

BMJ Open Diabetes-related behaviours among elderly people with pre-diabetes in rural communities of Hunan, China: a cross-sectional study

Bangan Luo,¹ Jianglin Zhang,² Zhao Hu,³ Fan Gao,³ Qihong Zhou,² Shuang Song,² Lulu Qin,^{3,4} Huilan Xu³

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BL and JZ contributed equally, LQ and HX contributed equally.

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¹Department of Mental Health, Brain Hospital of Hunan Province, Changsha, China

²Xiangya Hospital of Central South University, Changsha, China

³Department of Social Medicine and Health Management, Xiangya School of Public Health, Central South University, Changsha, China

⁴Department of Preventive Medicine, Medical School, Hunan University of Chinese Medicine, Changsha, China

Correspondence to

Lulu Qin;
powerestlulu@163.com and
Huilan Xu;
huilanxu1963@sina.com

ABSTRACT

Objective To explore diabetes-related behaviours and their influencing factors among elderly individuals with pre-diabetes in rural areas of China.

Design, setting and participants A cross-sectional survey was conducted among elderly individuals (≥60 years) in rural communities in Yiyang City of China. Multistaged cluster random sampling was carried out to select 42 areas, and interviews were conducted among 434 elderly individuals with pre-diabetes (fasting plasma glucose 6.1–7.0 mmol/L and/or 2-hour post-glucose load of 7.8–11.1 mmol/L) using questionnaires on diabetes-related behaviours. The diabetes-related behaviours included eight categories: average daily sedentary time; frequency of physical activities per week; regular or irregular diet; whether paying attention to diet control or not; daily dietary preferences; frequency of physical examinations per year; current smoking status; and current consumption of alcohol. Each of the risky behaviours was scored –1 and each of the healthy behaviours was scored +1. Each individual's score of diabetes-related behaviours was the sum of the score for all behaviours.

Main outcome measures Participants were asked about general information (age, gender, marital status, history of hyperglycaemia, family history of diabetes mellitus, presence of other diseases, body mass index, waist-to-hip ratio and education) and their diabetes-related behaviours. Multivariate linear regression analysis was performed to identify the risk factors for diabetes-related behaviour among elderly individuals with pre-diabetes.

Results The average score of diabetes-related behaviours of elderly individuals with pre-diabetes in rural China was 2.7. The prevalences of risky diabetes-related behaviours were as follows: <1 physical examination per year (57.6%), insufficient physical activities (55.3%), lack of attention paid to diet control (51.4%), high-salt and high-fat diets (41.0%), sedentary lifestyle (35.9%), smoking (22.8%), regular alcohol uptake (15.0%) and irregular diet (3.9%). Gender and a history of hyperglycaemia were found to be influencing factors of the diabetes-related behaviour score.

Conclusions The prevalence of risky diabetes-related behaviours was high among pre-diabetic elderly individuals in rural China. More effort should be made to promote the prevention and control of diabetes in rural

Strengths and limitations of this study

- This is the first study to examine diabetes-related behaviours and their influencing factors among the elderly pre-diabetic population in rural China.
- Diabetes-related behaviours in rural China were assessed using a condition-specific measurement tool—the Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China—instead of vignettes based on Western cultural contexts.
- The cross-sectional study design makes causal relationships undeterminable.
- The study is limited by its self-reported design.

China. Future studies should be undertaken on diabetes prevention strategies tailored specially for this population.

Trial registration number ChiCTR-IOR-15007033; Results.

INTRODUCTION

Pre-diabetes is defined by blood glucose levels between normal and diabetic, which are categorised into three types: impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and IFG combined with IGT.¹ The global prevalence rates of diabetes mellitus and pre-diabetes are increasing rapidly, making diabetes a threat to public health worldwide.^{2–3} This is particularly marked in developing countries.⁴ In China, during the past 30 years, the prevalence of diabetes has increased rapidly.⁵ In conjunction with the epidemic of type 2 diabetes mellitus (T2DM), the prevalence of pre-diabetes has risen rapidly. The prevalence of diabetes and pre-diabetes in China is estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.⁶ Pre-diabetes poses several threats; there is an increased risk for T2DM and other diseases, including microvascular and macrovascular disease.

