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Blood glucose control among type 2 diabetic farmers in Chinese resettlement areas: a mixed methods study

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Abstract

Background Due to China's rapid urbanization, many farmers have relocated to urban resettlement regions. There is limited research on the glycemic control of Type 2 diabetes mellitus (T2DM) farmers in these areas. This study examined their blood glucose control and its determinants.

Methods This study took place from March 2021 to January 2022 in a resettlement community in Yiwu, Zhejiang Province, China. In the first phase, a quantitative survey of 181 T2DM farmers was conducted using a questionnaire to gather demographic data, blood glucose control status, disease cognition levels, and treatment compliance. Inclusion criteria were migrant workers with ≥ 3 months of residence and local household registration and T2DM patients who met the diagnostic criteria of the Chinese guidelines. In the second phase, qualitative research involved face-to-face, semi-structured interviews with 15 patients with varying blood glucose control levels to analyze their experiences.

Results The blood glucose control rate in this particular group was 27.62%, and the average disease cognition score was 2.5 ± 0.75. Many patients (67.96%) had inadequate treatment compliance, specifically in monitoring compliance (4.45 ± 1.92) and regular review compliance (3.58 ± 1.74).

Conclusion There is a need for tailored programs to improve glycemic control among resettled farmers. Enhancing disease awareness and treatment compliance through targeted education and support is crucial. Further studies are needed to evaluate different treatment regimens' impact on glycemic control.

Clinical trial number Not applicable.

Keywords Diabetes, Glycemic management, Rural communities, Agricultural workers

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Background

Diabetes is a significant public health problem affecting human health. The prevalence of diabetes in China in 2017 was 11.20%, of which approximately 90% were patients with type 2 diabetes mellitus (T2DM) [1, 2]. Currently, there is no cure for diabetes. As the disease progresses, long-term failure to control blood glucose has irreversibly damaged patients' microvascular, macrovascular, nervous systems, diabetic foot, etc. Various complications have become the leading cause of disability and death in patients with diabetes, burdensome to society, families, and individual patients [3–5].

Studies have shown that strict blood glucose control in patients with early diabetes can significantly reduce the risk of complications, such as diabetic microangiopathy, myocardial infarction, and mortality [6]. According to previous studies, HbA1c control is at an average of 6.6%, including 20% of patients with diabetes aged > 50 years without diabetic complications [7]. Good self-management and health care conditions have been confirmed to positively affect blood glucose control in elderly patients with diabetes. However, the blood glucose levels in Chinese patients with diabetes are not optimal. Only 49.2% of Chinese patients with diabetes were under control in 2013, which is still low, especially in famer groups [1, 8].

Since the early 2000s, China has experienced rapid urbanization, with 100 million farmers predicted to live in resettled areas by 2030 [9]. Resettled farmers are an important and special group of farmers arising from rapid urbanization. Various policy differences result in difficulties in employment, social security, disease burden, and health care [9, 10]. Furthermore, cultural differences, health literacy, disease awareness, and other factors make managing diabetes more challenging. However, there are few reports on the epidemiology and management of diabetes in resettled areas.

Blood glucose control in diabetes is related to many factors including obesity, age, smoking, education level, disease cognition, treatment compliance, and health education [11, 12]. As a demonstration province for common prosperity in China, Zhejiang Province exhibits significant urbanization and has established a comprehensive land acquisition compensation mechanism. Yiwu, located in the central region of Zhejiang, is a relatively developed area with representative characteristics in land acquisition and resettlement of farmers, ensuring an adequate sample size. Therefore, this study takes Yiwu City in Zhejiang Province as a case example to investigate the current situation of blood glucose control in farmers with T2DM in resettlement areas, conducts face-to-face and semi-structured in-depth interviews with patients, and analyzes the causes and authentic experience with different blood glucose control status, in order to help relevant practitioners formulate interventions to control blood glucose levels effectively.

This study adopts an explanatory sequence design of the mixed empirical method, which is divided into two stages. First, a cross-sectional study was conducted. Survey data were collected and analyzed for blood glucose control, disease awareness, and treatment compliance among T2DM farmers in resettlement areas to identify the questions to be raised in the qualitative research based on the analysis results. Second, semi-structured interviews were used to collect and analyze qualitative data to examine the reasons for the differences in blood glucose control in T2DM patients and their experiences. Figure 1 shows the process in detail.

Materials and methods

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting this study [13].

