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Prevalence of impaired fasting glucose, type 2 diabetes and associated risk factors in undiagnosed Chinese rural population: the Henan Rural Cohort Study

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ABSTRACT

Objective This study estimated the burden and characterised the risk factors associated with diabetes and impaired fasting glucose (IFG) in an undiagnosed rural population.

Design Data for 36 960 participants from the Henan Rural Cohort baseline with undiagnosed diabetes were analysed. X^2 test and multivariate logistic regression analyses were performed to test for association between risk factors and diabetes and IFG.

Results Women constituted 60.30% of the study participants, mean age of participants was 55.32±12.18 years, risk factors for diabetes and IFG were prevalent (75% dyslipidaemia, 57% overweight/obese, 50% central obesity and 18% metabolic syndrome). The prevalence of diabetes and IFG was 4.19% and 7.22%, respectively. Having a metabolic syndrome (adjusted OR (aOR) 4.7, 95% CI 4.27 to 5.33), dyslipidaemia (aOR 2.76, 95% CI 2.31 to 3.21), centrally obese (aOR 2.38, 95% CI 2.11 to 2.70), being overweight/obese (aOR 1.66, 95% CI 1.45 to 1.79) and a family history of diabetes (aOR 1.50, 95% CI 1.15 to 1.92) were associated with diabetes. These factors were also associated with IFG. Intake of high salt diet (aOR 1.16, 95% CI 1.02 to 1.32) and smoking (aOR 1.22, 95% CI 1.02 to 1.47; significant in men) were also associated with diabetes. Engaging in moderate physical activity (aOR 0.94, 95% CI 0.89 to 0.98) was noted to be negatively associated with diabetes.

Conclusion Diabetes and IFG remain prevalent in Chinese population with obesity and dyslipidaemia being some of the most significant predictors. Regular physical activity and consumption of fruits and vegetables may be beneficial in keeping blood glucose level low.

Trial registration number ChiCTR-OOC-15006699

Strengths and limitations of this study

- This study was conducted among a large population and therefore will control for random error.
- Lifestyle behaviour and dietary patterns were assessed through self-reported questionnaires and therefore had the possibility of over/underestimation due to recall bias.
- This study was a baseline cross-sectional study and therefore not able to establish a causal relationship between diabetes/impaired fasting glucose and the risk factors identified.

INTRODUCTION

Annually, a reported 3.2 million people worldwide die from complications associated with diabetes. In the Pacific and Middle Eastern countries, as many as one-fourth deaths in adults aged between 35 and 64 years are due to the complications from diabetes.[1]

Diabetes mellitus is a chronic disease that occurs as a result of inadequate production of insulin or the ineffective utilisation of it by the body; this usually leads to raised levels of glucose in the blood. Diabetes, if uncontrolled over the long term, can damage various body organs, leading to the progression of disabling and life-threatening health complications such as cardiovascular disease, neuropathy, nephropathy and retinopathy.[2] Health cost on the individual, family and healthcare systems of the country often can be unimaginable, and there is, therefore, required a concerted effort in the control and prevention of diabetes.

Diabetes mellitus is typically classified into three types depending on the period/time of onset; type 1 (in children), type 2 (in adults) and gestational diabetes (during pregnancy). The most common is type 2 diabetes[3] accounting for nearly 90% of all cases of diabetes.[2–6] In the last three decades, the prevalence of type 2 diabetes has risen considerably in all countries regardless of their income levels, with countries that have witnessed economic prosperity and increased life expectancy during the same period

having a higher increase in both absolute numbers and prevalence.[2] There is, however, a disproportionate rise in the burden of diabetes, both in terms of prevalence and number of adults affected, with the rate of increase faster in low-income and middle-income countries than in high-income countries.[7]

Type 2 diabetes affects some 425 million people worldwide (about 6% of the global population); some countries/regions are disproportionately affected, especially Southeast Asian and Middle Eastern and North African countries.[2 7 8] China, with about 20% of the world's population, has some 114 million people with diabetes (over a quarter of all global diabetes cases) with a national prevalence of about10%.[2 8 9] China leads in absolute numbers of diabetes cases and is third in terms of prevalence; rise in diabetes in China is mainly due to ageing, but recent studies paint a worrying picture of young adults increasingly getting diagnosed with diabetes.[2 7 8 10] The cause of diabetes is multifaceted, usually resulting from the interactions of several factors. Genetics and the environment have been established to be pivotal in the progression from normoglycaemia to hyperglycaemia.[3 9 11 12]

