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A cross-sectional study of diabetes-related behavior among elderly individuals with prediabetes in rural communities of Hunan, China

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Keywords: prediabetes; diabetes-related behaviors; elderly; rural areas

Word accounts: 2,920; Tables: 3

ABSTRACT:

Objectives: To study the behaviors and its influencing factors in elderly individuals with prediabetes in rural areas.

Design, setting and participates: A cross-sectional survey was conducted among the elderly in rural communities in Yiyang City of China. Multistage cluster and random sampling was carried out to select 42 areas and 434 elderly individuals with prediabetes who were interviewed using a questionnaire on diabetes-related behaviors.

Main outcome measures: Participants were asked general information(age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases, BMI, the waist-to-hip ratio (WHR) and education). The multivariate linear regression analysis was performed to detect the risk factors of the diabetes-related dangerous behaviors of the elderly with prediabetes.

Results: The average score of diabetes-related behaviors of the elderly with prediabetes in the rural area was 2.7. The rates of diabetes-related dangerous behaviors were as follows: less than one 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%). Patients' gender and history of hyperglycemia were found to be the influencing factors of the diabetes-related behavior score.

Conclusions: The state of prediabetes in rural China areas is alarming. The elderly with prediabetes in the rural areas were prone to diabetes-related dangerous behaviors, including less than one physical examination per year, insufficient physical activity, lack of attention to diet control, consumption of high-salt and high-fat diets, and smoking. More efforts should be made to promote the prevention and control of diabetes in rual China.

Trial registration number: CTXY-150002-7; ChiCTR-IOR-15007033.

Strengths and limitations of this study

This is the first study to examine the diabetes-related behaviors and its influencing factors among the elderly prediabetic population in rural China.

The study provides valuable information on the diabetes-related behaviors and its influencing factors and scientific recommendations for diabetes prevention among the elderly prediabetic population in rural communities.

The study is limited by its cross-sectional and self-reported design.

INTRODUCTION

Prediabetes is defined by blood glucose levels between normal and diabetic, with resultant obesity and metabolic consequences. The global prevalence rates of diabetes mellitus and prediabetes are increasing rapidly, making diabetes a threat to public health worldwide.[1-2] This is particularly marked in developing countries.[3] In China, during the past 30 years, the prevalence of diabetes has increased rapidly.[4] In conjunction with the epidemic of type 2 diabetes mellitus (T2DM), the prevalence of prediabetes has skyrocketed. The prevalence of diabetes and prediabetes in China is estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[5] Prediabetes poses several threats; there is increased risk of T2DM, and there are risks inherent to the prediabetes state, including microvascular and macrovascular disease.

Mounting of studies have shown that the lifestyle behaviors of prediabetes population play an important role in the incidence and development of diabetes. These behaviors can be collectively referred to as diabetes-related behaviors, such as sedentary lifestyle, overeating, and insufficient physical activity. Some studies have shown that healthy versions of these behaviors can delay or prevent the incidence and development of diabetes. For example, a study of 2909 healthy adults found an inverse association between intake of dietary fiber measured by food frequency screeners and both fasting insulin and two-hour postprandial insulin;[6] large cross-sectional, retrospective studies have shown that the prevalence of T2DM among people who regularly exercise is lower than among people who do not.[7] Other studies have suggested that unhealthy behaviors of patients with prediabetes aggravate the progress of their diseases, speeding up the development of diabetes. A large cohort study revealed an increase in the risk of T2DM of over 80% for women who drank one sugar-sweetened beverage (SSB) per day, relative to women who had less than one such drink per month.[8] And Albright et al. Found that habitual lack of physical activity appears to have a detrimental impact on glucose tolerance.[9]

Chinese Guidelines for T2DM Prevention and Treatment (2013 Edition) shows that age ≥ 60 years and prediabetes are important risk factors for diabetes.[10] Therefore, prediabetes patients at age of 60 years and above have extremely high possibility of developing diabetes. A study published by Yang et al. shows that the development of diabetes in rural areas of China has developed rapidly with the higher incidence of prediabetes than the urban cities.5 Considerring the large population and the aging of rural China, delayed and ineffective interventions for the disease will cause the development of diabetes to proliferate in rural areas. However, few reports have addressed diabetes-related behaviors of elderly with prediabetes in rural China, and no epidemiological information is available on diabetes-related behaviors among rural prediabetic elderly. Our study was performed using a questionnaire covering diabetes-related behaviors of elderly population with prediabetes in rural areas 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. The study included 434 elderly prediabetes patients who were diagnosed using the criteria for diagnosis and classification of diabetes (WHO 1999). All patients were aged 60 years or older and met the diagnostic standards for prediabetes. Those with severe physical or mental illness were excluded from the study. Three thousand one hundred ninety-seven elderly residents from the 42 selected areas underwent oral glucose-tolerance tests (OGTTs). The design and procedure have been described in detail in a previous study.[11]

Data Collection

Prediabetes screening were instructed to maintain their usual physical activity and diet for a minimum of three days before the oral glucose tolerance test (OGTT). The collecting of socio-demographic information included age, gender, marital status, education, presence of other diseases, family history of diabetes and history of hyperglycaemia. And the measuring and grouping of blood pressure, BMI, the waist-to-hip ratio (WHR) were described in the previous study. [11]

Prediabetes' diabetes-related behaviors were assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China", which designed by the Chinese Center of Health Education has a high reliability and validity with a Cronbach's α of 0.866.[12] Diabetes-related behaviors of this questionnaire included eight categories: average daily sedentary time; frequency of physical activities per week; regular or irregular diet; paying attention to diet control or not; daily dietary preferences (e.g., bland diets, high-salt diets, and high-fat diets); frequency of physical examinations per year; current smoking status; and current consumption of alcohol. Among the eight categories, the questions regarding dietary preferences were given in multiple choice format; while the question format of rest of the categories was in single-topic selection. Sedentary lifestyle (average daily sedentary time ≥ 6 h), insufficient physical activity (engaging in physical activity fewer than 3 times per week), irregular diet, lack of attention paid to diet, high-salt diet, high-fat diet, fewer than one physical examination per year, frequent alcohol consumption (drinking ≥ 3 times/week), and smoking currently were defined as dangerous behaviors, and the rest of the behaviors were defined as healthy behaviors. Each of the dangerous behaviors was scored "−1", and each of the healthy behaviors was scored "+1". Each individual's score of diabetes-related behaviors was the sum of the scores for all behaviors.

Statistical analysis

In this study, Epidata 3.1 software was used to build the database, and SPSS 20.0 (SPSS Inc., Chicago, IL, U.S.) software was used for the statistical analysis. All questionnaires were doubly iuput into the database by two independent professional data processors. Data are presented as the percentage and mean ± standard deviation (SD). Pearson's χ^2 testing was used for categorical variables, and the Cochra-Mantel-Haenszel test for ranked variables. Multivariate linear regression was used to analyze the factors influencing diabetes-related behavior. The sum of the scores for all behaviors was selected as the dependent variable. Age (actual value), gender (1 = male and 2 = female), marital status (1 = stable marital status and 2 = unstable), education (1=less than 1 years, 2=from 1 to 6 years, and 3= 6 years and above), history of hyperglycaemia (1 = yes and 2 = no), family history of diabetes (1 = yes and 2 = no), other chronic disease status (1=yes and 2=no), BMI (1=lean, 2=normal, 3=overweight, and 4=obese), WHR (1=normal and 2=abnormal) and blood pressure (1=normal and 2=abnormal) were entered as independent variables. These variables were further used for multiple linear regression analysis (using ENTER method). All hypothesis tests used two-side tests and a *P*-value less than 0.05 was considered to be statistically significant.

RESULTS

The characteristics of participants

In our study, a total of 2,114 non-diabetic patients aged 60 years old and above were screened. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes completed the questionnaire. The effective response rate was 97.8% in this study.

Among the 434 survey respondents, there were 180 men (41.5%) and 254 women (58.5%). Participants were with an average (±SD) age of 69.4 (±6.45) years. Among them, 313 patients had stable marriage status (married and living with spouse, accounting for 72.1%), and 121 patients did not (e.g., single, divorced, and widowed, accounting for 27.9%); 353 patients (81.3%) had a low education (Education duration < 6 years). Only 28 patients (6.5%) had a history of hyperglycemia and 36 patients (8.3%) had a family history of diabetes. 82.3% of the patients had abnormal WHR, and 45.9% of them 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%) (see details in a previously published paper[11]).

The prevalence of diabetes-related behavior among the elderly individuals with prediabetes

Among the 434 survey respondents, the reporting rates of the diabetes-related dangerous behaviors 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%), less than one physical examination per year (57.6%), smoking currently (22.8%), and frequent alcohol consumption (15.0%) (Table 1).

Table 1 Diabetes-related behavior among the survey participants (n = 434)

Behaviors	n	Prevelance(%)
Average daily sedentary time(h/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
Everyday	108	24.9
The regularity of 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 preferrences		
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

Somking		
Somking currently	99	22.8
Having quitted smoking	41	9.4
Never smoking	294	67.7
Frequency of alcohol consumption		
Frequently	65	15.0
Occasionally	37	8.5
Never	332	76.5

Comparison of diabetes-related dangerous behaviors between different characteristics of the rural prediabtic elderly

There were statistically significant differences in the prevalence of the diabetes-related dangerous behaviors among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases siuation, and family history of diabetes in the elderly individuals with prediabetes in rural China ($P < 0.05$, see Table 2 for details). Different education, BMI, WHR, blood pressure, and type of prediabetes all showed no significant differences in elderly individuals with prediabetes in rural China in the diabetes-related dangerous behaviors ($P > 0.05$).

Table 2 Comparison of diabetes-related dangerous behavior 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,%)	Less than one 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	0.000†)	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	0.037‡	0.278	0.328	0.097	0.529	0.295	0.000$^{\dagger)}$	0.000$^{\dagger)}$
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	0.637	0.681	0.212	0.696	0.021‡	0.778	0.008$^{\dagger)}$	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	0.109	0.329	0.922	0.086	0.003$^{\dagger)}$	0.103	0.518	0.140
Family history								

of diabetes								
Yes	21（58.3）	213（53.5）	1（2.8）	17(47.2)	13(36.1)	16(44.4)	9（25.0）	4（11.1）
No	135（33.9）	27（75.0）	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	2,784	0.107	0.461
P	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	0.047‡	0.213	0.957	0.912	0.104	0.022‡	0.110	0.036‡

†$P<0.01$.

‡$P<0.05$.

Risk factors for the diabetes-related behaviors among the rural prediabtic elderly

The average score of diabetes-related behaviors of the survey respondents was 2.7, with the lowest score of −8 and the highest 8. Each diabetes-related behavior was considered a dependent variables. Results from the univariate analysis showed female gender to be a beneficial factor for diabetes-related behavior among the elderly with prediabetes in the rural areas ($\beta' = 0.253$, $P = 0.000$). In elderly individuals with prediabetes, without a history of hyperglycemia was an risk factor for diabetes-related behavior ($\beta' = -0.114$, $P = 0.016$) (Table 3).

Table 3 Multiple linear regression analysis of diabetes-related behaviors

Variables	B	Std. Error	Beta	*t*	*P*	95%*CI* for B
Constant	1.132	1.779	-	0.636	0.525	(-2.364, 4.629)
Gender	1.392	0.257	0.253	5.415	0.000	(0.887, 1.897)
History of hyperglycaemia	-0.600	0.247	-0.114	-2.425	0.016	(-1.086,-0.144)

CI: Confidence Interval.

DISCUSSION

Elderly individuals with prediabetes in the rural area had a high incidence of diabetes-related dangerous behaviors and low score for diabetes-related behaviors

In this study, the average score of diabetes-related behavior of the elderly with prediabetes in the rural areas was 2.7, which was relatively low. Except for eating and alcohol consumption habits, the reporting rates of diabetes-related dangerous behaviors, such as sedentary lifestyle, insufficient physical activity, lack of attention paid to the diet, high-salt and high-fat diet, less than one physical examination per year, and smoking were relatively high, which was consistent with the findings of other studies from China.[13]

The reporting rates of diabetes-related dangerous behaviors of "not paying attention to diet control" and "consuming high-salt/fat/sugar diets" of the elderly with prediabetes in the rural area were relatively high at 51.4% and 41.0%, respectively. Mounting evidence indicates that diet is an important factor in the development of diabetes. Some studies of individual food items and large cohort have showed that a decreased relative risk of diabetes is associated with higher intake of whole grains, as reported by food frequency screeners.[14-16] Cooper et al. found that fiber consumption (in fruit, vegetables, and whole grains) has been shown to be protective against prediabetes and diabetes.[17-18] Sugar intake has been directly related to increased risk for T2DM.[19] Excess fat has been shown to be a significant contributor to the development of obesity and insulin resistance.[20] In this way, the dietary modification is a crucial aspect of preventing and managing pre-existing type 2 diabetes. It is necessary for individuals with prediabetes who pay no attention and used to high-fat and salty food to change their lifestyle as it pertains to diet.

The rates of sedentary lifestyles and insufficient physical activity recorded in the current survey population was relatively high, compared with the survey of urban residents by Wei et al.[13] suggesting that might be associated with the elderly population in this studies. Sedentary behaviors, defined by low-energy expenditure in a sitting or reclining position during waking hours,[21] have emerged as an additional concern regarding physical activity and health.[22-23] Epidemiological evidence indicates that excessive time spent in sedentary behaviors (too much sitting) is associated with an increased risk of type 2 diabetes. Habitual lack of physical activity appears to have a detrimental impact on glucose tolerance[7], and the results of several large prospective studies including the Women's Health Study, the Nurses' Health Study, and the Health Professionals Follow-up Study have shown that, in both men and women, regular moderate exercise (such as walking) reduces the risk for T2DM by as much as 34%.[9] Regular participation in moderate vigorous physical activity remains a cornerstone in the prevention and management of T2DM.[24] One study showed that improved glucose (standing and walking) and insulin (walking only) responses were maintained into the next day.[25] Another study also showed reductions in postprandial insulin and C-peptide levels but not glucose to be associated with ambulatory breaks (5 min every hour) in adults with impaired glucose tolerance.[26] So sitting less, moving more, and more often may be a practical strategy for improving T2DM prevention and management.[27]

T2DM often goes undiagnosed for many years because hyperglycemia develops gradually and may not produce symptoms.[28] Several recent observational studies and a meta-analysis have suggested an association between chronic hyperglycemia and cardiovascular disease and stroke. Individuals with hyperglycemia are at increased risk of microvascular and macrovascular complications. In addition, T2DM and abnormal changes in glucose can be detected during the asymptomatic period through some tests that have been shown to be valid and reliable.[29] Physical examination can reveal abnormal changes in blood glucose in patients with prediabetes patients in a timely fashion. Therefore, it is beneficial for individuals with prediabetes to undergo physical examination regularly, which may find and prevent diabetes early.

