

# Mediating Role of Depressive Symptoms on the Association Between Neighborhood Social Cohesion and Quality of Life in Individuals with Type 2 Diabetes Mellitus

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**Purpose:** Few studies have explored the association between neighborhood social cohesion (NSC), a type of social capital, and the quality of life of patients with type 2 diabetes mellitus (T2DM). In addition, the potential mechanism for this association remains unclear. The current study examined the mediation effect of depressive symptoms on the relationship between NSC and quality of life among diabetes patients in China.

**Patients and Methods:** A cross-sectional study of 1747 T2DM patients was conducted. The specific quality of life (DSQL), Center for Epidemiological Survey Depression (CES-D), and social capital scales were administered using a face-to-face survey. Partial correlation analysis and a linear regression model were employed to explore the relationship between NSC, depressive symptoms, and quality of life. Bootstrap analysis using PROCESS was used to test the mediation model.

**Results:** After controlling for covariates, NSC was negatively correlated with depressive symptoms ( $r=-0.24$ ,  $P<0.01$ ) and DSQL score ( $r=-0.20$ ,  $P<0.01$ ) while depressive symptoms were positively correlated with DSQL score ( $r=0.46$ ,  $P<0.01$ ). Linear regression analysis also found that NSC was negatively associated with the DSQL score, while depressive symptoms were positively associated with the DSQL score. Depressive symptoms mediated the relationship between NSC and quality of life in T2DM patients (explaining 50.7% of the total variance).

**Conclusion:** NSC was positively associated with improved quality of life among Chinese T2DM patients in this study, and depressive symptoms were likely to partially explain this relationship. These findings may be used to help maintain a good quality of life among at-risk individuals. Additional prospective studies are needed to confirm these findings.

**Keywords:** neighborhood social cohesion, depressive symptoms, quality of life, mediating effect, T2DM patients

## Introduction

Diabetes mellitus is a global health problem that impacts approximately 467 million people worldwide.<sup>1</sup> The rate of diabetes has risen each year in China, reaching 116.4 million in 2019 and accounting for the highest prevalence globally.<sup>2</sup> Diabetes refers to a type of chronic metabolic disease caused by disorders in insulin secretion or utilization. Approximately 90% of diabetes mellitus cases are classified as Type 2 diabetes mellitus (T2DM).<sup>3</sup> Diabetes can cause many complications, including damage to the heart, blood vessels, eyes, kidneys, and nerves, resulting in both organic and functional diseases.<sup>2</sup> This illness harms the physical and mental health of patients, increases the economic burden on both individuals and society, and is a serious threat to human health and life.

The quality of life in individuals with T2DM is usually highly impacted<sup>4</sup> given the burden of living with this pathology.<sup>5</sup> Mexican patients living with T2DM were shown to experience high emotional distress and have a decreased quality of life.<sup>5</sup> It is reported that the quality of life of T2DM patients is directly associated with a multitude of factors including the educational and economic level of the patient, the use of self-care activities, attitudes about the disease and treatment, and related comorbidities.<sup>6,7</sup> Quality of life can be reflective of the severity of disease and is an important indicator for diabetes research. Thus, it is critical to identify factors that influence the quality of life in diabetes patients in order to develop more effective treatments.

Neighborhood social cohesion (NSC) is a type of social capital that refers to the network of relationships that encompass social bonds and shared values, as well as the norms of residents in a neighborhood.<sup>8</sup> NSC is associated with a number of beneficial health outcomes.<sup>9</sup> As a social determinant of health, NSC may play a critical role in the overall quality of life of diabetes patients. One study showed that NSC improves the quality of life of older diabetes patients by enhancing purpose and supporting an individual's capacity to achieve.<sup>10</sup> Another study found that lower social support was significantly associated with a decreased mental health component score for T2DM patient quality of life.<sup>11</sup> However, few studies have examined illness perception among T2DM patients in China or the potential mechanisms underlying the relationship between NSC and quality of life among patients with T2DM.

NSC has been associated with depressive symptoms.<sup>12–14</sup> A notable exception is a study by Rostila et al,<sup>15</sup> which suggested that depression is a function of the lack of social cohesion among people living in more equal countries. It was suggested that social ties within a neighborhood are a way for people to obtain the necessary resources and support in these countries and the absence of social cohesion could have important repercussions for the mental and physical health of adults.<sup>16</sup>

The present study investigated the relationship between NSC and quality of life among T2DM patients and explored the impact of depressive symptoms on this relationship. It was hypothesized that depressive symptoms mediated the relationship between NSC and quality of life in this population.