The incidence of type 2 diabetes has risen at an alarming rate in the last three decades and is projected to follow this trajectory in the coming decades if preventive efforts are not stepped up.[7 13] The risk factors of type 2 diabetes have been well documented, but the roles of these factors in the cause of diabetes are yet to be fully understood. Genetics and ageing are some of the predisposing risks that cannot be controlled, but the progression to diabetes is usually aggravated by modifiable lifestyle factors that we may have control over. Lifestyle behaviour is one of the most critical risk factors for type 2 diabetes; unhealthy diet, physical inactivity (leading to overweight and obesity) and smoking are well known as some of the most important modifiable risk factors.[2 7 14–22] Prior history of gestational diabetes, being a man and impaired fasting glucose (IFG/pre-diabetes) are also known to increase the risk for diabetes[16 21 23] highly. Previous studies have, however, placed less emphasis on IFG, but there is evidence that if preventive measures are instituted on detection of IFG, the progression to diabetes can often be delayed or halted altogether.[2]

IFG is defined as the condition in which people have a higher than normal blood glucose level but not high enough for a diagnosis of diabetes.[24] Globally, about 233–577 million people are projected to have pre-diabetes/IFG, and given the commitment by countries to reduce premature mortality from non-communicable diseases (NCDs) (including diabetes) by one-third by 2030 in the framework of the 2030 Agenda for Sustainable Development,[2 8 25] if significant effort is not made in halting the progression from IFG to diabetes this may only be a mirage.

This study characterised the risk factors associated with diabetes and IFG in the undiagnosed population of the Henan Rural cohort.

METHODS

This population-based survey was carried out in five counties of the Henan province, PR China. Henan province is in the central part of China with a population of about 95 million inhabitants, agriculture, manufacturing and commence are some of the predominant economic activities in the province.

A multistage, stratified cluster sampling was used to select the study sites. The target population was adults who were permanent residents in the selected counties and available for completing follow-up.

Patient and public involvement

Patients were not involved in this study. This study was a population-based survey, and men and women born during 1938–1999 in five rural counties (Suiping, Yuzhou, Xinxiang, Tongxu and Yima counties) of the Henan province in China were invited to participate in the Henan Rural Cohort. A total of 15 490 men and 23 769 women participated in the baseline study in July 2015 and September 2017.

Data collection

Trained personnel administered questionnaires for sociodemographic information, lifestyle behaviours and other relevant information about the study. Nurses and allied health personnel made anthropometric and blood pressure (BP) measurements, and also collected venous fasting blood samples (taken after at least 8 hours overnight fast). Study participants were weighed dressed in light clothing with no shoes, using a digital scale. Height was determined using a standard tape measure attached to a wall. Height and weight were measured to the nearest centimetre and 100 g, respectively. The design of this study has been described extensively elsewhere.[26]

Sample selection for data analysis

Thirty-six thousand nine hundred and sixty (n=36 960) participants were recruited from the Henan baseline Cohort study into the current analysis (online supplementary figure 1). Participants with no glucose readings (71), less than 20 years (72), with diagnosed type 2 diabetes (2152) and type 1 diabetes (4) were excluded from the current analysis. Basline characteristics of excluded participants are presented in online supplementary table 1.

Laboratory methods

Fasting glucose and blood lipids analyses were carried out by ROCHE Cobas C501 automatic biochemical analyser with glucose oxidative method (GOD-PAP, Switzerland).

Statistical analysis

Categorical variables were analysed and presented as counts and proportions while descriptive statistics was computed for continuous variables. Age was recategorised into four groups (20–34, 35–49, 50–64 and ≥65 years), body mass index (BMI) into three (normal weight, overweight and obese) and waist circumference

(WC) into a binary variable (central obesity vs no central obesity) using WHO Asian population reference for BMI and WC for men and women.[27] These transformations were essential for our logistic regression modelling since there was no linearity between these variables and blood glucose level (the outcome variable). Glucose measurements were categorised into three (<6.1 mmol/L as normoglycaemia, 6.1–6.99 mmol/L as IFG (pre-diabetes) and ≥7 mmol/L as diabetes patient) using WHO recommended diagnostic criteria for diabetes.[24]

Univariate and multivariate logistic regression models were used to determine the association between diabetes, IFG and risk factors (age, gender, obesity, etc). All candidate variables initially underwent univariate logistic modelling and those with p<0.5 were retained for the multivariate analysis. Age and sex were controlled for in a second and third model, and all other covariates fitted into a fourth model. A multicollinearity test was conducted for covariates and collinear variables were not inputted concurrently in the multivariate logistic regression analysis. The adjusted ORs (aORs) with CI at 95% are used for interpretation of the results. The selection of variables was informed by findings from previous studies on the risk factors for diabetes and IFG[19 22 28] and goodness-of-fit test together with receiver operating characteristic curves performed to determine the suitability of our models (online supplementary figures 2 and 3). We also considered salt intake variable in our analysis which has not been reported in previous studies.

