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Association between diabetes-specific health literacy and health-related quality of life among elderly individuals with pre-diabetes in rural Hunan Province, China: a cross-sectional study

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ABSTRACT

Objectives To examine the association between diabetes-specific health literacy (DSHL) and health-related quality of life (HRQoL) among elderly individuals with pre-diabetes in rural China.

Design, setting and participants This cross-sectional study included 434 elderly individuals with pre-diabetes from 42 villages in rural China.

Main outcome measures HRQoL was assessed using the Medical Outcomes Study 36-Item Short-Form Health Survey. DSHL was measured by a validated questionnaire in China. Differences in HRQoL between groups with and without high DSHL were tested by multivariate analysis of covariance (MANCOVA).

Results The prevalence of pre-diabetes was 21.5%. The average age of participants (n=434) was 69.4±6.4 years, and 58.5% were female. Bivariate analysis showed that those with high DSHL had increases of 2.9 points in the physical health component score and 4.4 points in the mental health component score (MCS) compared with those without. After adjustment for potential confounders, a significant MANCOVA model (Wilks' λ=0.974, F=5.63, p=0.004) indicated that individuals with pre-diabetes who had high DSHL reported higher MCS (M_{diff}=3.5, 95% CI 1.8 to 6.3, effect size=0.38). This remained significant across subscales: general health (p=0.028), vitality (p=0.014), social functioning (p=0.017) and mental health (p=0.005).

Conclusions Low DSHL was associated with worsening HRQoL among elderly individuals with pre-diabetes in rural China, particularly in the mental health components.

Trial registration number ChiCTR-IOR-15007033.

Strengths and limitations of this study

- ► This is the first study to examine the association between health-related quality of life (HRQoL) and diabetes-specific health literacy (DSHL) among elderly individuals with pre-diabetes in rural China.
- ► The study provides valuable information on HRQoL among elderly individuals with pre-diabetes in rural areas in China.
- ► The association between HRQoL and DSHL was analysed in eight domains, as well as in the physical health component and the mental health component, making the results more comprehensive.
- ► The cross-sectional study design makes causal relationships undeterminable.

INTRODUCTION

Pre-diabetes describes individuals who have impaired fasting glucose (IFG) or/and impaired glucose tolerance (IGT).[1] Pre-diabetes is a less common but important condition that constitutes an intermediate state between type 2 diabetes and healthy status. Several studies have identified that individuals with pre-diabetes have a high risk of developing diabetes, and the occurrence increases with age.[2–4] Approximately 5%–10% of people with pre-diabetes become diabetic annually, although the progression rate varies by population and the definition of pre-diabetes.[5 6] In China, the estimated prevalence of pre-diabetes was 35.7% in adults and 45.8% in the elderly population in 2013.[7] Therefore, people with pre-diabetes, especially elderly, are an important target group for interventions intended to prevent diabetes.

Health-related quality of life (HRQoL) is a comprehensive and multidimensional condition that refers to an individual's perceived physical and mental health under the influence of illness, injury and treatment over time.[8 9] Several studies have demonstrated that many risk factors, such as smoking, chronic diseases, poor diet, insufficient physical activity and overweight, lead to lower HRQoL.[10–12] Because biomedical measures sometimes may not sensitively indicate the deterioration or improvement in symptoms and health status, HRQoL has been increasingly incorporated as a complementary and essential outcome measure in medical interventions and population health surveys to assess changes in the physical, mental and social well-being of these individuals. Studies have found that the HRQoL is usually impaired in individuals with pre-diabetes compared with the healthy population; additionally, individuals with pre-diabetes progressing to diabetes suffer from a great loss in HRQoL.[13–15] Moreover, HRQoL affects both the entry and subsequent utilisation of health services and the cost of healthcare in China.[16 17] Thus, assessing HRQoL in the intermediate period between normal plasma glucose and type 2 diabetes is important; because the concept has a broader definition that enables us to fully understand both the somatic and emotional health statuses of individuals with pre-diabetes and consequently create interventions to improve it, especially by relieving pain, malaise and consequences of diseases.[18]

Health literacy (HL) is the degree to which individuals have the capacity to obtain, process and understand the basic health information and service need to make informed health decision.[19] Over the past decades, a growing body of research suggests that inadequate HL is associated with adverse health outcomes, such as poor self-rated health, misunderstandings about medical conditions and increased mortality risk.[20–22] However, HL is arguably a broad multidimensional concept that serves as a bridge between literacy skills and abilities and the illness context in which individuals find themselves.[23]Clearly, some dimensions of literacy skills and abilities are generalisable across all health populations. However, in the presence of a specific illness context, some disease-specific HL would seem necessary for successful self-management of that disease. For example, diabetes-specific HL (DSHL) is particularly salient in the assessment of self-care for type 2 diabetes in adults.[24] Nevertheless, there is no clear definition of DSHL in the current literature. In general, DSHL represents the ability to obtain and understand diabetes-related information and to make informed diabetes care decisions. A study demonstrated that DSHL was positively associated with self-graded assessment of diabetes care.[25] Some studies have indicated that DSHL is associated with the diabetes-related knowledge, diabetes-care behaviours and glycaemic control.[26 27]

Thus, pre-diabetes patients with lower levels of DSHL may not have knowledge of the signs or symptoms of concern and may have a higher risk of developing poor health outcomes than those who have higher DSHL.