Studies have showed that both passive and active smoking is associated with T2DM.[30] Willi et al. conducted a review showing there to be a direct correlation between smoking and risk of diabetes.[31] First, the insulin-mediated glucose-uptake is lower than in non-smokers;[32-34] second, studies have shown that smoking leads to an adverse distribution of body fat with smokers having lower body mass indices but larger waist-to-hip ratios;[35] third, tobacco ingredients are likely to have toxic effects on the pancreas;[36] fourth, smoking might activate inflammation leading to diabetes; and finally, smoking contributes to dyslipidemia because smokers have higher levels of free fatty acids, triglycerides, and LDL cholesterol and lower levels of HDL-cholesterol, factors usually associated with diabetes.[34,37] These support the conclusion abstaining from smoking will benefit individuals with prediabetes and diabetes, that it is necessary to encourage them to quit smoking.

Gender and hyperglycemia are the factors influencing of diabetes-related behaviors in elderly individuals with prediabetes in rural areas

The results showed that female gender was a favorable factor for diabetes-related behavior among the elderly with prediabetes in the rural areas ($\beta' = 0.253$, $P = 0.000$). This is consistent with others. Being male is a risk factor for diabetes in the Chinese population younger than 50 years.[38] In addition, many studies have shown that men have lower diabetes health literacy than women.[39-41] As reported before, the level of diabetes health literacy among men was lower than among women (OR 2.831, 95%; CI 1.818 to 4.408). 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. It is considered as a key health determinant because of its link to behavioral choices and service usage.[42] There is a relationship between health literacy and risky lifestyle behaviors.[43-44] Men are more likely to engage in risky lifestyle behaviors because of this limited health literacy. A study showed that male college students are more inclined to maintain an independent social image and pay less attention to the impact of their current behavior on their future health status.[45] Men are also more likely to neglect potential health problems and to underestimate the necessity of seeking medical advice and services. For example, women are more likely to provide care to sick family members than men and thus have more contact with the healthcare environment.[46-48] Therefore, as the consequence, these social psychological characteristics increase males' risk for diabetes.

In this study, we found that the absence of the history of hyperglycemia was a risk factor of the scores of the diabetes-related behaviors ($\beta' = -0.114$, $P = 0.016$). This the first report to discuss the relationship between the history of hyperglycemia and diabetes-related behaviors. As reported previously, people with a history of hyperglycemia were more literate concerning diabetes. This may be why individuals with prediabetes who have a history of hyperglycemia are more likely to become diabetes patients, so they concern themselves with diabetes-related behaviors very much and abstain from them. Given the sex-specific nature and the role of the history of hyperglycemia in the sociopsychological characteristics of elderly prediabetes, diabetes prevention strategies tailored specifically to their needs are required.

The present work has two limitations in this study. First, we cannot infer causations from its cross-sectional design. Second, because of the self-reported design, introduced bias cannot be excluded, so further studies are needed to confirm these findings.

CONCLUSIONS

The current study has revealed that the high prevalence of risk diabetes-related behaviors among elderly patients with prediabetes in rural China, such as sedentary lifestyle, insufficient physical activity, lack of attention paid to diet control, consuming high-salt and fat diets, having less than one physical examination per year, and smoking. Being male and not having a history of hyperglycemia were risk factors for scores of diabetes-related behaviors among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes among the elderly in rural China, the low health literacy, low income, and the high prevalence of behavior associated with increased risk of diabetes, future studies should evaluate diabetes prevention strategies tailored specially for this population.

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Author Contributions Huilan Xu and Lulu Qin had the original idea for the study and carried out the design. Zhao Hu, Fan Gao, Qiuhong Zhou and Shuang Song took part in this study as investigator. Lulu Qin, Jianglin Zhang and Bangan Luo completed the statistical analyses and drafted the manuscript. All authors read and approved the final manuscript.

Confilct of Interest The authors declare no conflict of interest.

Ethics approval The study was approved by the Medical Ethics Committee of Central South University (Changsha, China; Identification Code: CTXY-150002-7; 27 Feburary, 2015) and the IRB of the Chinese Clinical Trial Registry (NO. ChiCTR-IOR-15007033).

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REFERENCES

1. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007, 370, 1929-1938.

2. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004, 27, 1047 – 1053.

3. Edwards C, Cusi K. Prediabetes: A Worldwide Epidemic. *Endocrinol Metab Clin North Am*. 2016, 45, 751-764.

4. Tian H, Song G, Xie H, et al. Prevalence of diabetes and impaired fasting glucose among 769,792 rural Chinese adults. *Diabetes Res Clin Pract* 2009, 84, 273-278.

5. Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. *N Engl J*

Med 2010, 362, 1090–1101.

6. Ludwig D, Pereira M, Kroenke C, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. *JAMA* 1999, 282, 1539–46.

7. Bassuk S, Manson J. Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology* 2005, 99, 1193–204.

8.Schulze M, Manson J, Ludwig D, et al.Sugarsweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *JAMA* 2004, 292, 927-34.

9. Albright A, Franz M, Hornsby G, et al. American College of Sports Medicine position stand. Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000, 32, 1345–60.

10. Chinese diabetes society. Chinese guidelines for the prevention and treatment of type 2 diabetes mellitus (2013 Edition). *Chin J Endocrinol Metab* 2014, 6, 447- 498.

11. Qin L, Xu H. A cross-sectiona study of the effect of health literacy on diabetes prevention and control among elderly individuals with prediabetes in rural China. *BMJ Open* 2016, 6, e011077.

12. Li L, Li Y, Nie X, et al. An analysis of health literacy about diabetes prevention and control and its influencing factors among the residents in six provinces in China. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014, 48, 561-565.

13. Wei W, Li F, Li Y, et al. The study of diabetes-related behavior status and affecting factors amongurban and suburban residents in six province in China[J]. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014, 48, 571-575.

14.Liu S, Serdula M, Janket S, et al. A prospective study of fruit and vegetable intake and the risk of type 2 diabetes in women. *Diabetes Care* 2004, 27, 2993-6.

15. Fung T, Hu F, Pereira M, et al. Whole-grain intake and the risk of type 2 diabetes: a

prospective study in men. *Am J Clin Nutr* 2002, 76, 535-40.

16. Montonen J, Knekt P, Jvinen R, et al. Whole-grain and fiber intake and the incidence of type 2 diabetes. *Am J Clin Nutr* 2003, 77, 622-9.

17. Cooper A, Sharp S, Lentjes M, et al. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes Care* 2012, 35, 1293-300.

18. Cooper A, Forouhi N, Ye Z, et al. Fruit and vegetable intake and type 2 diabetes: EPIC-InterAct prospective study and meta-analysis. *Eur J Clin Nutr* 2012, 66, 1082-92.

19. Spruijt-Metz D, O'Reilly G, Cook L, et al. Behavioral Contributions to the Pathogenesis of Type 2 Diabetes. *Curr Diab Rep* 2014, 14, 475.

20. Cao, Y.; Chang, S.; Dong, J.; Zhu, S.; Zheng, X.; Li, J.; Long, R.; Zhou, Y.; Cui, J.; Zhang, Y. Emodin ameliorates high-fat-diet induced insulin resistance in rats by reducing lipid accumulation in skeletal muscle. *Eur J Pharmacol* 2016, 780, 194-201.

21. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours”. *Appl Physiol NutrMetab* 2012, 37, 540- 2.

22. Matthews C, Chen K, Freedson P, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol* 2008, 167, 875–81.

23. Owen N, Healy G, Matthews C, et al. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010, 38, 105-13.

24. Colberg S, Albright A, Blissmer B, et al. Exercise and type 2 diabetes: American College of SportsMedicine and the American Diabetes Association: joint position statement. *Med Sci Sports Exerc* 2010, 42, 2282–303.

25. Henson J, Davies M, Bodicoat D, et al. Breaking up prolonged sitting with standing or walking attenuates the postprandial metabolic response in postmenopausal women: a randomized

acute study. *Diabetes Care* 2016, 39, 130–8.

26. Holmstrup M, Fairchild T, Keslacy S, et al. Multiple short bouts of exercise over 12-h period reduce glucose excursions more than an energy-matched single bout of exercise. *Metabolism* 2014, 63, 510–9.

27. Dempsey P, Owen N, Yates Y, et al. Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management[J]. *Curr Diab Rep* 2016, 16, 114.

28. Gregg E, Cadwell B, Cheng Y, et al.Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabetes Care* 2004, 27, 2806-12.

29. Harris R, Donahue K, Rathore S, et al. Screening adults for type 2 diabetes: a review of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med* 2003, 138, 215-29.

30. KowallB B, Rathmann W, Strassburger K, et al. Association of passive and active smoking with incident type 2 diabetes mellitus in the elderly population: the KORA S4/F4 cohort study. *Eur J Epidemiol* 2010 , 25, 393-402.

31. Willi C, Bodenmann P, Ghali W, et al. Active smoking and the risk of type 2 diabetes. A systematic review and meta-analysis. *JAMA* 2007, 298, 2654–64.

32. Attvall S, Fowelin J, Lager I, et al. Smoking induces insulin resistance-A potential link with the insulin resistance syndrome. *J Intern Med* 1993, 233, 327–32.

33. Facchini F, Hollenbeck C, Jeppesen J, et al. Insulin resistance and cigarette smoking. *Lancet* 1992, 339, 1128–30.

34. Eliasson B, Mero N, Taskinen M, et al. The insulin resistance syndrome and postprandial lipid intolerance in smokers. *Atherosclerosis* 1997, 129, 79–88.

35. Shimokata H, Muller D, Andres R. Studies in the distribution of body fat. III. Effects of cigarette smoking. *JAMA* 1989, 261,169–73.

36. Chowdhury P, MacLeod S, Udupa K, et al. Pathophysiological effects of nicotine on the

pancreas: an update. *Exp Biol Med* 2002, 227, 445–54.

37. Berlin I. Smoking-induced metabolic disorders: a review. *Diabetes Metab* 2008, 34, 307–14.

38. Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA: the journal of the American Medical Association* 2013, 310, 948–59.

39. Barber M, Staples M Osborne R, et al. Up to a quarter of the Australian population may have suboptimal health literacy depending upon the measurement tool: results from a population-based survey. *Health Promot Int* 2009, 24, 252 – 61.

40. Von-Wagner C, Steptoe A, Wolf M, et al. Health literacy and health actions: a review and a framework from health psychology. *Health Educ Behav* 2009, 36, 860-77.

41. Sudore R, Mehta K, Simonsick E, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006, 54, 770-6.

42. Australian Commission on Safety and Quality in Health Care. Health literacy: taking action to improve safety and quality. Sydney: ACSQHC; 2014.

43. Aihara Y, Mina J. Barriers and catalysts of nutrition literacy among elderly Japanese people. *Health Promot Int* 2011, 26, 421-31.

44. Suka M, Odajima T, Okamoto M, et al. Relationship between health literacy, health information access,health behavior, and health status in Japanese people. *Patient Educ Couns* 2015, 98, 660-8.

45. Davies J, McCrae B, Frank J, et al. Identifying male college students' perceived health needs, barriers to seeking help, and recommendations to help men adopt healthier lifestyles. *Journal of American college health* 2000, 48, 259–67.

46. Thompson R, Lewis S, Murphy M, et al. Are there sex differences in emotional and biological responses in spousal caregivers of patients with Alzheimer's disease? *Biol Res Nurs* 2004, 5, 319–330.

47. Covinsky K, Eng C, Lui L, et al. Reduced employment in caregivers of frail elders: Impact of ethnicity, patient clinical characteristics, and caregiver haracteristics. *J Gerontol A Biol Sci Med Sci* 2001, 56, M707-13.

48. Williams-Wallace S, Dilworth-Anderson P, Goodwin P. Caregiver role strain: The contribution of multiple roles and available resources in African-American women. *Aging Ment Health* 2003, 7, 103–112.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-6
Bias	9	Describe any efforts to address potential sources of bias	5-6

Study size	10	Explain how the study size was arrived at	Described in a previous article.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	No.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	Described in a previous article.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	Described in a previous article.
Outcome data	15*	Report numbers of outcome events or summary measures	7-8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	7-11

		interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	No.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A cross-sectional study of diabetes-related behavior among elderly individuals with prediabetes in rural communities of Hunan, China

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Keywords: prediabetes; diabetes-related behavior; elderly; rural areas

Word accounts: 3,840; Tables: 4

ABSTRACT:

Objectives: To study the diabetes-related behavior and its influencing factors in elderly individuals with prediabetes in rural areas.

Design, setting and participates: A cross-sectional survey was conducted among the elderly (≧60 years) in rural communities in Yiyang City of China. Multistage cluster and random sampling was carried out to select 42 areas and 434 elderly individuals with prediabetes (fasting plasma glucose of 6.1-7.0mmol/L and/or a 2-hour post-glucose load of 7.8-11.1 mmol/L) who were interviewed using a questionnaire on diabetes-related behavior. The diabetes-related behavior included eight categories: average daily sedentary time; frequency of physical activities per week; regular or irregular diet; 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 risk behavior was scored "−1", and each of the healthy behavior was scored "+1". Each individual's score of diabetes-related behavior was the sum of the scores for all behavior.

Main outcome measures: Participants were asked general information (age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases, body mass index (BMI), the waist-to-hip ratio (WHR) and education) and their diabetes-related behavior. The multivariate linear regression analysis was performed to detect the risk factors of the diabetes-related behavior of the elderly with prediabetes.

Results: The average score of diabetes-related behavior of the elderly with prediabetes in the rural area was 2.7. The prevalence of diabetes-related risk behavior were as follows: less than one 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%). Patients' gender and history of hyperglycemia were found to be influencing factors of the diabetes-related behavior score.

Conclusions: The prevalence of diabetes-related risk behavior was high among prediabetic elderly in rural China. More efforts should be made to promote the prevention and control of diabetes in rural China, and future studies should evaluate diabetes prevention strategies tailored specially for this population.

Trial registration number: CTXY-150002-7; ChiCTR-IOR-15007033.

Strengths and limitations of this study

This is the first study to examine the diabetes-related behavior and its influencing factors among the elderly prediabetic population in rural China.

The study provides valuable information on the diabetes-related behavior and its influencing factors and scientific recommendations for diabetes prevention among the elderly prediabetic population in rural communities.

The study is limited by its cross-sectional and self-reported design.

INTRODUCTION

Prediabetes is defined by blood glucose levels between normal and diabetic, which were categorized 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 prediabetes 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 prediabetes has risen rapidly. The prevalence of diabetes and prediabetes in China is estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[6] Prediabetes poses several threats; there is increased risk of T2DM, and there are risks to other diseases, including microvascular and macrovascular disease.