The International Diabetes Federation (IDF) definition of metabolic syndrome (MetS) was used for our analysis: WC >90 cm in men and >80 cm in women plus any two of the following four factors: (1) raised triglycerides (1.7 mmol/L) or specific treatment for lipid abnormality, (2) reduced HDL cholesterol (1.03 mmol/L) in males <50 mg/dL (1.29 mmol/L) in females, (3) raised BP systolic BP ≥130 or diastolic BP ≥85 mm Hg or treatment of previously diagnosed hypertension and (4) raised fasting blood glucose (FBG) of above 5.6 mmol/L.[1] Dyslipidaemia was defined using the IDF criteria for raised triglycerides, low density lipoprotein cholesterol (LDL-C) and reduced high density lipoprotein cholesterol (HDL-C).[1]

All statistical analyses were performed using Stata software V.13 (StataCorp) and IBM statistics (SPSS) V.23 and the level of significance set at p≤0.05 (two tailed).

RESULTS

A total of 41 893 invitations were sent out to those who met the inclusion criteria, and 39 259 people (93.7%) responded in the baseline study. Thirty-six thousand nine hundred and sixty (n=36 960) participants were recruited from the Henan baseline Cohort study into this study, 22 287 (60.30%) were women with a mean age of 54.57±12.05, and 14 673 (39.70%) were men with a mean age of 56.47±12.29. Men had higher propensity for diabetes (4.46% vs 4.0%, p=0.035) and IFG (7.59% vs 6.99%, p=0.029). The prevalence of diabetes and IFG among the undiagnosed population was 4.19% and 7.22%, respectively, age-adjusted prevalence for diabetes and IFG was 3.78% and 6.41%. Persons with diabetes and IFG were overweight/obese, more centrally obese, had higher total cholesterol, older and had higher BP compared with those who were normoglycaemic (table 1).

Diabetes and IFG risk factors were prevalent in the study population; dyslipidaemia (74.76%), obesity (BMI, 56.63%), central obesity (WC) (50.57%), ever smoked (27.5%), MetS (18.36%) and high salt diet intake (17%). These risks factors were more prevalent in persons with diabetes and IFG compared with normoglycaemic individuals.

Risk factors associated with diabetes and IFG

The risk factors for diabetes and IFG considered for our study population were age, gender, smoking and drinking status, high salt diet intake, MetS, dyslipidaemia, central and general obesities. MetS (aOR 4.77, 95% CI 4.27 to 5.33), dyslipidaemia (aOR 2.76, 95% CI 2.31 to 3.21), central obesity (aOR 2.38, 95% CI 2.11 to 2.70), obesity (aOR 1.66, 95% CI 1.45 to 1.79) and family history of diabetes (aOR 1.50, 95% CI 1.15 to 1.92) were independently strongly associated with diabetes following a multivariate logistic regression analyses. High salt diet intake, age and being a man were also significantly associated with having diabetes in our study population (table 2).

The association of smoking and the presence of diabetes was found in men in stratified logistic regression analysis by gender but not in women (aOR 1.22, 95% CI 1.02 to 1.47, p=0.034 vs aOR 0.92, 95% CI 0.74 to 1.15, p=0.477) (data not shown). Men who had ever smoked had a higher propensity of developing diabetes compared with non-smokers and current smokers.

Engaging in moderate exercise was noted to be negatively associated with diabetes. Fruits/vegetables consumption and socioeconomic status were not associated with diabetes.

The risks associated with IFG were generally similar to those for diabetes, with the exception of smoking, alcohol consumption, exercise and high salt diet intake (table 2). Alcohol intake was associated with IFG (aOR 1.10, 95% CI 1.05 to 1.15). We did not find an association between exercise and socioeconomic status with IFG. Fruits/vegetables consumption was found to be negatively associated with IFG.

