

BMJ Open Patients' and family members' knowledge, attitudes and perceived family support for SMBG in type 2 diabetes: a fuzzy-set qualitative comparative analysis

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ABSTRACT

Aims and objectives To examine the combined effects of the patient's and family members' knowledge, attitudes and perceived family support on self-monitoring of blood glucose (SMBG) behaviour of patients with type 2 diabetes.

Design A cross-sectional design using the framework of knowledge–attitude–behaviour (KAB) combined with family support.

Setting Shanghai, China.

Participants Seventy type 2 diabetes patient–family member dyads recruited from 26 residential committees in Shanghai were investigated. Twenty-three health providers were interviewed.

Primary outcome measures The knowledge, attitudes and perceived family support of patients' and their family members' data were measured through scales. Combined effects were analysed by a fuzzy-set qualitative comparative analysis (fsQCA) using fsQCA V.3.0. Other analyses and calculations were performed by STATA V.14.0.

Results SMBG was very poor (20%), and behaviour was characterised by 'multiple complications,' and 'all paths lead to the same destination' for patients. There were two solution paths toward patients' SMBG (solution coverage=0.4239, solution consistency=0.7604). One path was the combination of 'patients with low risk perception, the patients' and family members' perceived negative support', the other was the combination of 'patients with high risk perception, the patients' perceived negative support'. In both paths, basic knowledge serves as an auxiliary condition.

Conclusion The study revealed that for patients with high and low risk perceptions that are relatively difficult to change, we could strengthen family support to achieve the desired SMBG behaviour. Knowledge is not a prerequisite to achieving SMBG. Moreover, negative family support plays a crucial role. Perceived family support by patients is more important than perceived family support by family members, which suggests that family members should improve support for patients so that the patients can perceive more family support.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The qualitative comparative analysis method was used to address the questions of the paths of the combination of complex factors.
- ⇒ The study considered both patients' and family members' knowledge–attitude–behaviour combined with perceived family support for analysing the paths to patients' self-monitoring of blood glucose behaviour.
- ⇒ The study was conducted in Shanghai, and the results may not be transferable to another region.

INTRODUCTION

Diabetes is a common global health problem that, over time, can cause serious damage and complications to the heart, kidneys, nerves, blood vessels and eyes.¹ The number of patients with diabetes worldwide will reach 578 million in 2030 and 700 million by 2045.²

The Chinese government launched a health management programme for type 2 diabetes as a part of their national basic public health services in 2009, wherein patients with diabetes could apply for registration in the health management system of their local community health centres. Though many patients with diabetes are managed in the health management system, many patients have poor glycaemic control.³ Therefore, finding feasible ways for patients with poor glycaemic control is needed.

Studies have found that strict blood glucose control can effectively reduce the risk of complications in patients.⁴ Since diabetes is a long-term chronic disease, self-management behaviours are very important; self-monitoring of blood glucose (SMBG) is significant for people with poor blood glucose control. SMBG can reflect the



immediate changes in blood sugar and guide patients to adjust diet, exercise and oral medication or insulin dose in time. In recent years, medical personnel have focused on and strengthened SMBG education, but the status of self-monitoring compliance of patients with diabetes is not optimistic. SMBG adherence rates were reported to be as low as 24% for adults with type 2 diabetes.⁵

There are many factors influencing diabetes self-management behaviours, some of which are from the perspective of patients themselves, such as knowledge⁶ and risk perception.⁷ Some from an external support perspective, such as family support.^{8,9} Family support can be positive or negative. Positive support includes the provision of emotional and instrumental support, and these supportive behaviours can promote self-management behaviours in patients with diabetes.⁸

Negative support can translate into vigilance over certain lifestyles and can lead to nagging patients to watch what they eat and to be physically active. Patients' responses to negative support vary, with some interpreting negative support by family members as expressions of concern and finding them helpful for self-management behaviours. Others find them unhelpful and annoying, causing patients to feel negative about self-management behaviours.⁸ However, the literature shows that the role of negative family support is inconsistent, and while some people think it is useful, some think otherwise.¹⁰

Considering that family support is an external factor, external factors work through internal factors. Therefore, when analysing the influence of external factors on patients' behaviour, it is necessary to explore the influence on patients with different psychological statuses such as risk perception. Previous study has shown that cognition of possible health risks in patients with diabetes is an important factor affecting their health decisions and self-management behaviours.¹¹ Despite the importance of health education for patients with diabetes,¹² the level of risk perception and knowledge in many older patients remains low.