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A large number of studies have shown that lifestyle behaviour of patients with pre-diabetes plays an important role in the incidence and development of diabetes and other diseases. These behaviours can be collectively referred to as risky diabetes-related behaviours such as sedentary lifestyle, overeating and insufficient physical activity. Some studies have shown that healthy versions of these behaviours can delay or prevent the incidence and development of diabetes. For example, Ludwig *et al* found that high-fibre diets may have the effect of protecting against obesity and cardiovascular disease by lowering insulin levels in healthy black and white adults.⁷ Epidemiological studies have shown that the risk of developing T2DM among people who exercise actively is 30–50% lower than for sedentary persons.⁸ Other studies have suggested that unhealthy behaviours of patients with pre-diabetes speed up the progress of their disease, including diabetes, microvascular and macrovascular diseases. The results of a large prospective cohort study conducted in the USA showed that there is an obvious association between higher consumption of sugar-sweetened beverages and an increased risk of developing T2DM in women.⁹ Albright *et al* reported that regular physical activity is necessary for maintaining glucose-lowering effects and improving insulin sensitivity.¹⁰

The Chinese Guidelines for T2DM Prevention and Treatment (2013 Edition) show that both old age (≥60 years) and pre-diabetes are important risk factors for diabetes.¹¹ Patients with pre-diabetes who are aged ≥60 years have a very high possibility of developing diabetes. A study published by Yang *et al* showed that the development of diabetes in rural areas of China developed rapidly with a higher incidence of pre-diabetes than in urban areas.⁶ Considering the large population and the ageing process in rural China, delayed and ineffective interventions will cause the development of diabetes to proliferate in rural areas. However, few reports have addressed diabetes-related behaviours of elderly people with pre-diabetes in rural China, and no epidemiological information is available on diabetes-related behaviours among rural pre-diabetic elderly people. Our study was performed, using

a questionnaire covering diabetes-related behaviours for pre-diabetic elderly individuals, to provide scientific recommendations for diabetes prevention in the future.

MATERIALS AND METHODS

Study population and procedures

This study is a population-based cross-sectional study of Chinese individuals in Yiyang City, Hunan Province. Sample size calculation was done using the formula for cross-sectional studies: $n = u_{\alpha/2}^2 P(1P)/d^2$, where u was 1.96 when α is 0.05, P is the prevalence of pre-diabetes (which is 20% in this study), and d is the admissible error (which was 4%). The theoretical sample was 423, which includes an extra 10% to allow for dropout of subjects during the study. By using a multistage cluster randomised sampling method, we selected a representative sample of the rural pre-diabetic population aged ≥60 years in Yiyang City of Hunan Province between April and July 2015; ‘cluster’ here refers to the village. In the first stage, sampling was stratified according to geographical characteristic status and two counties (Yuanjiang and Nanxian) were selected. In the second stage, four townships (Yangluozhou, Yinfengqiao, Qingshuzui, and Maocaojie) were randomly selected within each chosen county. In the third stage, 25% of the rural villages were randomly selected in each chosen township. In the final stage, all households with elderly individuals within each village were listed.

All elderly individuals who had lived in these selected villages for ≥3 years were allowed to take part in the pre-diabetes screening. Elderly individuals with diabetes or with severe mental or physical diseases were excluded from the pre-diabetes screening. In brief, a total of 2144 elderly individuals participated in the screening and 461 were found to have pre-diabetes; 27 pre-diabetic elderly subjects were not investigated or refused to take part in the subsequent study for various reasons. Thus, 434 pre-diabetic elderly individuals with complete data were included in the study. The design and procedure have been described in detail in a previous study.¹²