DISCUSSION

Our study considered only participants with no known history of diabetes for analysis for the prevalence of diabetes, IFG and associated risk factors. We considered this population because they are most likely to alter their health behaviours the least and will, therefore, reflect the true patterns and behaviours of the general population. The crude prevalence of diabetes and IFG was 4.19%

Table 1 Baseline characteristics of participants stratified by blood glucose category

	Normoglycaemic 32740 (88.58%)	IFG 2670 (7.22%)	Diabetes 1550 (4.19%)	Total 36960	P value (unadjusted)
Age (years) mean±SD	54.88±12.33	58.71±10.52	58.77±10.0	55.32±12.18	<0.001
BMI (kg/m^2) mean±SD	24.59±3.49	26.03±3.63	26.46±3.74	24.76±3.55	<0.001
Glucose (mmol/L) mean±SD	5.09±0.47	6.42±0.25	8.97±2.45	5.34±1.07	<0.001
WC (cm) mean±SD	83.20±10.20	88.20±10.40	89.90±10.40	83.78±10.35	<0.001
TG (mmol/L) mean±SD	1.61±1.05	1.92±1.30	2.20±1.48	1.66±1.10	<0.001
HDL-C (mmol/L) mean±SD	1.34±0.33	1.28±0.34	1.23±0.33	1.33±0.33	0.881
SBP (mm Hg) mean±SD	124±19.67	134±19.67	134±19.59	126±19.90	<0.001
DBP (mm Hg) mean±SD	77±11.56	82±11.69	81±11.10	77±11.66	<0.001
Gender					0.008
Male n (%)	12905 (87.95)	1113 (7.59)	655 (4.46)	14673 (39.70)	
Female n (%)	19835 (89.00)	1557 (6.99)	895 (4.02)	22287 (60.30)	
Education level					<0.001
No formal education n (%)	5122 (85.54)	537 (8.97)	329 (5.49)	5988 (16.20)	
Less than high school n (%)	22481 (89.09)	1737 (6.88)	1017 (4.03)	25235 (68.28)	
High school and higher n (%)	5137 (89.54)	396 (6.90)	204 (3.56)	5737 (15.52)	
Marital status					<0.001
Married/cohabitating n (%)	29535 (88.80)	2354 (7.08)	1370 (4.12)	33259 (89.99)	
Widowed	2522 (85.17)	284 (9.59)	155 (5.23)	2961 (8.01)	
Divorced/separated	185 (90.69)	9 (4.41)	10 (4.90)	204 (0.55)	
Single	498 (92.91)	23 (4.29)	15 (2.80)	536 (1.45)	
Exercise					<0.001
Low n (%)	10198 (86.77)	986 (8.39)	569 (4.84)	11753 (31.80)	
Moderate n (%)	12546 (89.58)	913 (6.52)	547 (3.91)	14006 (37.90)	
Vigorous n (%)	9996 (89.24)	771 (6.88)	434 (3.87)	11201 (30.30)	
Smoking status					<0.001
Never n (%)	23771 (88.71)	1904 (7.11)	1120 (4.18)	26795 (72.50)	
Ever n (%)	2523 (85.35)	285 (9.64)	148 (5.01)	2956 (8.00)	
Current n (%)	6446 (89.42)	481 (6.67)	282 (3.91)	7209 (19.50)	
Drinking status					0.012
Never n (%)	25315 (88.88)	1997 (7.01)	1171 (4.11)	28483 (77.06)	
Ever n (%)	1448 (86.65)	141 (8.44)	82 (4.91)	1671 (4.52)	
Current n (%)	5977 (87.82)	532 (7.82)	297 (4.36)	6806 (18.42)	
Fruits/vegetables					<0.001
Yes n (%)	14077 (90.17)	935 (5.99)	600 (3.84)	15612 (42.24)	
No n (%)	18662 (87.43)	1735 (8.13)	949 (4.45)	21346 (57.76)	
High salt diet intake					0.002
Yes n (%)	5781 (87.51)	502 (7.60)	323 (4.89)	6606 (17.90)	
No n (%)	26921 (88.83)	2160 (7.13)	1225 (4.04)	30306 (82.10)	
Metabolic syndrome					<0.001
Yes n (%)	4876 (14.89)	1123 (42.06)	788 (50.84)	6787 (18.36)	
No n (%)	27864 (85.11)	1547 (57.94)	762 (49.16)	30173 (81.64)	
Dyslipidaemia					<0.001
Yes n (%)	23962 (86.72)	2276 (8.24)	1393 (5.04)	27631 (74.76)	
No n (%)	8778 (94.09)	394 (4.22)	157 (1.68)	9329 (25.24)	