Several studies have evaluated the impact of HL on HRQoL in patients with type 2 diabetes,[28] hypertension[29]and ischaemic heart disease.[30] However, these studies focus on HL related to obtaining and comprehending general medical information rather than disease-specific or condition-specific HL. Furthermore, some HRQoL measures have also been widely used in cost-utility analyses to determine the cost-effectiveness of treatments and interventions in several populations, including those with chronic conditions.[31 32] Therefore, an exploration of the impact of DSHL on HRQoL would also be of great importance for determining whether it is necessary to incorporate it as a potential confounding factor in cost-utility analyses of type 2 diabetes interventions. Moreover, examining the association between DSHL and HRQoL could help us to identify new targets and create more precise and multifaceted prevention and intervention strategies to delay the development of type 2 diabetes. At present, there are a few studies that have investigated the relationship between specific HL and HRQoL, and almost no studies in the literature have explored the effect of DSHL on HRQoL among individuals with pre-diabetes.

Therefore, to address these issues and to help to bridge the gap between HL and outcome research in individuals with pre-diabetes, the current study aimed to explore the impact of DSHL on HRQoL among elderly individuals with pre-diabetes in rural areas in China. We hypothesised that elderly individuals with pre-diabetes with high DSHL would report better HRQoL. We hope that this study will contribute to the formulation of effective interventions to improve HRQoL and promote diabetes prevention.

RESEARCH DESIGN AND METHODS

Study design

This cross-sectional study was conducted in the rural areas of Yiyang City of Hunan Province in China between April and July 2015.

Sample size

The sample size was calculated using the formula for cross-sectional studies, as follows:

$$N = \frac{Z^2_{1-/2}\,p(1-p)}{d^2}$$

where $Z^2_{1-/2}$=1.96 when α=0.05, p is the prevalence of pre-diabetes (which was 20% in this study according to our presurvey) and d is an admissible error (which was 4%). According to the formula, the theoretical sample size was 423, which included an extra 10% to allow for subjects lost during the study.

Participants

Participants in this study were aged 60 years and older and were from the rural areas of Yiyang City of Hunan Province. To select a representative sample of the elderly population with pre-diabetes, a screening programme was carried out among the elderly population in Yiyang City. A multistage cluster randomised sampling method was used to select a representative sample. In the first stage, two (Nanxian and Yuanjiang) out of six counties were selected according to geographical characteristics (north and south of Yiyang City). In the second stage, 2 (Yangluozhou and Yinfengqiao) out of 11 townships from Yuanjiang county and 2 (Qingshuzui and Maocaojie) out of 9 townships from Nanxian county were randomly selected by drawn lots. In the third stage, as each township contains 30–50 villages, a proportionate sampling method was used to select 25% of the villages from each selected township. Thus, 11 villages from Yangluozhou township, 10 villages from Yinfengqiao township, 11 villages from Qingshuzui township and 10 villages from Maocaojie township were randomly selected. In the final stage, all households in each selected village with elderly individuals who had lived in the area for 3 years or longer were eligible to participate in the screening programme (n=3197). Among them, 603 moved away, 336 had a severe physical or mental illness and 114 refused to participate. Finally, a total of 2144 individuals participated in the screening programme.

An oral glucose tolerance test was used to distinguish between pre-diabetes and normal plasma glucose. The diagnostic standards for pre-diabetes as stated in the 1999 WHO criteria[33] were (1) an IFG group with fasting plasma glucose of 6.1–7.0 mmol/L and a 2-hour postglucose load of <7.8 mmol/L; (2) an IGT group with a 2-hour postglucose load of 7.8–11.1 mmol/L and fasting plasma glucose of ≤6.1 mmol/L and (3) an IFG+IGT group.

More details of the study population and screening procedure have been published elsewhere.[34] In brief, 2144 elderly individuals took part in the screening programme, and 461 elderly individuals had pre-diabetes. For various reasons, 21 of those with pre-diabetes provided no response, and the response rate was 95.4%. Six individuals who had incomplete data were also excluded from this study. Finally, a total of 434 individuals with pre-diabetes from 42 villages were included in this study.