A large number of studies have shown that the lifestyle behavior of people with prediabetes play an important role in the incidence and development of diabetes and other diseases. These behavior can be collectively referred to as diabetes-related risk behavior, such as sedentary lifestyle, overeating, and insufficient physical activity. Some studies have shown that healthy versions of these behavior can delay or prevent the incidence and development of diabetes. For example, a study of 2,909 healthy adults found an inverse association between intake of dietary fiber measured by food frequency investigators and both fasting insulin and two-hour postprandial insulin.[7] A lot of studies have shown that the prevalence of T2DM among people who regularly exercise is lower than among people who do not.[8] Other studies have suggested that unhealthy behavior of patients with prediabetes speed up the progress of their diseases, such as diabetes, microvascular and macrovascular diseases. A large cohort study revealed an increase in the risk of T2DM of over 80% for women who drank one sugar-sweetened beverage (SSB) per day, relative to women who had less than one such drink per month.[9] And Albright et al. found that habitual lack of physical activity appears to have a detrimental impact on glucose tolerance.[10]

Chinese Guidelines for T2DM Prevention and Treatment (2013 Edition) shows that age ≥ 60 years and prediabetes are important risk factors for diabetes.[11] Prediabetes patients at age of 60 years and above have extremely 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 the higher incidence of prediabetes than the urban areas.[6] Considering the large population and the aging process in rural areas of China, delayed and ineffective interventions for the disease will cause the development of diabetes to proliferate in rural areas. However, few reports have addressed diabetes-related behavior of elderly with prediabetes in rural China, and no epidemiological information is available on diabetes-related behavior among rural prediabetic elderly. Our study was performed using a questionnaire covering diabetes-related behavior of elderly population with prediabetes in rural areas 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: $n= u_{\alpha/2}^2P(1-P)/d^2$, where u was 1.96 when α is 0.05, P is the prevalence of prediabetes (which is 20% in this study), and d is the admissible error which was 4% here. The theory sample was 423 after increasing 10% observed subjects taken account of lost during investigation. Using a multistage cluster randomized sampling method, we selected a representative sample of the rural prediabetic population aged 60 years and over in Yiyang city of Hunan province between April and July 2015. In the first stage, sampling was stratified according to geographical characteristic status, and 2 counties (Yuanjiang and Nanxian) were selected. In the second stage, 4 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 households with elderly individuals in each selected villages who had lived in the area for 3 years or longer were eligible to participate prediabetes screening. Those with severe physical and mental illness were excluded from the screening. Individuals who had diabetes were also excluded from the screening. Participants diagnosed as prediabetes by using oral glucose tolerance tests (OGTT). The diagnostic standards for prediabetes as stated in the 1999 WHO criteria and were categorized into three group[1]: (1) IFG group: Fasting plasma glucose of 6.1-7.0mmol/L (110-126 mg/dl) and a 2-hour post-glucose load of < 7.8 mmol/L (140 mg/dl); (2) IGT group: Fasting plasma glucose of 6.1mmol/L (110 mg/dl) and a 2-hour post-glucose load of 7.8-11.1 mmol/L (140-200 mg/dl); (3) IFG+IGT group. In brief, the 2144 elderly took part in the OGTT and 461 elderly individuals had prediabetes. For many reasons, 27 prediabetic elderly were not investigated or refused to take part in subsequent study. Finally, 434 prediabetes were included in our intervention study. The design and procedure have been described in detail in a previous study.[11]

Data Collection

Participants screening were instructed to maintain their usual physical activity and diet for a minimum of three days before the oral glucose tolerance test (OGTT). The collecting of socio-demographic information included age, gender, marital status, education, presence of other diseases, family history of diabetes and history of hyperglycemia.

Anthropometric measurements included blood pressure, height, weight and waist circumference, and the measuring of blood pressure, BMI, the waist-to-hip ratio (WHR) were described in the previous study.[12] Blood pressure was assessed twice (2 minutes apart) using an electronic blood pressure monitor (A&D Medical, Life Source UA-767PV) after the participant had been seated for at least 5 minutes 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 mmHg and/or diastolic pressure ≧90 mmHg.[13] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[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 = 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≧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 that 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 waist-to-hip ratio (WHR) was calculated by dividing the waist measurement by the hip measurement. And the WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[15]

Diabetes-related behavior were assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China", which was designed by the Chinese Center of Health Education and has a high reliability and validity with a Cronbach's α of 0.866.[16] The questionnaire includs eight categories (Table 1): average daily sedentary time; frequency of physical activities per week; regular or irregular diet; paying attention to diet control or not; daily dietary preferences (e.g., bland diets, high-salt diets, and high-fat diets); frequency of physical examinations per year; current smoking status; and current consumption of alcohol. Among the eight categories, the questions regarding dietary preferences were given in multiple choice format; while the question format of rest of the categories was in single-topic selection. Sedentary lifestyle (average daily sedentary time ≥ 6 h), insufficient physical activity (engaging in physical activity fewer than 3 times per week), irregular diet, lack of attention paid to diet, high-salt diet, high-fat diet, fewer than one physical examination per year, frequent alcohol consumption (drinking ≥ 3 times/week), and smoking currently were defined as risk behavior, and the rest of the behavior were defined as healthy behavior. Each of the risk behavior was scored "−1", and each of the healthy behavior was scored "+1". Each individual's score of diabetes-related behavior was the sum of the scores for all behavior. The sum of the diabetes-related behavior scores were from -8 to 8 in this questionnaire. The higher the sum of the scores, the better the diabetes-related behavior were.

Table 1 The outline of the diabetes-related behavior questionnaire

Categories	Behavior (score)	
	Risk behavior(−1)	Healthy behavior(+1)
Average daily sedentary time (h)	≥6	<6
Frequency of physical activities per week	<3	≥3
The 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	Having quitted smoking, or never smoking
Current consumption of alcohol	Frequent alcohol consumption (drinking ≥ 3 times/week)	Occasional alcohol consumption (drinking <3 times/week), or never alcohol consumption

Statistical analysis

In this study, Epidata 3.1 software was used to build the database, and SPSS 20.0 (SPSS Inc., Chicago, IL, U.S.) software for the statistical analysis. All questionnaires were doubly input into the database by two independent professional data processors. Data are presented as the prevalence and mean ± standard deviation (SD). The chi square testing was used for categorical variables, and the Cochra-Mantel-Haenszel test for ranked variables. Multivariate linear regression was used to analyze the factors influencing diabetes-related behavior. The sum of the scores for all behavior was selected as the dependent variable. Age (actual value), gender (1 = male and 2 = female), marital status (1 = stable marital status and 2 = unstable), education (1=less than 1 years, 2=from 1 to 6 years, and 3= 6 years and above), history of hyperglycemia

(1 = yes and 2 = no), family history of diabetes (1 = yes and 2 = no), other chronic disease status (1=yes and 2=no), BMI (1=lean, 2=normal, 3=overweight, and 4=obese), WHR (1=normal and 2=abnormal) and blood pressure (1=normal and 2=abnormal) were entered as independent variables. These variables were further used for multiple linear regression analysis. All hypothesis tests used two-side tests and a *P*-value less than 0.05 was considered to be statistically significant.

RESULTS

The characteristics of participants

In our study, a total of 2,114 non-diabetic patients aged 60 years old and above were screened. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes participants completed the questionnaire. The effective response rate was 97.8% in this study.

Among the 434 survey respondents, there were 180 men (41.5%) and 254 women (58.5%). Participants had an average (±SD) age of 69.4 (±6.45) years. Among them, 313 patients had stable marriage status (married and living with spouse, accounting for 72.1%); 353 patients (81.3%) had a low education (Education duration < 6 years). Only 28 participants (6.5%) had a history of hyperglycemia and 36 patients (8.3%) had a family history of diabetes. 82.3% of the patients had abnormal WHR, and 45.9% of them 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 prediabetics elderly were no significant differences to the non prediabetics (*P*>0.05). (see details in a previously published paper[11]).

The prevalence of diabetes-related behavior among the elderly individuals with prediabetes

Among the 434 survey respondents, the reporting rates of the diabetes-related risk behavior 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%), less than one physical examination per year (57.6%), smoking currently (22.8%), and frequent alcohol consumption (15.0%) (Table 2).

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

Behavior	n	Prevalence(%)
Average daily sedentary time(h/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
Everyday	108	24.9
The regularity of 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
Having quitted smoking	41	9.4
Never smoking	294	67.7
Frequency of alcohol consumption		
Frequently	65	15.0
Occasionally	37	8.5
Never	332	76.5

Comparison of diabetes-related risk behavior between different characteristics of the rural prediabetic elderly

There were statistically significant differences in the prevalence of the diabetes-related risk behavior among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China ($P < 0.05$, see Table 3 for details). Different education, BMI, WHR, blood pressure, and type of prediabetes all showed no significant differences in elderly individuals with prediabetes in rural China in the diabetes-related risk behavior ($P > 0.05$).

Table 3 Comparison of diabetes-related risk behavior 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,%）	Less than one 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	<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	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	0.637	0.681	0.212	0.696	0.021[‡]	0.778	0.008[†)]	0.245
History of hyperglycemia								
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	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	2,784	0.107	0.461
P	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	0.047[‡]	0.213	0.957	0.912	0.104	0.022[‡]	0.110	0.036[‡]

†P＜0.01.

‡P＜0.05.

Risk factors for the diabetes-related behavior among the rural prediabetic elderly

The average score of diabetes-related behavior of the survey respondents was 2.7, with the lowest score of −8 and the highest 8. Each diabetes-related behavior was considered a dependent variable. Results from the univariate analysis showed female gender to be a beneficial factor for diabetes-related behavior among the elderly with prediabetes in the rural areas ($\beta' = 0.253$, $P< 0.001$). In elderly individuals with prediabetes, without a history of hyperglycemia was an risk factor for diabetes-related behavior ($\beta' = -0.114$, $P = 0.016$) (Table 4).

Table 4 Multiple linear regression analysis of diabetes-related behavior

Variables	B	Std. Error	Beta	*t*	*P*	95%*CI* for B
Constant	1.132	1.779	-	0.636	0.525	（-2.364, 4.629）
Gender	1.392	0.257	0.253	5.415	0.000	（0.887, 1.897）
History of hyperglycemia	-0.600	0.247	-0.114	-2.425	0.016	（-1.086,-0.144）

CI: Confidence Interval.

DISCUSSION

Elderly individuals with prediabetes in the rural area had a high prevalence of diabetes-related risk behavior and low score for diabetes-related behavior

In this study, the average score of diabetes-related behavior of the elderly with prediabetes in the rural areas was 2.7, which was relatively low comparing to urban population in China.[17] Except for eating and alcohol consumption habits, the prevalence of diabetes-related risk behavior, such as sedentary lifestyle, insufficient physical activity, lack of attention paid to the diet, high-salt and high-fat diet, less than one physical examination per year, and smoking were relatively high, which was consistent with the findings of other studies from China.[17]

The prevalence of diabetes-related risk behavior of “not paying attention to diet control” and “consuming high-salt/fat/sugar diets” of the elderly with prediabetes in the rural area were relatively high at 51.4% and 41.0%, respectively. Mounting evidence indicates that diet is an important factor in the development of diabetes. Some studies of individual food items and large cohort have showed that a decreased relative risk of diabetes is associated with higher intake of whole grains, as reported by food frequency screeners.[18-20] Cooper et al. found that fiber consumption (in fruit, vegetables, and whole grains) has been shown to be protective against prediabetes and diabetes.[21-22] Sugar intake has been directly related to increased risk for T2DM.[23] Excess fat has been shown to be a significant contributor to the development of obesity and insulin resistance.[24] In this way, the dietary modification is a crucial aspect of preventing and managing pre-existing type 2 diabetes. It is necessary for individuals with prediabetes who pay no attention and used to high-fat and salty food to change their lifestyle as it pertains to diet.

The rates of sedentary lifestyles and insufficient physical activity recorded in the current survey population was relatively high, compared with the survey of urban residents by Wei et al.[17] suggesting that might be associated with the elderly population in this studies. Sedentary behavior, defined by low-energy expenditure in a sitting or reclining position during waking hours,[25] have emerged as an additional concern regarding physical activity and health.[26-27] Epidemiological evidence indicates that excessive time spent in sedentary behavior (too much sitting) is associated with an increased risk of type 2 diabetes. Habitual lack of physical activity appears to have a detrimental impact on glucose tolerance[8]. Several large prospective studies such as the Women Health Study, the Nurses' Health Study, and the Health Professionals Follow-up Study have shown that, in both men and women, regular moderate exercise (such as walking) reduces the risk for T2DM by as much as 34%.[10] Regular participation in moderate vigorous physical activity remains a cornerstone in the prevention and management of T2DM.[28] One study showed that improved glucose (standing and walking) and insulin (walking only) responses were maintained into the next day.[29] Another study also showed reductions in postprandial insulin and C-peptide levels but not glucose to be associated with ambulatory breaks (5 min every hour) in adults with impaired glucose tolerance.[30] So sitting less, moving more, and more often may be a practical strategy for improving T2DM prevention and management.[31]

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

Studies have shown that both passive and active smoking is associated with T2DM.[33] Willi et al. conducted a review showing there to be a direct correlation between smoking and risk of diabetes.[34] First, smoke exposure results in insulin resistance through oxidative stress;[35] second, study has shown that childhood passive smoke exposure was associated with increased adiposity;[36] third, tobacco ingredients are likely to have toxic effects on the pancreas;[37] fourth, smoking might activate inflammation leading to diabetes; and finally, smoking contributes to dyslipidemia because smokers have higher levels of free fatty acids, triglycerides, and LDL cholesterol and lower levels of HDL-cholesterol, factors usually associated with diabetes.[38] These support the conclusion abstaining from smoking will benefit individuals with prediabetes and diabetes, that it is necessary to encourage them to quit smoking in future work of preventing diabetes.

Diabetes-related risk behavior distribution in different populations

The prevalence of diabetes-related risk behavior were different among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China. The prevalence of sedentary lifestyle of prediabetic elderly aged 60 years and above was higher than that of young people, which was consistent with other studies.[16,39-40] Matthews et al. reported that adults older than 60 years spend approximately 80% of their awake time in sedentary activities which represents 8 to 12 hours per day.[39] Similarly, Hallal et al. conducted a global assessment in more than 60 countries and found that the elderly had the highest prevalence of reporting a minimum of 4 hours of sitting time daily.[40] The elderly aged 60 years and above have higher prevalence of sedentary lifestyle than young people, which may mainly due to the aging of the body. The prevalence of current smoking and consumption of alcohol in male prediabtic elderly were higher than female, which may be the different lifestyle between male and female. This was similar with other studies.[41-42] Bu et al. reported that men were more likely to drink alcohol and smoke cigarettes but less likely to be under diet control comparing with women in middle-aged

Chinese.[41] Alicia et al. found that risky alcohol consumption was a risk factor for prediabetes in men. [42]

The prevalence of high-salt/fat/sugar diet in prediabetic elderly with the stable marital status was higher than who without the stable marital status. There may be two reasons. On one hand, person with unstable marital status are at low income. On the other hand, Yang et al. found that unstable marital status had bad effect on diet among the elderly in rural China.[43] The prevalence of high-salt/fat/sugar diet in prediabetic elderly without a history of hyperglycemia was higher that with a history of hyperglycemia. As we reported before that hyperglycemia influenced diabetes health literacy.[13] People with a history of hyperglycemia are concerned about developing diabetes and actively keep healthy behaviors on preventing diabetes.