Table 1 Outline of the diabetes-related behaviour questionnaire

Categories	Behaviour (score)	
	Risky behaviour(−1)	Healthy behaviour(+1)
Average daily sedentary time (hours)	≥6	<6
Frequency of physical activities per week	<3	≥3
Regularity of daily diet	No	Yes
Paying attention to diet control	No	Yes
Daily dietary preferences	High-salt/fat/sugar diet	Bland diet
Frequency of physical examinations per year	<1	≥1
Current smoking status	Smoking currently	Have quit smoking or never smoked
Current consumption of alcohol	Frequent alcohol consumption (drinking ≥3 times/week)	Occasional alcohol consumption (drinking <3 times/week) or never consumed alcohol

Table 2 Diabetes-related behaviour among the survey participants (n=434)

Behaviour	n	Prevalence (%)
Average daily sedentary time (hours/day)		
<2	73	16.8
3–5.9	205	47.2
≥6	156	35.9
Frequency of physical activities per week		
Never	185	42.6
<2	55	12.7
3–5	86	19.8
Every day	108	24.9
Regular daily diet		
Yes	417	96.1
No	17	3.9
Paying attention to diet control		
Yes	211	48.6
No	223	51.4
Daily dietary preferences		
Bland diet	256	59.0
High-salt/fat/sugar diet	178	41.0
Frequency of physical examinations (times/year)		
<1	250	57.6
≥1	184	42.4
Current smoking status		
Smoking currently	99	22.8
Quit smoking	41	9.4
Never smoked	294	67.7
Frequency of alcohol consumption		
Frequently	65	15.0
Occasionally	37	8.5
Never	332	76.5

Data collection and measurements

Pre-diabetes screening

Participants were diagnosed with pre-diabetes using oral glucose tolerance tests (OGTT). During screening they were instructed to maintain their usual physical activity and diet for a minimum of 3 days before the OGTT. The diagnostic standards for pre-diabetes as stated in the 1999 WHO criteria were categorised into three groups¹: (1) IFG group: fasting plasma glucose 6.1–7.0 mmol/L (110–126 mg/dL) and 2-hour post-glucose load of <7.8 mmol/L (140 mg/dL); (2) IGT group: fasting plasma glucose 6.1 mmol/L (110 mg/dL) and 2-hour post-glucose load of 7.8–11.1 mmol/L (140–200 mg/dL); (3) IFG + IGT group.

Sociodemographic information

Sociodemographic information collected included age, gender, marital status, education, presence of other diseases, family history of diabetes and a history of hyperglycaemia. Education was assessed by asking the participants to select their highest level of education from the following choices: <1 year, 1–6 years and ≥6 years.

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference; the measuring of blood pressure, BMI and waist-to-hip ratio (WHR) were described in a previous study.¹² Blood pressure was assessed twice (2 min apart) with an electronic blood pressure monitor (A&D Medical, Life Source UA-767PV) after the participant had been seated for at least 5 min in a quiet room. The two blood pressure readings were averaged to obtain a mean resting blood pressure value for each participant. Hypertension is defined as systolic blood pressure ≥140 mm Hg and/or diastolic pressure ≥90 mm Hg.¹³ Hypotension is defined as systolic blood pressure <90 mm Hg and/or diastolic pressure <60 mm Hg.¹³ Both hypertension and hypotension are abnormal blood pressure. Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured without shoes and light indoor clothing to the nearest 0.1 kg. BMI was computed using the following formula: $BMI = \text{kg/m}^2$. Participants were defined as lean ($BMI < 18.5$), normal ($18.5 < BMI < 24.0$), overweight ($24.0 < BMI < 28.0$) and obese ($BMI \geq 28.0$), according to Chinese standards.¹⁴ Waist circumference was measured to the nearest 0.1 cm by placing a non-stretching measuring tape horizontally around a participant's abdomen at the top of the iliac crest. The reading was taken after expiration while ensuring the tape was secure but not too tight. Hip measurement was taken at the point of maximum circumference over the buttocks, with the measuring tape held horizontally and touching the surface of the light clothing. The WHR was calculated by dividing the waist measurement by the hip measurement, and WHR >0.9 in men and WHR >0.8 in women was defined as abnormal.¹⁵

