BMJ Open

Health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011077
Article Type:	Research
Date Submitted by the Author:	08-Jan-2016
Complete List of Authors:	qin, lu; School of Public Health, Central South University, Department of Social Medicine and Health Management xu, huilan; School of Public Health, Central South University, Department of Social Medicine and Health Management
Primary Subject Heading:	Public health
Secondary Subject Heading:	Diabetes and endocrinology
Keywords:	Health literacy, prediabetes, elderly, rural areas

Health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Lulu Qin[1], Huilan Xu[1]

[1] Department of Social Medicine and Health Management, School of Public Health, Central South University, Changsha, Hunan 410078, China;

Correspondence author: Huilan Xu, E-Mail: huilanxu1963@sina.com

Tel./Fax: +86-0731-8484-5454.

Key words: Health literacy; prediabetes; elderly; rural areas;

Word accounts: 3512; Tables: 3

Abstract

Objectives: This study was designed to examine the health literacy on diabetes prevention and control and its risk factors among the elderly with prediabetes in rural areas in China.

Design, setting and participates: A cross-sectional survey was conducted among the elderly in rural communities in Yiyang City of China. 42 areas were selected by multi-staged cluster random sampling and 432 rural elders with prediabetes were investigated via face-to-face interviews by the "questionnaire of health literacy of diabetes of the public in China."

Main outcome measures: Participants were asked general information(age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education). The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes.

Results: The median score of health literacy on diabetes prevention and prediabetes control was 10.0 (interquartile range=7.0-13.0). The level of health literacy on diabetes prevention and control among men was lower than that among women (OR=2.831, 95% CI: 1.818-4.408). Relative to those with less than a primary school education, the level of health literacy on diabetes prevention and control of respondents with a primary school education was higher (OR=2.685, 95% CI: 5.927-34.375), and that of respondents with middle school or higher education was the highest (OR=3.439, 95% CI: 11.661-83.204). The level of health literacy on diabetes prevention and control among the prediabetic elderly with a history of hyperglycemia was higher than that of those without a history of hyperglycemia (OR=0.984, 95% CI: 1.101-6.504).

Conclusions: The health literacy on diabetes prevention and control of elderly individuals with prediabetes was very low in rural China. Thus, suitable and feasible health education for elderly individuals with low education levels should be incorporated into diabetes-prevention efforts.

Strengths and limitations of this study

This is the first study to examine health literacy regarding diabetes prevention and control among the elderly prediabetic population in rural China or other countries.

The study provides valuable information on the diabetes prevention and control among the elderly prediabetic population in rural communities.

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

Introduction

Diabetes mellitus is a threat to public health worldwide[1,2] as the global prevalence rates of diabetes and prediabetes are rapidly increasing. During the past 30 years, the prevalence rates of diabetes and prediabetes in China have also increased because Chinese people have changed their lifestyles following rapid economic development.[3] The prevalence rates of diabetes and prediabetes in China were estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[4] Prediabetes is an intermediate state of hyperglycemia characterized by glycemic parameters above normal levels but below the diabetic threshold and is also called "borderline diabetes." There are three types of prediabetes: impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and IFG combined with IGT. Prediabetes is strongly associated with an increased risk of developing type 2 diabetes (T2DM), stroke and cardiovascular diseases.[5]

The occurrence rates of diabetes and prediabetes increase with age, especially in the elderly (defined here as adults aged 60 years and above). The elderly contribute approximately 52% to diabetes-attributable mortality worldwide.[6] In North America and the Caribbean, the elderly accounted for 63% of diabetic patients[6] and 86% of all annual diabetes-related deaths in 2007.[7] In China, more than 20% of the elderly population suffers from prediabetes, in both urban and rural areas.[4] As noted, nearly 150 million Chinese residents have prediabetes. If even one third of these patients transition to T2DM over the next 6 years, we will face a potential increase in T2DM prevalence. Therefore, prediabetes will cause a huge burden of diabetes on the public health system because without timely and effective intervention or treatment, prediabetes is very likely to progress to diabetes within ten years.[8]

Health literacy is defined as 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 has been theorized to be an important non-clinical factor that may decrease the risk of adverse outcomes.[9,10] The diabetes health literacy is associated with diabetes-related knowledge, and adequate health literacy is highly correlated with a better understanding of health education.[11] Health literacy is a predictor of the utilization of preventive healthcare. As reported

previously, health literacy mediates the relationship between education and glycemic control in low-income diabetic patients.[12] Moreover, health literacy is associated with disease-related knowledge, a requisite level of which is necessary for effective behavior change.[13,14] People with a high level of health literacy are more likely to engage in health-promoting behaviors and therefore have better health outcomes.[15]

However, low-level health literacy is common. Approximately 55% of diabetic patients in the US have inadequate literacy,[16] and Korean immigrants with low-level health literacy are at a greater risk of T2DM.[17] People with low-level health literacy usually have less disease-specific knowledge, lower quality of life, and poorer health-related outcomes. Patients with low health literacy may also have trouble reading prescriptions, following medical instructions, and interacting with the health care system.[18,19,20] Based on the link between diseases and health literacy, health literacy has become an important part of the rapidly developing public health sector worldwide.[21]

In China, few studies have investigated diabetes health literacy among rural residents, and no statistical information is available on the health literacy regarding prediabetes prevention and control for the rural elderly. Through a community-based study, we investigated the health literacy relevant to diabetes prevention and control among rural elderly individuals in China. We aim to understand the factors associated with the health literacy relevant to diabetes prevention and control and provide scientific recommendations for diabetes prevention in the future.

Materials and Methods

Study population and procedures

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.

The participants diagnosed as prediabetic via oral glucose-tolerance tests (OGTTs) were enrolled in the study. The diagnostic standard for prediabetes was applied according to the 2013 Diabetes Prevention and Cure Guidelines of China [22]. In this study, individuals with a history of diabetes or who met the diagnosis standards for diabetes were excluded from this study. The elderly resident population (who had achieved registered permanent residence or not achieved registered permanent residence but had resided in the area for 3 years or longer) who met the diagnostic standards for prediabetes were eligible to participate. Those with severe physical or mental illness were excluded from the study. Thus, a total of 42 rural villages and 432 prediabetic individuals were included in our study.

The participants who were diagnosed as prediabetic via OGTTs were enrolled in the study. Prediabetes was diagnosed according to the 1999 World Health Organization diagnostic criteria.[22] People with a history of diabetes or meeting the diagnostic standards for diabetes were excluded from this study. The elderly residents (with registered permanent residence or without registered permanent residence but with ≥ 3 years of residence) who met the diagnostic standards for prediabetes were eligible to participate. People with severe physical or mental illness were excluded. Finally, a total of 42 rural villages and 434 prediabetic patients were included.

Data collection and measurements

Prediabetes screening

The participants were instructed to maintain their usual physical activity and diet for at least 3 days before the OGTT. After at least 10 hours of overnight fasting, venous blood was collected from each participant in a vacuum tube containing sodium fluoride and used to measure plasma glucose. The blood samples were stored at -80 °C for subsequent analysis of blood glucose (mmol/L). Each participant was given

a standard 75-g glucose solution, and then, blood was sampled at 0 and 120 min after consuming the glucose load to measure glucose levels. The plasma glucose level was measured using a hexokinase enzymatic method, and serum cholesterol and triglyceride levels were assessed enzymatically with commercially available reagents in the clinical biochemical laboratory of the primary care center in each village. Fasting plasma glucose was analyzed enzymatically using an Olympus AU640 autoanalyzer (Olympus, Kobe, Japan). All the laboratories had successfully completed a standardization and certification program. Prediabetes was diagnosed according to the 1999 WHO criteria as follows[22]: (1) an IFG group with fasting plasma glucose 6.1-7.0 mmol/L (110-126 mg/dL) and 2-hour post-glucose load <7.8 mmol/L (140 mg/dL); (2) an IGT group with 2-hour post-glucose load 7.8-11.1 mmol/L (140-200 mg/dL) and fasting plasma glucose ≤6.1 mmol/L (110 mg/dL); and (3) an IFG+IGT group.

Socio-demographic information

In this study, the socio-demographic information included age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education. Education was assessed by asking the participants to select their highest level of education completed from among the following choices: below primary school, primary school and middle school or above.

Health literacy regarding diabetes prevention and control

Health literacy regarding diabetes prevention and control was assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China" designed by the Chinese Center for Health Education. The questionnaire included diabetes-related knowledge, diabetes-related behavior, and the acquisition and utilization of diabetes information. This questionnaire has a high reliability and validity with a Cronbach's alpha of 0.866. In the knowledge section, participants were given a score of 1 for a right answer and 0 for a wrong answer. In the "behavior and information acquisition and utilization" section, participants who completed the section were given a score of 2, and all others were given a score of 0. The scores of

the questionnaire range from 0 to 54, and a person with a score of >43.2 is defined as having diabetes-related health literacy.[23]

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference. 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.[24] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[24] 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.[25]

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. WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[26]

Statistical analysis

The data were analyzed using SPSS V20.0 (SPSS/IBM, Armonk, NY, USA). Data are presented as the percentage, mean±standard deviation, median and interquartile range. Non-parametric tests were used because the distribution of the

health literacy scores regarding diabetes prevention and control was non-Gaussian. The Kruskal-Wallis test was used to explore differences in the health literacy on diabetes prevention and control levels among prediabetic individuals with different characteristics. In these analyses, the two-tailed significance threshold was $P<0.05$.

The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes. In the binary logistic regression analysis, the health literacy scores for diabetes prevention and control were selected as the dependent variables and classified into group 1 (score>10.0) and group 2 (score≤10.0). Gender (1=men and 2=women), age (1=age from 60 to 69 years, 2=age 70 to 79 years, and 3=age≥80 years), education (1=below primary school, 2=primary school, and 3=middle school and above), marital status (1=stable marital status and 2=unstable marital status), 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. Step-wise logistic regression was conducted to analyze the risk factors of health literacy on diabetes using significance levels of 0.05 for entry and 0.10 for removal from the model.

Result

The characteristic of the study population

A total of 42 countries were selected and 2144 subjects took part in the study. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes completed the questionnaire. Descriptive characteristics of the elderly with prediabetes are given in Table 1.

The average age of of the prediabetes was (69.4±6.45) years old. Men comprised 41.5% of participants. Most of the elderly with prediabetes were in stable marital status(72.1%,n=313). Most of them were with lower education level, below primary school(62.7%,n=272) and primary school(18.7%, n=81). Few of them had a history of hyperglycemia(6.5%, n=28) and a family history of diabetes(8.3%, n=36). 40.6% of

the prediabetic elderly were with other chronic diseases. 29.7% of the elderly with prediabetes were overweight (n=129) and 12.7% of them were obesity(n=55). Most of the prediabetic elderly with abnormal WHR(82.3%, n=357), and nearly half of them with abnormal blood pressure(45.9%, n=199). The prevalence of IGT(43.8%, N=190) was higher than IFG(42.9%, n=186) and IFG+IGT(13.4%, n=58).

Table 1 The characteristic of the study population

	N	Mean (SD) or %
Age	434	69.4±6.45
Gender		
Men	180	41.5
Women	254	58.5
Marital Status		
Stable	313	72.1
Unstable	121	27.9
Education		
Below primary school	81	18.7
Primary school	272	62.7
Middle school or above	81	18.7
History of hyperglycemia		
Yes	28	6.5
No	406	93.5
Family history of diabetes		
Yes	36	8.3
No	398	91.7
Having other chronic disease		
Yes	176	40.6
No	258	59.4
BMI		
Lean	17	3.9
Normal	233	53.7
Overweight	129	29.7
Obesity	55	12.7
WHR		
Normal	77	17.7
Abnormal	357	82.3
Blood pressure		
Normal	235	54.1
Abnormal	199	45.9
Types		
IFG	186	42.9
IGT	190	43.8

IFG+IGT	58	13.4

The scores of the health literacy about diabetes prevention and control of prediabetes

The score of the health literacy about diabetes prevention and control f prediabetes is shown in Table 2. The median score was 10.0(interquartile range=7.0-13.0). Only one person had the diabetes-related health literacy.

