survey, physical examination and serum lipid level were also conducted in the study.

**Results:** The rough prevalence of diabetes in adults in Gansu province of northwest China was 10.6% (12.3% among men and 9.2% among women) and the age-standardized prevalence of diabetes is 9.0%. The prevalence of diagnosed and emerging diabetes was 5.2% and 5.4%, respectively. The prevalence of diabetes among Han, Hui, Tibetan, Yugur, Dongxiang nationality and the Baoan nationality were 10.7%, 11.3%, 5.5%, 7.7%, 8.9% and 7.9% respectively. In addition, the prevalence of prediabetes was estimated to be 15.2% (15.7% among men and 14.7% among women). The prevalence of impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) were 3.5% and 11.6% respectively. The prevalence of diabetes and prediabetes increased with increasing age and body mass index (BMI). The prevalence of diabetes among urban residents was higher than that among rural residents (11.5% vs. 9.5%) which is different from prediabetes (14.2% vs. 16.3%). Binary logistic regression analysis showed that age, male sex, urban residents, smoking, family history of diabetes, abdominal obesity, overweight, generalized obesity, hypertension, dyslipidemia, low levels of education, and high level of economic development were significantly associated with diabetes. Simultaneously, age, male sex, rural residents, drinking, abdominal obesity, overweight, general obesity, hypertension and low levels of education were significantly associated with prediabetes.

**Conclusions:** The epidemic situation of diabetes in northwest China's Gansu province is serious. The distribution of diabetes between different sex, age groups and different ethnic groups were significantly different. More than half of the diabetes patients are undiagnosed, which showed the low hospitalizing rate and the lack of public awareness of diabetes.


# 1. Background

Attributing to rapid economic development, improved living standards, urbanization, an aging population and a sedentary lifestyle, the prevalence of diabetes is high and is increasing (1). The International Diabetes Federation has estimated that in 2013, 382 million people had diabetes throughout the world and this number is expected to rise to 592 million by 2035, indicating a growing burden of diabetes, particularly in developing countries (2). China as the largest developing country, the prevalence of diabetes has markedly increased from less than 1% to 11.6% in the past three decades (3-7). The newest data documented that the prevalence of diabetes and prediabetes was 11.6% and 50.1% respectively (7).

In addition, hyperglycemia and diabetes are important causes of mortality and morbidity worldwide (8-10), patients with type 2 diabetes have greater increased risks of CVDs (11), which also cause significant morbidity and mortality among diabetic subjects. The economic costs for diabetes are high and will continue to rise accordingly(12-13). Gansu is a province with multi-ethnic and located in the northwest of China, which is not very developed when compared with the eastern coastal provinces. People in Gansu province almost live at middle altitude. Considering the epidemic of diabetes mellitus, the increasing healthcare expenditures, the paucity of data about the prevalence of Gansu province in recent years and the importance of the prevalence for rational planning of health services, we successfully conducted a cross-section survey between 2013 and 2014 to estimate the prevalences and risk factors of diabetes and prediabetes in the general population in northwest China's Gansu province.

# 2. Methods

### 2.1 population

We conducted a population-based, cross-sectional survey in the 14 regions in Gansu province between 2013 and 2014. In each region, a stratified, cluster and random sampling design was used to select participants who were representative of residents in Gansu province. Only persons who had been living in their local residence for at least 5 years were qualified to participate. In the first stage, all the 14 regions were chosen and separated by whether there are minorities. In the second stage, if there are minorities, one general county and one ethnic minority county were chosen, otherwise, tow general counties were chosen randomly. In the third stage, each county was stratified by urban and rural locations, 3 subdistricts in urban areas or town in rural areas were selected randomly according to economic development status from each site with probability proportional to size. In the fourth stage, 3 neighborhood communities or administrative villages were selected randomly with probability proportional to size. In the fifth stage, households in each neighborhood community and administrative village were listed, 50 households were selected randomly, all persons who were 20-74 years old in these household were selected. If the selected households or persons refused to take part in, we conducted a replacement from all households in the nearest neighborhood or village to ensure an adequate sample size within each selected neighborhood community and administrative village. We achieved the information of all the households from the government household registration system. All these counties were segmented into developed area, intermediately developed area and undeveloped area based on gross domestic product (GDP) per capita. We also divided the participants into two levels according to the elevation of people living: 1000m-2000m and 2000m-3000m.

A representative sample of 34,792 adults, aged 20-74 years, from all the 14 regions participated in the study. After the exclusion of 3375 persons for whose information was incomplete or fasting or 2-hour plasma glucose levels were missing, 31,417 adults (14,083 men and 17,334 women) were included in the final analysis.

The study protocol was approved by the ethical review committee and the institutional review board of people's hospital in Gansu province. Written informed consent was obtained from all study participants.

## 2.2 Variables collection

First, the participants were invited to attend a interview to complete a questionnaire at their health centre. Information including age, sex, education level, income levels, smoking, drinking, leisure time sports, eating habits, the history of menstruation and reproduction, personal medical history and family history of diabetes (first and/or second degree relatives) were recorded.

After checking their personal information, physical examinations including weight, height, body mass index, (BMI) waist and hip circumference, waist hip rate (WHR), blood pressure and heart rate were measured by standard methods. BMI is calculated as weight in kilograms divided by height in meters squared. Using a mercury sphygmomanometer, three blood pressure measurements were obtained from the right arm in a seated position by nurses according to a common protocol adapted from procedures recommended by the American Heart Association (14), the mean of the three measurements was used in the statistical analysis.

Venous blood samples were collected by trained nurses in all participants after an overnight fast of about 8-10 hours in the local health stations. Plasma glucose, TG, TC, HDL and LDL levels were measured. A standard OGTT using 75 g glucose load was performed if participants without a self reported history of diabetes and the 2-hour plasma glucose level was measured. Blood specimens were centrifuged and placed in ice-cooled containers immediately and measured within 2 hours. Plasma glucose was measured using glucose oxidase method and blood lipid was detected using enzyme method by Olympus AU5400.