Data collection

Sociodemographic information was collected by trained staff using a set of structured questionnaires, which included age, gender, education, marital status, presence of other chronic disease, history of hyperglycaemia, family history of diabetes, physical activity, smoking and alcohol drinking. Marital status was classified as married and non-married. Non-married status included divorced, never married and lost a partner. Chronic diseases included hypertension, coronary heart disease, dyslipidaemia and others. History of hyperglycaemia was defined as a situation of fasting glucose>6.1 mmol/L or 2-hour glucose>7.8 mmol/L without a diagnosis of diabetes. Physical activity was assessed using the International Physical Activity Questionnaire—long version, and individuals who achieved ≥600 metabolic equivalent-min/week were categorised as active.[35] Smoking was defined as averaging one or more cigarettes per day in the last year. Alcohol drinking was defined as drinking more than one glass of wine (approximately 250 mL beer or 100 mL sake or 20 mL liquor) per month in the last year.

Anthropometric measurements, including height, weight, blood pressure, waist circumference and hip circumference, were assessed using a standard tool. The measurement procedure was published in a previous study.[36] Body mass index (BMI) was calculated using the formula of weight in kg divided by height in m^2 (kg/m^2). The current Chinese standard classification states that the cut-off values for normal weight, overweight and obesity BMI are 18.5, 24.0 and 28.0 kg/m^2,[37] respectively. Hypertension was defined as systolic blood pressure≥140 mm Hg and/or diastolic blood pressure≥90 mm Hg. The waist-to-hip ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. A WHR>0.9 in men or >0.8 in women was defined as abnormal WHR.[38]

DSHL was assessed using the Questionnaire of Health Literacy of Diabetes Mellitus of the Public in China, which was designed by the Chinese Center for Health Education to assess HL about diabetes prevention and control in the general population.[39] This questionnaire has been widely used in epidemiological studies in China, and has high reliability and validity, with a Cronbach's α of 0.866.[39] DSHL can provide a comprehensive evaluation of an individual's diabetes prevention and control knowledge, risk awareness and ability to manage risk factors. The questionnaire is organised into three main domains: diabetes-related knowledge, diabetes-related behaviour, and acquisition and utilisation of diabetes information. The diabetes-related knowledge section assessed attitudes towards diabetes, typical symptoms of diabetes, complications of diabetes, factors conferring a high risk of developing diabetes and methods to prevent diabetes. The diabetes-related behaviours included sitting time duration, physical exercise, dietary pattern, physical examination, and smoking and alcohol drinking habits. In the part about the acquisition and utilisation of diabetes information, the participants were asked about the method or way to find diabetes-related information, the degree of their acquisition of diabetes-related information and their ability to identify the correctness of diabetes-related information. An alternative classification was used where the scores 19.5 points and above were classified as high DSHL and the remaining were classified as low. Although the prediabetic population may not experience certain symptoms of diabetes, people with a high HL status can identify the risk factors related to the development of type 2 diabetes, and thus engage in diabetes care behaviour. The purpose and structure of this questionnaire allow it to effectively and accurately measure the participants' ability to obtain, process and understand diabetes-related information and make informed diabetes care decisions.

HRQoL was assessed using the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36).[40] The SF-36 health survey questionnaire has been translated and validated in Chinese, and the Chinese version has been proven to be reliable and valid in an elderly population.[41] This 36-item measure is organised into eight domains that constitute two main components: the physical health component and the mental health component. The physical health component includes four parts: physical functioning (PF), role physical (RP), bodily pain (BP) and general health (GH). Vitality (VT), social functioning (SF), role emotional (RE) and mental health (MH) are included in the mental health component. The eight domains were scored from 0 to 100, indicating the worst to best possible health. Each domain score was further summarised and standardised into the physical health component score (PCS) and the mental health component score (MCS) according to American norms to allow for international comparisons.[42]

Data analysis

Data were presented as n (%) for categorical variables and mean±SD or median (P_{25}–P_{75}) for numerical variables. Non-parametric tests were used because the distribution of the DSHL scores was non-Gaussian. The Mann-Whitney U or Kruskal-Wallis test was used to identify the differences in total DSHL scores according to different variables. The t-test or one-way analysis of variance was used to compare the differences in the scores for different domains of HRQoL. General linear models of multivariate analysis of covariance (MANCOVA) were used to test differences in HRQoL between the adequate DSHL and inadequate groups. Sociodemographic and anthropometric variables were treated as possible covariates. A significant MANCOVA was followed by univariate F tests using the Wilks' λ statistic. Linear independent pairwise comparisons were analysed to examine the magnitude of the difference in the mean scores of the dependent variables. Effect sizes (ESs) (d) were computed by dividing the difference in means between groups by the pooled SD and were interpreted as small (d≤0.20), medium (0.20<d≤0.50) or large (0.50<d≤0.80).[43] The data were analysed using SPSS V.20.0.

Patient and public involvement

Neither patients nor the public was directly involved in the development, design or recruitment of the study. Anthropometric and glucose test results were provided to the participants at the point of testing.