## Patients and Methods

### Study Design and Patients

Based on the geographic distribution and hospital level, 1747 T2DM inpatients were enrolled from 10 public hospitals (include 3 tertiary class A hospitals, 3 secondary class A hospitals, 3 tertiary class B hospitals and 1 secondary class B hospital) in all five cities of Ningxia from August 2019 to November 2020. A probability proportionate to size (PPS) sampling method was developed to recruit the participants. A similar sampling procedure was described previously.<sup>17</sup> The total sample size was evaluated by the formula:  $n = Z_{\alpha/2}^2 (1 - P)/\epsilon^2 P$ . According to a previous study, the prevalence of quality of life in Chinese diabetes patients was 55%.<sup>18</sup> Hence, we set  $P = 0.55$  in this study. If  $\alpha$  was 0.05,  $Z_{\alpha/2}$  was 1.96, and  $\epsilon = 0.05$ , the calculated sample size was 1257. To prevent an invalid survey sample, we increased the sample by 20%, which made the minimum sample size in the survey 1508. To prevent an invalid survey sample size, the sample was increased by 20%, making 571 the minimum sample size. Patients who met study eligibility criteria were invited to participate in the study. The inclusion criteria included patients  $\geq 18$  years of age who were living at their present address for at least 6 months. Individuals with a severe mental disorder or a severe illness or language barrier that prevented communication, who were pregnant or lactating, had diabetic ketoacidosis in the past month, had a malignant tumor, or refused to sign the informed consent were excluded. Research procedures of this study involving human participants conformed with the ethical standards of the Institutional Review Board of Ningxia Medical University and with the 1964 Helsinki declaration and the later amendments or similar ethical standards.

## Measures of Key Variables

### Measurement of Quality of Life

Quality of life was assessed using the 27 item (26 positive items and 1 negative item) diabetes-specific quality of life (DSQL) scale, a validated questionnaire developed by Liao et al<sup>19</sup> to assess quality of life among patients with T2DM in China. The scale includes four dimensions: (1) Physiological problems (12 items): the physical discomfort caused by

diabetes, the impact of the disease on sensory function and intelligence, and the impact of diabetes complications; (2) Psychological problems (8 items): the impact of diabetes on mental health, any unhealthy psychological problems, and confidence in disease treatment; (3) Social relationships (4 items): the degree of damage to interpersonal relationships caused by diabetes, and its impact on the economy, society and family status; (4) Therapy-related problems: satisfaction with treatment, the impact of adverse drug reactions, and the status of hypoglycemia and diet control. Each item ranges from 1 to 5 (1 = absolutely not, 2 = occasionally, 3 = about half of the time, 4 = often, and 5 = almost all the time). Higher scores indicate poorer quality of life.<sup>19</sup> Prior study have shown that the Chinese version of the DSQL scale has good reliability and validity.<sup>20</sup> The Cronbach's alpha was 0.91 in this study.

## Measurement of Neighborhood Social Cohesion

Neighborhood social cohesion was assessed using a validated questionnaire of four items developed by Mujahid et al that relate to unique neighborhood characteristics.<sup>21</sup> Each item was measured using a 1–5 Likert scale in which 1 represents strongly disagree and 5 represents strongly agree: 1) People around here are willing to help their neighbors, 2) People in my neighborhood generally get along with each other, 3) People in my neighborhood can be trusted, and 4) People in my neighborhood share the same values. The Cronbach's alpha was 0.81 among the Chinese general population,<sup>22</sup> and 0.96 for patients with T2DM.

## Measurement of Depressive Symptoms

The Center for Epidemiological Survey Depression (CES-D) scale, which is comprised of 20 items,<sup>23</sup> was used to screen for the presence and severity of depressive symptoms through epidemiological investigation or clinical examination over the last week. Each question was scored as “0” (not at all/less than one day), “1” (sometimes/1–2 days), “2” (more than half the days/3–4 days), or “3” (most of the time/5–7 days) giving a range of scores between 0 and 60, with higher scores indicating higher levels of depressive symptoms. The Chinese version of this scale has been validated and shown to be reliable.<sup>24</sup>

## Demographic, Lifestyle, and Clinical Characteristics

Demographic variables included age, gender (male vs female), ethnicity (Han vs minority), residence (urban vs rural), education level, marital status (unmarried vs married), occupation (farmer vs other), and family income (measured by the self-reported family average individual income per month). Patient lifestyle information was also collected, including smoking status, alcohol use, and physical activity. Clinical data relating to body mass index ( $BMI = \text{weight (kg)} / \text{height (m)}^2$ ), other (hypertension, hyperlipidemia, coronary heart disease, etc.) chronic diseases (yes vs no), T2DM complications (yes vs no), duration of T2DM (continuous data), and take medicine (yes vs no), were abstracted from the medical records.