Participants and indicators and tools

Participants

We screened 2,966 farmers in a resettlement community after land requisition in Yiwu, Zhejiang Province, China, between March 2021 and January 2022 using convenience sampling. Based on the sample size calculation formula $n = \frac{z^2 \bullet p \bullet (1-p)}{d^2}$, at least 169 subjects were required for this study, considering a 10-20% sample loss rate. A total of 181 subjects were included in our study for the questionnaire, based on our inclusion and exclusion criteria, with no dropouts or missing subjects. Among these, 15 subjects were selected for in-depth interviews.

The inclusion criteria were as follows: (1) resettlement farmers with residence time ≥ 3 months and local household registration; and (2) According to the Chinese guidelines for the prevention and treatment of T2DM, patients with T2DM who satisfied the diagnostic criteria. (3) adult patients aged 18 years and older.

Exclusion criteria were: (1) persons with obvious psychiatric and personality disorders; (2) those with unclear consciousness, non-cooperation, and unclear language expression; and (3) patients who were unwilling to sign the informed consent form.

Indicators and tools

(1) According to WHO/ADA standard: The effective control rate of fasting blood glucose (FPG) was 4.4-7.0 mmol/L, glaciated hemoglobin (HbA_1c) was ≤7.0% [14]. This study divided the 181 research subjects into Group 1 (blood glucose control compliance group) with HbA1c ≤ 7.0% and Group 2 (unmet glycemic control group) with HbA1c > 7.0%, based on laboratory indicators. It further conducted a comparative analysis to