It is questionable whether family support can promote SMBG behaviour in patients with poor knowledge and risk perception. Therefore, this study considers the following questions: 'can feasible interventions be explored for patients with uncontrolled diabetes with low risk perception based on family support?' and 'does improving patients' knowledge and perception of risk facilitate SMBG behaviour for some elderly patients?' Interestingly, family members and patients may have inconsistent perceptions of family members' support.¹³ Therefore, it is necessary to analyse family support from the perspectives of patients and family members.

The knowledge–attitude–behaviour (KAB) model is relatively common in studies to improve diabetes self-management behaviours. Many researchers believe that improving patients' knowledge through health education can improve their self-management behaviours¹⁴; however, patients' knowledge and attitudes do not always lead to changes in attitudes.¹⁵ This study aimed to

determine the feasible paths for patients with or without knowledge and risk perception based on the KAB model combined with family support.

In this study, we used the qualitative comparative analysis (QCA) method¹⁶ to address questions of complex causation, analysing the joint effect, interactive relationship and action path among different influencing factors. Especially for some unnecessary conditions, it also can find a path through other conditions, which will provide information for developing targeted intervention measure to improve patients' SMBG behaviour.

METHODS

Conceptual framework

This study focused on the SMBG behaviour in patients based on the KAB model.¹⁷ Behaviours of patients are influenced by their knowledge and attitudes. In addition, family support also influences patients' behaviours. In addition, family members' supporting behaviours influence their knowledge and attitudes.

Knowledge is directly or indirectly related to behaviours. With better knowledge, patients and their families can develop better attitudes, resulting in better behaviours. Knowledge includes basic knowledge of diabetes and basic knowledge of diabetes complications. Studies have found that the level of diabetes knowledge in patients is closely related to the level of self-management.¹⁸ Other studies suggested that knowledge alone is not sufficient to improve diabetes self-management behaviours.¹⁹

Attitudes referred to psychological aspects related to diabetes and included self-efficacy^{20,21} and risk perception⁷ in this study. Self-efficacy is a key measurement variable influenced by attitude, subjective norms, perceived behavioural control and other factors. This is an important theoretical viewpoint of planned behaviour theory.²² Clara *et al*²³ found that patients with better self-efficacy had higher levels of self-management. Risk perception refers to the subjective perception of the likelihood that a negative health-related event will occur for a certain person or group of people in a particular period.²⁴ In recent years, the key role of risk perception in behavioural processes has received increasing attention.²⁵

Family support is an important aspect of social support. It mainly refers to the help provided by other family members for patients, including positive and negative support. Studies have shown that family members participating in diabetes management can help patients overcome health-related obstacles.²⁶

Finally, this study proposed the framework of the KAB model, combined with family support, as shown in figure 1.

Study design and setting

This cross-sectional study was conducted in Shanghai, located in the eastern mainland China during from January to March in 2019.

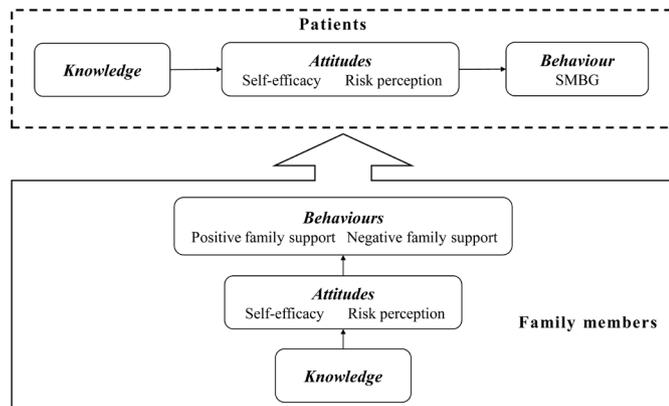


Figure 1 Conceptual framework. SMBG, self-monitoring of blood glucose.

According to government statistics, the annual per capita gross domestic product in Shanghai was ¥157 279 in 2019, ranking it second among the 31 provinces in mainland China (National Bureau of Statistics, 2020), while that of the whole of mainland China was ¥70 892.

Study participants

Patients

This study aimed to find ways to improve the SMBG of elderly patients with type 2 diabetes with poor blood glucose control. Based on the guideline for the prevention and control of type 2 diabetes in China,²⁷ glycosylated haemoglobin (HbA1c) is one of the main indicators of long-term blood glucose control. For most non-pregnant adult patients with type 2 diabetes, a reasonable HbA1c control target is <7%. Patients registered in the health management system with an HbA1c of >7.0% were selected for the study.

The QCA method has relatively loose requirements regarding sample size, resulting in studies with small and medium-sized samples of between 10 and 100 cases,²⁸ larger sample sizes allowing more conditions in the analysis.¹⁶ Recruitment for this study was completed in 26 residential committees in Shanghai, in which 70 patient–family member dyads were interviewed.