Continued

Table 1 Continued

	Normoglycaemic 32740 (88.58%)	IFG 2670 (7.22%)	Diabetes 1550 (4.19%)	Total 36960	P value (unadjusted)
Family history of diabetes					<0.001
Yes n (%)	1143 (85.30)	125 (9.33)	72 (5.37)	1340 (3.63)	
No n (%)	31597 (88.71)	2545 (7.14)	1478 (4.15)	35620 (96.37)	

BMI, body mass index; DBP, diastolic blood pressure; HDL-C, high density lipoprotein cholesterol; IFG, impaired fasting glucose; SBP, systolic blood pressure; TG, triglycerides; WC, waist circumference.

and 7.22%, respectively, in our undiagnosed population. These findings are similar to findings of previous studies[3 22] that used FBG measurement for the diagnoses of diabetes and IFG. Other studies[11 12 28] reported comparatively higher prevalence due to the use of different diagnostic procedure (OGTT), or there may be a difference in the health-seeking behaviour of the study populations and other underlying factors that affect undiagnosed diabetes status in a population.

Dysglycaemia is caused by multimediating factors; biological/genetic and environmental risk factors as have been cited in previous studies.[7 19 29] In our study population, central obesity was perhaps the singular most strongly associated modifiable risk factor for both diabetes and IFG. Participants with diabetes and IFG were nearly three times likely to be centrally obese compared with their counterparts with normoglycaemia. Central obesity has been demonstrated to be more strongly associated with diabetes and IFG in previous studies.[18 30–32] Central obesity results from the deposition of adipocytes in the abdominal area,[18] and this has been linked with insulin resistance.[33] It is, therefore, imperative that WC is included in the taking of vital sign measurements of patients visiting the outpatient department since is easy and cheaper to measure in populations and a better index for diabetes and hypertension compared with BMI.

MetS and dyslipidaemia were also strongly associated with the odds of having diabetes and IFG. Persons with MetS and dyslipidaemia were 3–4 times more likely to have diabetes or IFG compared with those without MetS and dyslipidaemia. In similar population-based studies, these indices have been found to be strongly associated with diabetes and IFG.[1 11 34] The presences of these two are associated with abnormal lipids metabolism and a consequent cause of insulin resistance.

Our study found further a significant difference in the burden of diabetes and IFG in the different sexes. Men had a higher burden compared with women. Numerous studies have noted this difference in the distribution of diabetes and IFG in men and women.[10 16 35] More fat is deposited around the abdominal area and visceral organs in men compared with women who have a more distributed deposition of fat in their body, partly explaining the sex difference. Hormones, different stress levels and different lifestyle behaviours have also been cited as a possible explanation for this difference.[16 35] The expectation is that generally women should have had a higher prevalence of diabetes and IFG compared with men because the risk factors for diabetes and IFG were more prevalent in women compared with men. We are hypothesising that this observed phenomenon may be due to differences in the cut-off points for these risk factors (women have lower cut-off points), which conversely put more women in the risk 'band' compared with men.

Men also tended to have diabetes and IFG at a relatively younger age compared with women (figure 1). The onset of diabetes was much earlier in men (mean age of men with diabetes and IFG=57 years) compared with women (mean age of women with diabetes and IFG=59 years) in a stratified analysis. Additionally, nearly 5% of men as against 3% of women who had diabetes were under 40 years, a similar trend was noted for IFG (data not shown). The early onset of diabetes in men is still unexplained.

Nearly 70% of men had ever smoked while only less than 1% of women had ever smoked. Smoking was, therefore, found to be associated with diabetes in only men in a stratified regression analysis. Weight gain after cessation of smoking has been reported by previous studies, and this may partly explain the link between smoking and diabetes.[14 32]

High salt diet intake was also found to be associated with diabetes. The relationship between high salt consumption and development of diabetes has not been established, and it appears its role in diabetes development has not been explored in previous studies. High salt diet has been demonstrated to aid increased lipid absorption in animal studies.[36] In our study, however, we found a strong association between high salt diet intake with BMI and WC, possibly suggesting that BMI and WC may mediate the association between high salt intake and diabetes.