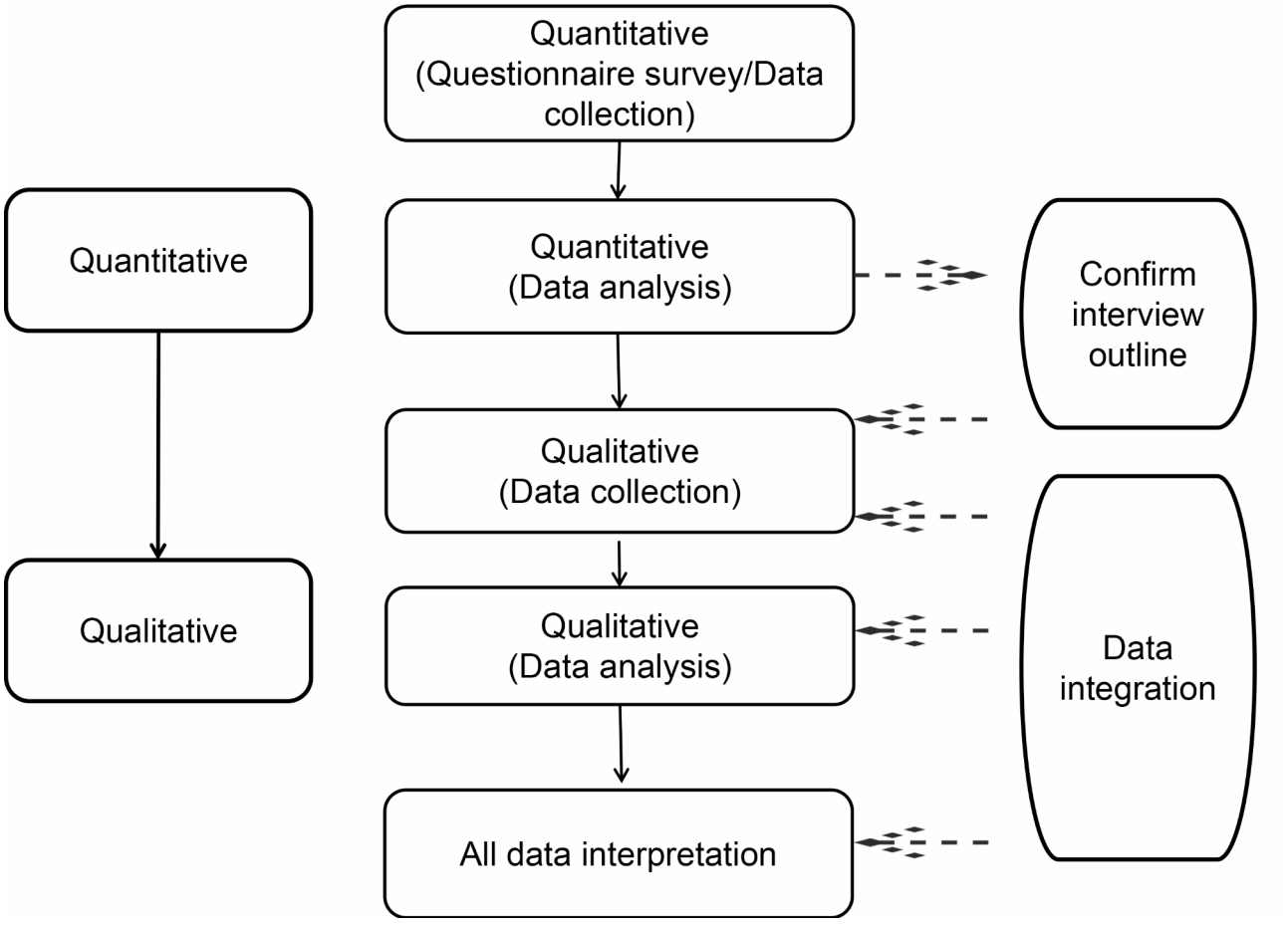

Fig. 1 Flow chart of research design method

identify specific factors influencing the differences in blood glucose control levels between the two groups.

(2) The Brief Illness Perception Questionnaire (BIPQ) [15]: Cronbach 's α coefficient of the BIPQ was 0.84, and the disease cognition of patients was evaluated from nine aspects of disease consequences, time characteristics, personal control, treatment control, disease identity, disease worry, disease understanding ability, emotional response, and disease causes. Each question had a score of 10 except for the last disease cause. The higher the total BIPQ score, the better the patient's understanding of the illness.

(3) Diabetes treatment compliance scale [16]: A 1–3 grade scoring method was used to evaluate treatment compliance based on five aspects: drugs, diet, exercise, self-monitoring, and regular review. Scores of 40–60 indicate good compliance, whereas scores below 40 were considered poor. Higher scores indicated better compliance with self-management. The Cronbach's α was 0.86, and the Cronbach's α for each dimension were 0.85, 0.84, 0.79, 0.78, and 0.82.

Grouping and criteria

Based on the study's objectives, the 181 subjects were divided into two groups according to their laboratory HbA1c levels: Group 1, with HbA1c≤7.0%, representing the blood glucose control group, and Group 2, with HbA1c>7.0%, representing the non-blood glucose control group. By grouping the data, we can directly compare factors such as the duration of diabetes, age, gender, and the presence of complications between the two groups. This allows for a more detailed analysis of the specific factors affecting blood glucose control in this population.

Questionnaire administration

The study was designed and overseen by the principal investigator, who was also responsible for training the research team. Four additional researchers participated in the study, all of whom received standardized training and passed assessments. The training covered the instructions for the questionnaire and the meanings of its items. All questionnaires were distributed and collected on-site, ensuring completeness and accuracy by immediately addressing any missing or incorrectly filled items. Questionnaires with more than 5% of items left

unanswered or incorrectly filled were deemed invalid. The surveys were administered by five researchers who visited the community, distributed the questionnaires, and assisted patients in completing them.

The questionnaire included general patient information, the BIPQ, and a treatment compliance scale. Researchers first obtained patient consent, explained the study's purpose and content, and then distributed the questionnaires. Patients completed the questionnaires independently; if they were unable to do so, researchers read the items aloud and recorded their responses. The collected questionnaires were double-entered into the Epdata 3.0 software by two researchers, and consistency checks were performed to ensure data accuracy.

Interview outline development

We initially drafted an interview outline, which underwent revisions after seeking advice from a diverse group of experts, including a general practitioner, a professor of preventive medicine, a diabetes specialist nurse, and a professor of nursing. Then, we conducted preliminary interviews with two patients to further refine the outline. The interview outline was finalized, with the following core contents: (1) How do you understand T2DM? (2) How do you manage your blood sugar level in your daily life? (3) How does T2DM and glycemic control affect health and quality of life? Emotionally, how are you affected? In the interview outline, the order of each topic was flexible and could be adjusted, if necessary. Face-to-face and in-depth interviews were conducted to collect interview data. A purposive sampling method was adopted to select T2DM patients of different ages, sexes, diabetes duration, blood glucose control, disease cognition, and treatment compliance based on the maximum difference method. In this step, information saturation occurs when a new patient repeats the content of the previous subject, thus ending the collection process.

Data collection

Quantitative research

(1) The questionnaires included patients' general information, the BIPQ, and the treatment compliance scale. First, the researcher obtained consent from the patients and explained the purpose and content of the study. Questionnaires were distributed on the spot for participants to complete. If they could not fill the questionnaires due to illiteracy, the researcher read them one by one and wrote them down based on what the patient said. It took approximately 20 min to complete the questionnaires. Before commencing the study, a group of four researchers collectively underwent a comprehensive training session encompassing instructions on the questionnaire administration and its associated components. The completed questionnaires were reviewed for their completeness and quality. If items were missing, they were replenished. If there were any questions, they were asked and verified again to ensure the completeness and authenticity of the questionnaire. Multiple choices, incorrect filling, or omissions of more than 5% were regarded as invalid questionnaires. (2) Laboratory indicators: the participants were notified one day before fasting for more than 10 h overnight and the next day blood sampling test time, place (in the hospital laboratory center). The following morning (07:30 − 08:30), three researchers drew about 5 mL of blood from each participant's elbow vein. The blood was kept in the coagulation tube and analyzed using an automatic biochemical analyzer (TOSOH, Japan) by hospital professional laboratory personnel to determine the patient's FPG and HbAlc values.