The median score of health literacy about diabetes prevention and control of prediabetes of men and women were 9.0 and 11.0, respectively($p<0.05$). The median score of the health literacy about diabetes prevention and control of prediabetes with stable marital status and who with unstable marital status were9.0 and 11.0, respectively ($p<0.05$). The median score of the health literacy about diabetes prevention and control of prediabetes with below primary school, primary school and middle were 8.0, 11.0 and 12.0, respectively($p<0.05$). The median score of the health literacy about diabetes prevention and control of prediabetes with the history of hyperglycemia and those who without history of hyperglycemia and who were 12.5 and 9.0, respectively($p<0.05$).

Table 2 The scores of the health literacy about diabetes prevention and control of prediabetes

	Mean (standard deviation)	Median (interquartile range)	*P*
Overall	11.0±6.33	10.0(7.0-13.0)	
Gender			0.000
Men	10.3±7.17	9.0(7.0-12.0)	
Women	11.5±5.63	11.0(8.0-13.0)	
Marital Status			0.044
Stable	11.4±6.51	10.0(7.0-13.0)	
Unstable	10.1±5.78	9.0(7.0-11.0)	
Education			0.000
Below primary school	7.7±2.55	8.0(6.5-9.0)	
Primary school	11.3±6.35	11.0(7.0-13.0)	
Middle school or above	13.2±7.57	12.0(9.0-16.0)	
History of hyperglycemia			0.001
Yes	15.1±8.11	12.5(9.3-20.5)	
No	10.7±6.10	9.0(7.0-12.0)	
Family history of diabetes			0.165
Yes	12.5±7.54	12.0(7.0-13.8)	
No	10.9±6.20	10.0(7.0-12.0)	

Having other chronic disease			0.544
Yes	11.5±7.08	10.0(7.0-13.0)	
No	10.7±5.76	10.0(7.0-13.0)	
BMI			0.547
Lower	9.9±5.33	9.0(5.5-13.5)	
Normal	10.7±5.95	9.0(7.0-13.0)	
Overweight	11.9±7.52	10.0(7.0-12.0)	
Obesity	10.5±4.87	10.0(7.0-13.0)	
WHR			0.074
Normal	10.4±6.72	9.0(7.0-12.0)	
Abnormal	11.2±6.25	10.0(7.0-13.0)	
Blood pressure			0.978
Normal	10.9±5.76	10.0(7.0-13.0)	
Abnormal	11.2±6.96	10.0(7.0-13.0)	
Types			0.451
IFG	11.4±6.49	10.0(7.0-13.0)	
IGT	10.6±6.09	9.0(7.0-12.3)	
IFG+IGT	11.2±6.65	10.0(7.0-12.0)	

Risk factors for the scores of the health literacy about diabetes prevention and control of prediabetes

The results of the binary logistic regression analysis of risk factors of the health literacy about diabetes prevention and control of prediabetes was shown in Table 3. The health literacy about diabetes prevention and control among men was lower than women (OR=2.831, 95%CI: 1.818-4.408). Taking the below primary school education level as reference, the health literacy level about diabetes prevention and control of respondents with primary school was higher (OR=2.685, 95%CI: 5.927-34.375), and that of middle school and above was the highest (OR:3.439, 95%CI: 11.661-83.204). The health literacy about diabetes prevention and control among the prediabetic elderly with having a history of hyperglycemia was higher than those who without (OR=0.984, 95%CI:1.101-6.504).

Table 3 The results of the binary logistic regression analysis of risk factors of the health literacy about diabetes prevention and control of prediabetes

	B	wals	p	OR	OR95%CI
Gender					
Men				1.000	
Women	1.041	21.225	0.000	2.831	(1.818,4.408)
Education Degree					
Below primary school				1.000	
Primary school	2.658	35.148	0.000	14.274	(5.927,34.375)
Middle school or above	3.439	47.055	0.000	31.148	(11.661,83.204)
History of hyperglycemia					
No				1.000	
Yes	0.984	4.722	0.030	2.676	(1.101,6.504)

Discussion

The prevalence of prediabetes among the elderly was high in rural areas

In this study, the prevalence rate of prediabetes among rural elderly is 21.5%, which is similar to a previous study[27] and indicates a high occurrence of prediabetes. As reported previously, the prevalence of prediabetes is rapidly increasing annually in China, especially in rural areas.[4,27] These results together with the large population living in poor rural areas suggest the existence of a very serious public health problem in rural China. Because diabetes can be prevented or delayed in prediabetic individuals through feasible and timely interventions, the rising prevalence of prediabetes and diabetes in rural China has highlighted a need for better prevention.

Health literacy regarding diabetes prevention and control among elderly prediabetics in rural areas was very low

We used a health literacy questionnaire specific to diabetes prevention and control to measure the level of health literacy of elderly with prediabetes, unlike some relevant studies, which adopted general health literacy measures, such as STOFHLA or REALM, which are not disease/condition-specific. This questionnaire was able to effectively examine the level of health literacy on diabetes prevention and control among prediabetics.[23] Yamashita T et al. showed a direct association between diabetes-specific health literacy and patients' assessments of their self-care practice

acumen and that the measurement of health literacy should include indicators of diseases-specific knowledge and/or understanding.[28] Thus, it is better to use health literacy specific to diabetes prevention and control to assess the health literacy level regarding diabetes prevention and control among elderly prediabetics. Health literacy specific to diabetes prevention and control is crucial to diabetes management and prevention. Thus, the questionnaire adopted here accurately reflected health literacy regarding diabetes prevention and control among elderly prediabetics.

The median score of the assessment of health literacy on prediabetes prevention and control was 10.0 (interquartile range=7.0-13.0); the lowest score was 1.0, and the highest score was 44.0. Only one person exhibited diabetes-related health literacy. This suggested that health literacy regarding prediabetes prevention and control among elderly individuals with prediabetes in rural areas is very limited. Our result is similar to those of previous studies. For instance, a survey administered to non-diabetic residents in six Chinese provinces showed a low level of diabetes health literacy[23]. Moreover, inadequate health literacy is associated with age, and health literacy is commonly limited among people aged 65 years or older.[17, 29] Thus, rural elderly prediabetic patients have a high risk of developing diabetes and should be the primary target group for diabetes prevention. Low-level health literacy is associated with healthcare processes and key health outcomes. Diabetes health literacy is related to diabetes knowledge, self-efficacy, self-care behaviors, and glycemic control.

The health literacy relevant to diabetes prevention and control of elderly with prediabetes in rural areas was low, and therefore, it is important to improve their health literacy on diabetes prevention and control because of the link between diabetes and health literacy. Thus, it is very urgent to improve the health literacy relevant to diabetes mellitus among the elderly in rural China.

Risk factors associated with health literacy regarding diabetes prevention and control among elderly prediabetics in rural areas

Understanding the risks and protective factors associated with health literacy about diabetes prevention and control is necessary for implementing preventive measures. In our study, the influencing factors included several socio-demographic

indices and a history of hyperglycemia. Binary logistic regression revealed that being a woman, having a high level of education and having a history of hyperglycemia are protective factors associated with health literacy regarding diabetes prevention and control among elderly individuals with prediabetes. These findings are consistent with those of previous studies,[17,29] although a history of hyperglycemia is mentioned here for the first time in the literature relevant to health literacy regarding diabetes.

Men have a lower level of health literacy regarding diabetes prevention and control than women, as reported in other countries.[30,31,32] Health literacy is identified as a key health determinant because of its link to behavioral choices and service usage.[33] The relationship between health literacy and risky lifestyle behaviors (e.g., tobacco smoking and risky alcohol consumption) has been confirmed.[34] In many countries, men are more likely to engage in risky lifestyle behaviors, have lower health knowledge and pay less attention to preventative healthcare than women.

Education is an important factor with regard to health literacy. Some studies have found an association between education and health literacy components (e.g., nutrition literacy, knowledge, and personal skills).[34,35,36] The level of evidence supporting a correlation between education and health literacy was rated as moderate; people with a high level of education had better health outcomes because of the mediating effect of health literacy.[29]

This is the first time that the relationship between a history of hyperglycemia and diabetes-related health literacy has been analyzed, and we found that hyperglycemia was an influencing factor on health literacy about diabetes prevention and control. People with a history of hyperglycemia had a higher level of diabetes health literacy , likely because they are concerned about developing diabetes and actively seek to learn diabetes-related knowledge and behaviors. These results suggest that people with a high level of health literacy may have better glycemic control, as indicated by previous studies.[12, 37] As reported, low-level health literacy is associated with nearly twofold lower odds of good glycemic control than high-level health literacy among diabetic patients (adjusted odds ratio: 2.03; 95% CI: 111.-3.73).[38]

Health literacy also mediates the relationship between education and glycemic control among low-income diabetic patients,[12, 39] and the effects of education on

glycemic control act through many mechanisms. People with low health literacy may face challenges in writing and communicating, and therefore, they are likely less prepared for and poorly supported in successful diabetes care, which involves interactive communication and participatory decision-making. Thus, elderly prediabetic patients in poor rural areas have low health literacy relevant to diabetes, low education levels and insufficient health education, and as a result, they may not seek effective or suitable resources. Because health literacy includes diabetes-specific knowledge, self-efficacy, self-care behaviors and glycemic control, strategies to improve health literacy are urgently needed.While the study is limited by its cross-sectional design, therefore causation cannot be inferred. Moreover we cannot reject the bias for the self-reported design,thus further studies are needed to confirm the findings.

Conclusions

Our study revealed that health literacy relevant to diabetes prevention and control among the prediabetic elderly population in poor rural areas in China was at a very low level. Being a man, having a low level of education and not having a history of hyperglycemia were risk factors associated with health literacy regarding diabetes prevention and control among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes in rural China and the low educational attainment, low income and old age of this population, future studies should evaluate suitable and feasible measures to improve diabetes-related health literacy among these residents.

Acknowledgements Thanks for Fan Gao,Yang Yang, Fangfan Jiang, Ting Zhang and Zhao Hu took part in this study as investigator.

Contributors Huilan Xu and Lulu Qin had the original idea for the study and carried out the design.

Competing interests None declared.

Ethics approval: The study was approved by 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.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.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.

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

5.Tabak AG, Herder C, Rathmann W, et al. Prediabetes: a high-risk state for diabetes development. *Lancet* 2012, 379, 2279-2290.

6.Diabetes Prevention Program Research Group, Knowler WC, Fowler SE, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009; 374, 1677-86.

7. International Diabetes Federation. IDF Diabetes Atlas. 6th ed. Brussels, Belgium: International Diabetes Federation, 2013. (www.idf.org/diabetesatlas).

8.American Diabetes Association. Economic costs of diabetes in the U.S.in 2007. *Diabetes Care* 2008; 31, 596–615.

9.Institute of Medicine (US) Committee on Health Literacy, Nielsen-Bohlman L, Panzer AM, et al. Health Literacy: A Prescription to End Confusion. The National Academies Press:Washington, US, 2004, 25-67.

10.Kutner M. United States Department of Education., National Center for Education Statistics. NCES (Series). Washington, DC: United States Department of Education; National Center for Education Statistics; The health literacy of America's adults : results from the 2003 National Assessment of Adult Literacy. (http://nces.ed.gov/pubs2006/2006483.pdf.)

11.Chen GD, Huang CN, Yang YS, et al. Patient perception of understanding health education and instructions has moderating effect on glycemic control.*BMC Public Health* 2014; 14, 683.

12.Schillinger D, Barton LR, Karter AJ, et al. Does Literacy Mediate the Relationship Between Education and Health Outcomes? A Study of a Low-Income Population with

Diabetes. *Public Health Report* 2006; 121, 245-54.

13.Kolb JM, Kitos NR, Ramachandran A, et al. What do primary care prediabetes patients need? A baseline assessment of patients engaging in a technology-enhanced lifestyle intervention. *J Bioinform Diabetes* 2014; 1,4.