## 2.3 Diagnostic Criteria

Diabetes was diagnosed and classified in accordance with the 1999 WHO criteria. Diabetes was confirmed according to a self-reported or those who had a fasting glucose≥7.0mmol/L and/or a 2h post-glucose level≥11.1 mmol/L; impaired fasting glucose(IFG) was defined as fasting glucose level ≥6.1 mmol/L and <7.0 mmol/L, and a 2 h post-glucose value <7.8 mmol/L; impaired glucose tolerance (IGT) was defined as a 2h post glucose ≥7.8 mmol/L and <11.1 mmol/L and a fasting value <7.0 mmol/L, prediabetes was defined as individuals with IFG and/or IGT (15). Hypertension was diagnosed based on the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure VII (JNC VII) guidelines, systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90mmHg or a previous diagnosis of hypertension was defined as hypertensive (16). Dyslipidemia was defined as the latest Chinese guidelines published in 2007 (17), TG≥200 mg/dL (2.26 mmol/L) and/or TC≥240 mg/dL (6.22 mmol/L) and/or LDL-C≥160 mg/dL (4.14 mmol/L) and/or HDL-C <40 mg/dL (1.04 mmol/L) and/or having been diagnosed dyslipidemia. According to the World Health Organization guidelines (18), obesity for men and women was defined as BMI≥30 kg/m$^2$, whereas overweight was

defined as BMI between 25 and 29.9 kg/m$^2$. Abdominal obesity, on the basis of waist circumference, was defined as waist circumference ≥90 cm in men and ≥80 cm in women (19).

### 2.4 Statistical analysis

The epidata 3.1 was used for data inputting and statistical analysis were performed using SPSS version 21.0. The results are described by mean and confidence interval for continuous variables, proportions and confidence interval for categorical variables. To compare categorical variables, chi-square tests were used to test the differences between proportions. Binary logistic regression analysis was used to examine the association between various exposures and outcomes. Using backward selection, variables that remained significant were retained in the final model. All P values are 2-tailed and a P value<0.05 was considered statistically significant. The age-standardized prevalences of diabetes and prediabetes were based on China statistical Yearbook in 2013 (20). Flowchart see figure 1

# 3. Results

The general characteristics and blood biochemical indexes of the study participants are shown in Table 1 and Table 2.

*Prevalences of Diabetes and Prediabetes*

The prevalences of diabetes and prediabetes are shown in Table 3. The overall prevalence of diabetes was estimated to be 10.6% (95% CI, 10.2% - 10.8%), 12.3% (95% CI, 11.8% -12.8%) in males and 9.2% (95% CI, 8.8%-9.6%) in females. The prevalences of previously diagnosed diabetes and new detected diabetes were 5.2% (95% CI, 5.0%, 5.4%) and 5.4% (95% CI, 5.2%, 5.6%), respectively. Furthermore the prevalence of diabetes was higher among urban residents than that among rural residents (11.5% vs. 9.5%, P0.01). The prevalence of diabetes among people live at 2000m-3000m elevation was lower than that live at 1000m-2000m (9.2% vs. 10.7%). In addition, the prevalence of diabetes was 10.7%, 11.3%, 5.5%, 7.7%, 8.9% and 7.9% among Han, Hui, Tibetan, Yugur, Dongxiang and the Baoan nationality, respectively. There was a general increasing trend in diabetes prevalence with increasing age (3.6%, 5.5%, 8.3%, 12.5% and 20.0% among participants who were 20-29, 30-39, 40-49, 50-59, 60-74 years old, respectively). The prevalence of diabetes also increased with economic development, increasing BMI and increasing waist circumstance. shown in figure 2 and table 4

The overall prevalence of prediabetes (impaired glucose regulation, IGR) was estimated to be 15.2% (95% CI, 14.8%-15.6%), the prevalence of IGR was slightly higher in the males (15.7%, 95% CI, 15.1%-16.3%) when compared with the females (14.7%, 95% CI, 14.2-15.2%). The prevalences of IGR among Han, Hui, Tibetan, Yugur, Dongxiang and the Baoan nationality were 15.0%, 16.9%, 21.4%, 24.5%, 10.1% and 9.5% , respectively. The prevalences of IFG and IGT were 3.5% (95% CI, 3.3%-3.7%) and 11.6% (95% CI, 11.2%, 12.0%), respectively. In contrast to diabetes, the prevalence of prediabetes among the urbanites is lower than rural folks (14.2% vs. 16.3%, P0.01). In accordance with diabetes, the prevalence of IGR, IFG and IGT increased with increasing age, increasing BMI and increasing waist circumstance (P0.01).

*The age-standardized prevalence of diabetes and prediabetes*

Based on population in China statistical Yearbook in 2013the age-standardized prevalence of diabetes is 9.0%, with 10.9% in males and 7.5% in females. The age-standardized prevalence of prediabetes is 14.1%, with 14.9% in males and 13.5% in females.

*Risk Factors of Diabetes and Prediabetes*

Binary logistic regression analyses revealed that male sex (OR 1.38, 95% CI, 1.25-1.52, p<0.001), age (OR 1.48, 95% CI, 1.43-1.53, p<0.001), urban residency (OR 1.20, 95% CI, 1.11-1.30, p<0.001), economic development (OR 1.27, 95% CI, 1.22-1.34, p<0.001), smoking (OR 1.25, 95% CI, 1.12-1.39, p<0.001), family history of diabetes (OR 2.45, 95% CI, 2.16-2.79, p<0.001), overweight (OR 1.15, 95% CI, 1.06-1.26, p=0.001), generalised obesity (OR 1.57, 95% CI, 1.28-1.93, p<0.001), abdominal obesity (OR 1.28, 95% CI, 1.17-1.39, p<0.001), hypertension (OR 1.60, 95% CI, 1.47-1.74, p<0.001) and dyslipidemia (OR 1.34, 95% CI, 1.24-1.44, p<0.001) were significantly associated with diabetes. For prediabetes, male sex (OR 1.11, 95% CI, 1.02-1.20, p=0.013), age (OR 1.18, 95% CI, 1.15-1.21, p<0.001), rural residency (OR 1.08, 95% CI, 1.00-1.14, p=0.042), less than college (OR 1.31, 95% CI, 1.20-1.43, p<0.001), drinking (OR 1.18, 95% CI, 1.07-1.30, p=0.001), overweight (OR 1.25, 95% CI 1.16-1.35, p<0.001), general obesity (OR 1.41, 95% CI, 1.16-1.71, p<0.001), hypertension (OR 1.08, 95% CI, 1.01-1.16, p=0.034), abdominal obesity (OR 1.09, 95% CI, 1.02-1.17, p<0.001), were relevant variables (Table 5).