Qualitative research

For this study, data were collected through face-to-face semi-structured interviews. The interviewees were informed about the purpose of the study and assured that their recordings would only be used for academic purposes. The time and location of the interviews were communicated to the interviewees one week in advance. Once the interviewees agreed to participate and signed the informed consent form, the interview commenced. The entire interview process lasted 15 min. Fifteen patients participated in the interview and were assigned numbers A-O based on their entry order. During the interviews, the patient's name was replaced with letters to protect the interviewer's privacy. Two researchers, who were blinded to the patients, conducted the interviews. Interviews were recorded to capture the content and non-verbal behavior of the interviewees. Through questioning, repetition, summarizing, and responding, interviewees' views were clarified and confirmed in a timely manner. The researchers ensured the accuracy and authenticity of the data, took notes, made memoranda, and avoided asking leading questions.

Ethical considerations

The participants volunteered to participate in this study and have no conflicts of interest. The hospital ethics committee approved this study (K2021104).

Statistical methods

Quantitative study

Using Epdate 3.0, two participants entered the questionnaire and checked for consistency. The input data were analyzed using SPSS 22.0. The measurement data are expressed as mean ± standard deviation (SD), and the differences between groups were compared using an independent sample t-test. Count data are expressed as frequency and percentage, and the chi-square test was

used for comparison between groups. $P<0.05$ indicated that the difference was considered statistically significant.

Qualitative research

To avoid bias resulting from personal judgment, researchers used the consensus method in this study. Data collection and analysis were synchronized. Within 24 h of the end of each interview, one researcher collated the audio data into Word documents, and the other checked the voice and transcription data and returned the text data to the respondents for verification to improve the credibility of the results. Using the BRAUN thematic analysis method to analyze data [17]: (1) it was read by two researchers independently, familiar with the transcription data, in order to get an overall understanding of the data; (2) open coding of data; (3) identifying and summarizing codes with similar or related meanings and forming potential themes; (4) integrate themes, make theme maps, and clarify the scope and definition of themes; and (5) two researchers determine the theme and sub-theme after deliberation and discussion. When opinions were inconsistent in the analysis process, they were discussed with other members of the research group and finally decided.

Results

Quantitative research results

Demographic data

A total of 181 questionnaires were distributed and successfully recovered, yielding a 100% recovery rate. As Table 1 illustrates, the prevalence of T2DM among farmers in the resettlement community stands at 6.10%, with an effective blood glucose control rate of 27.62%. The average age of the population is 62.43 years, showing no significant variance between the two study groups. Notably, Group 1 has a slightly longer diabetes diagnosis duration (3.28 years) compared to Group 2 (2.93 years). Group 1 also features a higher female representation (62%) than Group 2 (47.33%). No discernible difference in BMI categories was observed.

Regarding education, a larger proportion of Group 1 (82%) has an education level below secondary school versus Group 2 (64.90%). Income-wise, Group 1 reports a lower personal annual income (≥20,000 YUAN) relative to Group 2. Drinking and smoking habits are more prevalent among Group 2 participants. No notable disparities in comorbidities or past medical histories exist between the two groups. Overall, 28.18% of the population reports a family history of diabetes, evenly distributed across both groups.

Disease cognition and treatment compliance of subjects

Significant disparities emerge between Group 1 and Group 2 in terms of diabetes cognition and treatment understanding. Specifically, Group 1 participants exhibit a stronger grasp of diabetes and its treatment duration (t=2.70, $p=0.008$) than their Group 2 counterparts. They also demonstrate superior diabetes knowledge (t=4.09, $p<0.001$) and a heightened awareness of the psychological impacts of the disease (t=3.64, $p<0.001$). Additionally, Group 1 members are more likely to believe in the heritability of diabetes (t=3.35, $p=0.001$) and report better self-management of blood glucose levels (t=3.08, $p=0.002$). However, both groups show similar understanding regarding abnormal blood sugar control awareness (t=1.57, $p=0.118$) and the overall life impact of diabetes (t=1.06, $p=0.290$) (Table 2).