The intake of fruits and vegetables were not found to be independently associated with diabetes in a multivariate logistic regression as has been reported in other studies.[37] We, however, found a significant association of fruits/vegetables consumption and IFG. Zhang *et al* found a similar relation of fruits and vegetables and IFG in a cross-sectional study among Chinese men.[38] It has been suggested that the association between fruit and vegetable intake and lower blood glucose may be due to the role of antioxidants and/or minerals (such as magnesium) in the metabolism of glucose.[39 40] This finding suggests that

Table 2 Logistic regression: association of covariates with diabetes and IFG

	Model 1 OR (95% CI)	P value	Model 2 OR (95% CI)	P value	Model 3 OR (95% CI)	P value	Model 4 OR (95% CI)	P value
Diabetes								
Age	1.03 (1.02 to 1.03)	<0.001			1.03 (1.02 to 1.03)	<0.001	1.02 (1.02 to 1.03)	<0.001
Gender	0.89 (0.81 to 0.99)	0.036	0.94 (0.85 to 1.04)	0.250			0.86 (0.77 to 0.96)	0.006
Smoking								
Never	1.00		1.00		1.00		1.00	
Ever (former)	1.21 (1.01 to 1.44)	0.035	1.10 (0.92 to 1.33)	0.286	1.01 (0.82 to 1.25)	0.921	0.90 (0.71 to 1.13)	0.397
Current	0.93 (0.82 to 1.07)	0.310	0.93 (0.81 to 1.07)	0.314	0.78 (0.65 to 0.93)	0.006	0.85 (0.71 to 1.04)	0.124
Ever and current	0.98 (0.92 to 1.05)	0.590	0.97 (0.91 to 1.04)	0.395	0.88 (0.80 to 0.96)	0.005	1.03 (0.96 to 1.10)	0.365
Drinking								
Never	1.00		1.00		1.00		1.00	
Ever (former)	1.20 (0.96 to 1.51)	0.114	1.14 (0.90 to 1.44)	0.283	1.12 (0.87 to 1.43)	0.364	1.13 (0.87 to 1.48)	0.354
Current	1.06 (0.93 to 1.21)	0.349	1.12 (0.97 to 1.28)	0.107	0.99 (0.85 to 1.16)	0.962	1.01 (0.85 to 1.20)	0.907
Ever and current	1.04 (0.97 to 1.11)	0.244	1.07 (0.99 to 1.13)	0.056	0.99 (0.92 to 1.08)	0.982	1.06 (0.99 to 1.13)	0.648
Fruits/vegetables	0.86 (0.77 to 0.95)	0.004	0.89 (0.80 to 0.99)	0.031	0.86 (0.77 to 0.95)	0.004	0.95 (0.86 to 1.06)	0.387
Exercise								
Low	1.00		1.00		1.00		1.00	
Moderate	0.80 (0.71 to 0.90)	<0.001	0.85 (0.75 to 0.97)	0.013	0.81 (0.72 to 0.92)	0.001	0.90 (0.79 to 1.03)	0.127
Vigorous	0.79 (0.69 to 0.90)	<0.001	0.83 (0.73 to 0.95)	0.006	0.79 (0.69 to 0.89)	<0.001	0.86 (0.75 to 0.98)	0.027
Moderate and vigorous	0.88 (0.82 to 0.94)	<0.001	0.91 (0.85 to 0.97)	0.004	0.88 (0.83 to 0.94)	<0.001	0.94 (0.89 to 0.98)	0.049
Hypertension	2.16 (1.95 to 2.40)	<0.001	1.91 (1.72 to 2.13)	<0.001	2.16 (1.95 to 2.39)	<0.001	1.43 (1.28 to 1.60)	<0.001
FamD	1.31 (1.03 to 1.67)	0.029	1.66 (1.29 to 2.12)	<0.001	1.32 (1.04 to 1.68)	0.024	1.50 (1.15 to 1.92)	0.002
WC*	2.44 (2.19 to 2.73)	<0.001	2.44 (2.19 to 2.73)	<0.001	2.70 (2.41 to 3.03)	<0.001	2.38 (2.11 to 2.70)	<0.001
BMI*	1.14 (1.12 to 1.15)	<0.001	1.15 (1.13 to 1.16)	<0.001	1.14 (1.11 to 1.15)	<0.001	1.045 (1.04 to 1.08)	<0.001
Normal weight	1.00		1.00		1.00		1.00	
Overweight	1.90 (1.67 to 2.15)	<0.001	1.88 (1.65 to 2.14)	<0.001	1.91 (1.68 to 2.17)	<0.001	1.72 (1.50 to 1.96)	<0.001
Obese	3.17 (2.76 to 3.63)	<0.001	3.17 (2.75 to 3.66)	<0.001	3.21 (2.79 to 3.67)	<0.001	2.69 (2.32 to 2.66)	<0.001
Overweight and obese	1.76 (1.64 to 1.88)	<0.001	1.80 (1.68 to 1.92)	<0.001	1.77 (1.65 to 1.89)	<0.001	1.66 (1.45 to 1.79)	<0.001
MetS*	4.68 (4.22 to 5.20)	<0.001	4.42 (3.98 to 4.91)	<0.001	4.74 (4.27 to 5.26)	<0.001	4.77 (4.27 to 5.33)	<0.001
Dyslipidaemia*	3.10 (2.62 to 3.66)	<0.001	2.91 (2.46 to 3.44)	<0.001	3.10 (2.62 to 3.66)	<0.001	2.76 (2.31 to 3.21)	<0.001
High salt	1.22 (1.08 to 1.38)	0.002	1.27 (1.12 to 1.44)	<0.001	1.21 (1.07 to 1.38)	0.003	1.16 (1.02 to 1.32)	0.022
IFG								
Age	1.41 (1.34 to 1.48)	<0.001			1.41 (1.30 to 1.48)	<0.001	1.02 (1.02 to 1.03)	<0.001