14.Rosa MC, Benjamin EM, Peko PS, et al. Opportunities and challenges for diabetes prevention at two community health centers. *Diabetes care* 2008; 31, 247–254.

15.Han HR, Kim J, Kim MT, et al. Measuring health literacy among immigrants with a phonetic primary language: a case of Korean American women. *J Immigr Minor Health* 2011;13,253-259.

16.Williams MV, Baker DW, Parker RM, et al. Relationship of unctional health literacy to patients' knowledge of their chronic disease. A study of patients with hypertension and diabetes. *Arch Intern Med* 1998;158, 166-172.

17.Choi SE, Rush E, Henry S. Health literacy in Korean immigrants at risk for type 2 diabetes. *J Immiqr Minor Health* 2013; 15, 553-339.

18.Health Literacy: report of the Council on Scientific Affairs. Ad Hoc Committee on Health Literacy for the Council on Scientific Affairs, American Medical Association. *JAMA* 1999; 281, 552–557.

19.Rothman RL, DeWalt DA, Malone R, et al. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. *JAMA* 2004; 292, 1711–1716.

20.Rothman R, Malone R, Bryant B, et al. The relationship between literacy and glycemic control in a diabetes disease-management program. *Diabetes Edu* 2004; 30, 263–273.

21.U.S. Department of Health and Human Services.(www.healthypeople.gov.)

22.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. (Accessed February 26, 2010, at http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf.)

23.L 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, 561-5.(in Chinese)

24.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)

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

26.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.

27.Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults.*JAMA* 2013; 310, 948-959.

28.Yamashita T, Kart CS. Is diabetes-specific health literacy associated with diabetes-related outcomes in older adults?.*J Diabetes* 2011; 3, 138-46.

29.Davey J, Holden CA, Smith BJ.The correlates of chronic disease-related health literacy and its components among men: a systematic review.*BMC Public Health* 2015; 15, 589.

30.Barber MN, Staples M, 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.

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

32.Sudore RL, Mehta KM, Simonsick EM, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770–6.

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

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

35.Lutfiyya MN, Lipsky MS, Bales RW, et al. Disparities in knowledge of heart attack and stroke symptoms among adult men: an analysis of behavioral risk factor

surveillance survey data. *J Natl Med Assoc* 2008; 100, 1116–24.

36.Sohn M, Stotts NA, Benowitz N, et al.Beliefs about health, smoking, and future smoking cessation among South Korean men hospitalized for cardiovascular disease. *Heart Lung* 2007; 36, 339–47.

37.Osborn CY, Bains SS, Egede LE. Health literacy, diabetes self-care, and glycemic control in adults with Type 2 diabetes. *Diabetes Technol Ther* 2010;12, 913–919.

38.Schillinger D, Grumbach K, Piette J, et al. Association of health literacy with diabetes outcomes. *JAMA* 2002; 288, 475–482.

39.Chaturvedi N, Stephenson JM, Fuller JH. The relationship between socioeconomic status and diabetes control and complications in the URODIAB IDDM Complications Study. *Diabetes Care* 1996;19:423-30.

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	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	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	6,7,8
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	6,7,8
Bias	9	Describe any efforts to address potential sources of bias	6,7,8

Study size	10	Explain how the study size was arrived at	5,6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7,8,9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	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
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	No.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9,10,11
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9,10,11,12
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	10,11,12
		(*b*) Report category boundaries when continuous variables were categorized	9

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10.11,12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11,12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14,15
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	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15,16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
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.

BMJ Open

A cross-sectional study on risk factors of health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011077.R1
Article Type:	Research
Date Submitted by the Author:	09-Mar-2016
Complete List of Authors:	qin, lu; School of Public Health, Central South University, Department of Social Medicine and Health Management xu, huilan; School of Public Health, Central South University, Department of Social Medicine and Health Management
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Public health, Diabetes and endocrinology
Keywords:	health literacy, prediabetes, elderly, rural areas

A cross-sectional study on risk factors of health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Lulu Qin[1], Huilan Xu[1]

[1] Department of Social Medicine and Health Management, School of Public Health, Central South University, Changsha, Hunan 410078, China;

Correspondence author: Huilan Xu, E-Mail: huilanxu1963@sina.com

Tel./Fax: +86-0731-8484-5454.

Key words: health literacy; prediabetes; elderly; rural areas;

Word accounts: 4,116; Tables: 3

Abstract

Objectives: This study was designed to examine the health literacy on diabetes prevention and control and its risk factors among the elderly with prediabetes in rural areas in China.

Design, setting and participates: A cross-sectional survey was conducted among the elderly in rural communities in Yiyang City of China. 42 areas were selected by multi-staged cluster random sampling and 434 rural elders with prediabetes were investigated via face-to-face interviews by the "questionnaire of health literacy of diabetes of the public in China."

Main outcome measures: Participants were asked general information(age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education). The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes.

Results: The median score of health literacy on diabetes prevention and prediabetes control was 10.0 (interquartile range=7.0-13.0). The level of health literacy on diabetes prevention and control among men was lower than that among women (OR=2.831, 95% CI: 1.818-4.408). Relative to those with education of 6 years and above, the level of health literacy on diabetes prevention and control of respondents with education years from 1 to 6 was lower (OR=14.274, 95%CI: 5.927-34.375), and that with education of less than 1 year was the lowest (OR=31.148, 95%CI: 11.661-83.204). The level of health literacy on diabetes prevention and control among the prediabetic elderly with not a history of hyperglycemia was lower than that with a history of hyperglycemia (OR=2.676, 95%CI:1.101-6.504).

Conclusions: The health literacy on diabetes prevention and control of elderly individuals with prediabetes was very low in rural China. Thus, suitable and feasible health education for elderly individuals with low education levels should be incorporated into diabetes-prevention efforts.

Strengths and limitations of this study

This is the first study to examine health literacy regarding diabetes prevention and control among the elderly prediabetic population in rural China or other countries.

The study provides valuable information on the diabetes prevention and control among the elderly prediabetic population in rural communities.

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

Introduction

Diabetes mellitus is a threat to public health worldwide[1,2] as the global prevalence rates of diabetes and prediabetes are rapidly increasing. During the past 30 years, the prevalence rates of diabetes and prediabetes in China have also increased because Chinese people have changed their lifestyles following rapid economic development.[3] The prevalence rates of diabetes and prediabetes in China were estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[4] Prediabetes is an intermediate state of hyperglycemia characterized by glycemic parameters above normal levels but below the diabetic threshold and is also called "borderline diabetes." There are three types of prediabetes: impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and IFG combined with IGT. Prediabetes is strongly associated with an increased risk of developing type 2 diabetes (T2DM), stroke and cardiovascular diseases.[5]

The occurrence rates of diabetes and prediabetes increase with age, especially in the elderly (defined here as adults aged 60 years and above). The elderly contribute approximately 52% to diabetes-attributable mortality worldwide.[6] In North America and the Caribbean, the elderly accounted for 63% of diabetic patients[6] and 86% of all annual diabetes-related deaths in 2007.[7] In China, more than 20% of the elderly population suffers from prediabetes, in both urban and rural areas.[4] As noted, nearly 150 million Chinese residents have prediabetes. If even one third of these patients transition to T2DM over the next 6 years, we will face a potential increase in T2DM prevalence. Therefore, prediabetes will cause a huge burden of diabetes on the public health system because without timely and effective intervention or treatment, prediabetes is very likely to progress to diabetes within ten years.[8]

Health literacy is defined as 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 has been theorized to be an important non-clinical factor that may decrease the risk of adverse outcomes.[9,10] The diabetes health literacy is associated with diabetes-related knowledge, and adequate health literacy is highly correlated with a better understanding of health education.[11] Health literacy is a predictor of the utilization of preventive healthcare. As reported previously, health literacy mediates the relationship between education and glycemic

control in low-income diabetic patients.[12] Moreover, health literacy is associated with disease-related knowledge, a requisite level of which is necessary for effective behavior change.[13,14] People with a high level of health literacy are more likely to engage in health-promoting behaviors and therefore have better health outcomes.[15]

However, low-level health literacy is common. Approximately 55% of diabetic patients in the US have inadequate literacy,[16] and Korean immigrants with low-level health literacy are at a greater risk of T2DM.[17] People with low-level health literacy usually have less disease-specific knowledge, lower quality of life, and poorer health-related outcomes. Patients with low health literacy may also have trouble in reading prescriptions, following medical instructions, and interacting with the health care system.[18,19,20] Based on the link between diseases and health literacy, health literacy has become an important part of the rapidly developing public health sector worldwide.[21]

In China, few studies have investigated diabetes health literacy among rural residents, and no epidemiological information is available on the health literacy regarding prediabetes prevention and control for the rural elderly. Through a community-based study, we investigated the health literacy relevant to diabetes prevention and control among the rural elderly individuals in China. Aim: to understand the factors associated with the health literacy relevant to diabetes prevention and control and provide scientific recommendations for diabetes prevention in the future.

Materials and Methods

Sample size calculation

Sample size calculation was done by using the formula for cross-sectional studies: $\alpha=0.05$, $n= u_{\alpha/2}^2 P(1-P)/d^2$. The u was 1.96 when α is 0.05, the P was the prevalence of a prediabetes which is 20% in this study, the 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. After our pre-investigation, there were about 10 prediabetes among the elderly in a village, so a total of 42 villages would to be selected.

Study population and procedures

With 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 and the "cluster" here is the village. In the first stage, sampling was stratified according to geographical characteristic status, and 2 counties (Yuanjiang and Nanxian) out of 6 countries were selected. In the second stage, 2 townships (Yangluozhou, Yinfengqiao) out of 11 townships and 2 townships (Qingshuzui, and Maocaojie) out of 9 townships were randomly selected. In the third stage, 25% of the rural villages were randomly selected from each chosen townships (the number of villages of each township accounts from 30 to 50). In the final stage, all households with elderly individuals of each chosen village were listed.

The participants diagnosed as prediabetic via oral glucose-tolerance tests (OGTTs) were enrolled in the study. The diagnostic standard for prediabetes was applied the 1999 WHO criteria. [22] The elderly resident population (who had achieved registered permanent residence or not achieved registered permanent residence but had resided in the area for 3 years or longer) who met the diagnostic standards for prediabetes were eligible to participate. Those with severe physical or mental illness were excluded from the study. And individuals who were diabetes patient or who met the diagnosis standards for diabetes were defined as diabetes patient and were excluded from this study. Our pre-trained interviewers went to the elderly subject's home to introduce the aim, plan, interest and the right of participant in this study carefully. All the elderly were invited to have a OGTT test and other tests(including blood pressure, height, weight and waist circumference). Then they interviewed participants face to face after each participant's being given written, informed consent. If the participants were illiterate, the written consent would be signed by their family members. The elderly have the right to decline to participate in the study without any disadvantage, and they can drop out if they have the desire at any time during the whole investigation.

There were a total of 3,197 elderly residents in the 42 selected areas(including 3,068 individuals having achieved registered permanent residence and 129 individuals

having living for more than 3 years with out achieved registered permanent), among which 603 had moved away for many reasons and 336 individuals were excluded for several physical or mental illness. And a total of 114 elderly who refused to take the OGTT test were excluded, which accounted for 5.0%(114/2,258). The prediabetes screening sample size was 2,144 people, the response rate of the OGTT test among the elderly was 95.0%(2,144/2,258). There were 21 prediabetes not being investigated for various reasons(Fig. 1). And the response rate of investigation was 95.4%(440/461). Among the remaining 440 individuals, 6 were excluded for incomplete data. In total, 434 elders were brought into statistical analysis and the efficiency was 94.1%(434/461). Thus, a total of 42 rural villages and 434 prediabetic individuals were included in our study.