# 4. Discussion

The crude prevalence of diabetes in Gansu province was 10.6%, indicating that diabetes is becoming epidemic in this area. When compared with the national data (6), the age-standardied prevalence of diabetes in Gansu province was lower (9.0% vs 9.7%). The reason for this phenomenon might be that Gansu province located in the northwest of China, where the economic development is lower than the national average level. The age-standardized prevalence of diabetes was nearly three times higher than that reported in 1999 (9.0% vs. 3.24%) (21). The emergency trend of rising prevalence of diabetes in Gansu province is not unexpected for the following changs which aroused by the western region development policies since 2000: rapid economic development , increasing urbanisation, sedentary lifestyle, growth of the middle class and improved longevity.

Among US adults, the odds of having diabetes among people living at high altitude (1500-3500m) was lower than living between 0-499m (22). The terrains of Gansu province are complex, including mountainous region, plateau, plain, valley, desert, so it varies in altitude and the people almost live at 1000 to 3000 meters above the sea level. The present study documented that people living at higher altitude (2000-3000m) have lower prevalence of diabetes than living between 1000m and 2000m. Gamboa JL demonstrated that the blood glucose level and the incident of diabetes of people living at high altitude tend to be lower and chronic hypoxia can increase insulin-stimulated glucose uptake by skeletal muscles (23). Chen also has documented that through the skeletal muscle AMPK-AS160-GLUT4 pathway, long term altitude training can improve insulin resistance (24).

Gansu province is a multi-ethnic areas, these ethnic minorities include Tibetans, Yugur, Dongxiang and the Baoan nationality. Different ethnic groups have different living habit and beliefs. For example, diet in Hui ethnic group rather than Han group is rich in carbohydrates, meat and fat but lack of vegetables and fruits. The Hui people like eating fried dough twist which is high-fat food, furthermore. In addition, the Hui people believe in Islam and they fast between sunrise and sunset during Ramadan, which can lead to glucose metabolic disorders, so the prevalence in Hui was higher than Han in this study. Tibetans in Gansu province almost live at the plateau area where the altitude is higher (2000-3000m) and animal husbandry is a traditional dominant industries. As nomads, Tibetans' work can lead to more physical activity and energy expenditure and the economy is not very developed in Tibetans, so the prevalence of diabetes among this ethnic group was lower than that in Han. The characteristics of the Baoan nationality are similar to Hui but the level of economic development is relatively low, so the prevalence was lower than Hui. The present study reported the prevalences of diabetes among different ethnic groups in Gansu province for the first time but didn't involve genetic effects of different ethnic groups.

More than one half of those diabetes mellitus cases (50.9%) were the new detected and this phenomenon was more serious in young people, which was consistent with the results reported in other parts of China (25-26). This finding indicated both a relatively rapid increase in the incidence of diabetes and the lack of medical examination. In gansu province, potatoes are the most popular and consumed vegetable.In addition, beef noodle is Gansu province's unique cuisine and rich in fat and salt. These may also contribute to the incidence of diabetes. The inadequate detection for diabetes is likely due to a range of factors, including the poor awareness of diabetes, the absence of routine screening particularly among younger people, and in gansu province, public health facilities are inadequate and funding for screening programs is tight. As patients with undiagnosed diabetes are at high risk of diabetes complications, so the need for early screening and popularizing knowledge about diabetes in northwest China's Gansu province, especially in remote and rural area is extremely urgent. When compared with the national data (6), the proportion of the newly diagnosed diabetes in Gansu province was lower (60.7% vs 50.9%). This phenomenon suggests that the incidence of diabetes in Gansu province is lower than that in the whole nation.

As is shown in the previous studies (6-7), diabetes prevalence was found to be higher among males than females. Perhaps it is because smoking and drinking are more common among males, which are related to diabetes. The present study showed that the prevalence of diabetes became higher with the increase of economic level, which was to be expected as the daily diet has more energy and calorie-rich in the more developed regions. As shown in table 1, civilian in the more developed regions had higher levels of TC, TG and LDL-c. All of these are implicated in the aetiology of diabetes. For the similar reason and the influx of fast food culture together with smaller energy consumption of sedentary lifestyle, the urbanites in Gansu province had much higher diabetes than the rural population, which was comparable with the results reported previously in developing countries (5). The prevalences of diabetes increased with increasing age in Gansu province for the elderly tend to have higher levels of BMI, BP, TC, TG and LDL.

The prevalence of IGR (predicting subsequent type 2 diabetes) was found to be 15.2% in the present study, which is an important potential threat in the development of clinical diabetes. The phenomenon is worrisome because it implies that a huge population is at a risk of harbinger diabetes in the near future in Gansu province. In a three years follow-up study, 23.42% of subjects with IGR developed diabetes (27). Meanwhile, not only diabetes but also prediabetes confers increased risk for mortality (28). The prevalence of IGT is higher than IFG in the present study, the reason may due to high carbohydrate diet in Gansu province. People with IGT have been shown to have higher risk of developing diabetes, which was reported to be 35.1% over eight years in Singapore and 67.7% over six years in China (29-30). Proper diet and moderate exercise can improve the deterioration of blood sugar in patients with prediabetes, so we should emphasize their importance and raise people's awareness of prediabetes.

It has been reported that moderate alcohol consumption could reduce the risk of diabetes by increasing insulin sensitivity, improving HDL and adiponectin (31). Contrary to the report, Wang reported a positive association between alcohol and diabetes (32). In the present study, we didn't stratify alcohol consumption and it showed a inverse association between drinking and diabetes but a positive association between prediabetes. As is reported in previous studies (33-35), the risk factors of diabetes include metabolic disorders, such as obesity (both overall obesity and central obesity), dyslipidemia and hypertension, so that we can control the prevalence of diabetes by changing high-salt, high-fat diet habits and increasing physical activity. It was reported that (36) treating hyperglycaemia early could significantly reduce microvascular and macrovascular events in patients with type 2 diabetes. Though there are drugs available now to prevent or rather delay the progress of diabetes, it has been consistently shown that lifestyle modifications are the most effective intervention (30). Family history of diabetes is one of the risk factors of diabetes, which alerts person with family history of diabetes should performe the screening test early, regularly and frequently. The risk factors of diabetes also included smoking in this study. Quitting smoking should be one of the key public health goals to reduce the prevalence of diabetes. In addition, OR of exercise is 1.38, reflecting that patients with diabetes tend to do physical activity when compared with those without diabetes.