Continued

Table 2 Continued

	Model 1 OR (95% CI)	P value	Model 2 OR (95% CI)	P value	Model 3 OR (95% CI)	P value	Model 4 OR (95% CI)	P value
Gender	0.91 (0.84 to 0.99)	0.030	0.95 (0.88 to 1.03)	0.258			0.87 (0.80 to 0.95)	0.001
Smoking								
Never	1.00		1.00		1.00		1.00	
Ever (former)	1.39 (1.22 to 1.59)	<0.001	1.23 (1.07 to 1.41)	0.003	1.28 (1.09 to 1.51)	0.003	1.08 (0.90 to 1.29)	0.399
Current	0.93 (0.84 to 1.03)	0.201	0.96 (0.86 to 1.07)	0.481	0.86 (0.74 to 0.99)	0.037	0.91 (0.78 to 1.06)	0.224
Ever and current	0.99 (0.95 to 1.04)	0.839	0.98 (0.94 to 1.03)	0.567	0.92 (0.86 to 0.98)	0.014	1.03 (0.98 to 1.01)	0.195
Drinking								
Never	1.00		1.00		1.00		1.00	
Ever (former)	1.22 (1.02 to 1.46)	0.027	1.11 (0.93 to 1.34)	0.248	1.20 (0.99 to 1.45)	0.067	1.09 (0.88 to 1.35)	0.403
Current	1.12 (1.02 to 1.24)	0.021	1.21 (1.10 to 1.35)	<0.001	1.10 (0.98 to 1.24)	0.109	1.16 (1.01 to 1.32)	0.033
Ever and current	1.07 (1.01 to 1.12)	0.009	1.09 (1.04 to 1.15)	<0.001	1.05 (0.99 to 1.11)	0.103	1.10 (1.05 to 1.15)	<0.001
Fruits/vegetables	0.72 (0.66 to 0.78)	<0.001	0.74 (0.68 to 0.80)	<0.001	0.72 (0.66 to 0.78)	<0.001	0.77 (0.71 to 0.84)	<0.001
Exercise								
Low	1.00		1.00		1.00		1.00	
Moderate	0.76 (0.69 to 0.84)	<0.001	0.79 (0.72 to 0.87)	<0.001	0.77 (0.70 to 0.85)	<0.001	0.88 (0.79 to 0.97)	0.012
Vigorous	0.81 (0.73 to 0.89)	<0.001	0.84 (0.76 to 0.93)	0.001	0.80 (0.72 to 0.89)	<0.001	0.92 (0.83 to 1.01)	0.108
Moderate and vigorous	0.89 (0.85 to 0.94)	<0.001	0.91 (0.86 to 0.95)	<0.001	0.89 (0.85 to 0.94)	<0.001	0.99 (0.94 to 1.04)	0.694
Hypertension	2.18 (2.01 to 2.36)	<0.001	1.96 (1.80 to 2.12)	<0.001	2.18 (2.01 to 2.36)	<0.001	1.50 (1.42 to 1.68)	<0.001
FamD	1.34 (1.11 to 1.61)	0.003	1.63 (1.35 to 1.98)	<0.001	1.34 (1.11 to 1.62)	0.002	1.58 (1.30 to 1.94)	<0.001
WC	2.06 (1.89 to 2.24)	<0.001	2.05 (1.89 to 2.23)	<0.001	2.24 (2.05 to 2.44)	<0.001	2.01 (1.84 to 2.21)	<0.001
BMI†	1.11 (1.09 to 1.12)	<0.001	1.12 (1.11 to 1.13)	<0.001	1.11 (1.10 to 1.12)	<0.001	1.10 (1.09 to 1.11)	<0.001
Normal weight	1.00		1.00		1.00		1.00	
Overweight	1.76 (1.60 to 1.93)	<0.001	1.77 (1.61 to 1.95)	<0.001	1.77 (1.61 to 1.94)	<0.001	1.65 (1.50 to 1.82)	<0.001
Obese	2.49 (2.24 to 2.78)	<0.001	2.58 (2.31 to 2.89)	<0.001	2.52 (2.26 to 2.81)	<0.001	2.22 (1.97 to 2.48)	<0.001
Overweight and obese	*1.56 (1.48 to 1.64)*	<0.001	1.60 (1.52 to 1.68)	<0.001	1.57 (1.49 to 1.65)	<0.001	1.49 (1.42 to 1.59)	<0.001
MetS	3.94 (3.63 to 4.28)	<0.001	3.74 (3.44 to 4.07)	<0.001	3.98 (3.66 to 4.33)	<0.001	3.42 (3.13 to 373)	<0.001
Dyslipidaemia	2.03 (1.82 to 2.27)	<0.001	1.91 (1.71 to 2.14)	<0.001	2.03 (1.82 to 2.27)	<0.001	1.62 (1.44 to 1.83)	<0.001
High salt intake	1.07 (0.97 to 1.18)	0.179	1.11 (1.00 to 1.23)	0.040	1.07 (0.96 to 1.18)	0.210	1.06 (0.95 to 1.17)	0.290