Data collection and measurements

Prediabetes screening

The participants were instructed to maintain their usual physical activity and diet for at least 3 days before the OGTT. After at least 10 hours of overnight fasting, venous blood was collected from each participant in a vacuum tube containing sodium fluoride and used to measure plasma glucose. The blood samples were stored at -80 °C no more than 1 hour for subsequent analysis of blood glucose (mmol/L). Each participant was given a standard 75-g glucose solution, and then, blood was sampled at 0 and 120 min after consuming the glucose load to measure glucose levels. The plasma glucose level was measured using a hexokinase enzymatic method, and serum cholesterol and triglyceride levels were assessed enzymatically with commercially available reagents in the clinical biochemical laboratory of the primary care center in each village. Fasting plasma glucose was analyzed enzymatically using an Olympus AU640 autoanalyzer (Olympus, Kobe, Japan). All the laboratories had successfully completed a standardization and certification program. Prediabetes was diagnosed according to the 1999 WHO criteria as follows[22]: (1) an IFG group with fasting plasma glucose 6.1-7.0 mmol/L (110-126 mg/dL) and 2-hour post-glucose load <7.8 mmol/L (140 mg/dL); (2) an IGT group with 2-hour post-glucose load 7.8-11.1 mmol/L (140-200 mg/dL) and fasting plasma glucose ≤6.1 mmol/L (110 mg/dL); and

(3) an IFG+IGT group.

Socio-demographic information

In this study, the socio-demographic information included age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education. 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.

Health literacy on diabetes prevention and control

Health literacy on diabetes prevention and control was assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China" designed by the Chinese Center for Health Education. The questionnaire included diabetes-related knowledge, diabetes-related behavior, and the acquisition and utilization of diabetes information. This questionnaire has a high reliability and validity with a Cronbach's alpha of 0.866. In the diabetes-related knowledge section, there were 8 questions about viewpoint of diabetes, typical symptoms of diabetes(4 questions), combinations of diabetes(7 questions), high risk of developing diabetes(6 questions) and prevention methods of diabetes(4 questions), and participants were given a score of 1 for a right answer and 0 for a wrong answer. In the diabetes-related behavior section, the time of sitting every day, the frequency of exercise and physical examination, the regularity, attention to diet control and taste of daily diet, the current status of smoking and drinking are included. The time of sitting every day less than 6 hours, exercise more than 3 times a week, daily diet regularly, paying attention to diet control, preferring bland diet, physical examine more than 1 time every year, no smoking, and no drinking or drinking less and occasionally were defined to be good diabetes-related behaviors, and the others were defined to be bad diabetes-related behaviors. In the acquisition and utilization of diabetes information, there were 5 questions: ①How much do you know about diabetes(much, less, no); ②Does your knowledge about diabetes meet with your require?(yes, no); ③The difficulty in finding diabetes-related knowledge(no, little difficult, very difficult, have no try);

□The understanding of diabetes-related knowledge(understand well, cannot understand, have no try to find any diabetes-related knowledge); □The ability of identifying diabetes-related knowledge(good, bad, have no try to find any diabetes-related knowledge). People who knew much about the diabetes-related knowledge, considered their diabetes-related knowledge met with their require, had no difficulty in finding diabetes-related knowledge, understood diabetes-related knowledge well and had a good ability to identify diabetes-related knowledge were defined as good information acquisition and utilization. In the behavior and information acquisition and utilization section, participants who had the good behavior or good information acquisition and utilization were given a score of 2, and all the others were given a score of 0. The scores of the questionnaire range from 0 to 54, and a person with a score >43.2 is defined as the one having diabetes-related health literacy.[23]

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference. Blood pressure was assessed twice (2 minutes apart) by 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.[24] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[24] 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 with the following formula: BMI = kg/m^2. Participants were defined as being 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.[25]

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. WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[26]

Statistical analysis

The data were analyzed by using SPSS V20.0 (SPSS/IBM, Armonk, NY, USA). Data are presented as the percentage, mean±standard deviation, median and interquartile range. Non-parametric tests were used because the distribution of the health literacy scores on diabetes prevention and control was non-Gaussian. The Kruskal-Wallis test was used to explore differences in the health literacy on diabetes prevention and control levels among prediabetic individuals with different characteristics. In these analyses, the two-tailed significance threshold was $P<0.05$.

The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes. In the binary logistic regression analysis, the median value was used to definite groups, and the health literacy score for diabetes prevention and control were selected as the dependent variables and classified into group 1 (score>10.0) and group 2 (score≤10.0). Gender (1=women and 2=men), age (1=age from 60 to 64 years, 2=age 65 to 69 years, 3=age from 70 to 74 years, 4=age from 75 to 79 years, 5=age from 80 to 84 years, and 6=age≧85years), education (1=less than 1 years, 2=from 1 to 6 years, and 3=middle school and 6 years and above), marital status (1=stable marital status and 2=unstable marital status), 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. Step-wise logistic regression was conducted to analyze the risk factors of health literacy on diabetes using significance levels of 0.05 for entry and 0.10 for removal from the model.

Result

The characteristic of the study population

A total of 42 villages were selected and 2,144 subjects took part in the study. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes completed the questionnaire. Descriptive characteristics of the elderly with prediabetes are given in Table 1.

The average age of of the prediabetes was (69.4±6.45) years old. Men comprised 41.5% of participants. Most of the participants were in stable marital status(n=313, 72.1%) and were with lower education level(n=353, 81.3%). There was no difference in education level between men and women(p>0.05).

Few participants had a history of hyperglycemia(n=28, 6.5%) and a family history of diabetes(n=36, 8.3%). A total of 176(40.6%) participants were with other chronic diseases. 29.7%(n=129) of the participants were overweight and 12.7%(n=55) of them were in obesity. Most of the participants had abnormal WHR(n=357, 82.3%), and nearly half of them had abnormal blood pressure(45.9%, n=199). The prevalence of IGT(n=190, 43.8%) was higher than IFG(n=186, 42.9%) and IFG+IGT(n=58, 13.4%).

Table 1 The characteristic of the study population

	N	Mean (SD) or %
Age	434	69.4±6.45
Gender		
Men	180	41.5
Women	254	58.5
Marital Status		
Stable	313	72.1
Unstable	121	27.9
Education		
Less than 1 years	81	18.7
From 1 to 6 years	272	62.6
6 years and above	81	18.7
History of hyperglycemia		
Yes	28	6.5
No	406	93.5
Family history of diabetes		
Yes	36	8.3
No	398	91.7
Having other chronic disease		

Yes	176	40.6
No	258	59.4
BMI		
Lean	17	3.9
Normal	233	53.7
Overweight	129	29.7
Obesity	55	12.7
WHR		
Normal	77	17.7
Abnormal	357	82.3
Blood pressure		
Normal	235	54.1
Abnormal	199	45.9
Types		
IFG	186	42.9
IGT	190	43.7
IFG+IGT	58	13.4

The scores of the health literacy on diabetes prevention and control of prediabetes

The score of the health literacy on diabetes prevention and control f prediabetes is shown in Table 2. The median score was 10.0(interquartile range=7.0-13.0). Only one person had the diabetes-related health literacy(1/434).

The scores of health literacy on diabetes prevention and control of the elderly prediabetics of men were lower than women(9.0 vs 11.0, $p<0.05$). The scores of the health literacy of the elderly prediabetes with stable marital were higher than that with unstable marital status(10.0 vs 9.0, $p<0.05$). The scores of the health literacy of the elderly prediabetics with education level of less than 1 years were the lowest in the three education levels(8.0 vs 11.0 vs 12.0, $p<0.05$). The scores of the health literacy of the elderly prediabetics with the history of hyperglycemia were higher than that without the history of hyperglycemia(12.5 vs 9.0, $p<0.05$). There were no difference in the scores of the health literacy on diabetes prevention and control in different age, family history of diabetes, other chronic diseases situation, BMI, WHR, pressure, and types($p>0.05$).

Table 2 The scores of the health literacy on diabetes prevention and control of prediabetes

	Mean (standard deviation)	Median (interquartile range)	*p*
Overall	11.0±6.33	10.0(7.0-13.0)	
Age(years)			0.553
60-64	12.1±7.2	11.0(7.0-14.0)	
64-69	11.2±6.7	10.0(7.0-13.0)	
70-74	10.6±6.6	9.0(7.0-12.0)	
75-79	10.4±4.3	10.0(7.8-12.0)	
80-85	9.4±3.9	9.0(6.5-11.0)	
>85	9.8±1.8	10.0(8.5-11.3)	
Gender			0.000
Men	10.3±7.17	9.0(7.0-12.0)	
Women	11.5±5.63	11.0(8.0-13.0)	
Marital Status			0.044
Stable	11.4±6.51	10.0(7.0-13.0)	
Unstable	10.1±5.78	9.0(7.0-11.0)	
Education			0.000
Less than 1 years	7.7±2.55	8.0(6.5-9.0)	
From 1 to 6 years	11.3±6.35	11.0(7.0-13.0)	
6 years and above	13.2±7.57	12.0(9.0-16.0)	
History of hyperglycemia			0.001
Yes	15.1±8.11	12.5(9.3-20.5)	
No	10.7±6.10	9.0(7.0-12.0)	
Family history of diabetes			0.165
Yes	12.5±7.54	12.0(7.0-13.8)	
No	10.9±6.20	10.0(7.0-12.0)	
Having other chronic disease			0.544
Yes	11.5±7.08	10.0(7.0-13.0)	
No	10.7±5.76	10.0(7.0-13.0)	
BMI			0.547
Lower	9.9±5.33	9.0(5.5-13.5)	
Normal	10.7±5.95	9.0(7.0-13.0)	
Overweight	11.9±7.52	10.0(7.0-12.0)	
Obesity	10.5±4.87	10.0(7.0-13.0)	
WHR			0.074
Normal	10.4±6.72	9.0(7.0-12.0)	
Abnormal	11.2±6.25	10.0(7.0-13.0)	
Blood pressure			0.978
Normal	10.9±5.76	10.0(7.0-13.0)	
Abnormal	11.2±6.96	10.0(7.0-13.0)	
Types			0.451

IFG	11.4±6.49	10.0(7.0-13.0)
IGT	10.6±6.09	9.0(7.0-12.3)
IFG+IGT	11.2±6.65	10.0(7.0-12.0)

Risk factors for the scores of the health literacy on *diabetes prevention and control of prediabetes*

The results of the binary logistic regression analysis of risk factors of the health literacy on diabetes prevention and control of prediabetes were shown in Table 3.

After controlling for gender, age, marital status, history of chronic disease, BMI, WHR, types and abnormal pressure, the independent risk factors of the health literacy on diabetes prevention and control of the elderly prediabetes were men, not having a history of hyperglycemia and low education. The elderly prediabetes who were men (OR=2.831, 95%CI: 1.818-4.408), not having a history of hyperglycemia (OR=2.676, 95%CI:1.101-6.504), with education of less than 1 years(OR=31.148, 95%CI: 11.661-83.204) and with education of from 1 to 6 years(OR=14.274, 95%CI: 5.927-34.375) were more likely to have lower health literacy on diabetes prevention and control.

Table 3 The results of the binary logistic regression analysis of risk factors of the health literacy on diabetes prevention and control of prediabetes

	B	wals	*p*	OR	OR95%CI
Gender					
Women				1.000	
Men	1.041	21.225	0.000	2.831	(1.818,4.408)
Education					
6 years and above				1.000	
From 1 to 6 years	2.658	35.148	0.000	14.274	(5.927,34.375)
Less than 1 years	3.439	47.055	0.000	31.148	(11.661,83.204)
History of hyperglycemia					
Yes				1.000	
No	0.984	4.722	0.030	2.676	(1.101,6.504)

Discussion

The prevalence of prediabetes among the elderly was high in rural areas

In this study, the prevalence rate of prediabetes among rural elderly is 21.5%, which is similar to a previous study[27] and indicates a high occurrence of prediabetes. As reported previously, the prevalence of prediabetes is rapidly increasing annually in China, especially in rural areas.[4,27] These results together with the large population living in poor rural areas suggest the existence of a very serious public health problem in rural China. Because diabetes can be prevented or delayed in prediabetic individuals through feasible and timely interventions, the rising prevalence of prediabetes and diabetes in rural China has highlighted a need for better prevention.