Diabetes-related behaviours

Diabetes-related behaviours were assessed using the Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China (QHLDLP), which was designed by the Chinese Centre of Health Education and had a high reliability and validity with Cronbach's α of 0.866.¹⁶ The questionnaire included eight categories (table 1): average daily sedentary time; frequency of physical activities per week; regular or irregular diet; whether paying attention to diet control or not; daily dietary preferences (eg, bland diets, high-salt diets, high-fat diets); frequency of physical examinations per year; current smoking status; and current consumption of alcohol. Among the eight categories, the question regarding dietary preferences was given in multiple choice format while the other seven questions were single selections. Sedentary lifestyle

Table 3 Comparison of risky diabetes-related behaviour in different populations (n=434)

Variables	Sedentary lifestyle, n (%)	Insufficient physical activities, n (%)	Irregular diet, n (%)	Lack of attention paid to diet, n (%)	High-salt/fat/sugar diet, n (%)	<1 physical examination per year, n (%)	Smoking currently, n (%)	Frequent alcohol consumption, n (%)
Age (years)								
60–69	56 (26.5)	129 (56.1)	10 (4.3)	118 (51.3)	98 (42.6)	133 (57.8)	44 (10.1)	38 (8.8)
70–79	82 (46.8)	92 (53.2)	5 (2.9)	92 (53.2)	65 (37.6)	97 (56.1)	48 (27.7)	25 (14.5)
≥80	18 (45.2)	19 (61.3)	2 (6.5)	13 (41.9)	15 (48.4)	20 (64.5)	7 (22.6)	2 (6.5)
χ^2	18.901	0.822	1.127	1.332	1.785	0.778	4.163	2.238
P value	<0.001*	0.663	0.569	0.514	0.410	0.678	0.125	0.327
Gender								
Men	75 (41.7)	94 (52.2)	9 (5.0)	101 (56.1)	77 (42.8)	109 (60.6)	83 (46.1)	50 (27.8)
Women	81 (31.9)	146 (57.5)	8 (3.1)	122 (28.1)	101 (39.8)	141 (55.5)	16 (6.3)	15 (5.9)
χ^2	4.374	1.178	0.958	2.753	0.396	1.097	94.829	39.577
P value	0.037†	0.278	0.328	0.097	0.529	0.295	<0.001*	<0.001*
Marital status								
Stable	113 (36.1)	175 (55.9)	10 (3.2)	159 (50.8)	139 (44.4)	179 (57.2)	61 (19.5)	43 (13.7)
Unstable	43 (27.6)	65 (53.7)	7 (5.8)	64 (52.9)	39 (32.2)	72 (58.7)	38 (31.4)	22 (18.2)
χ^2	0.222	0.170	1.556	0.153	5.349	0.079	7.037	1.353
P value	0.637	0.681	0.212	0.696	0.021†	0.778	0.008*	0.245
History of hyperglycaemia								
Yes	14 (50.0)	13 (46.4)	1 (3.6)	10 (35.7)	159 (39.2)	12 (42.9)	5 (17.9)	1 (3.6)
No	142 (35.0)	227 (55.9)	16 (3.9)	213 (52.5)	19 (67.9)	238 (58.6)	94 (23.2)	64 (15.8)
χ^2	2.568	0.953	0.009	2.941	8.915	2.665	0.417	2.175
P value	0.109	0.329	0.922	0.086	0.003*	0.103	0.518	0.140
Family history of diabetes								
Yes	21 (58.3)	27 (75.0)	1 (2.8)	17 (47.2)	13 (36.1)	16 (44.4)	9 (25.0)	4 (11.1)
No	135 (33.9)	213 (53.5)	16 (4.0)	206 (51.8)	165 (41.5)	234 (58.8)	90 (22.6)	61 (15.3)
χ^2	8.546	6.164	0.135	0.272	0.390	2784	0.107	0.461
P value	0.003*	0.013†	0.713	0.602	0.532	0.095	0.744	0.497
Other chronic diseases								
Yes	73 (41.5)	91 (51.7)	7 (4.0)	91 (51.7)	64 (36.4)	113 (64.2)	47 (26.7)	34 (19.3)
No	83 (32.2)	149 (57.8)	10 (3.9)	132 (51.2)	114 (44.2)	137 (53.1)	52 (20.2)	31 (12.0)
χ^2	3.936	1.548	0.003	0.012	2.646	5.282	2.549	4.382
P value	0.047†	0.213	0.957	0.912	0.104	0.022†	0.110	0.036†

*P<0.01, †P<0.05.