Model 1=unadjusted, model 2=age adjusted, model 3=gender adjusted, model 4=all covariates.
*Collinear variables.
†Modelled as both continuous and categorical variables.
BMI, body mass index; FamD, family history of diabetes; IFG, impaired fasting glucose; MetS, metabolic syndrome; WC, waist circumference.

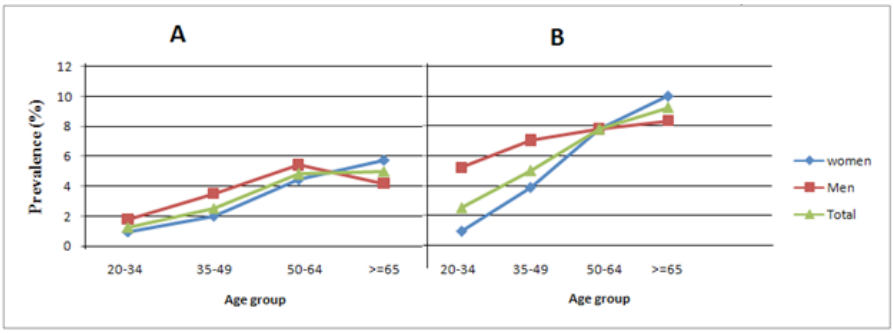

Figure 1 Prevalence trend (age groups) of diabetes (A) and IFG (B) by gender. IFG, impaired fasting glucose.

moderate and regular consumption of fruits and vegetables could be beneficial in keeping blood glucose level low.

There are a few limitations to be noted in this study. First, risk factors that were assessed through self-reported questionnaires have a possibility of over/underestimation due to recall bias. Second, the lack of an association between smoking and diabetes in women may be due to a lack of statistical power because of the small number of women who smoked. This study was a baseline cross-sectional study and therefore not able to establish a causal relationship between diabetes/IFG and the risk factors identified. The prevalence of diabetes and IFG maybe underestimated because of the use of FBG for diagnosis, nonetheless., this study has some strengths; it was carried out on a large sample and therefore will control for random error, and can be generalisable to Chinese rural population. We also controlled for all possible confounders in our analysis to minimise bias.

CONCLUSION

The prevalence of undiagnosed diabetes in our study population is similar to previous studies in China, although our analysis was restricted to the undiagnosed population. Men had a higher propensity to have diabetes and IFG compared with women even though the risk factors for diabetes and IFG were more prevalent in women. Being centrally obese, overweight/obese, older and having dyslipidaemia were significantly associated with diabetes and IFG. High salt diet intake that has not been established to be associated with diabetes was significantly associated with diabetes in our study. Smoking was also associated with diabetes in men while drinking alcohol was associated with IFG.

These findings could have significant public health implications for the prevention of diabetes and reduction of risk factors in rural populations. The role of salt in diabetes should be further investigated in longitudinal studies. Public health education should be intensified to adopt more healthy lifestyles to stem the increase in the prevalence of diabetes and IFG.

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