The most important strength of this study is that it is currently the largest survey in Gansu province, the number of endpoint in the survey was 31417, approximately 0.12% of the total Gansu province's population, so it can provide the most reliable information on the prevalence of diabetes in the adult population in Gansu province. In addition, this survey covered all the 14 regions with different minorities, so we provided data for each region, including these unique ethnic groups in Gansu province for the first time.

However, there were also limitations in this study. First, it was not possible to discriminate between type 1 and type 2 diabetes mellitus, because we only measured blood glucose level without pancreatic beta-cell function. Second, there are considerable differences in sample size among different ethnic groups for minority population is much smaller than Han population.

In summary, our results indicate the diabetes situation in Gansu province is very severe, what is even more important is that more than half of the diabetes patients are undiagnosed. Our findings are of value for public health implications. Public efforts to introduce healthy lifestyle and government efforts to establish a systematic diabetes prevention programs and treatment policies are urgent to control the epidemiology of diabetes and its complications. Preventive intervention, screening, and treatment policies may effectively decrease the prevalence and complications of diabetes and therefore save costs.

# Declarations


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### Availability of data and materials



### Conflicts of Interest

The authors declare that they have no conflict of interest.

### Authors' contributions

Qi Zhang and Tiankang Guo contributed equally to this study.

### Ethics approval and consent to participate

The ethical approval and consent of the study has been approved by the Medical Ethics Research Committee of the Medical Center of Gansu Provincial people's Hospital (Agreement No: 2013-213). Written informed consent to participate in the study will be obtained from all participants.

### Consent for publication

Not applicable.

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# Tables

Table1.Blood Biochemical Index

| | | Mean (95% CI), mmol/l | | | | | |
|---|---|---|---|---|---|---|---|
| | Number | TG | TC | LDL | HDL | FPG | 2hPG |
| Overall | 31417 | 1.74 (1.72,1.75) | 4.46 (4.45,4.47) | 2.61 (2.60,2.62) | 1.46 (1.45,1.47) | 5.38 (5.36,5.40) | 6.51 (6.49,6.54) |
| Sex | | | | | | | |
| male | 14083 | 1.82 (1.80,1.84) | 4.43 (4.41,4.44) | 2.63 (2.62,2.65) | 1.38 (1.37,1.39) | 5.45 (5.42,5.48) | 6.62 (6.58,6.66) |
| female | 17334 | 1.67 (1.65,1.68) | 4.48 (4.47,4.50) | 2.60 (2.58,2.61) | 1.52 (1.51,1.53) | 5.32 (5.29,5.35) | 6.43 (6.39,6.46) |
| Age groups,y | | | | | | | |
| 20-29 | 5061 | 1.53 (1.51,1.56) | 4.19 (4.16,4.22) | 2.45 (2.43,2.47) | 1.52 (1.51,1.54) | 4.92 (4.87,4.96) | 5.93 (5.88,5.97) |
| 30-39 | 5103 | 1.70 (1.67,1.73) | 4.33 (4.30,4.36) | 2.53 (2.51,2.55) | 1.46 (1.44,1.48) | 5.06 (5.03,5.09) | 6.24 (6.18,6.29) |
| 40-49 | 7932 | 1.76 (1.73,1.78) | 4.44 (4.42,4.46) | 2.57 (2.56,2.59) | 1.41 (1.40,1.42) | 5.23 (5.20,5.27) | 6.46 (6.41,6.51) |
| 50-59 | 6138 | 1.84 (1.81,1.87) | 4.60 (4.58,4.63) | 2.71 (2.69,2.73) | 1.45 (1.43,1.46) | 5.53 (5.48,5.58) | 6.63 (6.57,6.69) |
| 60-74 | 7183 | 1.79 (1.77,1.82) | 4.64 (4.61,4.66) | 2.74 (2.73,2.76) | 1.48 (1.46,1.49) | 5.97 (5.91,6.03) | 7.12 (7.05,7.19) |
| Area | | | | | | | |
| rural | 14480 | 1.66 (1.64,1.67) | 4.40 (4.39,4.42) | 2.54 (2.52,5.55) | 1.49 (1.48,1.50) | 5.39 (5.36,5.42) | 6.48 (6.44,6.52) |
| urban | 16937 | 1.81 (1.79,1.82) | 4.50 (4.49,4.52) | 2.68 (2.67,2.69) | 1.43 (1.42,1.44) | 5.37 (5.34,5.40) | 6.54 (6.50,6.58) |
| Altitude | | | | | | | |
| 1000-2000m | 28656 | 1.74 (1.73,1.75) | 4.43 (4.42,4.44) | 2.61 (2.60,2.62) | 1.44 (1.43,1.45) | 5.24 (5.22,5.25) | 6.52 (6.50,6.55) |
| 2000-3000m | 2761 | 1.70 (1.66,1.73) | 4.63 (4.59,4.66) | 2.53 (2.50,2.56) | 1.75 (1.72,1.79) | 5.29 (5.22,5.35) | 6.40 (6.30,6.50) |
| Econimic development | | | | | | | |
| undeveloped | 10532 | 1.72 (1.70,1.74) | 4.40 (4.38,4.42) | 2.53 (2.51,2.55) | 1.72 (1.70,1.73) | 5.25 (5.22,5.27) | 6.31 (6.27,6.35) |
| intermediately developed | 10063 | 1.70 (1.68,1.72) | 4.49 (4.47,4.51) | 2.60 (2.58,2.61) | 1.39 (1.38,1.40) | 5.37 (5.33,5.40) | 6.49 (6.45,6.54) |
| developed | 10822 | 1.79 (1.77,1.81) | 4.49 (4.47,4.50) | 2.71 (2.69,2.72) | 1.27 (1.27,1.28) | 5.52 (5.48,5.57) | 6.72 (6.68,6.77) |
| BMI[a],Kg/m$^2$ | | | | | | | |
| <18.5 | 1428 | 1.42 (1.37,1.46) | 4.23 (4.17,4.28) | 2.40 (2.36,2.44) | 1.64 (1.60,1.67) | 5.11 (5.03,5.20) | 6.27 (6.15,6.39) |
| 18.5-24.99 | 21430 | 1.65 (1.64,1.66) | 4.42 (4.41,4.43) | 2.59 (2.58,2.60) | 1.48 (1.47,1.49) | 5.27 (5.25,5.29) | 6.40 (6.37,6.43) |
| 25-29.99 | 7870 | 1.99 (1.97,2.02) | 4.58 (4.56,4.61) | 2.70 (2.69,2.72) | 1.38 (1.37,1.40) | 5.66 (5.61,5.70) | 6.82 (6.76,6.88) |
| ≥30 | 670 | 2.15 (2.04,2.26) | 4.68 (4.60,4.76) | 2.75 (2.68,2.81) | 1.38 (1.34,1.43) | 6.25 (5.90,6.60) | 7.20 (6.99,7.41) |
| Waist circum- | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ference,cm | | | | | | | |
| <90 in men; <80 in women | 16722 | 1.58 (1.57,1.60) | 4.35 (4.33,4.37) | 2.54 (2.53,2.55) | 1.48 (1.47,1.49) | 5.24 (5.21,5.27) | 6.36 (6.33,6.40) |
| ≥90 in men; ≥80 in women | 14671 | 1.91 (1.89,1.93) | 4.58 (4.56,4.60) | 2.69 (2.68,2.71) | 1.43 (1.42,1.44) | 5.53 (5.50,5.57) | 6.69 (6.64,6.73) |