## Statistical Analysis

The distributions of continuous variables were described as the mean  $\pm$  SD for normally distributed data. Categorical variables were expressed as counts and proportions. Partial correlation was used to create a correlation matrix after adjusting for covariates (age, gender, ethnicity, marital status, education, occupation, economic condition, residence, smoking, alcohol use, physical exercise, BMI, new cases of diabetes, other chronic diseases, disease duration, T2DM complications, and take medicine). A linear regression model was used to examine the association between NSC with depressive symptoms and quality of life among T2DM patients. Hayes et al.'s<sup>25</sup> PROCESS and modal 4 bootstrap method were employed to test the mediation effect of depressive symptoms on the relationship between neighborhood social cohesion and quality of life. The bias-corrected percentile bootstrap confidence interval did not contain 0 indicating that the mediation effect was statistically significant.<sup>26</sup> All analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (SPSS Inc., Chicago, Illinois).

## Results

### Demographic, Lifestyle, and Clinical Characteristics

The demographic, lifestyle and clinical information of the patient population are presented in Table 1. A total of 1747 enrolled patients included 958 males (54.8%) and 789 females (45.2%). The average age was  $58.6 \pm 12.1$  years. Almost

**Table 1** Demographic Characteristics of Patients

	Total (n=1747)
Age, mean (SD), years	58.6 (12.1)
Gender, male, n (%)	958 (54.8)
Ethnicity, Han, n (%)	1284 (73.5)
Residence, urban, n (%)	1095 (62.7)
Marital status, married, n (%)	1630 (93.3)
Education level, n (%)	
Illiterate	348 (19.9)
Primary	392 (22.4)
Junior and Senior	616 (35.3)
College degree or above	391 (22.4)
Occupation, farmer, n (%)	701 (40.1)
FPCMI, <2000, n (%)	680 (38.9)
Smoking, yes, n (%)	393 (22.5)
Alcohol use, yes, n (%)	365 (20.9)
Physical exercise, yes, n (%)	1169 (66.9)
BMI, mean (SD), kg/m <sup>2</sup>	24.9 (6.0)
New cases of diabetes, yes, n (%)	273 (15.6)
Other chronic diseases, yes, n (%)	1149 (65.8)
Disease duration, mean (SD), years	8.3 (7.5)
T2DM complications, yes, n (%)	1048 (60.0)
Take medicine, yes, n (%)	1457 (83.4)
NSC, mean (SD)	15.2 (3.1)
Depressive symptoms, mean (SD)	11.1 (7.3)
DSQL, mean (SD)	55.4 (12.0)

**Abbreviations:** FPCMI, family per capita monthly income; NSC, neighborhood social cohesion; SD, standard deviation; BMI, body mass index; T2DM, type 2 diabetes mellitus.

one-fifth of the patients were illiterate, and 93.3% were married. Most (65.8%) of the patients had a history of other chronic diseases, and 393 patients (22.5%) smoked. The mean neighborhood social cohesion score was 15.2 (SD=3.1), the mean CES-D score was 11.1 (SD=7.3), and the mean DSQL score was 55.4 (SD=12.0).

## The Binary Correlation Matrix

The partial correlation matrix is shown in Table 2. After controlling for age, gender, ethnicity, marital status, education, occupation, economic condition, residence, smoking, alcohol use, physical exercise, BMI, new cases of diabetes, other chronic diseases, disease duration, T2DM complications, and take medicine, NSC was negatively correlated with depressive symptoms ( $r=-0.24$ ,  $P<0.01$ ) and DSQL score ( $r=-0.20$ ,  $P<0.01$ ) while depressive symptoms were positively correlated with DSQL score ( $r=0.46$ ,  $P<0.01$ ).

**Table 2** Correlation Matrix (n=1747)

	Mean	SD	Neighborhood Social Cohesion	Depressive Symptoms	DSQL
NSC	15.2	3.1	I		
Depressive symptoms	11.1	7.3	-0.24**	I	
DSQL	55.4	12.0	-0.20**	0.46**	I

**Notes:** \*\* $p<0.01$ , \* $p<0.05$ , After controlling for age, gender, ethnicity, marital status, education, occupation, economic condition, residence, smoking, alcohol use, physical exercise, BMI, New cases of diabetes, other chronic diseases, disease duration, T2DM complications, take medicine.