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Table 4 Multiple linear regression analysis of diabetes-related behaviour

Variables	B	Standard error	β'	t	P Value	95% CI for B
Constant	1.132	1.779	–	0.636	0.525	(–2.364 to 4.629)
Gender	1.392	0.257	0.253	5.415	0.000	(0.887 to 1.897)
History of hyperglycaemia	–0.600	0.247	–0.114	–2.425	0.016	(–1.086 to –0.144)

(average daily sedentary time ≥ 6 hours), insufficient physical activity (engaging in physical activity < 3 times per week), irregular diet, lack of attention paid to diet, high-salt diet, high-fat diet, < 1 physical examination per year, frequent alcohol consumption (drinking ≥ 3 times/week) and currently smoking were defined as risky behaviours, and the rest of the behaviours were defined as healthy behaviours. Each of the risky behaviours was scored -1 and each of the healthy behaviours was scored $+1$. Each individual's score for the diabetes-related behaviours was the sum of the scores for all the behaviours. The sum of the diabetes-related behaviours scores ranged from -8 to 8 in the questionnaire. The higher the sum of the scores, the better the diabetes-related behaviours were.

Statistical analysis

Epidata 3.1 software was used to build the database and SPSS 20.0 software (SPSS, Chicago, Illinois, USA) was used for the statistical analysis. All questionnaires were doubly input into the database by two independent professional data processors. Data were presented as the prevalence and mean \pm SD. The χ^2 test was used for categorical variables and the Cochran–Mantel–Haenszel test was used for ranked variables. Multivariate linear regression was performed to explore factors influencing diabetes-related behaviours. The sum of the scores for all behaviours was selected as the dependent variable. Age (actual value), gender (1=male, 2=female), marital status (1=stable marital status, 2=unstable), education (1= < 1 year, 2=1–6 years, 3= ≥ 6 years), history of hyperglycaemia (1=yes, 2=no), family history of diabetes (1=yes, 2=no), other chronic disease status (1=yes, 2=no), BMI (1=lean, 2=normal, 3=overweight, 4=obese), WHR (1=normal, 2=abnormal) and blood pressure (1=normal, 2=abnormal) were entered as independent variables. All hypothesis tests used two-sided tests and a P value < 0.05 was considered to be statistically significant.

RESULTS

Characteristics of participants

A total of 2114 non-diabetic patients aged ≥ 60 years were screened. The prevalence of pre-diabetes was 21.5% (461/2144) and 434 participants with pre-diabetes completed the questionnaire. The effective response rate was 97.8%.

Among the 434 survey respondents there were 180 men (41.5%) and 254 women (58.5%). Participants had a mean \pm SD age of 69.4 ± 6.45 years; 313 (72.1%) had a

stable marriage status (married and living with spouse) and 353 (81.3%) had a low level of education (< 6 years). Only 28 participants (6.5%) had a history of hyperglycaemia and 36 patients (8.3%) had a family history of diabetes; 82.3% of the patients had abnormal WHR and 45.9% had abnormal blood pressure. More individuals had IGT (n=190, 43.8%) than IFG (n=186, 42.9%) or IGT+IFG (n=58, 13.4%). The characteristics of the pre-diabetic elderly individuals were not significantly different from those without pre-diabetes ($p > 0.05$; see details in previously published paper¹²).