[a]There were 14 missing value for BMI.
SI conversion factors: To convert plasma glucose to mg/dl, multiply by 18; total, low-density lipoprotein, and high-density lipoprotein cholesterol to mg/dl multiply by38.67; and triglycerides to mg/dl, multiply by 88.545.

Table 2. Characteristics of Participants

| | % (95% CI) | | | | Mean (95% CI) | | |
|---|---|---|---|---|---|---|---|
| | Family History of DM | College or more | Smoking | Drinking | Body Mass Index | Waist Circumference, cm | Mean of SBP, mm Hg |
| Overall | 5.7 (5.4,6.0) | 25.9 (25.4,26.4) | 23.6 (23.1,24.0) | 17.2 (16.8,17.6) | 23.31 (23.28,23.35) | 83.55 (83.44,83.65) | 123.84 (123.65,124.03) |
| Sex | | | | | | | |
| male | 5.8 (5.4,6.2) | 29.2 (28.4,30.0) | 50.7 (49.9,51.5) | 34.8 (34.0,35.6) | 23.72 (23.67,23.76) | 85.91 (85.75,86.07) | 125.89 (125.63,126.16) |
| female | 5.6 (5.3,5.9) | 23.2 (22.6,23.8) | 1.6 (1.4,1.8) | 2.8 (2.6,3.0) | 22.99 (22.94,23.04) | 81.62 (81.49,81.76) | 122.17 (121.90,122.44) |
| Age groups,y | | | | | | | |
| 20-29 | 3.9 (3.4,4.4) | 54.3 (52.9,55.7) | 18.3 (17.2,19.4) | 18.7 (17.6,19.8) | 21.69 (21.61,21.77) | 80.03 (79.79,80.27) | 114.16 (113.82,114.49) |
| 30-39 | 6.9 (6.2,7.6) | 44.5 (43.1,45.9) | 25.5 (24.3,26.7) | 23.9 (22.7,25.1) | 23.01 (22.94,23.09) | 82.33 (82.07,82.59) | 117.56 (117.19,117.93) |
| 40-49 | 7.3 (6.7,7.9) | 23.5 (22.6,24.4) | 26.1 (25.1,27.1) | 19.8 (18.9,20.7) | 23.69 (23.63,23.76) | 83.52 (83.31,83.72) | 122.28 (121.94,122.61) |
| 50-59 | 6.1 (5.5,6.7) | 13.1 (12.3,13.9) | 24.1 (23.0,25.2) | 16.0 (15.1,16.9) | 23.91 (23.83,23.98) | 84.86 (84.62,85.10) | 128.38 (127.95,128.82) |
| 60-74 | 3.9 (3.5,4.3) | 6.2 (5.6,6.8) | 23.0 (22.0,24.0) | 9.4 (8.7,10.1) | 23.75 (23.67,23.82) | 85.81 (85.58,86.04) | 132.97 (132.53,133.40) |
| Area | | | | | | | |
| rural | 4.7 (4.4,5.0) | 10.4 (9.9,10.9) | 26.7 (26.0,27.4) | 17.9 (17.3,18.5) | 23.38 (23.33,23.43) | 83.33 (83.18,83.48) | 125.89 (125.59,126.20) |
| urban | 6.5 (6.1,6.9) | 39.1 (38.4,39.8) | 21.1 (20.5,21.7) | 16.5 (15.9,17.1) | 23.26 (23.21,23.31) | 83.73 (83.58,83.88) | 122.09 (121.85,122.32) |
| Altitude | | | | | | | |
| 1000-2000m | 5.9 (5.6,6.2) | 27.6 (27.1,28.1) | 23.5 (23.0,24.0) | 17.5 (17.1,17.9) | 23.35 (23.31,23.38) | 83.55 (83.44,83.67) | 123.64 (123.44,123.84) |
| 2000-3000m | 3.6 (2.9,4.3) | 7.7 (6.7,8.7) | 25.1 (23.5,26.7) | 14.1 (12.8,15.4) | 22.96 (22.85,23.07) | 83.48 (83.11,83.85) | 126.00 (125.29,126.71) |
| Econimic development | | | | | | | |
| undeveloped | 7.3 (6.8,7.8) | 27.5 (26.6,28.4) | 22.6 (21.8,23.4) | 16.4 (15.7,17.1) | 23.25 (23.20,23.31) | 83.12 (82.92,83.31) | 123.16 (122.80,123.52) |
| intermediately developed | 3.5 (3.1,3.9) | 21.0 (20.2,21.8) | 24.4 (23.6,25.2) | 16.9 (16.2,17.6) | 23.14 (23.08,23.20) | 83.45 (83.26,83.63) | 123.59 (123.28,123.89) |
| developed | 6.0 (5.6,6.4) | 28.8 (27.9,29.7) | 23.9 (23.1,24.7) | 18.1 (17.4,18.8) | 23.53 (23.47,23.59) | 84.06 (83.89,84.23) | 124.74 (124.42,125.06) |
| BMI[a],Kg/m$^2$ | | | | | | | |
| 18.5 | 3.3 (2.4,4.2) | 38.2 (35.7,40.7) | 12.6 (10.9,14.3) | 8.5 (7.1,9.9) | 17.56 (17.51,17.60) | 76.57 (76.19,76.95) | 114.90 (114.08,115.72) |
| 18.5-24.99 | 5.0 (4.7,5.3) | 26.8 (26.2,27.4) | 22.6 (22.0,23.2) | 16.0 (15.5,16.5) | 22.19 (22.16,22.21) | 81.58 (81.47,81.70) | 121.93 (121.71,122.15) |
| 25-29.99 | 7.6 (7.0,8.2) | 22.4 (21.5,23.3) | 28.7 (27.7,29.7) | 22.2 (21.3,23.1) | 26.71 (26.68,26.73) | 89.10 (88.91,89.30) | 129.71 (129.32,130.10) |
| ≥30 | 7.8 (5.8,9.8) | 13.0 (10.5,15.5) | 20.3 (17.3,23.3) | 13.7 (11.1,16.3) | 31.85 (31.65,32.04) | 95.91 (95.20,96.61) | 135.31 (133.80,136.82) |
| Waist circum- | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ference,cm | | | | | | | |
| <90 in men; <80 in women | 5.3 (5.0,5.6) | 28.8 (28.1,29.5) | 27.5 (26.8,28.2) | 19.2 (18.6,19.8) | 22.29 (22.25,22.33) | 77.21 (77.12,77.30) | 120.95 (120.70,121.18) |
| ≥90 in men; ≥80 in women | 6.1 (5.7,6.5) | 22.6 (21.9,23.3) | 19.2 (18.6,19.8) | 14.9 (14.3,15.5) | 24.48 (24.43,24.53) | 90.77 (90.64,90.90) | 127.15 (126.86,127.44) |