**Abbreviations:** SD, standard deviation; NSC, neighborhood social cohesion; DSQL, diabetes specific quality of life.

## Linear Regression Analysis

In the three models, NSC was negatively associated with DSQL score and T2DM patients with strong NSC were predicted to have a better quality of life (Table 3). In contrast, depressive symptoms were positively associated with the DSQL score. When adding the interaction between NSC and depression (model 3), the moderate effect no longer existed ( $p=0.928$ ), indicating that depressive symptoms are a possible mediator.

## Mediation Effect of Depressive Symptoms on the Relationship Between NSC and Quality of Life Among T2DM Patients

After controlling for covariates, there was a significant mediation effect of depressive symptoms on the relationship between NSC and the quality of life of T2DM patients (Table 4). The results showed that both the direct ( $p<0.001$ ) and indirect ( $p<0.001$ ) effects were significant. The mediation effect explained 50.7% ( $-0.382/-0.754$ ) of the total variance.

## Discussion

To the best of our knowledge, this is the first study to investigate the relationship between NSC and quality of life among T2DM patients in China. As hypothesized, the results showed that (1) more than half (58.6%) of T2DM patient DSQL scores were higher than the mean value, (2) NSC was negatively associated with the DSQL and CES-D scores of T2DM patients, respectively while CES-D score was positively related to the DSQL score, and (3) depressive symptoms mediated the association between NSC and quality of life, accounting for 50.7% of the total effect.

This study found that 58.6% of T2DM patients with lower quality of life had a median of 54 points, higher than a previous study that reported a median of 50.1 points.<sup>27</sup> This may be due to differences in the study samples, survey

**Table 3** Linear Regression Model for Interaction Between NSC and Depressive Symptoms on DSQL (n=1747)

Variables	Model 1		Model 2		Model 3	
	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)	P value	$\beta$ (95% CI)
NSC	<0.001	-0.57 (-0.75, -0.38)	<0.001	-0.37 (-0.53, -0.20)	0.011	-0.35 (-0.63, -0.08)
Depressive symptoms	<0.001	0.81 (0.74, 0.88)	<0.001	0.73 (0.65, 0.79)	<0.001	0.74 (0.43, 1.04)
Age	NA	NA	0.314	0.02 (-0.02, 0.07)	0.321	0.02 (-0.02, 0.07)
Gender (reference=female)	NA	NA	0.903	-0.07 (-1.26, 1.12)	0.900	-0.08 (-1.93, 0.38)
Ethnicity (reference=minority)	NA	NA	0.187	-0.78 (-1.93, 0.38)	0.187	-0.78 (-1.93, 0.38)
Residence (reference=rural)	NA	NA	0.003	-2.02 (-3.35, -0.70)	0.003	-2.02 (-3.35, -0.70)
Marital status (reference=married)	NA	NA	0.009	-2.60 (-4.56, -0.64)	0.010	-2.60 (-4.56, -0.63)
Education (reference=illiterate)	NA	NA	0.001	-1.18 (-1.86, -0.49)	0.001	-1.18 (-1.86, -0.49)
Occupation (reference=non-farmers)	NA	NA	0.761	-0.22 (-1.67, 1.22)	0.763	-0.22 (-1.67, 1.22)
FPCMI	NA	NA	<0.001	1.17 (0.72, 1.63)	<0.001	1.17 (0.72, 1.63)
Smoking (reference=no)	NA	NA	0.994	0.05 (-1.35, 1.45)	0.941	0.05 (-1.35, 1.45)
Alcohol use (reference=no)	NA	NA	0.091	1.23 (-0.19, 2.65)	0.090	1.23 (-0.19, 2.65)
Physical exercise (reference=no)	NA	NA	0.119	0.83 (-0.21, 1.88)	0.120	0.83 (-0.22, 1.88)
BMI	NA	NA	0.101	-0.07 (-0.15, 0.01)	0.101	-0.07 (-0.15, 0.01)
New cases of diabetes (reference=no)	NA	NA	0.002	-2.56 (-4.17, -0.96)	0.002	-2.57 (-4.17, -0.96)
Other chronic diseases (reference=no)	NA	NA	0.019	1.31 (0.21, 2.41)	0.019	1.31 (0.21, 2.41)
T2DM complications (reference=no)	NA	NA	<0.001	2.96 (1.88, 4.04)	<0.001	2.96 (1.88, 4.04)
Disease duration	NA	NA	<0.001	0.24 (0.16, 0.32)	<0.001	0.24 (0.16, 0.32)
Take medicine (reference=no)	NA	NA	0.239	-0.83 (-2.22, 0.55)	0.239	-0.83 (-2.22, 0.55)
NSC $\times$ Depressive symptoms	NA	NA	NA	NA	0.928	-0.01 (-0.02, 0.02)