Prevalence of diabetes-related behaviours among elderly individuals with pre-diabetes

Among the 434 survey respondents the reporting rates of risky diabetes-related behaviours included sedentary lifestyle (35.9%), insufficient physical activities (55.3%), irregular diet (3.9%), lack of attention paid to diet (51.4%), high-salt/fat/sugar diet (41.0%), < 1 physical examination per year (57.6%), smoking currently (22.8%) and frequent alcohol consumption (15.0%) (table 2).

Comparison of risky diabetes-related behaviours between different characteristics of rural pre-diabetic elderly individuals

There were statistically significant differences in the prevalences of risky diabetes-related behaviours among people of different ages, genders, marital statuses, history of hyperglycaemia, other chronic diseases situation and a family history of diabetes in elderly individuals with pre-diabetes in rural China ($P < 0.05$, see table 3 for details). There were no significant differences in the prevalences of risky diabetes-related behaviours between those with different levels of education, BMI, WHR, blood pressure and type of pre-diabetes in the elderly individuals with pre-diabetes surveyed ($p > 0.05$).

Risk factors for diabetes-related behaviours among the rural pre-diabetic elderly population

The average score of diabetes-related behaviours of the survey respondents was 2.7, with the lowest score -8 and the highest 8. Multiple linear regression analysis showed that being female was a beneficial factor for diabetes-related behaviours among elderly people with pre-diabetes in rural areas ($\beta = 0.253$, $P < 0.001$), and no history of hyperglycaemia was a risk factor for diabetes-related behaviours in this population ($\beta = -0.114$, $p = 0.016$) (table 4).

DISCUSSION

Elderly individuals with pre-diabetes in rural China have a high prevalence of risky diabetes-related behaviours and a low score for diabetes-related behaviours.

In this study the average score of diabetes-related behaviours in elderly individuals with pre-diabetes in the rural areas was 2.7, which was relatively low compared with the urban population in China.¹⁷ Except for eating and alcohol consumption habits, the prevalences of risky diabetes-related behaviours such as sedentary lifestyle, insufficient physical activity, lack of attention paid to diet, high-salt and high-fat diet, <1 physical examination per year and smoking were relatively high, which were consistent with the findings of other studies from China.¹⁷

The prevalences of not paying attention to diet control and consuming high-salt/fat/sugar diets in elderly people with pre-diabetes in the rural areas were relatively high at 51.4% and 41.0%, respectively. Mounting evidence indicates that diet is an important factor in the development of diabetes. Liu *et al* found an association between a high diet of green leafy or dark yellow vegetables and a reduced risk of T2DM among overweight women.¹⁸ Large cohort studies have shown that there is an inverse relationship between whole grain intake in diets and the risk of T2DM.^{19 20} Cooper *et al* found that a diet characterised by a high intake of vegetables and fruit may be beneficial for the prevention of pre-diabetes and diabetes.^{21 22} It has been proved that sugar intake is associated with an increased risk of diabetes,²³ and too much fat has also been shown to be an important contributor to the development of obesity, insulin resistance and diabetes.²⁴ Thus, dietary modification is crucial for the prevention and management of pre-existing T2DM. It is therefore necessary for individuals with pre-diabetes who pay no attention to diet and eat high-fat and salty food to change their lifestyle.

The rates of sedentary lifestyle and insufficient physical activity recorded in the current survey population were relatively high compared with a survey of urban residents by Wei *et al*.¹⁷ Sedentary behaviour, defined by low-energy expenditure in a sitting or reclining position during waking hours,²⁵ has emerged as an additional concern regarding physical activity and health.^{26 27} There is evidence to show that spending excessive time in sedentary behaviours is related to an increased risk of diabetes. Physical inactivity has been associated with some potential risk factors of diabetes.⁸ Some large-sample studies have reported that habitual physical activity (such as moderate exercise) may significantly reduce the risk for T2DM.¹⁰ Regular participation in moderate exercise such as walking is a cornerstone of the prevention and management of diabetes.²⁸ Henson *et al* found that breaking up prolonged sitting with 5 min bouts of standing or walking improved the glucose (standing and walking) and insulin (walking only) responses, which were maintained into the next day.²⁹ Another study reported that short and frequent periods of exercise have the effect of attenuating glucose excursions and insulin concentrations

among obese persons with impaired glucose tolerance.³⁰ So, sitting less and moving more often may be a practical strategy for improving the prevention and management of T2DM.³¹

T2DM often goes undiagnosed for many years because hyperglycaemia develops gradually and may not produce symptoms.³² Physical examination can reveal abnormal changes in blood glucose in patients with pre-diabetes in a timely fashion. Therefore, it is beneficial for individuals with pre-diabetes to undergo physical examination regularly, which may find and prevent diabetes early.