In terms of treatment compliance, Group 1 consistently outperforms Group 2. They exhibit higher adherence across all treatment aspects, particularly in drug compliance (t=1.93, $p=0.055$) and dietary adherence (t=3.24, $p=0.001$). While exercise adherence doesn't show a statistically significant difference (t=0.41, $p=0.682$), Group 1 demonstrates better compliance with regular checkups (t=2.38, $p=0.018$) and self-monitoring (t=2.40, $p=0.017$). Overall, Group 1's aggregate compliance score is significantly higher (t=3.25, $p=0.001$), with 32.04% showing good compliance compared to 67.96% with poor compliance (Table 3).

Qualitative research results

Basic information of qualitative research objects

Eventually, 15 patients with type 2 diabetes in community resettlement farmers were selected as qualitative research subjects as A-O. We conducted 15 interviews, averaging (27.0±9.5) minutes (15–55). Eight patients had blood glucose levels that met the standard, and seven did not. Other essential data are listed in Table 4.

Interview results

Identifying real-world experiences and causes of differences in disease cognition and treatment compliance between patients with and without blood glucose control.

Disease cognition

(1) Lack of T2DM knowledge: People who had reached the standard of blood glucose control have a strong demand for diabetes knowledge and hope to understand the relevant knowledge, such as causes, prevention, and treatments. L: "My disease is always important to me. I hope someone can explain how it develops and what can be observed daily." N: "Generally, I read books and surf the Internet to obtain diabetes-related information and knowledge; however, too many things are presented online. In my case, I do not know what is useful for me, and I am hoping that professionals can guide me."

Table 1 Summary of the associations between demographic and FPG and HbA_1c ($n=181$)

Item	Total($n=181$)		Group 1($n=50$)	Group 2($n=131$)	Statistic	*P*
Age (y, mean ± SD)	62.43 ± 13.76		64 ± 12.43	61.83 ± 14.24	-0.95[1]	0.35
≤ 18 (y, %)	0	0	0	0	9.83[2]	0.01
18 ~ 40 (y, %)	14	7.73%	3(6.00%)	11(8.40%)		
40 ~ 65 (y, %)	85	46.96%	15(30.00%)	70(53.44%)		
>65 (y, %)	82	45.30%	32(64.00%)	50(38.16%)		
Diabetes diagnosis time (y, mean ± SD)	1.15 ± 0.54		3.28 ± 1.77	2.93 ± 1.04	28.99[1]	0.00
≤ 1(y, %)	30	16.57%	3(6.00%)	27(20.61%)	161.23[2]	0.00
1 ~ 5(y, %)	78	43.09%	23(46.00%)	55(41.98%)		
5 ~ 10(y, %)	43	23.77%	13(26.00%)	30(16.57%)		
>10(y, %)	30	16.57%	11(22.00%)	19(6.00%)		
Sexuality						
males(%)	88	48.62%	19(38.00%)	69(52.67%)	5.79[2]	0.02
female(%)	93	51.38%	31(62.00%)	62(47.33%)		
BMI						
<24 kg/m^2	47	25.97%	12(24.00%)	35(25.90%)	0.06[2]	0.97
24 ~ 27.9 kg/m^2	68	37.57%	20(40.00%)	48(37.10%)		
≥ 28 kg/m^2	66	36.46%	18(36.00%)	48(37.10%)		
Level of education(%)						
Below secondary school	126	69.61%	41(82.00%)	85(64.90%)	5.01[2]	0.03
Above secondary school	55	30.39%	9(18.00%)	46(35.10%)		
Personal annual income(¥, %)						
≥ 20,000 (≈ 2750.44$ or 2550.39€)	115	63.54%	17(34.00%)	98(74.81%)	26.01[2]	0.00
<20,000 (≈ 2750.44$ or 2550.39€)	66	36.46%	33(66.00%)	33(25.19%)		
Drinking(%)						
find	82	45.30%	14(28.00%)	68(76.67%)	8.35[2]	0.004
nil	99	54.70%	36(72.00%)	63(70.25%)		
Smoking(%)						
find	48	26.52%	9(18.00%)	39(29.77%)	5.30[2]	0.02
nil	133	73.48%	41(82.00%)	92(70.23%)		
Complication(%)						
find	55	30.39%	14(28.00%)	41(31.27%)	0.19[2]	0.67
nil	126	69.61%	36(72.00%)	90(68.73%)		
Previous medical history (%)						
find	107	59.12%	36(72.00%)	71(54.20%)	4.75[2]	0.03
nil	74	40.88%	14(28.00%)	60(45.80%)		
Family medical history (%)						
find	51	28.18%	14(28.00%)	37(72.55%)	264[2]	0.00
nil	93	50.83%	10(20.00%)	83(89.25%)		
non consta	37	20.99%	26(52.00%)	11(29.73%)		
FPG (mmol/L)						
	8.18 ± 2.88		5.76 ± 1.01	9.12 ± 2.12	8.21[1]	0.00
HbA_1c (%)						
	8.17 ± 2.38		5.96 ± 0.80	9.03 ± 2.23	9.48[1]	0.00