RESULTS

A total of 461 elderly individuals had pre-diabetes, and the prevalence of pre-diabetes was 21.5% (461/2144) in rural areas of Yiyang City. In total, 434 elderly individuals with pre-diabetes were included in this study. The average age of all participants was 69.4±6.4 years. The average fasting plasma glucose was 5.9±0.5 mmol/L, and the average 2-hour plasma glucose load was 7.2±1.9 mmol/L. A majority of the subjects were female, had completed less than 6 years of education, smoked, drank no alcohol and had no hypertension. The characteristics of the study subjects are presented in table 1.

The overall median DSHL score was 10.0 (IQR 7.0–13.0). Men had lower HL scores than women. Furthermore, married elderly individuals had higher DSHL scores than non-married individuals. Individuals with a history of hyperglycaemia had a higher DSHL score than people with no history. Similarly, individuals with pre-diabetes

Table 1 The DSHL score according to different characteristics

Characteristics	n (%)	DSHL score*	P value†
Age			
60–69 years	239 (55.1)	10.0 (8.0–15.0)	0.461
70 years and older	195 (44.9)	10.0 (7.5–11.0)	
Gender			
Male	180 (41.5)	9.0 (7.0–12.0)	<0.001
Female	254 (58.5)	11.0 (8.0–13.0)	
Marital status			
Married	312 (71.9)	10.0 (7.0–13.0)	0.044
Non-married	122 (28.1)	9.0 (7.0–11.0)	
Education			
Less than 6 years	353 (81.3)	9.0 (6.5–12.0)	<0.001
6 years and more	81 (18.7)	12.0 (9.0–16.0)	
History of hyperglycaemia			
Yes	28 (6.5)	12.5 (9.3–20.5)	0.001
No	406 (93.5)	9.0 (7.0–12.0)	
Family history of diabetes			
Yes	36 (8.3)	12.0 (7.0–13.8)	0.165
No	398 (91.7)	10.0 (7.0–12.0)	
Have other chronic disease			
Yes	176 (40.6)	10.0 (7.0–13.0)	0.544
No	258 (59.4)	10.0 (7.0–13.0)	
Physical activity			
Active	182 (41.9)	10.5 (8.0–13.5)	0.227
Inactive	252 (58.1)	9.5 (8.0–13.0)	
Smoking			
Yes	99 (22.8)	10.0 (8.0–12.0)	0.525
No	335 (77.2)	10.0 (8.0–13.0)	
Alcohol drinking			
Yes	98 (22.6)	10.0 (8.0–12.0)	0.308
No	336 (77.4)	10.0 (7.5–13.0)	
BMI			
Lean	17 (3.9)	9.0 (5.5–13.5)	0.547
Normal	233 (53.7)	9.0 (7.0–13.0)	
Overweight	129 (29.7)	10.0 (7.0–12.0)	
Obese	55 (12.7)	10.0 (7.0–13.0)	
Hypertension			
Yes	173 (39.9)	10.5 (8.5–13.0)	0.256
No	261 (60.1)	9.5 (8.0–12.0)	
WHR			
Normal	77 (17.7)	9.0 (7.0–12.0)	0.074
Abnormal	357 (82.3)	10.0 (7.0–13.0)	

*Data are presented as the median (P_{25}–P_{75}).
†P value was determined by Kruskal-Wallis or Mann-Whitney U test.
BMI, body mass index; DSHL, diabetes-specific health literacy; WHR, waist-to-hip ratio.

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who had completed 6 years or more of education had a higher score than those who had completed less than 6 years. The DSHL score according to different characteristics is presented in table 1.

HRQoL score

Individuals with pre-diabetes reported a PCS of 42.1 points (95% CI 41.2 to 43.1) and an MCS of 46.4 points (95% CI 45.5 to 47.1). The scores for the four domains of the PCS were 76.1±23.4, 71.4±42.4, 75.7±15.9 and 57.8±21.5, respectively, and the MCS were 72.2±18.1, 79.7±17.1, 85.1±33.3 and 74.8±17.5, respectively. The means and their SDs for eight subscales of HRQoL scores according to different characteristics are presented in table 2. Neither domain score showed a significant difference for the variables of gender, family history of diabetes or alcohol drinking (all p>0.05). The BP and GH scores were lower among people aged 70 years and older. The MH score was lower among people who were not married. Individuals with pre-diabetes who had completed 6 years of education or more had higher SF and RE scores than people educated 1–6 years. Individuals who achieved active physical activity seemed to have higher scores in the PF, BP and GH domains. The RP, GH and RE scores were similarly higher among elderly people with normal BMI. Moreover, individuals with normal WHR had higher BP, SF and RE scores.