**Notes:** Model 1 = social cohesion or depressive symptoms separately; Model 2 = Model 1 + covariates (age, gender, ethnicity, marital status, education, occupation, economic condition, residence, smoking, alcohol use, physical exercise, BMI, new cases of diabetes, other chronic diseases, disease duration, T2DM complications, take medicine); Model 3 = Model 2 + interaction between social cohesion and depressive symptoms.

**Abbreviations:** NSC, neighborhood social cohesion; DSQL, diabetes specific quality of life; FPCMI, family per capita monthly income;  $\beta$ ,  $\beta$  value; 95% CI, 95% confidence interval; NA, not apply.

**Table 4** The Mediating Effect of Depressive Symptoms on the Relationship Between Neighborhood Social Cohesion and DSQL\*

Effect				Bias-Corrected 95% CI	
	$\beta$	SE	P value	Lower	Upper
Total effect	-0.754	0.088	<0.001	-0.926	-0.582
Indirect Effects	-0.382	0.047	<0.001	-0.477	-0.294
Direct Effects	-0.372	0.082	<0.001	-0.533	-0.212

**Notes:** \*After controlling for age, gender, ethnicity, marital status, education, occupation, economic condition, residence, smoking, alcohol use, physical exercise, BMI, new cases of diabetes, other chronic diseases, disease duration, T2DM complications, take medicine.

sites, or survey questions. The possible reasons for the lower quality of life in T2DM patients include the duration of diabetes, the coexistence of various health problems, and disease complications<sup>28</sup> Moreover, similar to previous studies, NSC, as a type of social capital, was negatively associated with DSQL score and positively correlated with the quality of life among T2DM patients. Several studies showed that social capital was positively associated with quality of life in adults,<sup>29</sup> old people,<sup>30</sup> and patients with various conditions.<sup>31</sup> A significant relationship was also observed between quality of life and social capital among diabetic patients in Iran.<sup>32</sup> In addition, Hu et al found that social capital was positively associated with quality of life among Chinese T2DM patients.<sup>33</sup> This may be because a higher level of neighborhood social cohesion provides a stronger social network that encourages individuals to engage in healthy behaviors in a socially cohesive environment.<sup>34</sup> In addition, social capital may contribute to glucose control during diabetes, thereby improving diabetes symptoms,<sup>35</sup> and further improving the quality of life of T2DM patients.

Depressive symptoms occurred more often among patients with lower NSC indicating a negative correlation between depression and NSC. A separate study found that individuals who perceived a higher level of NSC had a lower rate of depression.<sup>36,37</sup> These results indicate that NSC should be considered when taking measures to address depression among T2DM patients. As shown previously, depressive symptoms in this study were significantly associated with quality of life among T2DM patients.<sup>38</sup> Egede and Ellis<sup>39</sup> also found that depression was significantly associated with decreased quality of life among T2DM patients. In summary, NSC is positively associated with quality of life and so should be considered a protective factor for the quality of life of T2DM patients. Patients with low NSC are more likely to have depressive symptoms, which in turn results in poor quality of life. Logically speaking, individuals with good sleep quality appear to affect their psychological status and further to influence quality of life among T2DM patients in this study. Hence, in clinical, medical personnel could pay more attention to patients' psychological health and lifestyle as well as physical health. However, this finding lacks prospective studies support, and further exploration is necessary in the future with a cohort study.

This study has several limitations. First, causal inferences between NSC and quality of life among T2DM patients cannot be made because of the study's cross-sectional design. A prospective study will be required to confirm and extend these findings. Second, other potential mediators of the relationship between NSC and quality of life, such as illness perception, were not assessed. Third, the patients were from a single region, the Ning Province, so the findings may not be representative of individuals in other areas of China or in different countries.

## Conclusions

This study shows that neighborhood social cohesion is positively associated with quality of life among T2DM patients, and depressive symptoms partly mediate this relationship. These findings provide primary evidence to better understand how NSC is related to the development of depressive symptoms in order to further improve the quality of life of T2DM patients. Clinicians should encourage patients to interact more with others to improve social capital, and in turn, maintain a good quality of life.

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## Disclosure

The authors report no conflicts of interest in this work.

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