The prevalence of sedentary lifestyle and insufficient physical activities in prediabetic elderly with family history of diabetes was high, which indicated that family history was associated with developing of diabetes. Bianco et al. showed that there was a correlation between type 2 diabetes family history and body weight, fat mass and alterations in basal glycemia values.[44] Aravindalochanan et al. found that increased sitting duration for≧180min/day was associated with elevated random capillary blood glucose, and there was a threefold higher risk for diabetes among these subjects with positive family history of diabetes.[45] Healthy diet and active lifestyle may significantly decrease the risk of T2DM in spite of having a family history of diabetes.[46]

The prevalence of less than one physical examination per year in people with other chronic diseases was higher than that of without other chronic diseases, which was not surprising. Yin et al. found that the elderly in rural China were not actively seeking health services because of poor economic conditions, high price of health services, and bad quality medical services.[47] The findings suggest that there are some differences in different populations, which should be taken into account when implementing specific recommendations to prevent or delay the onset of diabetes in the rural prediabetic elderly population. Specific strategies to reduce modifiable risk factors for the prevention and control of diabetes may be warranted.

Gender and hyperglycemia are the factors influencing of diabetes-related behavior in elderly individuals with prediabetes in rural areas

The results showed that female gender was a favorable factor for diabetes-related behavior among the elderly with prediabetes in the rural areas. This is consistent with others. Being male is a risk factor for diabetes in the Chinese population younger than 50 years.[48] In addition, many studies have shown that men have lower diabetes health literacy than women.[49-51] 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 as a key health determinant because of its link to behavioral choices and service usage.[52] There is a relationship between health literacy and risky lifestyle behavior.[53-54] Men are more likely to engage in risky lifestyle behavior because of this limited health literacy. A study showed that male college students are more inclined to maintain an independent social image and pay less attention to the impact of their current behavior on their future health status.[55] Men are also more likely to neglect potential health problems and to underestimate the necessity of seeking medical advice and services. For example, women are more likely to provide care to sick family members than men and thus have more contact with the healthcare environment.[56-58] Therefore, as the consequence, these social psychological characteristics increase males' risk for diabetes.

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

The present work has two limitations in this study. First, we cannot infer causations from its cross-sectional design. Second, because of the self-reported design, introduced bias cannot be excluded, so further studies are needed to confirm these findings.

CONCLUSIONS

The current study has revealed that the high prevalence of risk diabetes-related behavior among elderly patients with prediabetes in rural China. Being male and not having a history of hyperglycemia were risk factors for scores of diabetes-related behavior among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes among the elderly in rural China, the low health literacy, low income, and the high prevalence of behavior associated with increased risk of diabetes, future studies should evaluate diabetes prevention strategies tailored specially for this population.

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Author Contributions Huilan Xu and Lulu Qin had the original idea for the study and carried out the design. Zhao Hu, Fan Gao, Qiuhong Zhou and Shuang Song implemented the intervention and follow-up in this study, and they collected the data and information at baseline and follow-up as investigator. Lulu Qin, Jianglin Zhang and Bangan Luo completed the statistical analyses and drafted the manuscript. Lulu Qin and Huilan Xu checked and revised the manuscript. All authors read and approved the final manuscript.

Confilct of Interest The authors declare no conflict of interest.

Ethics approval The study was approved by the Medical Ethics Committee of Central South University (Changsha, China; Identification Code: CTXY-150002-7; 27 Feburary, 2015) and the IRB of the Chinese Clinical Trial Registry (NO. ChiCTR-IOR-15007033).

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Data sharing statement No additional data are available.

REFERENCES

1.Department of Noncommunicable Disease Surveillance.Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation. Part 1. Diagnosis and classification of diabetes mellitus. Geneva: World Health Organization,1999. http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf (accessed 26 Feb 2010).

2. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007; 370, 1929-1938.

3. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; 27, 1047 – 1053.

4. Edwards C, Cusi K. Prediabetes: A Worldwide Epidemic. *Endocrinol Metab Clin North Am*. 2016, 45, 751-764.

5. Tian H, Song G, Xie H, et al. Prevalence of diabetes and impaired fasting glucose among 769,792 rural Chinese adults. *Diabetes Res Clin Pract* 2009; 84, 273-278.

6. Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. *N Engl J Med* 2010, 362, 1090–1101.

7. Ludwig D, Pereira M, Kroenke C, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. *JAMA* 1999; 282, 1539–46.

8. Bassuk S, Manson J. Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology* 2005; 99, 1193–204.

9.Schulze M, Manson J, Ludwig D, et al.Sugarsweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *JAMA* 2004; 292, 927-34.

10. Albright A, Franz M, Hornsby G, et al. American College of Sports Medicine position stand.

Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000; 32, 1345–60.

11. Chinese diabetes society. Chinese guidelines for the prevention and treatment of type 2 diabetes mellitus (2013 Edition). *Chin J Endocrinol Metab* 2014; 6, 447- 498.

12. Qin L, Xu H. A cross-sectiona study of the effect of health literacy on diabetes prevention and control among elderly individuals with prediabetes in rural China. *BMJ Open* 2016; 6, e011077.

13. Writing group of 2010 Chinese guidelines for the management of hypertension. 2010 Chinese guidelines for management of hypertension.*Chinese Journal of Hypertension* 2011; 18, 701-743.[in Chinese]

14. Health industry standard of the people's Republic of China.WS/T 428-2013

15. Obesity in Asia Collaboration. Is central obesity a better discriminator of the risk of hypertension than body mass index in ethnically diverse populations? *J Hypertens.* 2008; 26, 169-177.

16. Li L, Li Y, Nie X, et al. An analysis of health literacy about diabetes prevention and control and its influencing factors among the residents in six provinces in China. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 561-565.

17. Wei W, Li F, Li Y, et al. The study of diabetes-related behavior status and affecting factors amongurban and suburban residents in six province in China[J]. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 571-575.

18. Liu S, Serdula M, Janket S, et al. A prospective study of fruit and vegetable intake and the risk of type 2 diabetes in women. *Diabetes Care* 2004; 27, 2993-6.

19. Fung T, Hu F, Pereira M, et al. Whole-grain intake and the risk of type 2 diabetes: a prospective study in men. *Am J Clin Nutr* 2002; 76, 535-40.

20. Montonen J, Knekt P, Jvinen R, et al. Whole-grain and fiber intake and the incidence of type

2 diabetes. *Am J Clin Nutr* 2003; 77, 622-9.

21. Cooper A, Sharp S, Lentjes M, et al. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes Care* 2012;35, 1293-300.

22. Cooper A, Forouhi N, Ye Z, et al. Fruit and vegetable intake and type 2 diabetes: EPIC-InterAct prospective study and meta-analysis. *Eur J Clin Nutr* 2012; 66, 1082-92.

23. Spruijt-Metz D, O'Reilly G, Cook L, et al. Behavioral Contributions to the Pathogenesis of Type 2 Diabetes. *Curr Diab Rep* 2014; 14, 475.

24. Cao, Y, Chang S, Dong J, et al. Emodin ameliorates high-fat-diet induced insulin resistance in rats by reducing lipid accumulation in skeletal muscle. *Eur J Pharmacol* 2016; 780, 194-201.

25. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours”. *Appl Physiol NutrMetab* 2012; 37, 540- 2.

26. Matthews C, Chen K, Freedson P, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol* 2008; 167, 875–81.

27. Owen N, Healy G, Matthews C, et al. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010; 38, 105-13.

28. Colberg S, Albright A, Blissmer B, et al. Exercise and type 2 diabetes: American College of SportsMedicine and the American Diabetes Association: joint position statement. *Med Sci Sports Exerc* 2010; 42, 2282–303.

29. Henson J, Davies M, Bodicoat D, et al. Breaking up prolonged sitting with standing or walking attenuates the postprandial metabolic response in postmenopausal women: a randomized acute study. *Diabetes Care* 2016; 39, 130–8.

30. Holmstrup M, Fairchild T, Keslacy S, et al. Multiple short bouts of exercise over 12-h period reduce glucose excursions more than an energy-matched single bout of exercise. *Metabolism*

2014; 63, 510–9.

31. Dempsey P, Owen N, Yates Y, et al. Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management[J]. *Curr Diab Rep* 2016; 16, 114.

32. Gregg E, Cadwell B, Cheng Y, et al.Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabetes Care* 2004; 27, 2806-12.

33. KowallB B, Rathmann W, Strassburger K, et al. Association of passive and active smoking with incident type 2 diabetes mellitus in the elderly population: the KORA S4/F4 cohort study. *Eur J Epidemiol* 2010; 25, 393-402.

34. Willi C, Bodenmann P, Ghali W, et al. Active smoking and the risk of type 2 diabetes. A systematic review and meta-analysis. *JAMA* 2007; 298, 2654–64.

35. Neema A, Shelley R. Starck, Cristina F, et al. CA Health Threat to Bystanders Living in the Homes of Smokers: How Smoke Toxins Deposited on Surfaces Can Cause Insulin Resistance

PLoS One 2016; 11(3): e0149510.

36. Davis CL, Tingen MS, Jia J, et al. Passive Smoke Exposure and Its Effects on Cognition, Sleep, and Health Outcomes in Overweight and Obese Children. *Child Obes* 2016; 12(2):119-25.

37. Chowdhury P, MacLeod S, Udupa K, et al. Pathophysiological effects of nicotine on the pancreas: an update. *Exp Biol Med* 2002, 227, 445–54.

38. Berlin I. Smoking-induced metabolic disorders: a review. *Diabetes Metab* 2008, 34, 307–14.

39. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behavior in the United States, 2003 – 2004. *Am J Epidemiol* 2008; 167: 875-881.

40. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247-257.

41. Bu S, Ruan D, Yang Z, et al. Sex-Specific Prevalence of Diabetes and Cardiovascular Risk

Factors in the Middle-Aged Population of China: A Subgroup Analysis of the 2007-2008 China National Diabetes and Metabolic Disorders Study. *PLoS One* 2015;10(9):e0139039.

42. Díaz-Redondo A, Giráldez-García C, Carrillo L, et al. Modifiable risk factors associated with prediabetes in men and women: a cross-sectional analysis of the cohort study in primary health care on the evolution of patients with prediabetes (PREDAPS-Study).*BMC Fam Pract* 2015;16:5.

43. Yang Y, Xu H, Tang G, et al. The characteristics and influencing factors of dietary behavior of left-behind elderly in rural areas of Chongqing in China. *Chinese Journal of Gerontology* 2017; 37(5):1242-1244. [in Chinese]

44. Bianco A, Pomara F, Thomas E, et al. Type 2 diabetes family histories, body composition and fasting glucose levels: a cross-section analysis in healthy sedentary male and female. *Iran J Public Health* 2013;42(7):681-90.

45. Aravindalochanan V, Kumpatla S, Rengarajan M, et al. Risk of diabetes in subjects with sedentary profession and the synergistic effect of positivefamily history of diabetes. *Diabetes Technol Ther* 2014;16(1):26-32.

46. Midhet FM, Al-Mohaimeed AA, Sharaf FK. Lifestyle related risk factors of type 2 diabetes mellitus in Saudi Arabia. *Saudi Med J* 2010;31(7):768-74.

47. Yin Z, Chen L, Tu H, et al. Survey on the demand and satisfaction of community health services for the elderly in Zhejiangin China. *Chinese Journal of Gerontology* 2013; 33(4): 899-900.[in Chinese]

48. Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA: the journal of the American Medical Association* 2013; 310, 948–59.

49. Barber M, Staples M Osborne R, et al. Up to a quarter of the Australian population may have suboptimal health literacy depending upon the measurement tool: results from a

population-based survey. *Health Promot Int* 2009; 24, 252–61.

50. Von-Wagner C, Steptoe A, Wolf M, et al. Health literacy and health actions: a review and a framework from health psychology. *Health Educ Behav* 2009; 36, 860-77.

51. Sudore R, Mehta K, Simonsick E, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770-6.

52. Australian Commission on Safety and Quality in Health Care. Health literacy: taking action to improve safety and quality. Sydney: ACSQHC; 2014.

53. Aihara Y, Mina J. Barriers and catalysts of nutrition literacy among elderly Japanese people. *Health Promot Int* 2011; 26, 421-31.

54. Suka M, Odajima T, Okamoto M, et al. Relationship between health literacy, health information access,health behavior, and health status in Japanese people. *Patient Educ Couns* 2015; 98, 660-8.

55. Davies J, McCrae B, Frank J, et al. Identifying male college students' perceived health needs, barriers to seeking help, and recommendations to help men adopt healthier lifestyles. *Journal of American college health* 2000, 48, 259–67.

56. Thompson R, Lewis S, Murphy M, et al. Are there sex differences in emotional and biological responses in spousal caregivers of patients with Alzheimer's disease? *Biol Res Nurs* 2004; 5, 319–330.

57. Covinsky K, Eng C, Lui L, et al. Reduced employment in caregivers of frail elders: Impact of ethnicity, patient clinical characteristics, and caregiver haracteristics. *J Gerontol A Biol Sci Med Sci* 2001; 56, M707-13.

58. Williams-Wallace S, Dilworth-Anderson P, Goodwin P. Caregiver role strain: The contribution of multiple roles and available resources in African-American women. *Aging Ment Health* 2003; 7, 103–112.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	5-8

Study size	10	Explain how the study size was arrived at	Described in a previous article.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	6-9
		(*c*) Explain how missing data were addressed	6-9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6-9
		(*e*) Describe any sensitivity analyses	No.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	Described in a previous article.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	Described in a previous article.
Outcome data	15*	Report numbers of outcome events or summary measures	9-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	11-13

		interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	6-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11-13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	No.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Diabetes-related behaviors among the elderly with prediabetes in rural communities of Hunan, China: a cross-sectional study

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Diabetes-related behaviors among the elderly with prediabetes in rural communities of Hunan, China: a cross-sectional study

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Keywords: prediabetes; diabetes-related behavior; elderly; rural areas

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ABSTRACT:

Objectives: To explore the diabetes-related behaviors and its influencing factors among elderly individuals with prediabetes in rural areas in China.

Design, setting and participates: A cross-sectional survey was conducted among the elderly (≧60 years) in rural communities in Yiyang City of China. Multi-staged cluster random sampling was carried out to select 42 areas, and 434 elderly individuals with prediabetes (fasting plasma glucose of 6.1-7.0mmol/L and/or a 2-hour post-glucose load of 7.8-11.1 mmol/L) were interviewed using a questionnaire on diabetes-related behavior. The diabetes-related behaviors 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 examination per year; current smoking status; and current consumption of alcohol. Each of the risky behavior was scored "−1", and each of the healthy behavior was scored "+1". Each individual's score of diabetes-related behavior was the sum of the score for all behaviors.