Association between DSHL and HRQoL

Crude analysis indicated that when the eight subscales of HRQoL were placed as the dependent variables and DSHL (as a binary variable) was entered as the independent variable, the overall MANCOVA showed significant differences in the GH, VT, SF and MH scores between the two groups (Wilks' λ=0.955, F=2.44, p=0.014). After adjusting for other covariants, individuals with high DSHL reported higher scores on GH (M_{diff}=6.8, p=0.028), VT (M_{diff}=6.6, p=0.014), SF (M_{diff}=6.0, p=0.017) and MH (M_{diff}=7.4, p=0.005) than did those with low DSHL. The associations between DSHL and different domains of HRQoL are presented in table 3.

Crude analysis showed that with two components of HRQoL entered as dependent variables, the overall MANCOVA was significant (Wilks' λ=0.965, F=7.87, p<0.001). Individuals with high DSHL had higher PCS (M_{diff}=2.9, ES=0.30) and MCS (M_{diff}=4.4, ES=0.47) than those with low DSHL. After adjusting for age, gender, education, marital status, other chronic disease, family history of diabetes, history of hyperglycaemia, physical activity, hypertension, smoking, drinking, BMI and WHR, a linear independent pairwise comparison indicated that individuals with pre-diabetes who had higher DSHL reported higher MCS (M_{diff}=3.5, 95% CI 1.8 to 6.3) with a medium ES (ES=0.38). The association between DSHL and HRQoL among elderly individuals with pre-diabetes is presented in table 4.

DISCUSSION

This cross-sectional study showed a high prevalence (21.5%) of pre-diabetes among the elderly population in rural areas in China, which is similar to the findings of the earlier study.[44] The results, together with the large elderly population living in rural areas, suggest that this serious public health problem in China requires better prevention.

Many studies have used general HL measurement instruments, such as The Rapid Estimate of Adult Literacy in Medicine(REALM) or The Test of Functional Health Literacy in Adults(TOFHLA), which are not disease-specific or condition-specific. However, our study used a DSHL questionnaire with high reliability and validity that was designed by the Chinese Center for Health Education, and is suitable for a non-diabetic population.[39] The questionnaire was able to effectively and accurately examine the level of HL about diabetes knowledge, diabetes prevention behaviours, and the acquisition and utilisation of diabetes information among individuals with pre-diabetes. There is a direct association between DSHL and patient assessments of their self-care ability, which indicates that HL measures should include indicators of knowledge and understanding.[25] Thus, in terms of prevention, knowing the HL of individuals with pre-diabetes regarding diabetes prevention and control contribute to the development of more effective interventions and health education methods. Based on the results of the univariate analysis, the DSHL score showed significant differences in the variables of gender, education and history of hyperglycaemia, which are consistent with the findings of other studies.[45 46]

Although the effect of HL on HRQoL has been widely discussed among some populations in previous studies,[47–49] few studies have explored the association between HL and HRQoL among individuals with pre-diabetes. There is also a lack of research probing the effect of disease-specific or condition-specific HL on HRQoL. To the best of our knowledge, this is the first study to examine the relationship between DSHL and HRQoL among elderly individuals with pre-diabetes. Our study found that DSHL was positively associated with some health domains of HRQoL according to bivariate and multivariate analyses. Compared with individuals with pre-diabetes with lower HL levels, subjects with higher HL reported higher scores on the GH, VT, SF and MH subscales of HRQoL. That is, prediabetic older adults with lower HL were more likely to have limited social activities (SF), poor general health perceptions (GH), tiredness (VT) and psychological distress (MH). When the eight domain scores were standardised and summarised as the PCS and MCS, the relationship between DSHL levels and HRQoL was significant in the mental well-being (SF-36 MCS), while it was significant in the physical health domain (SF-36 PCS) only in the bivariate model and became non-significant after controlling for sociodemographic and somatometric covariates. On one hand, more subscales of the MCS component than of the PCS were significantly associated with DSHL; this finding could be helpful in further studies exploring the influence of HL on certain subscales of HRQoL. On the other