There has been evidence to show that both passive and active smoking are associated with T2DM.³³ Willi *et al* conducted a meta-analysis which showed that active smoking is associated with an increased risk of diabetes.³⁴ First, smoke exposure causes insulin resistance by compromising the activity of the antioxidant enzymes and inducing a state of oxidative stress in the skeleton.³⁵ Second, Davis *et al* have reported that passive smoke exposure in childhood is associated with fatness, poor cognition and worse sleep.³⁶ Third, cigarette smoking (especially nicotine ingredients) induces pancreatic injury through some toxic effects on the pancreas.³⁷ Fourth, tobacco use may activate body inflammation leading to diabetes; and finally, tobacco use leads to impaired glucose tolerance, T2DM and abdominal-type obesity directly and indirectly via metabolic risk factors.³⁸ These findings support the conclusion that abstaining from smoking will benefit individuals with pre-diabetes and diabetes, and it is necessary to encourage them to quit smoking in future work on preventing diabetes.

Distribution of risky diabetes-related behaviours in different populations

In the population studied, the prevalences of risky diabetes-related behaviours were different among subjects of different ages, genders, marital status, history of hyperglycaemia, other chronic diseases and a family history of diabetes. The prevalence of a sedentary lifestyle in pre-diabetic elderly individuals aged ≥60 years was higher than that of young people, which is consistent with the findings of other studies.^{16 26 39} Matthews *et al* reported that older adults (aged 60–85 years) in the USA spent approximately 60% of their time in sedentary behaviours.²⁶ Hallal *et al* conducted a worldwide assessment in 66 countries where citizens have either high or low incomes and found that those aged ≥60 years had a higher prevalence of spending ≥4 hours sitting daily.³⁹ Elderly people have a higher prevalence of a sedentary lifestyle than young people, which may be mainly due to ageing of the body. The prevalences of current smoking and consumption of alcohol in pre-diabetic elderly men were higher than in women, which may be due to the different lifestyles between men and women. This was similar to other studies.^{40 41} Bu *et al* reported that men were more likely to drink alcohol and smoke cigarettes but less likely to be under dietary control than women in a middle-aged Chinese population.⁴⁰ Alicia *et al*

found that risky alcohol consumption was a risk factor for pre-diabetes in men.⁴¹

The prevalence of a high-salt/fat/sugar diet in pre-diabetic elderly people with a stable marital status was higher than in those without a stable marital status. There may be two reasons for this. On the one hand, persons with an unstable marital status may have a low income. On the other hand, Yang *et al* found that an unstable marital status had a bad effect on diet among the elderly population in rural China.⁴² The prevalence of a high-salt/fat/sugar diet in pre-diabetic elderly people without a history of hyperglycaemia was higher than in those with a history of hyperglycaemia. As we reported previously, hyperglycaemia influenced diabetes health literacy.¹² People with a history of hyperglycaemia are concerned about developing diabetes and actively keep healthy behaviours to prevent diabetes.