[a]There were 14 missing value for BMI.

Table 3. Estimated Prevalence of Diabetes and Prediabetes

| | Prevalence (95% CI), % | | | | |
|---|---|---|---|---|---|
| | diabetes | new detected diabetes | IFG | IGT | IGR |
| Overall | 10.6 (10.3,10.9) | 5.4 (5.2,5.6) | 3.5 (3.3,3.7) | 11.6 (11.2,12.0) | 15.2 (14.8,15.6) |
| Sex | | | | | |
| male | 12.3 (11.8,12.8) | 6.5 (6.1,6.9) | 3.7 (3.4,4.0) | 11.9 (11.4,12.4) | 15.7 (15.1,16.3) |
| female | 9.2 (8.8,9.6) | 4.5 (4.2,4.8) | 3.3 (3.0,3.6) | 11.4 (10.9,11.9) | 14.7 (14.2,15.2) |
| P Value | <0.01 | <0.01 | 0.04 | 0.15 | 0.02 |
| Age groups,y | | | | | |
| 20-29 | 3.6 (3.1,4.1) | 3.2 (2.7,3.7) | 2.4 (2.0,2.8) | 6.7 (6.0,7.4) | 9.0 (8.2,9.8) |
| 30-39 | 5.5 (4.9,6.1) | 4.1 (3.6,4.6) | 3.0 (2.5,3.5) | 9.3 (8.5,10.1) | 12.3 (11.4,13.2) |
| 40-49 | 8.3 (7.7,8.9) | 5.0 (4.5,5.5) | 3.3 (2.9,3.7) | 11.8 (11.1,12.5) | 15.1 (14.3,15.9) |
| 50-59 | 12.5 (11.7,13.3) | 6.1 (5.5,6.7) | 4.1 (3.6,4.6) | 12.7 (11.9,13.5) | 16.8 (15.9,17.7) |
| 60-74 | 20.0 (19.1,20.9) | 7.6 (7.0,8.2) | 4.5 (4.0,5.0) | 15.7 (14.9,16.5) | 20.2 (19.3,21.1) |
| P Value | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Area | | | | | |
| rural | 9.5 (9.0,10.0) | 5.2 (4.8,5.6) | 4.4 (4.1,4.7) | 11.9 (11.4,12.4) | 16.3 (15.7,16.9) |
| urban | 11.5 (11.0,12.0) | 5.5 (5.2,5.8) | 2.7 (2.5,2.9) | 11.4 (10.9,11.9) | 14.2 (13.7,14.7) |
| P Value | <0.01 | =0.12 | <0.01 | 0.2 | <0.01 |
| Altitude | | | | | |
| 1000-2000m | 10.7 (10.3,11.1) | 5.4 (5.1,5.7) | 3.4 (3.2,3.6) | 12.1 (11.7,12.5) | 15.5 (15.1,15.9) |
| 2000-3000m | 9.2 (8.1,10.3) | 5.3 (4.5,6.1) | 4.7 (3.9,5.5) | 6.8 (5.9,7.7) | 11.5 (10.3,12.7) |
| P Value | =0.01 | =0.85 | <0.01 | <0.01 | <0.01 |
| Econimic development | | | | | |
| undeveloped | 8.2 (7.7,8.7) | 3.7 (3.3,4.0) | 3.1 (2.8,3.4) | 12.6 (12.0,13.2) | 15.6 (14.9,16.3) |
| intermediately developed | 9.6 (9.0,10.2) | 5.1 (4.7,5.5) | 4.4 (4.0,4.8) | 9.4 (8.8,10.0) | 13.8 (13.1,14.5) |
| developed | 13.9 (13.2,14.6) | 7.2 (6.7,7.7) | 3.1 (2.8,3.4) | 12.8 (12.2,13.4) | 16.0 (15.3,16.7) |
| P Value | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| BMI[a],Kg/m$^2$ | | | | | |
| <18.5 | 6.9 (5.6,8.2) | 4.4 (3.3,5.5) | 2.2 (1.4,3.0) | 10.3 (8.7,11.9) | 12.5 (10.8,14.2) |
| 18.5-24.99 | 9.1 (8.7,9.5) | 4.8 (4.5,5.1) | 3.4 (3.2,3.6) | 10.5 (10.1,10.9) | 13.9 (13.4,14.4) |
| 25-29.99 | 14.5 (13.7,15.3) | 6.7 (6.1,7.3) | 4.1 (3.7,4.5) | 14.5 (13.7,15.3) | 18.6 (17.7,19.5) |
| ≥30 | 20.6 (17.5,23.7) | 9.6 (7.4,11.8) | 4.5 (2.9,6.1) | 17.2 (14.3,20.1) | 21.6 (18.5,24.7) |
| P Value | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Waist circumference,cm | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| <90 in men; <80 in women | 8.4 (8.0,8.8) | 4.8 (4.5,5.1) | 3.3 (3.0,3.6) | 10.4 (9.9,10.9) | 13.7 (13.2,14.2) |
| ≥90 in men; ≥80 in women | 13.1 (12.6,13.6) | 6.0 (5.6,6.4) | 3.8 (3.5,4.1) | 13.0 (12.5,13.5) | 16.8 (16.2,17.4) |
| P Value | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 |