Table 2 HRQoL scores of eight domains measured by SF-36

Characteristics	Physical health components				Mental health components			
	PF	RP	BP	GH	VT	SF	RE	MH
Overall	76.1±23.4	71.4±42.4	75.7±15.9	57.8±21.5	72.2±18.1	79.7±17.1	85.1±33.3	74.8±17.5
Age								
60–69 years	76.9±23.5	74.1±41.6	77.4±16.6*	60.0±21.5*	72.9±17.7	80.5±16.6	87.2±31.1	75.7±17.4
70 years and older	74.9±23.1	67.2±43.4	73.1±14.4*	54.8±21.1*	71.1±18.8	78.5±17.8	82.0±36.3	73.4±17.7
Gender								
Male	75.8±23.4	73.3±41.4	74.9±16.5	58.5±20.7	72.5±18.3	80.7±16.3	86.0±32.3	74.2±18.5
Female	76.3±23.4	70.1±43.2	76.3±15.5	57.2±22.1	72.0±18.0	79.0±17.6	84.5±34.0	75.2±16.9
Marital status								
Married	75.6±23.9	73.2±42.2	75.3±16.3	58.8±21.6	73.0±18.1	79.7±16.9	85.4±33.2	76.0±16.9*
Non-married	77.5±21.8	66.6±42.9	76.7±14.9	54.9±20.8	69.9±18.1	79.8±17.7	84.4±33.6	71.4±18.8*
Education								
Less than 6 years	75.9±23.6	71.0±42.7	75.7±15.7	57.4±21.5	71.5±18.5	78.8±16.9*	83.1±34.9*	74.4±17.6
6 years and more	76.9±22.8	73.3±41.4	75.7±16.7	59.1±21.4	75.0±16.3	83.2±17.5*	93.1±24.5*	76.3±17.2
History of hyperglycaemia								
Yes	75.9±23.5	67.9±43.3	73.2±12.9	51.2±30.1*	64.0±20.9*	76.0±17.3	80.9±36.6	69.2±19.9
No	77.2±22.5	71.9±42.3	76.0±16.2	58.5±20.3*	73.2±17.5*	80.2±17.0	85.7±32.9	75.5±17.1
Family history of diabetes								
Yes	75.7±23.9	72.9±42.3	75.2±16.2	58.4±21.9	72.7±18.2	79.5±16.8	84.5±34.0	75.6±17.2
No	77.2±22.1	67.5±42.5	77.1±15.0	55.9±20.3	70.8±17.8	80.3±17.9	86.8±31.4	72.6±18.4
Other chronic disease								
Yes	72.9±24.1*	72.0±42.6	71.7±16.2*	56.7±20.5	71.9±18.0	78.7±17.1	84.8±33.5	74.0±18.3
No	78.1±22.7*	71.1±42.4	78.1±15.2*	58.4±22.1	72.4±18.2	80.3±17.1	85.3±33.2	75.3±17.0
Physical activity								
Active	80.4±24.5*	72.9±42.8	78.5±17.2*	61.6±21.8*	73.8±16.4	80.9±18.3	90.1±28.0	76.3±16.4
Inactive	74.5±23.7*	70.9±42.3	74.6±15.3*	56.3±21.2*	71.6±18.7	79.2±16.6	83.3±34.9	74.2±17.9
Smoking								
Yes	76.2±24.2	70.1±43.2	75.3±16.3	57.2±21.4	71.9±18.1	78.1±17.8*	85.0±33.8	73.8±17.4
No	75.9±22.4	73.0±41.5	76.1±15.5	58.5±21.5	72.6±18.2	81.7±16.1*	85.4±32.8	75.9±17.7
Alcohol drinking								
Yes	76.3±23.1	71.1±42.7	75.3±15.7	57.7±21.4	72.7±18.0	79.6±16.9	84.0±34.5	74.8±17.4
No	75.4±24.5	72.4±41.5	76.8±16.7	57.9±21.7	70.4±18.6	80.1±17.9	89.1±28.6	74.5±18.0
BMI								
Lean	79.1±25.4	60.9±45.7*	73.9±13.4	53.7±23.5*	65.6±17.7	78.7±16.0	78.3±39.7*	69.2±20.7
Normal	76.7±22.8	77.0±39.6*	76.1±16.0	59.9±20.3*	73.7±18.0	81.2±17.1	89.2±28.5*	75.7±17.3
Overweight	75.1±24.5	76.6±39.2*	76.2±15.3	57.7±21.5*	70.7±18.8	78.7±17.5	82.6±36.2*	73.9±16.9
Obese	74.1±23.2	47.0±47.2*	73.9±17.4	51.6±23.9*	71.1±17.3	76.0±16.3	76.1±40.5*	74.4±18.0
Hypertension								
Yes	78.0±22.9*	66.9±44.4	75.3±17.1	55.5±23.8	71.0±18.7	77.8±17.5	78.5±38.0*	74.7±17.7
No	73.1±23.8*	74.3±40.9	75.9±15.1	59.2±19.8	73.0±17.9	80.9±16.7	89.4±29.2*	74.8±17.5
WHR								
Normal	77.3±23.5	72.8±41.6	78.4±17.1*	59.2±21.6	72.8±18.3	81.6±15.8*	88.1±29.8*	76.0±17.6
Abnormal	74.4±23.2	69.4±43.6	71.8±13.1*	55.8±21.2	71.4±17.8	76.9±18.4*	80.9±37.5*	73.1±17.4

Data are presented as the mean±SD, and analysis was performed using the analysis of variance or t-test.
*P<0.05.
BMI, body mass index; BP, bodily pain; GH, general health; HRQoL, health-related quality of life; MH, mental health; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; VT, vitality; WHR, waist-to-hip ratio.