1: t-text value; 2: χ^2, Chi-square value; Group 1: Blood glucose control compliance group; Group 2: Unmet glycemic control group; BMI: body mass index; FPG: fasting blood-glucose; HbA_1c: glycated hemoglobin

People who did't reach this standard mostly gained knowledge from discussions between patients or their doctors' advice, needing more initiative and enthusiasm to learn. D: "I do not know anything; many people in our community have diabetes. I occasionally hear them say what they cannot eat or do; I pay attention."

(2) Emotional response and disease anxiety differed significantly: people who had reached the standard of blood glucose control had excessive stress emotions, such as regret or more serious social support pressure for previous unscientific control behaviors. G: "Previously, I did not control my blood sugar, eating randomly, until I spent money on a dizzy

Table 2 Status of Disease Cognition ($n=181$)

Item	Aggregate score	Average score (mean ± SD)	Group 1 ($n=50$)	Group 2 ($n=131$)	t-value	*P*
Perception of diabetes and treatment duration.	216	2.08 ± 0.62	2.24 ± 0.58	1.99 ± 0.63	2.70	0.008
Awareness of abnormal blood sugar control	128	1.23 ± 0.59	1.32 ± 0.61	1.19 ± 0.58	1.57	0.118
Knowledge about diabetes	223	2.14 ± 0.72	2.42 ± 0.68	1.99 ± 0.70	4.09	< 0.001
Impact of diabetes on life	260	2.5 ± 0.75	2.58 ± 0.79	2.46 ± 0.73	1.06	0.290
Psychological impact of diabetes	212	2.04 ± 0.62	2.26 ± 0.60	1.93 ± 0.61	3.64	< 0.001
Belief in diabetes inheritance	212	2.04 ± 0.82	2.30 ± 0.83	1.90 ± 0.79	3.35	0.001
Self-control of blood glucose	161	1.55 ± 0.81	1.80 ± 0.82	1.43 ± 0.78	3.08	0.002
Total score	1412	13.67 ± 2.86	14.65 ± 2.68	13.18 ± 2.91	3.52	< 0.001

Table 3 Status of treatment compliance ($n=181$)

Item	Maximum value	Minimum value	Average score (mean ± SD)	Group 1 ($n=50$)	Group 2 ($n=131$)	t-value	*P*
Drug compliance	12	6	9.31 ± 2.06	9.65 ± 1.85	9.10 ± 2.10	1.93	0.055
Diet compliance	12	7	9.17 ± 2.25	9.75 ± 1.95	8.85 ± 2.25	3.24	0.001
Exercise adherence	12	5	8.37 ± 2.48	8.45 ± 2.35	8.32 ± 2.50	0.41	0.682
Regular review compliance	6	3	4.45 ± 1.92	4.80 ± 1.75	4.25 ± 1.85	2.38	0.018
Self-monitoring compliance	5	3	3.58 ± 1.74	3.90 ± 1.60	3.38 ± 1.70	2.40	0.017
Total score	47	19	38.71 ± 6.99	40.50 ± 6.50	37.50 ± 6.80	3.25	0.001
Good compliance	58	32.04%	P<0.05				
Poor compliance	123	67.96%					

Table 4 Data of 15 interviewers ($n=15$)

Numbering	Sexuality	Age(y)	Duration of diabetes (yr)	Disease cognition score	Treatment compliance score	Blood glucose control	Level of education
A	males	47	2	17	22	non-reaching standard	Above secondary school
B	males	55	5	24	38	non-reaching standard	Above secondary school
C	female	72	12	43	47	compliance	Below secondary school
D	males	53	2	21	33	non-reaching standard	Below secondary school
E	female	49	3	36	47	compliance	Below secondary school
F	female	35	3	22	36	non-reaching standard	Above secondary school
G	female	39	1	32	44	compliance	Above secondary school
H	female	66	25	32	43	compliance	Below secondary school
I	males	62	8	22	39	non-reaching standard	Below secondary school
J	males	68	17	25	41	compliance	Below secondary school
K	males	32	5	27	33	non-reaching standard	Above secondary school
L	female	53	1	41	45	compliance	Above secondary school
M	males	27	3	22	36	non-reaching standard	Above secondary school
N	males	67	13	41	42	compliance	Below secondary school
0	female	57	15	37	44	compliance	Below secondary school