Health literacy on *diabetes prevention and control among the elderly prediabetics in rural areas was very low*

We used a health literacy questionnaire specific to diabetes prevention and control to measure the level of health literacy of elderly with prediabetes, unlike some relevant studies, which adopted general health literacy measures, such as STOFHLA or REALM, which are not disease/condition-specific. This questionnaire was able to effectively examine the level of health literacy on diabetes prevention and control among prediabetics.[23] Yamashita T et al. showed a direct association between diabetes-specific health literacy and patients' assessments of their self-care practice acumen and that the measurement of health literacy should include indicators of diseases-specific knowledge and/or understanding.[28] Thus, it is better to use health literacy specific to diabetes prevention and control to assess the health literacy level regarding diabetes prevention and control among the elderly prediabetics. Health literacy specific to diabetes prevention and control is crucial to diabetes management and prevention. Thus, the questionnaire adopted here accurately reflected health literacy regarding diabetes prevention and control among the elderly prediabetics.

The median score of the assessment of health literacy on prediabetes prevention and control was 10.0 (interquartile range=7.0-13.0); the lowest score was 1.0, and the highest score was 44.0. Only one person exhibited diabetes-related health literacy. This suggested that health literacy on prediabetes prevention and control among

elderly individuals with prediabetes in rural areas is very limited. Our result is similar to previous studies.[17,23,29] A survey administered to non-diabetic residents in six Chinese provinces with a total of 4,282 people (aged from 18 to 60 years)showed a low level of diabetes health literacy with the same instrument.[23] The rate of having health literacy on diabetes was 20.7% among people with education of less than 1 years, and that was 18.7% among farmers in rural areas.[23] Moreover, inadequate health literacy is associated with age, and health literacy is commonly limited among people aged 65 years or older.[17,29] Thus, the rural elderly prediabetic patients have a high risk of developing diabetes and should be the primary target group for diabetes prevention. Low-level health literacy is associated with healthcare processes and key health outcomes. Diabetes health literacy is related to diabetes knowledge, self-efficacy, self-care behaviors, and glycemic control.

The health literacy on diabetes prevention and control of elderly with prediabetes in rural areas was low, and therefore, it is important to improve their health literacy on diabetes prevention and control because of the link between diabetes and health literacy. Thus, it is very urgent to improve the health literacy relevant to diabetes mellitus among the elderly in rural China.

Risk factors associated with health literacy on *diabetes prevention and control among the elderly prediabetics in rural areas*

Understanding the risky and protective factors associated with health literacy on diabetes prevention and control is necessary for implementing preventive measures. In our study, the influencing factors included several socio-demographic variables and a history of hyperglycemia. Binary logistic regression revealed that health literacy on diabetes prevention and control was associated with risk factors including being a man, having a low level of education and not having a history of hyperglycemia among the elderly individuals with prediabetes. These findings are consistent with previous studies,[17,29] although a history of hyperglycemia is mentioned here for the first time in the literature relevant to health literacy on diabetes.

Men have a lower level of health literacy on diabetes prevention and control than women, as reported in other countries.[30,31,32] Health literacy is identified as a key

health determinant because of its link to behavioral choices and service usage.[33] The relationship between health literacy and risky lifestyle behaviors (e.g., tobacco smoking and risky alcohol consumption) has been confirmed.[34,35] In many countries, men are more likely to engage in risky lifestyle behaviors, have lower health knowledge and pay less attention to preventative healthcare than women. And women are more likely to provide care to sick family members [36,37,38] than men and thus have more contact with the healthcare environment.

Education is an important factor with regard to health literacy. Some studies have found an association between education and health literacy components (e.g., nutrition literacy, knowledge, and personal skills).[34,39,40] The level of evidence supporting a correlation between education and health literacy was rated as moderate; people with a high level of education had better health outcomes because of the mediating effect of health literacy.[29]

This is the first time that the relationship between a history of hyperglycemia and diabetes-related health literacy has been analyzed, and we found that hyperglycemia was an influencing factor of health literacy on diabetes prevention and control. People with a history of hyperglycemia had a higher level of diabetes health literacy, likely because they are concerned about developing diabetes and actively seek to learn diabetes-related knowledge and behaviors. These results suggest that people with a high level of health literacy may have better glycemic control, as indicated by previous studies.[12, 41] As reported, low-level health literacy is associated with nearly twofold lower odds of good glycemic control than high-level health literacy among diabetic patients (adjusted odds ratio: 2.03; 95% CI: 111.-3.73).[42]

Health literacy also mediates the relationship between education and glycemic control among low-income diabetic patients,[12, 43] and the effects of education on glycemic control act through many mechanisms. People with poor overall literacy may face challenges in writing and communicating, especially those with low health literacy are less likely to prepare for and support in successful diabetes care, which involves interactive communication and participatory decision-making. Thus, elderly prediabetic patients in poor rural areas have low health literacy relevant to diabetes, low education levels and insufficient health education, and as a result, they may not

seek effective or suitable resources. Because health literacy includes diabetes-specific knowledge, self-efficacy, self-care behaviors and glycemic control, strategies to improve health literacy are urgently needed. While the study is limited by its cross-sectional design, therefore causation cannot be inferred. Moreover we cannot reject the bias for the self-reported design, thus further studies are needed to confirm the findings.

Conclusions

Our study revealed that health literacy was at a very low level, which was relevant to diabetes prevention and control among the prediabetic elderly population in poor rural areas of China. Males, a low educational level and not having a story of hyperglycemia were risk factors of health literacy on diabetes prevention and control among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes in rural China and the low educational attainment, low income and old age of this population, future studies should evaluate suitable and feasible measures to improve diabetes-related health literacy among these residents.

Acknowledgements Thanks for Fan Gao,Yang Yang, Fangfan Jiang, Ting Zhang and Zhao Hu took part in this study as investigator.

Contributors Huilan Xu and Lulu Qin had the original idea for the study and carried out the design.

Competing interests None declared.

Ethics approval: The study was approved by 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.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.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.

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

5.Tabak AG, Herder C, Rathmann W, et al. Prediabetes: a high-risk state for diabetes development. *Lancet* 2012, 379, 2279-2290.

6.Diabetes Prevention Program Research Group, Knowler WC, Fowler SE, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009; 374, 1677-86.

7. International Diabetes Federation. IDF Diabetes Atlas. 6th ed. Brussels, Belgium: International Diabetes Federation, 2013. (www.idf.org/diabetesatlas).

8.American Diabetes Association. Economic costs of diabetes in the U.S.in 2007. *Diabetes Care* 2008; 31, 596–615.

9.Institute of Medicine (US) Committee on Health Literacy, Nielsen-Bohlman L, Panzer AM, et al. Health Literacy: A Prescription to End Confusion. The National Academies Press:Washington, US, 2004, 25-67.

10.Kutner M. United States Department of Education., National Center for Education Statistics. NCES (Series). Washington, DC: United States Department of Education; National Center for Education Statistics; The health literacy of America's adults : results from the 2003 National Assessment of Adult Literacy. (http://nces.ed.gov/pubs2006/2006483.pdf.)

11.Chen GD, Huang CN, Yang YS, et al. Patient perception of understanding health education and instructions has moderating effect on glycemic control.*BMC Public Health* 2014; 14, 683.

12.Schillinger D, Barton LR, Karter AJ, et al. Does Literacy Mediate the Relationship Between Education and Health Outcomes? A Study of a Low-Income Population with Diabetes. *Public Health Report* 2006; 121, 245-54.

13.Kolb JM, Kitos NR, Ramachandran A, et al. What do primary care prediabetes patients need? A baseline assessment of patients engaging in a technology-enhanced lifestyle intervention. *J Bioinform Diabetes* 2014; 1,4.

14.Rosa MC, Benjamin EM, Peko PS, et al. Opportunities and challenges for diabetes

prevention at two community health centers. *Diabetes care* 2008; 31, 247–254.

15.Han HR, Kim J, Kim MT, et al. Measuring health literacy among immigrants with a phonetic primary language: a case of Korean American women. *J Immigr Minor Health* 2011;13,253-259.

16.Williams MV, Baker DW, Parker RM, et al. Relationship of functional health literacy to patients' knowledge of their chronic disease. A study of patients with hypertension and diabetes. *Arch Intern Med* 1998;158, 166-172.

17.Choi SE, Rush E, Henry S. Health literacy in Korean immigrants at risk for type 2 diabetes. *J Immiqr Minor Health* 2013; 15, 553-339.

18.Health Literacy: report of the Council on Scientific Affairs. Ad Hoc Committee on Health Literacy for the Council on Scientific Affairs, American Medical Association. *JAMA* 1999; 281, 552–557.

19.Rothman RL, DeWalt DA, Malone R, et al. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. *JAMA* 2004; 292, 1711–1716.

20.Rothman R, Malone R, Bryant B, et al. The relationship between literacy and glycemic control in a diabetes disease-management program. *Diabetes Edu* 2004; 30, 263–273.

21.U.S. Department of Health and Human Services.(www.healthypeople.gov.)

22.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. (Accessed February 26, 2010, at http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf.)

23.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, 561-5.(in Chinese)

24.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)

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

26.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.

27.Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults.*JAMA* 2013; 310, 948-959.

28.Yamashita T, Kart CS. Is diabetes-specific health literacy associated with diabetes-related outcomes in older adults?.*J Diabetes* 2011; 3, 138-46.

29.Davey J, Holden CA, Smith BJ.The correlates of chronic disease-related health literacy and its components among men: a systematic review.*BMC Public Health* 2015; 15, 589.

30.Barber MN, Staples M, 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.

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

32.Sudore RL, Mehta KM, Simonsick EM, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770–6.

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

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

35.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(5):660-8.

36.Thompson RL, Lewis SL, Murphy MR 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.

37.Covinsky KE, Eng C, Lui LY 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;56A:M707–M713.

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

39.Lutfiyya MN, Lipsky MS, Bales RW, et al. Disparities in knowledge of heart attack and stroke symptoms among adult men: an analysis of behavioral risk factor surveillance survey data. *J Natl Med Assoc* 2008; 100, 1116–24.

40.Sohn M, Stotts NA, Benowitz N, et al.Beliefs about health, smoking, and future smoking cessation among South Korean men hospitalized for cardiovascular disease. *Heart Lung* 2007; 36, 339–47.

41.Osborn CY, Bains SS, Egede LE. Health literacy, diabetes self-care, and glycemic control in adults with Type 2 diabetes. *Diabetes Technol Ther* 2010;12, 913–919.

42.Schillinger D, Grumbach K, Piette J, et al. Association of health literacy with diabetes outcomes. *JAMA* 2002; 288, 475–482.

43.Chaturvedi N, Stephenson JM, Fuller JH. The relationship between socioeconomic status and diabetes control and complications in the URODIAB IDDM Complications Study. *Diabetes Care* 1996;19:423-30.

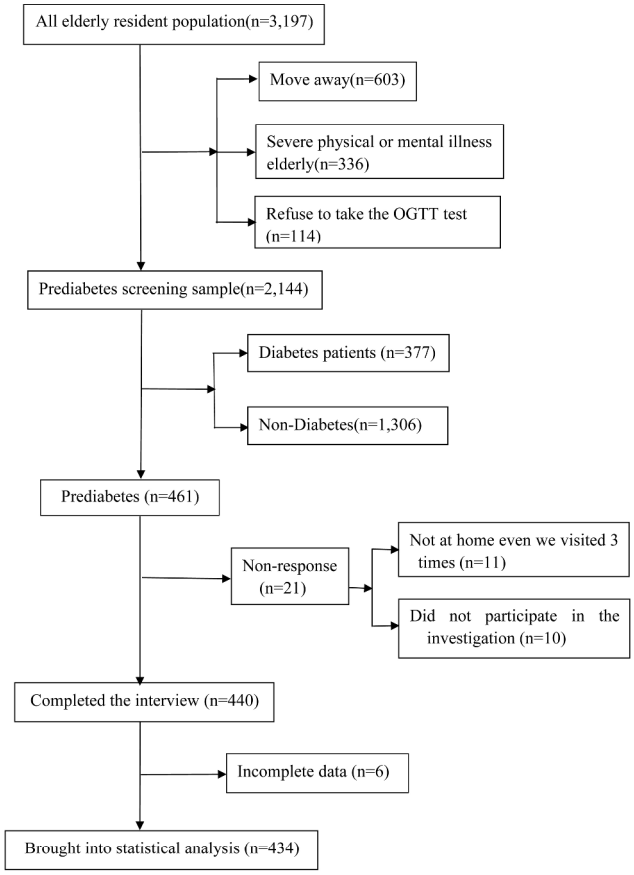

Figure 1 Response of subjects

Figure 1 Response of subjects
296x419mm (300 x 300 DPI)

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	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	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5,6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8,9,10
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	7,8,9,10
Bias	9	Describe any efforts to address potential sources of bias	7,8,9,10

Study size	10	Explain how the study size was arrived at	5,6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8,9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*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	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	Yes.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
Outcome data	15*	Report numbers of outcome events or summary measures	10,11,12,13,14
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	12,13,14
		(*b*) Report category boundaries when continuous variables were categorized	10

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12,13,14
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13,14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15,16,17
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	17,18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17,18
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.