Main outcome measures: Participants were asked general information (age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases, body mass index (BMI), the waist-to-hip ratio (WHR) and education) and their diabetes-related behavior. The multivariate linear regression analysis was performed to identify the risk factors of the diabetes-related behavior among elderly individuals with prediabetes.

Results: The average score of diabetes-related behavior of the elderly with prediabetes in the rural area was 2.7. The prevalences of risky diabetes-related behaviors were as follows: less than one 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%). Patients' gender and history of hyperglycemia were found to be influencing factors of the diabetes-related behavior score.

Conclusions: The prevalences of risky diabetes-related behaviors were high among prediabetic elderly in rural China. More efforts should be made to promote the prevention and control of diabetes in rural China, and future studies should evaluate diabetes prevention strategies tailored specially for this population.

Trial registration number: CTXY-150002-7; ChiCTR-IOR-15007033.

Strengths and limitations of this study

This is the first study to examine the diabetes-related behavior and its influencing factors among the elderly prediabetic population in rural China.

The study provides valuable information on the diabetes-related behavior and its influencing factors and scientific recommendations for diabetes prevention among the elderly prediabetic population in rural communities.

The study is limited by its cross-sectional and self-reported design.

INTRODUCTION

Prediabetes is defined by blood glucose levels between normal and diabetic, which were categorized 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 prediabetes 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 prediabetes has risen rapidly. The prevalence of diabetes and prediabetes in China is estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[6] Prediabetes poses several threats; there is an increased risk for T2DM, and there are risks to other diseases, including microvascular and macrovascular disease.

A large number of studies have shown that lifestyle behavior of prediabetes patients play an important role in the incidence and development of diabetes and other diseases. These behavior can be collectively referred to as risky diabetes-related behavior, such as sedentary lifestyle, overeating, and insufficient physical activity. Some studies have shown that healthy versions of these behavior can delay or prevent the incidence and development of diabetes. For example, a study of 2,909 healthy adults found an inverse association between intake of dietary fiber measured by food frequency investigators and both fasting insulin and two-hour postprandial insulin.[7] A lot of studies have shown that the prevalence of T2DM among people who regularly exercise is lower than among people who do not.[8] Other studies have suggested that unhealthy behavior of patients with prediabetes speed up the progress of their diseases, including diabetes, microvascular and macrovascular diseases. A large cohort study revealed an increase in the risk of T2DM of over 80% for women who drank one sugar-sweetened beverage (SSB) per day, relative to women who had less than one such drink per month.[9] And Albright et al. found that habitual lack of physical activity appeared to have a detrimental impact on glucose tolerance.[10]

Chinese Guidelines for T2DM Prevention and Treatment (2013 Edition) shows that both the old age (≥ 60 years) and prediabetes are important risk factors for diabetes.[11] Prediabetes patients at age of 60 years and above have extremely 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 the higher incidence of prediabetes than the urban areas.[6] Considering the large population and the aging 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 behavior of elderly with prediabetes in rural China, and no epidemiological information is available on diabetes-related behavior among rural prediabetic elderly. Our study was performed using a questionnaire covering diabetes-related behavior for prediabetic elderly 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: $n = u_{\alpha/2}^2 P(1-P)/d^2$, where u was 1.96 when α is 0.05, P is the prevalence of prediabetes (which is 20% in this study), and d is the admissible error which was 4% here. The theory sample was 423 which includes an extra 10% to allow for subjects lost during the study. Using a multistage cluster randomized sampling method, we selected a representative sample of the rural prediabetic population aged 60 years and over 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 2 counties (Yuanjiang and Nanxian) were selected. In the second stage, 4 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 households with elderly individuals in each selected villages who had lived in the area for 3 years or longer were eligible to participate prediabetes screening. Those with severe physical and mental illness were excluded from the screening. Individuals who had diabetes were also excluded from the screening. In brief, the 2144 elderly took part in the oral glucose tolerance tests (OGTT) and 461 elderly individuals had prediabetes. For many reasons, 27 prediabetic elderly were not investigated or refused to take part in subsequent study. Finally, 434 prediabetes with complete data were included in our study. The design and procedure have been described in detail in a previous study.[12]

Data Collection and measurements

Prediabetes screening

Participants diagnosed as prediabetes by using oral glucose tolerance tests (OGTT). Participants screening were instructed to maintain their usual physical activity and diet for a minimum of three days before the OGTT. The diagnostic standards for prediabetes as stated in the 1999 WHO criteria and were categorized into three group[1]: (1) IFG group: Fasting plasma glucose of 6.1-7.0mmol/L (110-126 mg/dl) and a 2-hour post-glucose load of < 7.8 mmol/L (140 mg/dl); (2) IGT group: Fasting plasma glucose of 6.1mmol/L (110 mg/dl) and a 2-hour post-glucose load of 7.8-11.1 mmol/L (140-200 mg/dl); (3) IFG+IGT group.

Socio-demographic information

The collecting of socio-demographic information included age, gender, marital status, education, presence of other diseases, family history of diabetes and history of hyperglycemia. Education was assessed by asking the participants to select their highest level of education completed from the following choices: less than 1 year, from 1 to 6 years and 6 years and above.

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference, and the measuring of blood pressure, BMI, the waist-to-hip ratio (WHR) were described in the previous study.[12] Blood pressure was assessed twice (2 minutes apart) using an electronic blood pressure monitor (A&D Medical, Life Source UA-767PV) after the participant had been seated for at least 5 minutes 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 mmHg and/or diastolic pressure ≧90 mmHg.[13] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[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 = 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≧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 that 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 waist-to-hip ratio (WHR) was calculated by dividing the waist measurement by the hip measurement. And the WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[15]

Diabetes-related behaviors

Diabetes-related behaviors were assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China", which was designed by the Chinese Center of Health Education and had a high reliability and validity with a 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 (e.g., bland diets, high-salt diets, and 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 rest seven questions were in single-topic selection. Sedentary lifestyle (average daily sedentary time ≥ 6 h), insufficient physical activity (engaging in physical activity fewer than 3 times per week), irregular diet, lack of attention paid to diet, high-salt diet, high-fat diet, fewer than one physical examination per year, frequent alcohol consumption (drinking ≥ 3 times/week), and smoking currently were defined as risky behavior, and the rest of the behavior were defined as healthy behavior. Each of the risky behavior was scored "−1", and each of the healthy behavior was scored "+1". Each individual's score of diabetes-related behavior was the sum of the score for all behaviors. The sum of the diabetes-related behavior score was from -8 to 8 in this questionnaire. The higher the sum of the score, the better the diabetes-related behavior were.

Table 1 The outline of the diabetes-related behavior questionnaire

Categories	Behavior (score)	
	Risky behavior(−1)	Healthy behavior(+1)
Average daily sedentary time (h)	≥6	<6
Frequency of physical activities per week	<3	≥3
The 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	Having quitted smoking, or never smoking
Current consumption of alcohol	Frequent alcohol consumption (drinking ≥ 3 times/week)	Occasional alcohol consumption (drinking <3 times/week), or never alcohol consumption

Statistical analysis

In this study, Epidata 3.1 software was used to build the database, and SPSS 20.0 (SPSS Inc., Chicago, IL, U.S.) software 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 ± standard deviation (SD). The chi square testing was used for categorical variables, and the Cochra-Mantel-Haenszel test for ranked variables. Multivariate linear regression was performed to explore factors influencing diabetes-related behavior. The sum of the score for all behavior was selected as the dependent variable. Age (actual value), gender (1=male and 2=female), marital status (1=stable marital status and 2=unstable), education (1=less than 1 years, 2=from 1 to 6 years, and 3=6 years and above), history of hyperglycemia (1=yes and 2=no), family history of diabetes (1=yes and 2=no), other chronic disease status (1=yes and 2=no), BMI (1=lean, 2=normal, 3=overweight, and 4=obese), WHR (1=normal and 2=abnormal) and blood pressure (1=normal and 2=abnormal) were entered as independent variables. All hypothesis tests used two-side tests and a *P*-value less than 0.05 was considered to be statistically significant.

RESULTS

The characteristics of participants

In our study, a total of 2,114 non-diabetic patients aged 60 years old and above were screened. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes participants completed the questionnaire. The effective response rate was 97.8% in this study.

Among the 434 survey respondents, there were 180 men (41.5%) and 254 women (58.5%). Participants had an average (±SD) age of 69.4 (±6.45) years. Among them, 313 patients had stable marriage status (married and living with spouse, accounting for 72.1%); 353 patients (81.3%) had a low education (Education duration <6 years). Only 28 participants (6.5%) had a history of hyperglycemia and 36 patients (8.3%) had a family history of diabetes. 82.3% of the patients had abnormal WHR, and 45.9% of them 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 prediabetics elderly were no significant differences to the non prediabetics (*P*>0.05). (see details in a previously published paper[12]).

The prevalence of diabetes-related behavior among the elderly individuals with prediabetes

Among the 434 survey respondents, the reporting rates of the risky diabetes-related behaviors 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%), less than one physical examination per year (57.6%), smoking currently (22.8%), and frequent alcohol consumption (15.0%) (Table 2).

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

Behavior	n	Prevalence(%)
Average daily sedentary time(h/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
Everyday	108	24.9
The regularity of 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
Having quitted smoking	41	9.4
Never smoking	294	67.7
Frequency of alcohol consumption		
Frequently	65	15.0
Occasionally	37	8.5
Never	332	76.5

Comparisons of risky diabetes-related behavior between different characteristics of the rural prediabetic elderly

There were statistically significant differences in the prevalence of the risky diabetes-related behavior among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China (*P*<0.05, see Table 3 for details). Different education, BMI, WHR, blood pressure, and type of prediabetes all showed no significant differences in elderly individuals with prediabetes in rural China in the risky diabetes-related behavior (*P*>0.05).

Table 3 Comparison of risky diabetes-related behavior 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,%）	Less than one 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	<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	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	0.637	0.681	0.212	0.696	0.021‡	0.778	0.008†)	0.245
History of hyperglycemia								
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	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	2,784	0.107	0.461
P	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	0.047[‡]	0.213	0.957	0.912	0.104	0.022[‡]	0.110	0.036[‡]

†$P < 0.01$.

‡$P < 0.05$.

Risk factors for the diabetes-related behavior among the rural prediabetic elderly

The average score of diabetes-related behavior of the survey respondents was 2.7, with the lowest score of −8 and the highest 8. As the multiple linear regression analysis showed, female was a beneficial factor for diabetes-related behavior among the elderly with prediabetes in the rural areas ($\beta' = 0.253$, $P < 0.001$); and without a history of hyperglycemia was an risk factor for diabetes-related behavior in rural prediabetic elderly($\beta' = -0.114$, $P = 0.016$) (Table 4).

Table 4 Multiple linear regression analysis of diabetes-related behavior

Variables	B	Std. Error	Beta	*t*	*P*	95%*CI* for B
Constant	1.132	1.779	-	0.636	0.525	（-2.364, 4.629）
Gender	1.392	0.257	0.253	5.415	0.000	（0.887, 1.897）
History of hyperglycemia	-0.600	0.247	-0.114	-2.425	0.016	（-1.086,-0.144）

CI: Confidence Interval.

DISCUSSION

Elderly individuals with prediabetes in rural China had a high prevalence of risky diabetes-related behaviors and low score for diabetes-related behaviors

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

The prevalences of risky diabetes-related behaviors of "not paying attention to diet control" and "consuming high-salt/fat/sugar diets" of the elderly with prediabetes in the rural area were relatively high at 51.4% and 41.0%, respectively. Mounting evidence indicates that diet is an important factor in the development of diabetes. Some studies of individual food items and large cohort have showed that a decreased relative risk of diabetes is associated with higher intake of whole grains, as reported by food frequency screeners.[18-20] Cooper et al. found that fiber consumption (in fruit, vegetables, and whole grains) has been shown to be protective against prediabetes and diabetes.[21-22] Sugar intake has been directly related to increased risk for T2DM.[23] Excess fat has been shown to be a significant contributor to the development of obesity and insulin resistance.[24] In this way, the dietary modification is a crucial aspect for preventing and managing pre-existing type 2 diabetes. So it is necessary for individuals with prediabetes who paid no attention to diet and used to 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 the survey of urban residents by Wei et al.[17] Sedentary behavior, defined by low-energy expenditure in a sitting or reclining position during waking hours,[25] have emerged as an additional concern regarding physical activity and health.[26-27] Epidemiological evidence indicates that excessive time spent in sedentary behavior (too much sitting) is associated with an increased risk of type 2 diabetes. Habitual lack of physical activity appears to have a detrimental impact on glucose tolerance[8]. Several large prospective studies such as the Women Health Study, the Nurses' Health Study, and the Health Professionals Follow-up Study have shown that, in both men and women, regular moderate exercise (such as walking) reduces the risk for T2DM by as much as 34%.[10] Regular participation in moderate vigorous physical activity remains a cornerstone in the prevention and management of T2DM.[28] One study showed that improved glucose (standing and walking) and insulin (walking only) responses were maintained into the next day.[29] Another study also showed reductions in postprandial insulin and C-peptide levels but not glucose to be associated with ambulatory breaks (5 min every hour) in adults with impaired glucose tolerance.[30] So sitting less, moving more, and more often may be a practical strategy for improving T2DM prevention and management.[31]

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

Studies have shown that both passive and active smoking are associated with T2DM.[33] Willi et al. conducted a review showing that there was to be a direct correlation between smoking and risk of diabetes.[34] First, smoke exposure results in insulin resistance through oxidative stress;[35] second, study has shown that childhood passive smoke exposure is associated with increased adiposity;[36] third, tobacco ingredients are likely to have toxic effects on the pancreas;[37] fourth, smoking may activate inflammation leading to diabetes; and finally, smoking contributes to dyslipidemia because smokers have higher level of free fatty acids, triglycerides, LDL cholesterol and lower level of HDL-cholesterol, which are usually associated with diabetes.[38] These support the conclusion abstaining from smoking will benefit individuals with prediabetes and diabetes, and it is necessary to encourage them to quit smoking in future work of preventing diabetes.

Risky diabetes-related behavior distribution in different populations

The prevalences of risky diabetes-related behaviors were different among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China. The prevalence of sedentary lifestyle of prediabetic elderly aged 60 years and above was higher than that of young people, which was consistent with other studies.[16,39-40] Matthews et al. reported that adults older than 60 years spent approximately 80% of their awake time in sedentary activities which represented 8 to 12 hours per day.[39] Similarly, Hallal et al. conducted a global assessment in more than 60 countries and found that the elderly had the highest prevalence of reporting a minimum of 4 hours of sitting time daily.[40] The elderly aged 60 years and above have higher prevalence of sedentary lifestyle than young people, which might mainly due to the aging of the body. The prevalences of current smoking and consumption of alcohol in male prediabtic elderly were higher than female, which may be the different lifestyle between male and female. This was similar with other studies.[41-42] Bu et al. reported that men were more likely to drink alcohol and smoke cigarettes but less likely to be under diet control comparing with women in middle-aged Chinese.[41] Alicia et al. found that risky alcohol consumption was a risk factor for prediabetes in men.[42]

The prevalence of high-salt/fat/sugar diet in prediabetic elderly with the stable marital status was higher than who without the stable marital status. There may be two reasons. On one hand, persons with unstable marital status are at low income. On the other hand, Yang et al. found that unstable marital status had bad effect on diet among the elderly in rural China.[43] The prevalence of high-salt/fat/sugar diet in prediabetic elderly without a history of hyperglycemia was higher than that with a history of hyperglycemia. As we reported before, the hyperglycemia influenced diabetes health literacy.[12] People with a history of hyperglycemia are concerned about developing diabetes and actively keep healthy behaviors on preventing diabetes.