[a]There were 14 missing value for BMI.

Table 4.Age-standardized Prevalences of Diabetes and Prediabetes

| | | males | | females | | Overall | |
|---|---|---|---|---|---|---|---|
| Age group,y | standard population | crude prevalence | expect population | crude prevalence | expect population | crude prevalence | expect population |
| 20-29 | 191678 | 5.1% | 9775 | 2.6% | 4984 | 3.6% | 6900 |
| 30-39 | 172640 | 7.2% | 12430 | 3.9% | 6733 | 5.5% | 9495 |
| 40-49 | 206844 | 11.1% | 22960 | 5.9% | 12204 | 8.3% | 17168 |
| 50-59 | 133319 | 15.0% | 19998 | 10.6% | 14132 | 12.5% | 16665 |
| 60-74 | 121231 | 20.2% | 24489 | 19.9% | 24125 | 20.0% | 24246 |
| Total | 825712 | | 89652 | | 62178 | | 74474 |
| Standardized | | | 10.9% | | 7.5% | | 9.0% |
| 20-29 | 191678 | 10.7% | 20510 | 7.9% | 15143 | 9. 0% | 17251 |
| 30-39 | 172640 | 13.8% | 23824 | 10.9% | 18818 | 12.3% | 21235 |
| 40-49 | 206844 | 16.0% | 33095 | 14.3% | 29579 | 15.1% | 31233 |
| 50-59 | 133319 | 16.4% | 21864 | 17.2% | 22931 | 16.8% | 22398 |
| 60-74 | 121231 | 19.5% | 23640 | 20.7% | 25095 | 20.2% | 24489 |
| Total | 825712 | | 122933 | | 111566 | | 116606 |
| Standardized | | | 14.9% | | 13.5% | | 14.1% |

Table 5. Risk Factors for Diabetes and Prediabetes

| Diabetes | | | Prediabetes | | |
|---|---|---|---|---|---|
| Risk Factors | OR（95%CI） | P | Risk Factors | OR（95%CI） | P |
| Male sex | 1.38 (1.25,1.52) | <0.001 | Male sex | 1.11 (1.02～1.20) | 0.013 |
| Age per 10y | 1.48 (1.43,1.53) | <0.001 | Age per 10y | 1.18 (1.15～1.21) | <0.001 |
| Urban | 1.20 (1.11,1.30) | <0.001 | Rural | 1.08 (1.00～1.14) | 0.042 |
| Economic development | 1.27 (1.22,1.34) | <0.001 | Less than college | 1.31 (1.20～1.43) | <0.001 |
| Smoking | 1.25 (1.12,1.39) | <0.001 | Smoking | 0.90 (0.82～0.98) | 0.021 |
| Drinking | 0.77 (0.69,0.87) | <0.001 | Drinking | 1.18 (1.07～1.30) | 0.001 |
| Exercise | 1.38 (1.27,1.49) | <0.001 | Obesity | 1.41 (1.16～1.71) | <0.001 |
| FHDM | 2.45 (2.16,2.79) | <0.001 | Overweight | 1.25 (1.16～1.35) | <0.001 |
| Obesity | 1.57 (1.28,1.93) | <0.001 | Hypertension | 1.08 (1.01～1.16) | 0.034 |
| Overweight | 1.15 (1.06,1.26) | =0.001 | Central obesity | 1.09 (1.02～1.17) | 0.011 |
| Dyslipidemia | 1.34 (1.24,1.44) | <0.001 | | | |
| Hypertension | 1.60 (1.47,1.74) | <0.001 | | | |
| Centralobesity | 1.28 (1.17,1.39) | <0.001 | | | |