BMJ Open

A cross-sectional study on risk factors of health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011077.R2
Article Type:	Research
Date Submitted by the Author:	14-Apr-2016
Complete List of Authors:	qin, lu; School of Public Health, Central South University, Department of Social Medicine and Health Management xu, huilan; School of Public Health, Central South University, Department of Social Medicine and Health Management
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Public health, Diabetes and endocrinology
Keywords:	health literacy, prediabetes, elderly, rural areas

A cross-sectional study on risk factors of health literacy on diabetes prevention and control among the elderly with prediabetes in rural China

Lulu Qin[1], Huilan Xu[1]

[1] Department of Social Medicine and Health Management, School of Public Health, Central South University, Changsha, Hunan 410078, China;

Correspondence author: Huilan Xu, E-Mail: huilanxu1963@sina.com

Tel./Fax: +86-0731-8484-5454.

Key words: health literacy; prediabetes; elderly; rural areas;

Word accounts: 4,144; Tables: 3

Abstract

Objectives: This study was designed to examine the health literacy on diabetes prevention and control and its risk factors among the elderly with prediabetes in rural areas in China.

Design, setting and participates: A cross-sectional survey was conducted among the elderly in rural communities in Yiyang City of China. 42 areas were selected by multi-staged cluster random sampling and 434 rural elders with prediabetes were investigated via face-to-face interviews by the "questionnaire of health literacy of diabetes of the public in China."

Main outcome measures: Participants were asked general information(age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education). The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes.

Results: The median score of health literacy on diabetes prevention and prediabetes control was 10.0 (interquartile range=7.0-13.0). The level of health literacy on diabetes prevention and control among men was lower than that among women (OR=2.831, 95% CI: 1.818-4.408). Relative to those with education of 6 years and above, the level of health literacy on diabetes prevention and control of respondents with education years from 1 to 6 was lower (OR=14.274, 95%CI: 5.927-34.375), and that with education of less than 1 year was the lowest (OR=31.148, 95%CI: 11.661-83.204). The level of health literacy on diabetes prevention and control among the prediabetic elderly with not a history of hyperglycemia was lower than that with a history of hyperglycemia (OR=2.676, 95%CI:1.101-6.504).

Conclusions: The health literacy on diabetes prevention and control of elderly individuals with prediabetes was very low in rural China. Thus, suitable and feasible health education for elderly individuals with low education levels should be incorporated into diabetes-prevention efforts.

Strengths and limitations of this study

This is the first study to examine health literacy regarding diabetes prevention and control among the elderly prediabetic population in rural China or other countries.

The study provides valuable information on the diabetes prevention and control among the elderly prediabetic population in rural communities.

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

Introduction

Diabetes mellitus is a threat to public health worldwide[1,2] as the global prevalence rates of diabetes and prediabetes are rapidly increasing. During the past 30 years, the prevalence rates of diabetes and prediabetes in China have also increased because Chinese people have changed their lifestyles following rapid economic development.[3] The prevalence rates of diabetes and prediabetes in China were estimated to be 9.7% (92.4 million adults) and 15.5% (148.2 million adults), respectively.[4] Prediabetes is an intermediate state of hyperglycemia characterized by glycemic parameters above normal levels but below the diabetic threshold and is also called "borderline diabetes." There are three types of prediabetes: impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and IFG combined with IGT. Prediabetes is strongly associated with an increased risk of developing type 2 diabetes (T2DM), stroke and cardiovascular diseases.[5]

The occurrence rates of diabetes and prediabetes increase with age, especially in the elderly (defined here as adults aged 60 years and above). The elderly contribute approximately 52% to diabetes-attributable mortality worldwide.[6] In North America and the Caribbean, the elderly accounted for 63% of diabetic patients[6] and 86% of all annual diabetes-related deaths in 2007.[7] In China, more than 20% of the elderly population suffers from prediabetes, in both urban and rural areas.[4] As noted, nearly 150 million Chinese residents have prediabetes. If even one third of these patients transition to T2DM over the next 6 years, we will face a potential increase in T2DM prevalence. Therefore, prediabetes will cause a huge burden of diabetes on the public health system because without timely and effective intervention or treatment, prediabetes is very likely to progress to diabetes within ten years.[8]

Health literacy is defined as 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 has been theorized to be an important non-clinical factor that may decrease the risk of adverse outcomes.[9,10] The diabetes health literacy is associated with diabetes-related knowledge, and adequate health literacy is highly correlated with a better understanding of health education.[11] Health literacy is a predictor of the utilization of preventive healthcare. As reported previously, health literacy mediates the relationship between education and glycemic

control in low-income diabetic patients.[12] Moreover, health literacy is associated with disease-related knowledge, a requisite level of which is necessary for effective behavior change.[13,14] People with a high level of health literacy are more likely to engage in health-promoting behaviors and therefore have better health outcomes.[15]

However, low-level health literacy is common. Approximately 55% of diabetic patients in the US have inadequate literacy,[16] and Korean immigrants with low-level health literacy are at a greater risk of T2DM.[17] People with low-level health literacy usually have less disease-specific knowledge, lower quality of life, and poorer health-related outcomes. Patients with low health literacy may also have trouble in reading prescriptions, following medical instructions, and interacting with the health care system.[18,19,20] Based on the link between diseases and health literacy, health literacy has become an important part of the rapidly developing public health sector worldwide.[21]

In China, few studies have investigated diabetes health literacy among rural residents, and no epidemiological information is available on the health literacy regarding prediabetes prevention and control for the rural elderly. Through a community-based study, we investigated the health literacy relevant to diabetes prevention and control among the rural elderly individuals in China. Aim: to understand the factors associated with the health literacy relevant to diabetes prevention and control and provide scientific recommendations for diabetes prevention in the future.

Materials and Methods

Sample size calculation

Sample size calculation was done by using the formula for cross-sectional studies: α=0.05，n= uα/22P(1-P)/d2. The u was 1.96 when α is 0.05, the P was the prevalence of a prediabetes which is 20% in this study, the 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. After our pre-investigation, there were about 10 prediabetes among the elderly in a village, so a total of 42 villages would to be selected.

Study population and procedures

With a multistage cluster randomized sampling method, we selected a representative sample of the rural prediabetic population aged 60 years and over form Yiyang city's rural areas of Hunan province between April and July 2015 and the "cluster" here is the village. In the first stage, sampling was stratified according to geographical characteristic status, and 2 counties (Yuanjiang and Nanxian) out of 6 countries were selected. In the second stage, 2 townships (Yangluozhou, Yinfengqiao) out of 11 townships and 2 townships (Qingshuzui, and Maocaojie) out of 9 townships were randomly selected. In the third stage, 25% of the rural villages were randomly selected from each chosen townships (the number of villages of each township accounts from 30 to 50). In the final stage, all households with elderly individuals of each chosen village were listed.

The participants diagnosed as prediabetic via oral glucose-tolerance tests (OGTTs) were enrolled in the study. The diagnostic standard for prediabetes was applied the 1999 WHO criteria. [22] The elderly resident population (who had achieved registered permanent residence or not achieved registered permanent residence but had resided in the area for 3 years or longer) who met the diagnostic standards for prediabetes were eligible to participate. Those with severe physical or mental illness were excluded from the study. And individuals who were diabetes patient or who met the diagnosis standards for diabetes were defined as diabetes patient and were excluded from this study. Our pre-trained interviewers went to the elderly subject's home to introduce the aim, plan, interest and the right of participant in this study carefully. All the elderly were invited to have a OGTT test and other tests(including blood pressure, height, weight and waist circumference). Then they interviewed participants face to face after each participant's being given written, informed consent. If the participants were illiterate, the written consent would be signed by their family members. The elderly have the right to decline to participate in the study without any disadvantage, and they can drop out if they have the desire at any time during the whole investigation.

There were a total of 3,197 elderly residents in the 42 selected areas(including 3,068 individuals having achieved registered permanent residence and 129 individuals having

living for more than 3 years with out achieved registered permanent), among which 603 had moved away for many reasons, 336 individuals were excluded for several physical or mental illness, and a total of 114 elderly who refused to take the OGTT test were excluded, which accounted for 5.0%(114/2,258). Moreover, there were no difference in age, sex, marital status and education among those who participated in the OGTT test vs those who refused after analysis. The prediabetes screening sample size was 2,144 people, the response rate of the OGTT test among the elderly was 95.0%(2,144/2,258). There were 21 prediabetes not being investigated for various reasons(Fig. 1). And the response rate of investigation was 95.4%(440/461). Among the remaining 440 individuals, 6 were excluded for incomplete data. In total, 434 elders were brought into statistical analysis and the efficiency was 94.1%(434/461). Thus, a total of 42 rural villages and 434 prediabetic individuals were included in our study.

Data collection and measurements

Prediabetes screening

The participants were instructed to maintain their usual physical activity and diet for at least 3 days before the OGTT. After at least 10 hours of overnight fasting, venous blood was collected from each participant in a vacuum tube containing sodium fluoride and used to measure plasma glucose. The blood samples were stored at -80 °C no more than 1 hour for subsequent analysis of blood glucose (mmol/L). Each participant was given a standard 75-g glucose solution, and then, blood was sampled at 0 and 120 min after consuming the glucose load to measure glucose levels. The plasma glucose level was measured using a hexokinase enzymatic method, and serum cholesterol and triglyceride levels were assessed enzymatically with commercially available reagents in the clinical biochemical laboratory of the primary care center in each village. Fasting plasma glucose was analyzed enzymatically using an Olympus AU640 autoanalyzer (Olympus, Kobe, Japan). All the laboratories had successfully completed a standardization and certification program. Prediabetes was diagnosed according to the 1999 WHO criteria as follows[22]: (1) an IFG group with fasting

plasma glucose 6.1-7.0 mmol/L (110-126 mg/dL) and 2-hour post-glucose load <7.8 mmol/L (140 mg/dL); (2) an IGT group with 2-hour post-glucose load 7.8-11.1 mmol/L (140-200 mg/dL) and fasting plasma glucose ≤6.1 mmol/L (110 mg/dL); and (3) an IFG+IGT group.

Socio-demographic information

In this study, the socio-demographic information included age, gender, marital status, history of hyperglycemia, family history of diabetes mellitus, presence of other diseases and education. 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.