hand, some information loss may occur in the process of standardising and summarising the scores of the eight domains into two components because of the different weights of the eight domains. However, the PCS and MCS scales are scored using the linear T-score transformation method so that a one-point difference is one-tenth of a

Table 3 Association between DSHL and different subscales of HRQoL among elderly individuals with pre-diabetes

	High DSHL		Low DSHL		Difference		
SF-36 domains	Mean	SE	Mean	SE	M_{diff} (95% CI)	ES (d)	P value
Crude analysis (Wilks' λ=0.955, F=2.44, p=0.014)							
PF	80.0	3.2	75.5	1.2	4.6 (–2.3 to 11.2)	0.20	0.193
RP	74.5	5.8	70.9	2.3	3.5 (–5.7 to 15.4)	0.08	0.224
BP	78.9	2.2	75.2	0.8	3.7 (–1.8 to 8.3)	0.23	0.110
GH	64.5	2.9	56.8	1.1	7.6 (1.6 to 13.7)	0.38	0.013
VT	78.9	2.5	71.3	0.9	7.5 (2.4 to 12.8)	0.42	0.004
SF	86.0	2.3	78.8	0.9	7.2 (2.4 to 12.1)	0.43	0.001
RE	91.2	4.6	84.3	1.7	6.9 (–2.7 to 16.5)	0.21	0.158
MH	81.8	2.4	73.8	0.9	8.0 (3.0 to 13.0)	0.46	0.002
Adjusted analysis (Wilks' λ=0.958, F=2.31, p=0.019)*							
PF	79.6	3.2	75.6	1.2	4.0 (–2.8 to 10.8)	0.17	0.252
RP	73.1	5.9	71.2	2.1	1.9 (–6.7 to 14.2)	0.07	0.186
BP	78.4	2.1	75.3	0.8	3.1 (–1.2 to 7.5)	0.19	0.161
GH	63.7	2.9	56.9	1.1	6.8 (1.7 to 12.9)	0.33	0.028
VT	78.0	2.5	71.4	0.9	6.6 (1.3 to 11.8)	0.37	0.014
SF	84.9	2.3	79.0	0.9	6.0 (1.1 to 10.9)	0.36	0.017
RE	88.0	4.6	84.7	1.7	3.4 (–6.2 to 12.9)	0.10	0.492
MH	81.2	2.4	73.9	0.9	7.4 (2.3 to 12.5)	0.43	0.005

*Adjusted for age, gender, education, marital status, other chronic disease, physical activity, family history of diabetes, history of hyperglycaemia, smoking, drinking, hypertension, BMI and WHR.

BMI, body mass index; BP, bodily pain; DSHL, diabetes-specific health literacy; ES (d), effect size (mean difference/pooled SD); GH, general health; HRQoL, health-related quality of life; M_{diff}, mean difference; MH, mental health; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; VT, vitality; WHR, waist-to-hip ratio.

SD, and higher scores indicate a better health status.[42] Therefore, a two-point to three-point difference in the PCS and MCS in our study is significant and meaningful. These results are in concordance with those of previous studies that targeted the relationship between general HL and HRQoL.[10 50–53] For instance, Jayasinghe *et al* found that HL accounted for 45% and 70% of the total between-patient variance explained in PCS-12 and MCS-12, respectively.[10] Furthermore, a study conducted in 605 patients with symptomatic heart failure showed that those with higher literacy had better HRQoL scores (mean difference=7.2, p<0.01) than did those with lower literacy.[52] A cross-sectional survey of 1841 cancer patients in Wisconsin also indicated that higher HL was positively associated with the physical, functional, emotional and social well-being subscales of HRQoL.[53] However, our results also contradict the findings of previous studies that examined the association.[28–30 54–56] Data from a clinical

Table 4 Association between DSHL and HRQoL among elderly individuals with pre-diabetes

	High DSHL		Low DSHL		Difference		
Variables	Mean	SE	Mean	SE	M_{diff} (95% CI)	ES (d)	P value
Crude analysis (Wilks' λ=0.965, F=7.87, p<0.001)							
PCS	44.6	1.3	41.7	0.5	2.9 (1.4 to 5.7)	0.30	0.046
MCS	50.2	1.3	45.8	0.5	4.4 (1.7 to 7.1)	0.47	0.001
Adjusted analysis (Wilks' λ=0.974, F=5.63, p=0.004)*							
PCS	44.4	1.3	41.8	0.6	2.6 (–1.2 to 5.4)	0.27	0.067
MCS	49.4	1.3	45.9	0.7	3.5 (1.8 to 6.3)	0.38	0.012

*Adjusted for age, gender, education, marital status, other chronic disease, physical activity, family history of diabetes, history of hyperglycaemia, smoking, drinking, hypertension, BMI and WHR.