hospitalization to control it. I must control it, but I am feeling late now." C: "Although I do not have good blood sugar control, it has not been uncomfortable. I did not tell my wife because she had surgery, was elderly, and was afraid of him worrying." O: "My husband helped me share much housework, and now I always have poor glycemic control. I feel guilty about him." People who did't reach this standard lack the experience of psychological fluctuation caused by disease, and most of them avoid the reality of disease and maintain the life experience of ordinary people. A: "Whether my blood glucose is controlled or uncontrolled, I will not die, so I have never been afraid." M: "I'm not old, so I do not want to deal with these things or be dragged down by disease.".

Self-control beliefs

People who had achieved the standard of blood glucose control still exhibit insufficient self-control beliefs and regret about it. G: "Previously, I did not control my blood sugar, eating randomly, until I spent money on a

dizzy hospitalization to control it. I must control it, but I am feeling late now." People who had not reached the standard of blood glucose control not only lack belief, but also show indifference. F: "There is too much housework for me to think about. In addition, I did not feel this. If there is something wrong, I will go to the hospital."

Treatment compliance

(1) Difficulty in taking appropriate diabetes control measures: Someone considered T2DM a chronic disease and strived for good self-management. However, they did not understand how to monitor the control effect and even resorted to excessive compensation behavior, such as monitoring blood sugar frequently, reduce food intake, so that hypoglycemia occurred. H: "Diabetes is a lifelong disease. It will accompany me until death. I control my diet. Although I have fainted several times due to hypoglycemia, as long as I don't go out often, there will be no problem."

(2) Lack of emphasis on continuous treatment: Most patients rely on their own sensation to determine whether treatment is needed, and when there are no obvious symptoms, they will discontinue treatment. C: "Taking medicine on time and eating less is all I can control because I am old, and my legs are uncomfortable. The doctor told me to exercise more, but I could not." I: "I have been at home anyway, feel uncomfortable eating less or taking medicine, no feeling will not eat." K: "I have discomfort going to the hospital directly. If normal, will not deal with it." A: "What is the point at which my blood sugar is controlled? I don't care, and I have not had any problems."

Social and psychological impact

Insufficient understanding of the harm caused by the disease, social pressure, and other factors lead to a lack of emphasis on treatment. Someone pay too much attention, which the diabetes causes destructive effects on their social interactions. J: "Diabetes has a great impact on me. After getting it, I am worried that I will inherit it from future generations and prevent my son from marrying his daughter-in-law. Therefore, I did not go to the hospital for medicine." Blood glucose control is often neglected by those who fail to meet standards owing to subjective awareness, travel inconvenience, and other factors. K: "Whenever I go to the hospital for a review, I have to wait a long time, which is very inconvenient. After several visits, I no longer want to go."

Discussion

This study delves into the glycemic control status and its determinants among T2DM farmers residing in resettlement areas amidst China's rapid urbanization. Employing a mixed-methods approach, which integrates both quantitative and qualitative analyses, the research sheds light on the peculiarities and challenges faced by this specific population in diabetes management.

The study found that despite the improved quality of life experienced by these farmers, such as the receipt of economic subsidies and medical insurance, many of them still maintain healthy farming and vegetarian dietary habits [18, 19]. This, to a certain extent, explains the lower prevalence rate of T2DM (6.10%) in this resettlement area compared to the national average (11.2%) [1]. Nonetheless, the glycemic control rate among this population stands at merely 27.62%, significantly lower than the national control level of 49.2% [1]. This indicates that despite the improvement in living standards, the glycemic control situation among this group remains concerning. This finding underscores the importance and urgency of developing effective intervention measures tailored specifically for this unique population.

The survey uncovered a prevalent occurrence of detrimental habits, notably smoking and alcohol consumption, among the study participants, significantly hindering their ability to manage blood glucose levels [20, 21]. Notably, several insights gained from this study diverge from those reported in other domestic and international research. Specifically, older female patients, those with comorbid conditions, and individuals with a familial history of diabetes exhibited superior glycemic control. Interviews delved into potential reasons, suggesting that these patients might benefit from pension plans post-relocation, affording them greater leisure time (averaging 5.32 ± 2.23 h per day) to engage in lifestyle modifications as compared to younger patients. Furthermore, female participants generally displayed less smoking and drinking behaviors, contributing to a more disciplined lifestyle and dietary regimen. For patients with comorbidities and a family history of diabetes, extended treatment duration coupled with familial interactions likely enhanced their disease understanding and adherence to treatment protocols [22–25]. Intriguingly, among those who achieved glycemic targets, a relatively low education level and personal income were observed, which may stem from a complex interplay of factors such as age, disease duration, and peer-to-peer education, necessitating further in-depth investigation to elucidate the underlying mechanisms.