# Figures

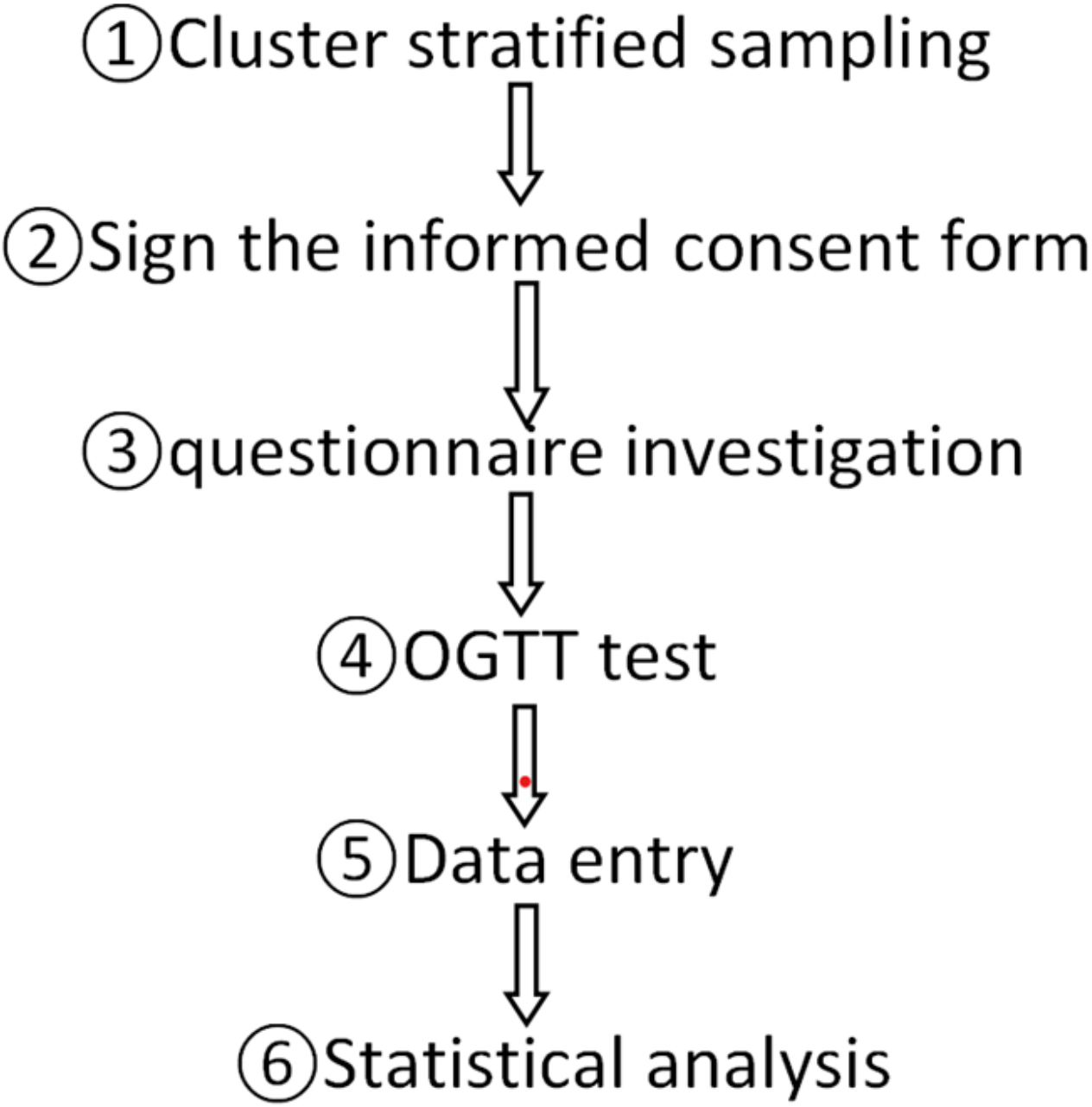


**Figure 1**

population inclusion and research process

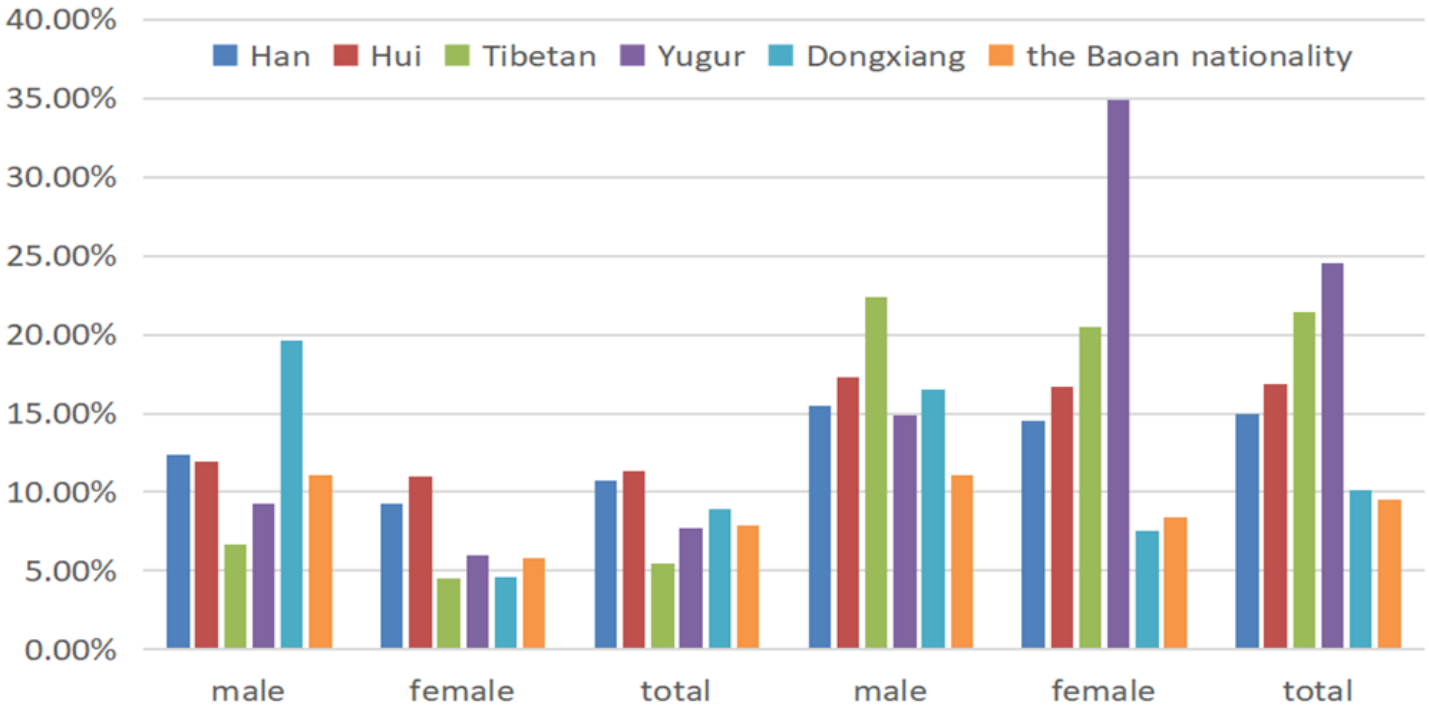


**Figure 2**

The prevalences of diabetes and prediabetes among different ethnic groups