The prevalences of a sedentary lifestyle and insufficient physical activity in pre-diabetic elderly people with a family history of diabetes were high, which indicates that family history is associated with the development of diabetes. Bianco *et al* showed that there were correlations between a family history of T2DM and body weight, fat mass and alterations in basal glycaemia values.⁴³ Aravindalochanan *et al* found that increased sitting duration for ≥ 180 min/day was associated with elevated random capillary blood glucose, and there was a threefold higher risk of diabetes among these subjects with a positive family history of diabetes.⁴⁴ A healthy diet and active lifestyle may significantly decrease the risk of T2DM in spite of a family history of diabetes.⁴⁵

It was not surprising that the prevalence of <1 physical examination per year in people with other chronic diseases was higher than in those without other chronic diseases. Yin *et al* found that elderly people in rural China did not actively seek health services because of poor economic conditions, high price of health services and bad quality medical services.⁴⁶ These findings suggest that there are some differences in different populations, which should be taken into account when we implement specific recommendations to prevent or delay the onset of diabetes in the rural pre-diabetic elderly population. Specific strategies to reduce modifiable risk factors for the prevention and control of diabetes may be warranted.

Gender and hyperglycaemia are influencing factors for diabetes-related behaviours in elderly individuals with pre-diabetes in rural areas

The results of our study showed that female gender was a favourable factor for diabetes-related behaviours among elderly people with pre-diabetes in rural areas. This is consistent with others. Being male is a risk factor for diabetes in the Chinese population aged <50 years.⁴⁷ In addition, many studies have shown that men have lower diabetes health literacy than women.^{48–50} Health literacy is the degree to which individuals have the capacity to obtain, process and understand the basic health information and services needed to make appropriate health

decisions. Health literacy is considered to be a key health determinant because of its link to behavioural choices and service usage.⁵¹ There is a relationship between health literacy and risky lifestyle behaviours.^{52–53} Men are more likely to engage in risky lifestyle behaviours because of their limited health literacy. Davies *et al* found that male college students' most important issues were alcohol and substance abuse,⁵⁴ and the substantial barriers to seeking services were socialising and paying less attention to the association between long-term health risks and current behaviours.⁵⁴ Women have more opportunity for contact with the healthcare environment since they are more likely to care for sick family members.^{55–57} Therefore, these social psychological characteristics increase the risk of diabetes in men.

In this study we found that the absence of a history of hyperglycaemia was a risk factor for diabetes-related behaviours. This is the first report to discuss the relationship between a history of hyperglycaemia and diabetes-related behaviours. As reported previously, people with a history of hyperglycaemia had a higher diabetes health literacy.¹² This may be the reason that individuals with pre-diabetes who have a history of hyperglycemia are more likely to become diabetes patients because they concern themselves with diabetes-related behaviours and abstain from them. Given the sex-specific nature and the role of a history of hyperglycaemia in the sociopsychological characteristics of elderly people with pre-diabetes, diabetes prevention strategies tailored specifically to their needs are required.

Our study is the first to explore the influencing factors of diabetes-related behaviours among pre-diabetic elderly people in rural China, which provides valuable information and scientific recommendations for diabetes prevention tailored specifically for this population. This study was conducted in Hunan where the elderly population is representative of elderly people in rural communities. We used a random sample which was derived from the rural communities, so the results have good representation and extrapolation can be extended to other populations. Considering the large population, low health literacy and low income of rural pre-diabetic elderly people in China and some other developing countries,^{3–6–12} timely and effective interventions should be carried out to prevent diabetes. These findings could be applied to other areas for diabetes prevention among pre-diabetic elderly people.

The present work has three limitations. First, we cannot infer causations from its cross-sectional design. Second, introduced bias cannot be excluded because of the self-reported design, so further studies are needed to confirm these findings. Third, there is no comparison between the QHLDP and other tools assessing diabetes-related behaviours. It is difficult to compare the behaviour properties of the Chinese version of QHLDP used in populations outside China because the QHLDP is designed and used only in China and the behaviours evaluated are particularly sample-dependent. Thus, future studies may

benefit from the application of the English version of the QHLPD with other scales in the same populations.

CONCLUSIONS

The current study has shown that there is a high prevalence of risky diabetes-related behaviours among elderly people with pre-diabetes in rural China. Being male and not having a history of hyperglycaemia were the main risk factors. Considering the high prevalence of pre-diabetes and diabetes among the elderly population in rural China and low health literacy, low income and high prevalence of behaviour associated with an increased risk of diabetes, future studies should evaluate diabetes prevention strategies tailored specially for this population.

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