The prevalences of sedentary lifestyle and insufficient physical activities in prediabetic elderly with family history of diabetes were high, which indicated that family history was associated with developing of diabetes. Bianco et al. showed that there were correlations between type 2 diabetes family history and body weight, fat mass and alterations in basal glycemia values.[44] Aravindalochanan et al. found that increased sitting duration for ≧180min/day were associated with elevated random capillary blood glucose, and there was a threefold higher risk for diabetes among these subjects with positive family history of diabetes.[45] Healthy diet and active lifestyle may significantly decrease the risk of T2DM in spite of having a family history of diabetes.[46]

The prevalence of less than one physical examination per year in people with other chronic diseases was higher than that of without other chronic diseases, which was not surprising. Yin et al. found that the elderly in rural China were not actively seeking health services because of poor economic conditions, high price of health services, and bad quality medical services.[47] These findings suggest that there are some differences in different populations, which should be taken into account when implementing specific recommendations to prevent or delay the onset of diabetes in the rural prediabetic elderly population. Specific strategies to reduce modifiable risk factors for the prevention and control of diabetes may be warranted.

Gender and hyperglycemia are the influencing factors of diabetes-related behaviors in

elderly individuals with prediabetes in rural areas

The results showed that female was a favorable factor for diabetes-related behavior among the elderly with prediabetes in the rural areas. This is consistent with others. Being male is a risk factor for diabetes in the Chinese population younger than 50 years.[48] In addition, many studies have shown that men have lower diabetes health literacy than women.[49-51] 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 as a key health determinant because of its link to behavioral choices and service usage.[52] There is a relationship between health literacy and risky lifestyle behaviors.[53-54] Men are more likely to engage in risky lifestyle behaviors because of their limited health literacy. A study showed that male college students were more inclined to maintain an independent social image and paid less attention to the impact of their current behavior on their future health status.[55] Men are also more likely to neglect potential health problems and to underestimate the necessity of seeking medical advice and services. For example, women are more likely to provide care to sick family members than men and thus have more contacts with the healthcare environment.[56-58] Therefore, as the consequence, these social psychological characteristics increase males' risk for diabetes.

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

Our study is the first study to explore the diabetes-related behavior and its influencing factors among the prediabetic elderly in rural China, which provides valuable information and scientific recommendations for diabetes prevention tailored specially for rural prediabtic elderly in rural communities. This study was conducted in Hunan, which was a typical south central province and was with a medium level of gross domestic product (GDP) in China. Elderly in rural communities of Hunan possess representative characteristics of rural elderly in rural China and in some other developing countries. Considering the large population, low health literacy and low income of rural prediabetic elderly in China and in some other developing countries[3,6,12], timely and effective interventions should be carried out to prevent diabetes. So this study may provide information and evidence for prevention strategies for this population in rural communities.

The present work has two limitations in this study. First, we cannot infer causations from its cross-sectional design. Second, because of the self-reported design, introduced bias cannot be excluded, so further studies are needed to confirm these findings.

CONCLUSIONS

The current study has revealed that the high prevalence of risky diabetes-related behaviors among elderly with prediabetes in rural China. Being male and not having a history of hyperglycemia were risk factors for the score of diabetes-related behavior among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes among the elderly in rural China, the low health literacy, low income, and the high prevalence of behavior associated with increased risk of diabetes, future studies should evaluate diabetes prevention strategies tailored specially for this population.

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Author Contributions Huilan Xu had the original idea for the study and Lulu Qin carried out the design. Zhao Hu, Fan Gao, Qiuhong Zhou and Shuang Song collected the data and information as investigator. Lulu Qin, Jianglin Zhang and Bangan Luo completed the statistical analyses and drafted the manuscript. Lulu Qin, Bangan Luo and Jianglin Zhang checked and revised the manuscript. All authors read and approved the final manuscript.

Confilct of Interest The authors declare no conflict of interest.

Ethics approval The study was approved by the Medical Ethics Committee of Central South University (Changsha, China; Identification Code: CTXY-150002-7; 27 Feburary, 2015) and the IRB of the Chinese Clinical Trial Registry (NO. ChiCTR-IOR-15007033).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1.Department of Noncommunicable Disease Surveillance.Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation. Part 1. Diagnosis and classification of diabetes mellitus. Geneva: World Health Organization,1999. http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf (accessed 26 Feb 2010).

2. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007; 370, 1929-1938.

3. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; 27, 1047 – 1053.

4. Edwards C, Cusi K. Prediabetes: A Worldwide Epidemic. *Endocrinol Metab Clin North Am*. 2016, 45, 751-764.

5. Tian H, Song G, Xie H, et al. Prevalence of diabetes and impaired fasting glucose among 769,792 rural Chinese adults. *Diabetes Res Clin Pract* 2009; 84, 273-278.

6. Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. *N Engl J Med* 2010, 362, 1090–1101.

7. Ludwig D, Pereira M, Kroenke C, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. *JAMA* 1999; 282, 1539–46.

8. Bassuk S, Manson J. Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology* 2005; 99,

1193–204.

9.Schulze M, Manson J, Ludwig D, et al.Sugarsweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *JAMA* 2004; 292, 927-34.

10. Albright A, Franz M, Hornsby G, et al. American College of Sports Medicine position stand. Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000; 32, 1345–60.

11. Chinese diabetes society. Chinese guidelines for the prevention and treatment of type 2 diabetes mellitus (2013 Edition). *Chin J Endocrinol Metab* 2014; 6, 447- 498.

12. Qin L, Xu H. A cross-sectiona study of the effect of health literacy on diabetes prevention and control among elderly individuals with prediabetes in rural China. *BMJ Open* 2016; 6, e011077.

13. Writing group of 2010 Chinese guidelines for the management of hypertension. 2010 Chinese guidelines for management of hypertension.*Chinese Journal of Hypertension* 2011; 18, 701-743.[in Chinese]

14. Health industry standard of the people's Republic of China.WS/T 428-2013

15. Obesity in Asia Collaboration. Is central obesity a better discriminator of the risk of hypertension than body mass index in ethnically diverse populations? *J Hypertens.* 2008; 26, 169-177.

16. Li L, Li Y, Nie X, et al. An analysis of health literacy about diabetes prevention and control and its influencing factors among the residents in six provinces in China. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 561-565.

17. Wei W, Li F, Li Y, et al. The study of diabetes-related behavior status and affecting factors amongurban and suburban residents in six province in China[J]. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 571-575.

18. Liu S, Serdula M, Janket S, et al. A prospective study of fruit and vegetable intake and the

risk of type 2 diabetes in women. *Diabetes Care* 2004; 27, 2993-6.

19. Fung T, Hu F, Pereira M, et al. Whole-grain intake and the risk of type 2 diabetes: a prospective study in men. *Am J Clin Nutr* 2002; 76, 535-40.

20. Montonen J, Knekt P, Jvinen R, et al. Whole-grain and fiber intake and the incidence of type 2 diabetes. *Am J Clin Nutr* 2003; 77, 622-9.

21. Cooper A, Sharp S, Lentjes M, et al. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes Care* 2012;35, 1293-300.

22. Cooper A, Forouhi N, Ye Z, et al. Fruit and vegetable intake and type 2 diabetes: EPIC-InterAct prospective study and meta-analysis. *Eur J Clin Nutr* 2012; 66, 1082-92.

23. Spruijt-Metz D, O'Reilly G, Cook L, et al. Behavioral Contributions to the Pathogenesis of Type 2 Diabetes. *Curr Diab Rep* 2014; 14, 475.

24. Cao, Y, Chang S, Dong J, et al. Emodin ameliorates high-fat-diet induced insulin resistance in rats by reducing lipid accumulation in skeletal muscle. *Eur J Pharmacol* 2016; 780, 194-201.

25. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". *Appl Physiol NutrMetab* 2012; 37, 540- 2.

26. Matthews C, Chen K, Freedson P, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol* 2008; 167, 875–81.

27. Owen N, Healy G, Matthews C, et al. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010; 38, 105-13.

28. Colberg S, Albright A, Blissmer B, et al. Exercise and type 2 diabetes: American College of SportsMedicine and the American Diabetes Association: joint position statement. *Med Sci Sports Exerc* 2010; 42, 2282–303.

29. Henson J, Davies M, Bodicoat D, et al. Breaking up prolonged sitting with standing or

walking attenuates the postprandial metabolic response in postmenopausal women: a randomized acute study. *Diabetes Care* 2016; 39, 130–8.

30. Holmstrup M, Fairchild T, Keslacy S, et al. Multiple short bouts of exercise over 12-h period reduce glucose excursions more than an energy-matched single bout of exercise. *Metabolism* 2014; 63, 510–9.

31. Dempsey P, Owen N, Yates Y, et al. Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management[J]. *Curr Diab Rep* 2016; 16, 114.

32. Gregg E, Cadwell B, Cheng Y, et al.Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabetes Care* 2004; 27, 2806-12.

33. KowallB B, Rathmann W, Strassburger K, et al. Association of passive and active smoking with incident type 2 diabetes mellitus in the elderly population: the KORA S4/F4 cohort study. *Eur J Epidemiol* 2010; 25, 393-402.

34. Willi C, Bodenmann P, Ghali W, et al. Active smoking and the risk of type 2 diabetes. A systematic review and meta-analysis. *JAMA* 2007; 298, 2654–64.

35. Neema A, Shelley R. Starck, Cristina F, et al. CA Health Threat to Bystanders Living in the Homes of Smokers: How Smoke Toxins Deposited on Surfaces Can Cause Insulin Resistance

PLoS One 2016; 11(3): e0149510.

36. Davis CL, Tingen MS, Jia J, et al. Passive Smoke Exposure and Its Effects on Cognition, Sleep, and Health Outcomes in Overweight and Obese Children. *Child Obes* 2016; 12(2):119-25.

37. Chowdhury P, MacLeod S, Udupa K, et al. Pathophysiological effects of nicotine on the pancreas: an update. *Exp Biol Med* 2002, 227, 445–54.

38. Berlin I. Smoking-induced metabolic disorders: a review. *Diabetes Metab* 2008, 34, 307–14.

39. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behavior in

the United States, 2003–2004. *Am J Epidemiol* 2008; 167: 875-881.

40. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247-257.

41. Bu S, Ruan D, Yang Z, et al. Sex-Specific Prevalence of Diabetes and Cardiovascular Risk Factors in the Middle-Aged Population of China: A Subgroup Analysis of the 2007-2008 China National Diabetes and Metabolic Disorders Study. *PLoS One* 2015;10(9):e0139039.

42. Díaz-Redondo A, Giráldez-García C, Carrillo L, et al. Modifiable risk factors associated with prediabetes in men and women: a cross-sectional analysis of the cohort study in primary health care on the evolution of patients with prediabetes (PREDAPS-Study).*BMC Fam Pract* 2015;16:5.

43. Yang Y, Xu H, Tang G, et al. The characteristics and influencing factors of dietary behavior of left-behind elderly in rural areas of Chongqing in China. *Chinese Journal of Gerontology* 2017; 37(5):1242-1244. [in Chinese]

44. Bianco A, Pomara F, Thomas E, et al. Type 2 diabetes family histories, body composition and fasting glucose levels: a cross-section analysis in healthy sedentary male and female.

Iran J Public Health 2013;42(7):681-90.

45. Aravindalochanan V, Kumpatla S, Rengarajan M, et al. Risk of diabetes in subjects with sedentary profession and the synergistic effect of positivefamily history of diabetes.

Diabetes Technol Ther 2014;16(1):26-32.

46. Midhet FM, Al-Mohaimeed AA, Sharaf FK. Lifestyle related risk factors of type 2 diabetes mellitus in Saudi Arabia. *Saudi Med J* 2010;31(7):768-74.

47. Yin Z, Chen L, Tu H, et al. Survey on the demand and satisfaction of community health services for the elderly in Zhejiangin China. *Chinese Journal of Gerontology* 2013; 33(4): 899-900.[in Chinese]

48. Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA: the journal of the American Medical Association* 2013; 310, 948–59.

49. Barber M, Staples M Osborne R, et al. Up to a quarter of the Australian population may have suboptimal health literacy depending upon the measurement tool: results from a population-based survey. *Health Promot Int* 2009; 24, 252–61.

50. Von-Wagner C, Steptoe A, Wolf M, et al. Health literacy and health actions: a review and a framework from health psychology. *Health Educ Behav* 2009; 36, 860-77.

51. Sudore R, Mehta K, Simonsick E, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770-6.

52. Australian Commission on Safety and Quality in Health Care. Health literacy: taking action to improve safety and quality. Sydney: ACSQHC; 2014.

53. Aihara Y, Mina J. Barriers and catalysts of nutrition literacy among elderly Japanese people. *Health Promot Int* 2011; 26, 421-31.

54. Suka M, Odajima T, Okamoto M, et al. Relationship between health literacy, health information access,health behavior, and health status in Japanese people. *Patient Educ Couns* 2015; 98, 660-8.

55. Davies J, McCrae B, Frank J, et al. Identifying male college students' perceived health needs, barriers to seeking help, and recommendations to help men adopt healthier lifestyles. *Journal of American college health* 2000, 48, 259–67.

56. Thompson R, Lewis S, Murphy M, et al. Are there sex differences in emotional and biological responses in spousal caregivers of patients with Alzheimer's disease? *Biol Res Nurs* 2004; 5, 319–330.

57. Covinsky K, Eng C, Lui L, et al. Reduced employment in caregivers of frail elders: Impact of ethnicity, patient clinical characteristics, and caregiver haracteristics. *J Gerontol A Biol Sci Med Sci* 2001; 56, M707-13.

58. Williams-Wallace S, Dilworth-Anderson P, Goodwin P. Caregiver role strain: The contribution of multiple roles and available resources in African-American women. *Aging Ment Health* 2003; 7, 103–112.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	5-9

Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	5-6, 8-9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8-9
		(*e*) Describe any sensitivity analyses	No.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6,9
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	Not here. It was described in the previous article.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	5-6,9
Outcome data	15*	Report numbers of outcome events or summary measures	9-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-9,11-13

		(*b*) Report category boundaries when continuous variables were categorized	8-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No relevant.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	No.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Diabetes-related behaviors among the elderly with prediabetes in rural communities of Hunan, China: a cross-sectional study

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Diabetes-related behaviors among the elderly with prediabetes in rural communities of Hunan, China: a cross-sectional study

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Keywords: prediabetes; diabetes-related behaviors; the elderly; rural areas

Word accounts: 4,092; Tables: 4

ABSTRACT:

Objectives: To explore the diabetes-related behaviors and its influencing factors among the elderly individuals with prediabetes in rural areas of China.