Health literacy on diabetes prevention and control

Health literacy on diabetes prevention and control was assessed using the "Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China" designed by the Chinese Center for Health Education. The questionnaire included diabetes-related knowledge, diabetes-related behavior, and the acquisition and utilization of diabetes information. This questionnaire has a high reliability and validity with a Cronbach's alpha of 0.866. In the diabetes-related knowledge section, there were 8 questions about viewpoint of diabetes, typical symptoms of diabetes(4 questions), combinations of diabetes(7 questions), high risk of developing diabetes(6 questions) and prevention methods of diabetes(4 questions), and participants were given a score of 1 for a right answer and 0 for a wrong answer. In the diabetes-related behavior section, the time of sitting every day, the frequency of exercise and physical examination, the regularity, attention to diet control and taste of daily diet, the current status of smoking and drinking are included. The time of sitting every day less than 6 hours, exercise more than 3 times a week, daily diet regularly, paying attention to diet control, preferring bland diet, physical examine more than 1 time every year, no smoking, and no drinking or drinking less and occasionally were defined to be good diabetes-related behaviors, and the others were defined to be bad diabetes-related behaviors. In the acquisition and utilization of diabetes information, there were 5

questions: ①How much do you know about diabetes(much, less, no); ②Does your knowledge about diabetes meet with your require?(yes, no); ③The difficulty in finding diabetes-related knowledge(no, little difficult, very difficult, have no try); The understanding of diabetes-related knowledge(understand well, cannot understand, have no try to find any diabetes-related knowledge); The ability of identifying diabetes-related knowledge(good, bad, have no try to find any diabetes-related knowledge). People who knew much about the diabetes-related knowledge, considered their diabetes-related knowledge met with their require, had no difficulty in finding diabetes-related knowledge, understood diabetes-related knowledge well and had a good ability to identify diabetes-related knowledge were defined as good information acquisition and utilization. In the behavior and information acquisition and utilization section, participants who had the good behavior or good information acquisition and utilization were given a score of 2, and all the others were given a score of 0. The scores of the questionnaire range from 0 to 54, and a person with a score >43.2 is defined as the one having diabetes-related health literacy.[23]

Anthropometric measurements

Anthropometric measurements included blood pressure, height, weight and waist circumference. Blood pressure was assessed twice (2 minutes apart) by 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.[24] Hypotension is defined as systolic blood pressure <90 mmHg and/or diastolic pressure <60 mmHg.[24] 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 with the following formula: BMI = kg/m^2. Participants were defined as being 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.[25]

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. WHR>0.9 in men and >0.8 in women was defined as abnormal WHR.[26]

Statistical analysis

The data were analyzed by using SPSS V20.0 (SPSS/IBM, Armonk, NY, USA). Data are presented as the percentage, mean±standard deviation, median and interquartile range. Non-parametric tests were used because the distribution of the health literacy scores on diabetes prevention and control was non-Gaussian. The Kruskal-Wallis test was used to explore differences in the health literacy on diabetes prevention and control levels among prediabetic individuals with different characteristics. In these analyses, the two-tailed significance threshold was $P<0.05$.

The binary logistic regression analysis was performed to detect the risk factors of health literacy relevant to diabetes prevention and control of the elderly with prediabetes. In the binary logistic regression analysis, the median value was used to definite groups, and the health literacy score for diabetes prevention and control were selected as the dependent variables and classified into group 1 (score>10.0) and group 2 (score≤10.0). Gender (1=women and 2=men), age (1=age from 60 to 64 years, 2=age 65 to 69 years, 3=age from 70 to 74 years, 4=age from 75 to 79 years, 5=age from 80 to 84 years, and 6=age≧85years), education (1=less than 1 years, 2=from 1 to 6 years, and 3=middle school and 6 years and above), marital status (1=stable marital status and 2=unstable marital status), 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. Step-wise logistic regression was conducted to analyze the risk factors of health literacy on diabetes using significance levels of 0.05 for entry and 0.10 for removal from the model.

Result

The characteristic of the study population

A total of 42 villages were selected and 2,144 subjects took part in the study. The prevalence of prediabetes was 21.5%(461/2144) and 434 prediabetes completed the questionnaire. Descriptive characteristics of the elderly with prediabetes are given in Table 1.

The average age of of the prediabetes was (69.4±6.45) years old. Men comprised 41.5% of participants. Most of the participants were in stable marital status(n=313, 72.1%) and were with lower education level(n=353, 81.3%). There was no difference in education level between men and women(p>0.05).

Few participants had a history of hyperglycemia(n=28, 6.5%) and a family history of diabetes(n=36, 8.3%). A total of 176(40.6%) participants were with other chronic diseases. 29.7%(n=129) of the participants were overweight and 12.7%(n=55) of them were in obesity. Most of the participants had abnormal WHR(n=357, 82.3%), and nearly half of them had abnormal blood pressure(45.9%, n=199). The prevalence of IGT(n=190, 43.8%) was higher than IFG(n=186, 42.9%) and IFG+IGT(n=58, 13.4%).

Table 1 The characteristic of the study population

	N	Mean (SD) or %
Age	434	69.4±6.45
Gender		
Men	180	41.5
Women	254	58.5
Marital Status		
Stable	313	72.1
Unstable	121	27.9
Education		
Less than 1 years	81	18.7
From 1 to 6 years	272	62.6
6 years and above	81	18.7
History of hyperglycemia		
Yes	28	6.5
No	406	93.5

Family history of diabetes		
Yes	36	8.3
No	398	91.7
Having other chronic disease		
Yes	176	40.6
No	258	59.4
BMI		
Lean	17	3.9
Normal	233	53.7
Overweight	129	29.7
Obesity	55	12.7
WHR		
Normal	77	17.7
Abnormal	357	82.3
Blood pressure		
Normal	235	54.1
Abnormal	199	45.9
Types		
IFG	186	42.9
IGT	190	43.7
IFG+IGT	58	13.4

The scores of the health literacy on diabetes prevention and control of prediabetes

The score of the health literacy on diabetes prevention and control f prediabetes is shown in Table 2. The median score was 10.0(interquartile range=7.0-13.0). Only one person had the diabetes-related health literacy(1/434).

The scores of health literacy on diabetes prevention and control of the elderly prediabetics of men were lower than women(9.0 vs 11.0, $p<0.05$). The scores of the health literacy of the elderly prediabetes with stable marital were higher than that with unstable marital status(10.0 vs 9.0, $p<0.05$). The scores of the health literacy of the elderly prediabetics with education level of less than 1 years were the lowest in the three education levels(8.0 vs 11.0 vs 12.0, $p<0.05$). The scores of the health literacy of the elderly prediabetics with the history of hyperglycemia were higher than that without the history of hyperglycemia(12.5 vs 9.0, $p<0.05$). There were no difference in the scores of the health literacy on diabetes prevention and control in different age, family history of diabetes, other chronic diseases situation, BMI, WHR, pressure, and types($p>0.05$).

Table 2 The scores of the health literacy on diabetes prevention and control of prediabetes

	Mean (standard deviation)	Median (interquartile range)	*p*
Overall	11.0±6.33	10.0(7.0-13.0)	
Age(years)			0.553
60-64	12.1±7.2	11.0(7.0-14.0)	
64-69	11.2±6.7	10.0(7.0-13.0)	
70-74	10.6±6.6	9.0(7.0-12.0)	
75-79	10.4±4.3	10.0(7.8-12.0)	
80-85	9.4±3.9	9.0(6.5-11.0)	
>85	9.8±1.8	10.0(8.5-11.3)	
Gender			0.000
Men	10.3±7.17	9.0(7.0-12.0)	
Women	11.5±5.63	11.0(8.0-13.0)	
Marital Status			0.044
Stable	11.4±6.51	10.0(7.0-13.0)	
Unstable	10.1±5.78	9.0(7.0-11.0)	
Education			0.000
Less than 1 years	7.7±2.55	8.0(6.5-9.0)	
From 1 to 6 years	11.3±6.35	11.0(7.0-13.0)	
6 years and above	13.2±7.57	12.0(9.0-16.0)	
History of hyperglycemia			0.001
Yes	15.1±8.11	12.5(9.3-20.5)	
No	10.7±6.10	9.0(7.0-12.0)	
Family history of diabetes			0.165
Yes	12.5±7.54	12.0(7.0-13.8)	
No	10.9±6.20	10.0(7.0-12.0)	
Having other chronic disease			0.544
Yes	11.5±7.08	10.0(7.0-13.0)	
No	10.7±5.76	10.0(7.0-13.0)	
BMI			0.547
Lower	9.9±5.33	9.0(5.5-13.5)	
Normal	10.7±5.95	9.0(7.0-13.0)	
Overweight	11.9±7.52	10.0(7.0-12.0)	
Obesity	10.5±4.87	10.0(7.0-13.0)	
WHR			0.074
Normal	10.4±6.72	9.0(7.0-12.0)	
Abnormal	11.2±6.25	10.0(7.0-13.0)	

Blood pressure			0.978
Normal	10.9±5.76	10.0(7.0-13.0)	
Abnormal	11.2±6.96	10.0(7.0-13.0)	
Types			0.451
IFG	11.4±6.49	10.0(7.0-13.0)	
IGT	10.6±6.09	9.0(7.0-12.3)	
IFG+IGT	11.2±6.65	10.0(7.0-12.0)	

Risk factors for the scores of the health literacy on *diabetes prevention and control of prediabetes*

The results of the binary logistic regression analysis of risk factors of the health literacy on diabetes prevention and control of prediabetes were shown in Table 3.

After controlling for gender, age, marital status, history of chronic disease, BMI, WHR, types and abnormal pressure, the independent risk factors of the health literacy on diabetes prevention and control of the elderly prediabetes were men, not having a history of hyperglycemia and low education. The elderly prediabetes who were men (OR=2.831, 95%CI: 1.818-4.408), not having a history of hyperglycemia (OR=2.676, 95%CI:1.101-6.504), with education of less than 1 years(OR=31.148, 95%CI: 11.661-83.204) and with education of from 1 to 6 years(OR=14.274, 95%CI: 5.927-34.375) were more likely to have lower health literacy on diabetes prevention and control.

Table 3 The results of the binary logistic regression analysis of risk factors of the health literacy on diabetes prevention and control of prediabetes

	B	wals	*p*	OR	OR95%CI
Gender					
Women				1.000	
Men	1.041	21.225	0.000	2.831	(1.818,4.408)
Education					
6 years and above				1.000	
From 1 to 6 years	2.658	35.148	0.000	14.274	(5.927,34.375)
Less than 1 years	3.439	47.055	0.000	31.148	(11.661,83.204)
History of hyperglycemia					
Yes				1.000	

No	0.984	4.722	0.030	2.676	(1.101,6.504)

Discussion

The prevalence of prediabetes among the elderly was high in rural areas

In this study, the prevalence rate of prediabetes among rural elderly is 21.5%, which is similar to a previous study[27] and indicates a high occurrence of prediabetes. As reported previously, the prevalence of prediabetes is rapidly increasing annually in China, especially in rural areas.[4,27] These results together with the large population living in poor rural areas suggest the existence of a very serious public health problem in rural China. Because diabetes can be prevented or delayed in prediabetic individuals through feasible and timely interventions, the rising prevalence of prediabetes and diabetes in rural China has highlighted a need for better prevention.

Health literacy on *diabetes prevention and control among the elderly prediabetics in rural areas was very low*

We used a health literacy questionnaire specific to diabetes prevention and control to measure the level of health literacy of elderly with prediabetes, unlike some relevant studies, which adopted general health literacy measures, such as STOFHLA or REALM, which are not disease/condition-specific. This questionnaire was able to effectively examine the level of health literacy on diabetes prevention and control among prediabetics.[23] Yamashita T et al. showed a direct association between diabetes-specific health literacy and patients' assessments of their self-care practice acumen and that the measurement of health literacy should include indicators of diseases-specific knowledge and/or understanding.[28] Thus, it is better to use health literacy specific to diabetes prevention and control to assess the health literacy level regarding diabetes prevention and control among the elderly prediabetics. Health literacy specific to diabetes prevention and control is crucial to diabetes management and prevention. Thus, the questionnaire adopted here accurately reflected health literacy regarding diabetes prevention and control among the elderly prediabetics.