BMI, body mass index; DSHL, diabetes-specific health literacy; ES (d), effect size (mean difference/pooled SD); HRQoL, health-related quality of life; MCS, mental health component score; M_{diff}, mean difference; PCS, physical health component score; WHR, waist-to-hip ratio.

trial that included 154 predominantly white patients with type 2 diabetes who screened positive for depression showed that the between-HL group difference in change over 1 year was only non-significant at 0.76 points for PCS and 0.56 points for MCS.[28] In another study conducted among frequent users of healthcare services, no association was found between HL and HRQoL on both PCS and MCS.[55] Two other studies[30 54] demonstrated that HL was not significantly associated with the mental component of HRQoL. A prospective cohort study of 4278 older adults in the UK showed that low HL significantly predicted declines in the physical, psychological and environmental domains of HRQoL but not in the social relationship HRQoL.[56] There are three reasons for this variance. First, most studies pay attention to the impact of general HL rather than specific HL on HRQoL. However, general HL includes the ability to obtain, process and understand all basic health information, not just a specific disease. Second, the various studies used different tools to measure HL and HRQoL. Last, the contradictory results were also likely due to differences in social and cultural factors, and in the study populations and sample sizes.

These results suggest that individuals with newly diagnosed pre-diabetes who have higher levels of DSHL may have higher HRQoL, especially for the mental health component. A potential explanation for the relationship between DSHL and the physical and mental components of HRQoL may be that low DSHL limits individuals' understanding of complex information about diabetes knowledge and prevention, and thus becomes a barrier to individuals' participation in diabetes education and intervention. Moreover, people with lower HL tend to have difficulty communicating, which prevents them from not only asking questions, but also clearly expressing their concerns, emotions, and needs to providers as well as seeking additional services, such as support for mental health.[50 53] Furthermore, a previous study found that subjects with low HL were three times more likely to have depression.[54] Considering that individuals with lower HL were more likely to have limited social activities, tiredness and psychological distress, lower DSHL may further limit individuals' ability to talk with their families and health education and care providers about difficult emotional issues or abstract psychosocial implications of diabetes. Thus, different DSHL groups may show differences in understanding and acceptance when faced with the same diabetes education information and intervention programmes. This process may be also associated with responsiveness during consultations and interventions. Individuals with lower levels of DSHL may not have knowledge of signs or symptoms of concern and may experience a psychological panic, reducing the MCS of HRQoL. The findings about the impact of DSHL on HRQoL in the prediabetic population could help us to identify new target groups and provide multifaceted and collaborative interventions to delay the development of type 2 diabetes. They also provide information that could contribute to assessments of the effects and cost-effectiveness of diabetes education and intervention. Healthcare staff should be aware of HL problems among elderly adults, and should simplify health-related information to increase the responsiveness of subjects with low HL during consultations and interventions. Although our findings were based on the results of a cross-sectional study, HRQoL could be viewed as an essential supplementary outcome in health surveys or intervention process; thus, it is important to carry out HRQoL monitoring to fully understand the health status of different HL groups. Furthermore, the finding that DSHL is associated with changes in HRQoL outcomes raises the need for testing the hypothesis of whether DSHL is a modifiable factor and, if so, considering whether interventions aimed at improving DSHL may also lead to improvements in HRQoL and health conditions in this population. Therefore, there are important public health implications of examining the association between DSHL and HRQoL.

Our study also revealed that individuals with pre-diabetes showed lower PCS than MCS, and the mean scores of the four domains of the mental health components were likewise higher than those of four subscales of the physical health components, which was consistent with the findings of other studies.[57 58] One explanation is that some elderly have difficulties in physical activities due to illness. A study has also shown that chronic diseases have a stronger effect on reducing physical function than psychological function.[59] Similar to the results of our study, elderly individuals with chronic disease, overweight or obesity and physical inactivity have lower scores on the subscales of physical function, BP and GH; however, these domains are components of the physical health aspect of HRQoL.

Our study also has several limitations. First, its cross-sectional design did not permit causal inferences. Furthermore, both cohort studies and randomised controlled trial designs garner a deeper understanding of the relationship between DSHL and HRQoL. Second, HL was measured using the public questionnaire of HL of diabetes mellitus. This may influence the way in which our study may be compared with previous studies, the majority of which measured multidimensional competences rather than a single competence of functional HL. Third, self-administered questionnaires were used to assess some variables, which might have introduced recall bias. However, this limitation was minimised because the instruments used in this study are valid and reliable. Finally, our study sample was taken from rural areas in one city of one province of China. Therefore, the generalisation of the results to other populations should be carefully considered.

CONCLUSIONS

In summary, lower DSHL was associated with poorer HRQoL among elderly individuals with pre-diabetes in rural areas in China, particularly in terms of the mental health component. These findings suggest that assessing and improving both DSHL and HRQoL may be important for individuals with pre-diabetes.

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