Design, setting and participates: A cross-sectional survey was conducted among the elderly (≧60 years) in rural communities in Yiyang City of China. Multi-staged cluster random sampling was carried out to select 42 areas, and interviews were conducted among 434 elderly individuals with prediabetes (fasting plasma glucose of 6.1-7.0mmol/L and/or a 2-hour post-glucose load of 7.8-11.1 mmol/L) , using questionnaires on diabetes-related behaviors. The diabetes-related behaviors 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 examination per year; current smoking status; and current consumption of alcohol. Each of the risky behaviors was scored "−1", and each of the healthy behaviors was scored "+1". Each individual's score of the diabetes-related behaviors was the sum of the score for all behaviors.

Main outcome measures: Participants were asked about general informations (age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases, body mass index (BMI), the waist-to-hip ratio (WHR) and education) and their diabetes-related behaviors. The multivariate linear regression analysis was performed to identify the risk factors of the diabetes-related behavior among the elderly individuals with prediabetes.

Results: The average score of diabetes-related behaviors of the elderly with prediabetes in the rural China was 2.7. The prevalences of risky diabetes-related behaviors were as follows: less than one 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 the history of hyperglycemia were found to be the influencing factors of diabetes-related behavior score.

Conclusions: The prevalences of risky diabetes-related behaviors were high among the prediabetic elderly in rural China. More efforts should be made to promote the prevention and control of diabetes in rural China, in addition, future studies should be evaluated on diabetes prevention strategies tailored specially for this population.

Trial registration number: CTXY-150002-7; ChiCTR-IOR-15007033.

Strengths and limitations of this study

This is the first study to examine the diabetes-related behaviors and its influencing factors among the elderly prediabetic population in rural China.

Assessing the diabetes-related behaviors in rural China 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 and self-reported design.

INTRODUCTION

Prediabetes is defined by blood glucose levels between normal and diabetic, which were categorized 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 prediabetes 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 prediabetes has risen rapidly. The prevalence of diabetes and prediabetes in China is estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[6] Prediabetes poses several threats; there is an increased risk for T2DM and other diseases, including microvascular and macrovascular disease.

A large number of studies have shown that lifestyle behavior of prediabetes patients plays an important role in the incidence and development of diabetes and other diseases. These behaviors can be collectively referred to risky diabetes-related ones, such as sedentary lifestyle, overeating, and insufficient physical activity. Some studies have shown that healthy versions of these behaviors can delay or prevent the incidence and development of diabetes. For example, Ludwig et al. found that high-fiber diets may have the effect of protecting against obesity and cardiovascular disease by lowering insulin levels in the 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 do sedentary persons.[8] Other studies have suggested that unhealthy behaviors of patients with prediabetes speed up the progress of their diseases, including diabetes, microvascular and macrovascular diseases. The results of a large prospective cohort study conducted in US showed that there is an obvious association between higher consumption of sugar-sweetened beverages and an increased risk for developing T2DM in women.[9] And Albright et al. reported that regular physical activity is a necessary condition for keeping glucose-lowering effects and improving insulin sensitivity.[10]

Chinese Guidelines for T2DM Prevention and Treatment (2013 Edition) shows that both the old age (≥ 60 years) and prediabetes are important risk factors for diabetes.[11] Prediabetes patients who are at age of 60 years and above have extremely 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 the higher incidence of prediabetes than the urban areas.[6] Considering the large population and the aging 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 behaviors of the elderly with prediabetes in rural China, and no epidemiological information is available on diabetes-related behaviors among the rural prediabetic elderly. Our study was performed, using a questionnaire covering diabetes-related behaviors for the prediabetic elderly 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: $n= u_{\alpha/2}^2 P(1-P)/d^2$, where u was 1.96 when α is 0.05, P is the prevalence of prediabetes (which is 20% in this study), and d is the admissible error which was 4% here. The theory sample was 423 which includes an extra 10% to allow for subjects lost during the study. By using a multistage cluster randomized sampling method, we selected a representative sample of the rural prediabetic population aged 60 years and over 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 2 counties (Yuanjiang and Nanxian) were selected. In the second stage, 4 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.

Every elderly individual who had lived in these selected villages for 3 years or longer were allowed to take part in the prediabetes sreening. Meanwhile, the elderly who were diabetes patients or with severe mental or physical diseases were excluded from the prediabetes screening. In brief, a total of 2,144 elders participated in the screening and 461 were found to be prediabetes.

There were 27 prediabetic elders who were not investigated or refused to take part in subsequent study for various reasons. In consequence, a number of 434 prediabetic elderly with complete data were included in this study. The design and procedure have been described in detail in a previous study.[12]

Data Collection and measurements

Prediabetes screening

Participants were diagnosed as prediabetes by using oral glucose tolerance tests (OGTT). Participants screening were instructed to maintain their usual physical activity and diet for a minimum of three days before the OGTT. The diagnostic standards for prediabetes as stated in the 1999 WHO criteria were categorized into three group[1]: (1) IFG group: Fasting plasma glucose of 6.1-7.0mmol/L (110-126 mg/dl) and a 2-hour post-glucose load of < 7.8 mmol/L (140 mg/dl); (2) IGT group: Fasting plasma glucose of 6.1mmol/L (110 mg/dl) and a 2-hour post-glucose load of 7.8-11.1 mmol/L (140-200 mg/dl); (3) IFG+IGT group.

Socio-demographic information

The collecting of socio-demographic information included age, gender, marital status, education, presence of other diseases, family history of diabetes and history of hyperglycemia. Education was assessed by asking the participants to select their highest level of education from the following choices: less than 1 year, 1—6 years and 6 years and above.

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference, and the measuring of blood pressure, BMI, the waist-to-hip ratio (WHR) were described in the previous study.[12] Blood pressure was assessed twice (2 minutes apart) with an electronic blood pressure monitor (A&D Medical, Life Source UA-767PV) after the participant had been seated for at least 5 minutes 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 mmHg and/or diastolic pressure ≧90 mmHg.[13] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[13] Both hypertension and hypotension are abnormal blood pressure. Height was measured to the nearest 0.1 cm by 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 = 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≧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 waist-to-hip ratio (WHR) was calculated by dividing the waist measurement by the hip measurement. And the WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[15]

Diabetes-related behaviors

Diabetes-related behaviors were assessed by using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China (QHLDP)", which was designed by the Chinese Center of Health Education and had a high reliability and validity with a 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 (e.g., bland diets, high-salt diets, and 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 rest seven questions were in single-topic selection. Sedentary lifestyle (average daily sedentary time ≥ 6 h), insufficient physical activity (engaging in physical activity fewer than 3 times per week), irregular diet, lack of attention paid to diet, high-salt diet, high-fat diet, fewer than one physical examination per year, frequent alcohol consumption (drinking ≥ 3 times/week), and smoking currently were defined as risky behaviors, and the rest of the behaviors were defined as healthy behaviors. Each of the risky behaviors was scored "−1", and each of the healthy behaviors was scored "+1". Each individual's score of the diabetes-related behaviors was the sum of the score for all the behaviors. The sum of the diabetes-related behaviors score was from -8 to 8 in this questionnaire. The higher the sum of the score was, the better the diabetes-related behaviors were.

Table 1 The outline of the diabetes-related behavior questionnaire

Categories	Behavior (score)	
	Risky behavior(−1)	Healthy behavior(+1)
Average daily sedentary time (h)	≥6	<6
Frequency of physical activities per week	<3	≥3
The 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	Having quitted smoking, or never smoking
Current consumption of alcohol	Frequent alcohol consumption (drinking ≥ 3 times/week)	Occasional alcohol consumption (drinking <3 times/week), or never alcohol consumption

Statistical analysis

In this study, Epidata 3.1 software was used to build the database, and SPSS 20.0 (SPSS Inc., Chicago, IL, U.S.) software 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 ± standard deviation (SD). The chi square testing was used for categorical variables, and the Cochra-Mantel-Haenszel test for ranked variables. Multivariate linear regression was performed to explore factors influencing diabetes-related behaviors. The sum of the score for all behaviors was selected as the dep endent variable. Age (actual value), gender (1=male and 2=female), marital status (1=stable marital status and 2=unstable), education (1=less than 1 years, 2=from 1 to 6 years, and 3=6 years and above), history of hyperglycemia (1=yes and 2=no), family history of diabetes (1=yes and 2=no), other chronic disease status (1=yes and 2=no), BMI (1=lean, 2=normal, 3=overweight, and 4=obese), WHR (1=normal and 2=abnormal) and blood pressure (1=normal and 2=abnormal) were entered as independent variables. All hypothesis tests used two-side tests and a *P*-value less than 0.05 was considered to be statistically significant.

RESULTS

The characteristics of participants

In our study, a total of 2,114 non-diabetic patients aged 60 years old and above were screened. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes participants had completed the questionnaire. The effective response rate was 97.8% in this study.

Among the 434 survey respondents, there were 180 men (41.5%) and 254 women (58.5%). Participants had an average (±SD) age of 69.4 (±6.45) . Among them, 313 patients had stable marriage status (married and living with spouse, accounting for 72.1%); 353 patients (81.3%) had a low education (Education duration <6 years). Only 28 participants (6.5%) had a history of hyperglycemia and 36 patients (8.3%) had a family history of diabetes. 82.3% of the patients had abnormal WHR, and 45.9% of them 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 prediabetic elderly were no significant differences to the non prediabetics (*P*>0.05). (see details in a previously published paper[12]).

The prevalence of diabetes-related behaviors among the elderly individuals with prediabetes

Among the 434 survey respondents, the reporting rates of the risky diabetes-related behaviors 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%), less than one physical examination per year (57.6%), smoking currently (22.8%), and frequent alcohol consumption (15.0%) (Table 2).

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

Behavior	n	Prevalence(%)
Average daily sedentary time(h/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
Everyday	108	24.9
The regularity of 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
Having quitted smoking	41	9.4
Never smoking	294	67.7
Frequency of alcohol consumption		
Frequently	65	15.0
Occasionally	37	8.5
Never	332	76.5

Comparisons of risky diabetes-related behaviors between different characteristics of the rural prediabetic elderly

There were statistically significant differences in the prevalences of the risky diabetes-related behaviors among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China (P<0.05, see Table 3 for details). There were no significant differences in the prevalences of the risky diabetes-related behaviors among different education, BMI, WHR, blood pressure, and type of prediabetes in the elderly individuals with prediabetes in rural China (P>0.05).

Table 3 Comparison of risky diabetes-related behavior 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,%）	Less than one 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	<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	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	0.637	0.681	0.212	0.696	0.021‡	0.778	0.008†）	0.245
History of hyperglycemia								
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	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	2,784	0.107	0.461
P	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	0.047‡	0.213	0.957	0.912	0.104	0.022‡	0.110	0.036‡

†$P<0.01$.

‡$P<0.05$.

Risk factors for the diabetes-related behaviors among the rural prediabetic elderly

The average score of diabetes-related behaviors of the survey respondents was 2.7, with the lowest score of −8 and the highest 8. As the multiple linear regression analysis showed, being female was a beneficial factor for diabetes-related behaviors among the elderly with prediabetes in the rural areas ($\beta' = 0.253$, $P < 0.001$); and no history of hyperglycemia was a risk factor for diabetes-related behaviors in rural prediabetic elderly($\beta' = -0.114$, $P = 0.016$) (Table 4).

Table 4 Multiple linear regression analysis of diabetes-related behavior

Variables	B	Std. Error	Beta	*t*	*P*	95%*CI* for B
Constant	1.132	1.779	-	0.636	0.525	（-2.364, 4.629）
Gender	1.392	0.257	0.253	5.415	0.000	（0.887, 1.897）
History of hyperglycemia	-0.600	0.247	-0.114	-2.425	0.016	（-1.086,-0.144）

CI: Confidence Interval.

DISCUSSION

Elderly individuals with prediabetes in rural China had a high prevalence of risky diabetes-related behaviors and low score for diabetes-related behaviors

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

The prevalences of risky diabetes-related behaviors of "not paying attention to diet control" and "consuming high-salt/fat/sugar diets" of the elderly with prediabetes 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 high diet of green leafy or dark yellow vegetables with a reduced risk of T2DM among overweight females.[18] Large cohort studies have showed that there is an inverse relationship between whole grains intake in diets and the risk of T2DM.[19-20] Cooper et al. found that a diet characterized by high intake of vegetables and fruit may be beneficial for the prevention of prediabetes and diabetes.[21-22] It has been proved that sugar intake is associated with an increased risk of diabetes..[23] Too much fat has been proved to be an important contributor in the development of obesity, insulin resistance and diabetes.[24] In this way, the dietary modification is a crucial aspect for the prevention and management of pre-existing type 2 diabetes. So it is necessary for individuals with prediabetes who paid no attention to diet and used to having 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 the survey of urban residents by Wei et al.[17] Sedentary behavior, defined by low-energy expenditure in a sitting or reclining position during waking hours,[25] have emerged as an additional concern regarding physical activity and health.[26-27] There were evidences showed that spending excessive time in sedentary behaviours is related with 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 (such as moderate exercise) may significantly reduce the risk for T2DM..[10] Habitual taking part 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] And another study reported that short and frequent periods of exercise have the effect of attenuating the 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 T2DM prevention and management.[31]

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

There have been evidences showing that both passive and active smoking are associated with T2DM.[33] Willi et al. conducted a meta-analysis revealing 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 skeletal;[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 active body inflammation leading to diabetes; and finally, tobacco use leads to impaired glucose tolerance, T2DM and abdominal-type obesity via directly and indirectly metabolic risk factors.[38] These evidences supporting the conclusion abstained from smoking will benefit individuals with prediabetes and diabetes, and it is necessary to encourage them to quit smoking in the future work of preventing diabetes.

Risky diabetes-related behaviors distribution in different populations

The prevalences of risky diabetes-related behaviors were different among different ages, genders, marital statuses, history of hyperglycemia, other chronic diseases situation, and family history of diabetes in the elderly individuals with prediabetes in rural China. The prevalence of sedentary lifestyle of the prediabetic elderly aged 60 and above was higher than that of young people, which was consistent with other studies.[16,39-40] Matthews et al. reported that older adults (ages 60-85 years) in the US spent approximately 60% of their time in sedentary behaviors.[39] Hallal et al. conducted a worldwide assessment in 66 countries where citizens have either high or low income, and found that the elderly aged 60 years and above had the highest prevalence of spending 4 hours or more sitting time daily.[40] The elderly aged 60 and above have higher prevalence of sedentary lifestyle than young people, which might mainly due to the aging of the body. The prevalences of current smoking and consumption of alcohol in the male prediabtic elderly were higher than that of female, which may due to the different lifestyle between male and female. This was similar with other studies.[41-42] Bu et al. reported that men were more likely to drink alcohol and smoke cigarettes but less likely to be under diet control comparing with women in middle-aged Chinese.[41] Alicia et al. found that risky alcohol consumption was a risk factor for prediabetes in men.[42]

The prevalence of high-salt/fat/sugar diet in the prediabetic elderly with the stable marital status was higher than those without the stable marital status. There may be two reasons. On one hand, persons with unstable marital status are at low income. On the other hand, Yang et al. found that unstable marital status had bad effect on diet among the elderly in rural China.[43] The prevalence of high-salt/fat/sugar diet in the prediabetic elderly without a history of hyperglycemia was higher than those with a history of hyperglycemia. As we reported before, the hyperglycemia influenced diabetes health literacy.[12] People with a history of hyperglycemia are concerned about developing diabetes and actively keep healthy behaviors on preventing diabetes.