The median score of the assessment of health literacy on prediabetes prevention

and control was 10.0 (interquartile range=7.0-13.0); the lowest score was 1.0, and the highest score was 44.0. Only one person exhibited diabetes-related health literacy. This suggested that health literacy on prediabetes prevention and control among elderly individuals with prediabetes in rural areas is very limited. Our result is similar to previous studies.[17,23,29] A survey administered to non-diabetic residents in six Chinese provinces with a total of 4,282 people (aged from 18 to 60 years)showed a low level of diabetes health literacy with the same instrument.[23] The rate of having health literacy on diabetes was 20.7% among people with education of less than 1 years, and that was 18.7% among farmers in rural areas.[23] Moreover, inadequate health literacy is associated with age, and health literacy is commonly limited among people aged 65 years or older.[17,29] Thus, the rural elderly prediabetic patients have a high risk of developing diabetes and should be the primary target group for diabetes prevention. Low-level health literacy is associated with healthcare processes and key health outcomes. Diabetes health literacy is related to diabetes knowledge, self-efficacy, self-care behaviors, and glycemic control.

The health literacy on diabetes prevention and control of elderly with prediabetes in rural areas was low, and therefore, it is important to improve their health literacy on diabetes prevention and control because of the link between diabetes and health literacy. Thus, it is very urgent to improve the health literacy relevant to diabetes mellitus among the elderly in rural China.

Risk factors associated with health literacy on *diabetes prevention and control among the elderly prediabetics in rural areas*

Understanding the risky and protective factors associated with health literacy on diabetes prevention and control is necessary for implementing preventive measures. In our study, the influencing factors included several socio-demographic variables and a history of hyperglycemia. Binary logistic regression revealed that health literacy on diabetes prevention and control was associated with risk factors including being a man, having a low level of education and not having a history of hyperglycemia among the elderly individuals with prediabetes. These findings are consistent with previous studies,[17,29] although a history of hyperglycemia is mentioned here for the

first time in the literature relevant to health literacy on diabetes.

Men have a lower level of health literacy on diabetes prevention and control than women, as reported in other countries.[30,31,32] Health literacy is identified as a key health determinant because of its link to behavioral choices and service usage.[33] The relationship between health literacy and risky lifestyle behaviors (e.g., tobacco smoking and risky alcohol consumption) has been confirmed.[34,35] In many countries, men are more likely to engage in risky lifestyle behaviors, have lower health knowledge and pay less attention to preventative healthcare than women. And women are more likely to provide care to sick family members [36,37,38] than men and thus have more contact with the healthcare environment.

Education is an important factor with regard to health literacy. Some studies have found an association between education and health literacy components (e.g., nutrition literacy, knowledge, and personal skills).[34,39,40] The level of evidence supporting a correlation between education and health literacy was rated as moderate; people with a high level of education had better health outcomes because of the mediating effect of health literacy.[29]

This is the first time that the relationship between a history of hyperglycemia and diabetes-related health literacy has been analyzed, and we found that hyperglycemia was an influencing factor of health literacy on diabetes prevention and control. People with a history of hyperglycemia had a higher level of diabetes health literacy, likely because they are concerned about developing diabetes and actively seek to learn diabetes-related knowledge and behaviors. These results suggest that people with a high level of health literacy may have better glycemic control, as indicated by previous studies.[12, 41] As reported, low-level health literacy is associated with nearly twofold lower odds of good glycemic control than high-level health literacy among diabetic patients (adjusted odds ratio: 2.03; 95% CI: 111.-3.73).[42]

Health literacy also mediates the relationship between education and glycemic control among low-income diabetic patients,[12, 43] and the effects of education on glycemic control act through many mechanisms. People with poor overall literacy may face challenges in writing and communicating, especially those with low health literacy are less likely to prepare for and support in successful diabetes care, which

involves interactive communication and participatory decision-making. Thus, elderly prediabetic patients in poor rural areas have low health literacy relevant to diabetes, low education levels and insufficient health education, and as a result, they may not seek effective or suitable resources. Because health literacy includes diabetes-specific knowledge, self-efficacy, self-care behaviors and glycemic control, strategies to improve health literacy are urgently needed. While the study is limited by its cross-sectional design, therefore causation cannot be inferred. Moreover we cannot reject the bias for the self-reported design, thus further studies are needed to confirm the findings.

Conclusions

Our study revealed that health literacy was at a very low level, which was relevant to diabetes prevention and control among the prediabetic elderly population in poor rural areas of China. Males, a low educational level and not having a story of hyperglycemia were risk factors of health literacy on diabetes prevention and control among elderly individuals with prediabetes. Considering the high prevalence of prediabetes and diabetes in rural China and the low educational attainment, low income and old age of this population, future studies should evaluate suitable and feasible measures to improve diabetes-related health literacy among these residents.

Acknowledgements Thanks for Fan Gao,Yang Yang, Fangfan Jiang, Ting Zhang and Zhao Hu took part in this study as investigator.

Contributors Huilan Xu and Lulu Qin had the original idea for the study and carried out the design.

Competing interests None declared.

Ethics approval: The study was approved by 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.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.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.

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

5.Tabak AG, Herder C, Rathmann W, et al. Prediabetes: a high-risk state for diabetes development. *Lancet* 2012, 379, 2279-2290.

6.Diabetes Prevention Program Research Group, Knowler WC, Fowler SE, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009; 374, 1677-86.

7. International Diabetes Federation. IDF Diabetes Atlas. 6th ed. Brussels, Belgium: International Diabetes Federation, 2013. (www.idf.org/diabetesatlas).

8.American Diabetes Association. Economic costs of diabetes in the U.S.in 2007. *Diabetes Care* 2008; 31, 596–615.

9.Institute of Medicine (US) Committee on Health Literacy, Nielsen-Bohlman L, Panzer AM, et al. Health Literacy: A Prescription to End Confusion. The National Academies Press:Washington, US, 2004, 25-67.

10.Kutner M. United States Department of Education., National Center for Education Statistics. NCES (Series). Washington, DC: United States Department of Education; National Center for Education Statistics; The health literacy of America's adults : results from the 2003 National Assessment of Adult Literacy. (http://nces.ed.gov/pubs2006/2006483.pdf.)

11.Chen GD, Huang CN, Yang YS, et al. Patient perception of understanding health education and instructions has moderating effect on glycemic control.*BMC Public Health* 2014; 14, 683.

12.Schillinger D, Barton LR, Karter AJ, et al. Does Literacy Mediate the Relationship Between Education and Health Outcomes? A Study of a Low-Income Population with Diabetes. *Public Health Report* 2006; 121, 245-54.

13.Kolb JM, Kitos NR, Ramachandran A, et al. What do primary care prediabetes patients need? A baseline assessment of patients engaging in a technology-enhanced lifestyle intervention. *J Bioinform Diabetes* 2014; 1,4.

14.Rosa MC, Benjamin EM, Peko PS, et al. Opportunities and challenges for diabetes prevention at two community health centers. *Diabetes care* 2008; 31, 247–254.

15.Han HR, Kim J, Kim MT, et al. Measuring health literacy among immigrants with a phonetic primary language: a case of Korean American women. *J Immigr Minor Health* 2011;13,253-259.

16.Williams MV, Baker DW, Parker RM, et al. Relationship of functional health literacy to patients' knowledge of their chronic disease. A study of patients with hypertension and diabetes. *Arch Intern Med* 1998;158, 166-172.

17.Choi SE, Rush E, Henry S. Health literacy in Korean immigrants at risk for type 2 diabetes. *J Immiqr Minor Health* 2013; 15, 553-339.

18.Health Literacy: report of the Council on Scientific Affairs. Ad Hoc Committee on Health Literacy for the Council on Scientific Affairs, American Medical Association. *JAMA* 1999; 281, 552–557.

19.Rothman RL, DeWalt DA, Malone R, et al. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. *JAMA* 2004; 292, 1711–1716.

20.Rothman R, Malone R, Bryant B, et al. The relationship between literacy and glycemic control in a diabetes disease-management program. *Diabetes Edu* 2004; 30, 263–273.

21.U.S. Department of Health and Human Services.(www.healthypeople.gov.)

22.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. (Accessed February 26, 2010, at http://www.staff.ncl.ac.uk/philip.home/who_dmg.pdf.)

23.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, 561-5.(in Chinese)

24.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)

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

26.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.

27.Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults.*JAMA* 2013; 310, 948-959.

28.Yamashita T, Kart CS. Is diabetes-specific health literacy associated with diabetes-related outcomes in older adults?.*J Diabetes* 2011; 3, 138-46.

29.Davey J, Holden CA, Smith BJ.The correlates of chronic disease-related health literacy and its components among men: a systematic review.*BMC Public Health* 2015; 15, 589.

30.Barber MN, Staples M, 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.

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

32.Sudore RL, Mehta KM, Simonsick EM, et al. Limited literacy in older people and disparities in health and healthcare access. *J Am Geriatr Soc* 2006; 54, 770–6.

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

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

35.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(5):660-8.

36.Thompson RL, Lewis SL, Murphy MR 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.

37.Covinsky KE, Eng C, Lui LY 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;56A:M707–M713.

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

39.Lutfiyya MN, Lipsky MS, Bales RW, et al. Disparities in knowledge of heart attack and stroke symptoms among adult men: an analysis of behavioral risk factor surveillance survey data. *J Natl Med Assoc* 2008; 100, 1116–24.

40.Sohn M, Stotts NA, Benowitz N, et al.Beliefs about health, smoking, and future smoking cessation among South Korean men hospitalized for cardiovascular disease. *Heart Lung* 2007; 36, 339–47.

41.Osborn CY, Bains SS, Egede LE. Health literacy, diabetes self-care, and glycemic control in adults with Type 2 diabetes. *Diabetes Technol Ther* 2010;12, 913–919.

42.Schillinger D, Grumbach K, Piette J, et al. Association of health literacy with diabetes outcomes. *JAMA* 2002; 288, 475–482.

43.Chaturvedi N, Stephenson JM, Fuller JH. The relationship between socioeconomic status and diabetes control and complications in the URODIAB IDDM Complications Study. *Diabetes Care* 1996;19:423-30.

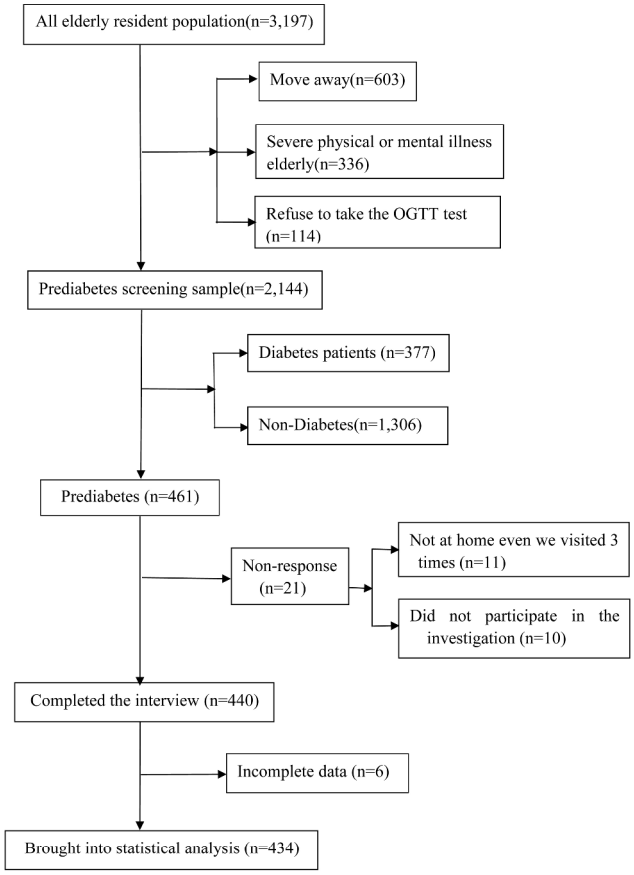

Figure 1 Response of subjects

Figure 1 Response of subjects
296x419mm (300 x 300 DPI)

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	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	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5,6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8,9,10
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	7,8,9,10
Bias	9	Describe any efforts to address potential sources of bias	7,8,9,10

Study size	10	Explain how the study size was arrived at	5,6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8,9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*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	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	Yes.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
Outcome data	15*	Report numbers of outcome events or summary measures	10,11,12,13,14
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	12,13,14
		(*b*) Report category boundaries when continuous variables were categorized	10

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12,13,14
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13,14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15,16,17
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	17,18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17,18
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.