In terms of disease cognition, our study underscores the distinctive features of the study population. Notably, there exists a pronounced divergence in attitudes towards T2DM between Group 1 and Group 2. The former group

exhibits a positive outlook towards the disease, albeit accompanied by elevated stress levels, reflecting their strong willingness to cope. This coping attitude positively correlates with their intention to manage the condition [26]. However, this dedication may also manifest as overcompensatory behaviors, highlighting the need for medical personnel to be vigilant of emotional fluctuations and offer timely psychological support. In contrast, those failing to meet glycemic targets display a lackadaisical approach, marked by avoidance and compromise strategies, underscoring the role of medical professionals in guiding patients towards a more proactive disease management stance.

Furthermore, the study highlights striking disparities in disease hazard perception and concern. Patients achieving glycemic control display a profound sense of identity with their condition, which, at times, can excessively influence their daily lives, including social interactions and work performance. This heightened awareness necessitates the involvement of patients' families in the management process, fostering communication and reinforcing familial support systems. Conversely, individuals with poor glycemic control tend to dismiss the implications of T2DM, attributing blood glucose fluctuations to the norm of diabetes treatment. This underscores the importance of enhancing healthcare providers' ability to recognize and address diabetic complications, thereby bolstering patients' understanding of the disease's significance and fostering a greater commitment to glycemic control [27].

Regarding treatment adherence, our findings reveal that patients generally struggle with adhering to medication, dietary regimens, follow-up visits, and self-monitoring practices, while demonstrating higher compliance with exercise routines. For those who successfully manage their blood glucose levels, a profound comprehension of the risks associated with inadequate control, coupled with a strong appetite for disease knowledge, is evident. Nonetheless, their limited educational backgrounds and advanced age hamper their capacity to assimilate new information [28]. This underscores the crucial need for tailored health education programs tailored to this unique patient group. Healthcare professionals play a pivotal role in this endeavor, not only by imparting essential disease knowledge and medical guidance but also by serving as a steadfast support system, enabling patients to effectively manage their condition [29]. By adapting health education content to cater to patients' specific needs and guiding them towards lifestyle interventions such as balanced diets and moderate exercise, healthcare professionals can significantly improve glycemic control and, consequently, enhance patients' overall quality of life. Conversely, for those failing to achieve glycemic targets, despite acknowledging the adverse effects of diabetes, their tendency to minimize the importance of glycemic control underscores the significance of fostering trust between patients and healthcare providers, thereby enhancing educational interventions' effectiveness and fostering improved treatment adherence.

Study limitations

The study has several limitations. The convenience sampling method was used, which limits the generalizability of the results. This sampling method may introduce selection bias, as the participants who were more readily accessible or willing to participate might not represent the broader population of T2DM patients in resettlement areas. Consequently, the findings may not be applicable to all T2DM patients in similar settings. Additionally, the selection of study locations, duration, prevailing conditions during the study, and sample size warrant further consideration. Future endeavors ought to encompass broader, multi-centered investigations.

Conclusion

The findings of this investigation indicate that medical practitioners should tailor behavioral change programs according to the unique characteristics of the farmer communities they serve. Such programs should incorporate moderate physical activity and dietary regulations as preventative measures against the onset of T2DM, especially among farmers who have escalated their living standards following resettlement, often leading to increased consumption of fatty foods and abandonment of agricultural labor.

Given that this cohort often scores poorly in treatment compliance, disease cognition, and experiences inadequate glycemic control, it becomes imperative for medical personnel to devise strategies that enhance disease awareness and treatment compliance. Measures such as peer-to-peer education and glucose control awareness training could be effective tools. Additionally, more extensive studies are needed to assess the impact of various treatment regimens on improving glycemic control within this population.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Not applicable.

Author contributions
Study concept and design: Y.L.; Analysis and interpretation of data: C.L., W.X.; Drafting of the manuscript: Y.L., C.L.; Critical revision of the manuscript for

important intellectual content: S.L., L.L.; Statistical analysis: W.X., S.L., L.L.; Study supervision: all authors; all authors have read and approved the manuscript.

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Data availability
The data used to support the findings of this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
This study was approved by the Medical Ethics Committee of the the Fourth Affiliated Hospital of School of Medicine, Zhejiang University (K2021104). All subjects signed the consent form before participation in the study.

Consent for publication
Written informed consent was obtained from each patient included in the study.

Competing interests
The authors declare no competing interests.

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