The prevalences of sedentary lifestyle and insufficient physical activities in the prediabetic elderly with family history of diabetes were high, which indicated that family history was associated with the developing of diabetes. Bianco et al. showed that there were correlations between type 2 diabetes family history and body weight, fat mass and alterations in basal glycemia values.[44] Aravindalochanan et al. found that increased sitting duration for≧180min/day were associated with elevated random capillary blood glucose, and there was a threefold higher risk for diabetes among these subjects with positive family history of diabetes.[45] Healthy diet and active lifestyle may significantly decrease the risk of T2DM in spite of having a family history of diabetes.[46]

It was not surprising that the prevalence of less than one physical examination per year in people with other chronic diseases was higher than those without other chronic diseases. Yin et al. found that the elderly in rural China were not actively seeking health services because of poor economic conditions, high price of health services, and bad quality medical services.[47] 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 prediabetic elderly population. Specific strategies to reduce modifiable risk factors for the prevention and control of diabetes may be warranted.

Gender and hyperglycemia are the influencing factors for diabetes-related behaviors in the elderly individuals with prediabetes in rural areas

The results showed that female was a favorable factor for diabetes-related behaviors among the elderly with prediabetes in the rural areas. This is consistent with others. Being male is a risk factor for diabetes in the Chinese population younger than 50 years.[48] In addition, many studies have shown that men have lower diabetes health literacy than women.[49-51] 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 as a key health determinant because of its link to behavioral choices and service usage.[52] There is a relationship between health literacy and risky lifestyle behaviors.[53-54] Men are more likely to engage in risky lifestyle behaviors because of their limited health literacy. Davies et al. found that collage men's most important issues were alcohol and substance abuse.[55] And their substantial barriers to seeking services were the men's socialization and less attention to the association between long-term health risks and current behaviors.[55] However, women have more chance to contact with the healthcare environment since they are more likely to care for sick family members.[56-58] Therefore, these social psychological characteristics increase males' risk for diabetes.

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

Our study is the first study to explore the diabetes-related behaviors and its influencing factors among the prediabetic elderly in rural China, which provides valuable information and scientific recommendations for diabetes prevention tailored specially for the rural prediabtic elderly. This study is conducted in Hunan where the elderly possess representative characteristics of the elderly in rural communities. And our sample is a random sample, which were derived from the rural communities. So the results have better representations and extrapolation, and it can be extended to other populations. Considering the large population, low health literacy and low income of the rural prediabetic elderly 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 some other areas for diabetes prevention among predibetic elderly.

The present work has three limitations in this study. First, we cannot infer causations from its cross-sectional design. Second, introduced bias cannot be excluded because of the self-reported design, in a consequence, further studies are needed to confirm these findings. Third, there is no comparison between the Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China (QHLDP) and other tools assessing diabetes-related behaviors. And it is difficult to compare the behaviors properties of the Chinese version of QHLDP used in populations outside China, for the reason that the QHLDP is designed and used only in China and the behaviors evaluating is particularly sample dependent. Thus, future studies may benefit from the application of the English version of the QHLDP with other scales in same populations.

CONCLUSIONS

The current study has revealed that the high prevalence of risky diabetes-related behaviors among the elderly with prediabetes in rural China. Being male and not having a history of hyperglycemia were risk factors for the score of diabetes-related behaviors among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes among the elderly in rural China, and the low health literacy, low income, and the high prevalence of behavior associated with increased risk of diabetes, future studies should be evaluated on diabetes prevention strategies tailored specially for this population.

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Author Contributions Huilan Xu had the original idea for the study and Lulu Qin carried out the design. Zhao Hu, Fan Gao, Qiuhong Zhou and Shuang Song collected the data and information as investigator. Lulu Qin, Jianglin Zhang and Bangan Luo completed the statistical analyses and drafted the manuscript. Lulu Qin, Bangan Luo and Jianglin Zhang checked and revised the manuscript. All authors read and approved the final manuscript.

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REFERENCES

1.Department of Noncommunicable Disease Surveillance.Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation. Part 1. Diagnosis and classification of diabetes mellitus. Geneva: World Health Organization,1999. http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf (accessed 26 Feb 2010).

2. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007; 370, 1929-1938.

3. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; 27, 1047 – 1053.

4. Edwards C, Cusi K. Prediabetes: A Worldwide Epidemic. *Endocrinol Metab Clin North Am*.

2016, 45, 751-764.

5. Tian H, Song G, Xie H, et al. Prevalence of diabetes and impaired fasting glucose among 769,792 rural Chinese adults. *Diabetes Res Clin Pract* 2009; 84, 273-278.

6. Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. *N Engl J Med* 2010, 362, 1090–1101.

7. Ludwig D, Pereira M, Kroenke C, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. *JAMA* 1999; 282, 1539–46.

8. Bassuk S, Manson J. Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology* 2005; 99, 1193–204.

9.Schulze M, Manson J, Ludwig D, et al.Sugarsweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *JAMA* 2004; 292, 927-34.

10. Albright A, Franz M, Hornsby G, et al. American College of Sports Medicine position stand. Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000; 32, 1345–60.

11. Chinese diabetes society. Chinese guidelines for the prevention and treatment of type 2 diabetes mellitus (2013 Edition). *Chin J Endocrinol Metab* 2014; 6, 447- 498.

12. Qin L, Xu H. A cross-sectiona study of the effect of health literacy on diabetes prevention and control among elderly individuals with prediabetes in rural China. *BMJ Open* 2016; 6, e011077.

13. Writing group of 2010 Chinese guidelines for the management of hypertension. 2010 Chinese guidelines for management of hypertension.*Chinese Journal of Hypertension* 2011; 18, 701-743.[in Chinese]

14. Health industry standard of the people's Republic of China.WS/T 428-2013

15. Obesity in Asia Collaboration. Is central obesity a better discriminator of the risk of

hypertension than body mass index in ethnically diverse populations? *J Hypertens.* 2008; 26, 169-177.

16. Li L, Li Y, Nie X, et al. An analysis of health literacy about diabetes prevention and control and its influencing factors among the residents in six provinces in China. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 561-565.

17. Wei W, Li F, Li Y, et al. The study of diabetes-related behavior status and affecting factors amongurban and suburban residents in six province in China[J]. *Zhonghua Yu Fang Yi Xue Za Zhi* 2014; 48, 571-575.

18. Liu S, Serdula M, Janket S, et al. A prospective study of fruit and vegetable intake and the risk of type 2 diabetes in women. *Diabetes Care* 2004; 27, 2993-6.

19. Fung T, Hu F, Pereira M, et al. Whole-grain intake and the risk of type 2 diabetes: a prospective study in men. *Am J Clin Nutr* 2002; 76, 535-40.

20. Montonen J, Knekt P, Jvinen R, et al. Whole-grain and fiber intake and the incidence of type 2 diabetes. *Am J Clin Nutr* 2003; 77, 622-9.

21. Cooper A, Sharp S, Lentjes M, et al. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes Care* 2012;35, 1293-300.

22. Cooper A, Forouhi N, Ye Z, et al. Fruit and vegetable intake and type 2 diabetes: EPIC-InterAct prospective study and meta-analysis. *Eur J Clin Nutr* 2012; 66, 1082-92.

23. Spruijt-Metz D, O'Reilly G, Cook L, et al. Behavioral Contributions to the Pathogenesis of Type 2 Diabetes. *Curr Diab Rep* 2014; 14, 475.

24. Cao Y, Chang S, Dong J, et al. Emodin ameliorates high-fat-diet induced insulin resistance in rats by reducing lipid accumulation in skeletal muscle. *Eur J Pharmacol* 2016; 780, 194-201.

25. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms

"sedentary" and "sedentary behaviours". *Appl Physiol NutrMetab* 2012; 37, 540- 2.

26. Matthews C, Chen K, Freedson P, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol* 2008; 167, 875–81.

27. Owen N, Healy G, Matthews C, et al. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010; 38, 105-13.

28. Colberg S, Albright A, Blissmer B, et al. Exercise and type 2 diabetes: American College of SportsMedicine and the American Diabetes Association: joint position statement. *Med Sci Sports Exerc* 2010; 42, 2282–303.

29. Henson J, Davies M, Bodicoat D, et al. Breaking up prolonged sitting with standing or walking attenuates the postprandial metabolic response in postmenopausal women: a randomized acute study. *Diabetes Care* 2016; 39, 130–8.

30. Holmstrup M, Fairchild T, Keslacy S, et al. Multiple short bouts of exercise over 12-h period reduce glucose excursions more than an energy-matched single bout of exercise. *Metabolism* 2014; 63, 510–9.

31. Dempsey P, Owen N, Yates Y, et al. Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management[J]. *Curr Diab Rep* 2016; 16, 114.

32. Gregg E, Cadwell B, Cheng Y, et al.Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabetes Care* 2004; 27, 2806-12.

33. Kowall B, Rathmann W, Strassburger K, et al. Association of passive and active smoking with incident type 2 diabetes mellitus in the elderly population: the KORA S4/F4 cohort study. *Eur J Epidemiol* 2010; 25, 393-402.

34. Willi C, Bodenmann P, Ghali W, et al. Active smoking and the risk of type 2 diabetes. A systematic review and meta-analysis. *JAMA* 2007; 298, 2654–64.

35. Neema A, Shelley R. Starck, Cristina F, et al. A Health Threat to Bystanders Living in the

Homes of Smokers: How Smoke Toxins Deposited on Surfaces Can Cause Insulin Resistance *PLoS One* 2016; 11(3): e0149510.

36. Davis CL, Tingen MS, Jia J, et al. Passive Smoke Exposure and Its Effects on Cognition, Sleep, and Health Outcomes in Overweight and Obese Children. *Child Obes* 2016; 12(2):119-25.

37. Chowdhury P, MacLeod S, Udupa K, et al. Pathophysiological effects of nicotine on the pancreas: an update. *Exp Biol Med* 2002, 227, 445–54.

38. Berlin I. Smoking-induced metabolic disorders: a review. *Diabetes Metab* 2008, 34, 307–14.

39. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behavior in the United States, 2003 – 2004. *Am J Epidemiol* 2008; 167: 875-881.

40. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247-257.

41. Bu S, Ruan D, Yang Z, et al. Sex-Specific Prevalence of Diabetes and Cardiovascular Risk Factors in the Middle-Aged Population of China: A Subgroup Analysis of the 2007-2008 China National Diabetes and Metabolic Disorders Study. *PLoS One* 2015;10(9):e0139039.

42. Díaz-Redondo A, Giráldez-García C, Carrillo L, et al. Modifiable risk factors associated with prediabetes in men and women: a cross-sectional analysis of the cohort study in primary health care on the evolution of patients with prediabetes (PREDAPS-Study).*BMC Fam Pract* 2015;16:5.

43. Yang Y, Xu H, Tang G, et al. The characteristics and influencing factors of dietary behavior of left-behind elderly in rural areas of Chongqing in China. *Chinese Journal of Gerontology* 2017; 37(5):1242-1244. [in Chinese]

44. Bianco A, Pomara F, Thomas E, et al. Type 2 diabetes family histories, body composition and fasting glucose levels: a cross-section analysis in healthy sedentary male and female.

Iran J Public Health 2013;42(7):681-90.

45. Aravindalochanan V, Kumpatla S, Rengarajan M, et al. Risk of diabetes in subjects with sedentary profession and the synergistic effect of positivefamily history of diabetes. *Diabetes Technol Ther* 2014;16(1):26-32.

46. Midhet FM, Al-Mohaimeed AA, Sharaf FK. Lifestyle related risk factors of type 2 diabetes mellitus in Saudi Arabia. *Saudi Med J* 2010;31(7):768-74.

47. Yin Z, Chen L, Tu H, et al. Survey on the demand and satisfaction of community health services for the elderly in Zhejiangin China. *Chinese Journal of Gerontology* 2013; 33(4): 899-900.[in Chinese]

48. Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA: the journal of the American Medical Association* 2013; 310, 948–59.

49. Barber M, Staples M Osborne R, et al. Up to a quarter of the Australian population may have suboptimal health literacy depending upon the measurement tool: results from a population-based survey. *Health Promot Int* 2009; 24, 252–61.

50. Von-Wagner C, Steptoe A, Wolf M, et al. Health literacy and health actions: a review and a framework from health psychology. *Health Educ Behav* 2009; 36, 860-77.

51. Sudore R, Mehta K, Simonsick E, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770-6.

52. Australian Commission on Safety and Quality in Health Care. Health literacy: taking action to improve safety and quality. Sydney: ACSQHC; 2014.

53. Aihara Y, Mina J. Barriers and catalysts of nutrition literacy among elderly Japanese people. *Health Promot Int* 2011; 26, 421-31.

54. Suka M, Odajima T, Okamoto M, et al. Relationship between health literacy, health information access,health behavior, and health status in Japanese people. *Patient Educ Couns*

2015; 98, 660-8.

55. Davies J, McCrae B, Frank J, et al. Identifying male college students' perceived health needs, barriers to seeking help, and recommendations to help men adopt healthier lifestyles. *Journal of American college health* 2000, 48, 259–67.

56. Thompson R, Lewis S, Murphy M, et al. Are there sex differences in emotional and biological responses in spousal caregivers of patients with Alzheimer's disease? *Biol Res Nurs* 2004; 5, 319–330.

57. Covinsky K, Eng C, Lui L, et al. Reduced employment in caregivers of frail elders: Impact of ethnicity, patient clinical characteristics, and caregiver haracteristics. *J Gerontol A Biol Sci Med Sci* 2001; 56, M707-13.

58. Williams-Wallace S, Dilworth-Anderson P, Goodwin P. Caregiver role strain: The contribution of multiple roles and available resources in African-American women. *Aging Ment Health* 2003; 7, 103–112.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	5-9

Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	5-6, 8-9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8-9
		(*e*) Describe any sensitivity analyses	No.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6,9
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	Not here. It was described in the previous article.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	5-6,9
Outcome data	15*	Report numbers of outcome events or summary measures	9-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-9,11-13

		(*b*) Report category boundaries when continuous variables were categorized	8-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No relevant.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	No funding.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.