Patients with a disease course of ≥6 months, age 50–79 years, and HbA1c between 7.0% and 10.0% were included in the study. Patients with type 1 diabetes, gestational diabetes or other types of diabetes, women who are pregnant or trying to become pregnant, those who are unwilling or unable to provide informed consent, are delirious or have other serious diseases, or participants in other diabetes studies were excluded. Family members in this study were defined as relatives living with the patients or in regular contact with the patients at least once a week.

Health providers

In addition, health providers were interviewed, including 23 people from a general hospital, 3 from community health service centres, and 3 from district centres for Disease Control and Prevention in Shanghai.

Data collection

Questionnaire survey

We conducted a questionnaire survey of 70 patient–family member dyads. The survey was conducted by qualified investigators who had received unified training. The following data were compiled: age, sex, marital status, education, employment, family average monthly income, duration of diabetes and HbA1c (online supplemental file 1). HbA1c data for 3 months were from the local community health centre’s health management system.

The measurements for each module in the conceptual framework are as follows (online supplemental file 2).

Self-management behaviours

Diabetes self-management behaviours refer to the ability of individuals to effectively manage their behaviours for extended periods.²⁹ Patient’s self-management was assessed using 11-items Summary of Diabetes Self-Care Activities³⁰ (online supplemental file 2). The score ranged from 0 to 7, indicating the number of days the behaviour was followed (except for item 11 (smoking), as this is a binary question, in which ‘yes’ was scored ‘0’ and ‘no’, ‘1’). The Cronbach’s α coefficient of the scale measured in this study was 0.91.

Knowledge

A Patient Knowledge Questionnaire was developed by the researchers. The patient knowledge in this study was examined using a 10-item questionnaire. There were three response choices for each question (true, false and unknown). The questions were scored 1 for correct and 0 for incorrect answers or unknown, respectively. The Cronbach’s α coefficient measured in this study was 0.79. We developed different questionnaires because of the lack of knowledge among family members.³¹ Family knowledge included two parts: basic knowledge of diabetes and basic knowledge of diabetes complications. Family members’ basic knowledge was examined by four single choices. Each response of ‘false’ and ‘unknown’ was scored ‘0’ and ‘true’ was scored ‘1’. Family members’ basic knowledge of diabetes complications were evaluated using one multiple choice. Based on the literature on diabetes complications,³² we listed 10 complications. Responses were recorded using a 4-point Likert scale: 1=less than two, 2=three to four, 3=five to six and 4=more than seven. The total score of family knowledge was the average of the basic knowledge and knowledge of complications scores. The Cronbach’s α coefficients of basic knowledge of diabetes and basic knowledge of diabetes complications measured in this study were 0.70 and 0.79, respectively.

Self-efficacy

The patient’s self-efficacy in controlling blood sugar (patient-self-efficacy) was measured using four questions that were selected from the Risk Perception Survey—Diabetes Mellitus (RPS-DM). Family members’ self-efficacy in helping patients to control blood glucose (family-self-efficacy) was measured by one question. The Cronbach’s

α coefficient of the patient-self-efficacy measured in this study was 0.60.

Risk perception

Risk perception items were adopted from the RPS-DM.³³ A patients' perception of complications and health problems (patient-risk-perception) is measured by the average score of optimistic bias, worry, relative environmental risk and personal disease risk. Family members' perception of the patient's risk of disease (family-risk-perception) was measured using 10 items. The higher the score, the higher was the overall perceived risk. In this study, Cronbach's α coefficients of patient-risk-perception and family-risk-perception were 0.84 and 0.78, respectively.

Positive family support and negative family support

Patients' perceived family support (patient-positive-support, patient-negative-support) and the family members' perceived support for the patients (family-positive-support, family-negative-support) were assessed by Diabetes Family Behaviour Checklist.^{34,35} The measurement items of positive and negative family support in this study include diet, exercise and blood glucose monitoring, with a total of 12 items, including 6 family positive support items and 6 family negative support items (online supplemental file 2). Each question was scored range from 1 to 5, with 1 representing no family support at all and 5 representing always supporting the patient. For positive family support, the higher the score, the more positive were behaviours; for negative family support, the higher the score, the more negative the behaviours. In this study, Cronbach's α coefficients of positive and negative family support that patients perceived were 0.74 and 0.60. On the other hand, we also surveyed the extent to which the family members thought they supported the patients, and Cronbach's α coefficients were 0.87 and 0.79.

Semistructured interview

The research group developed the semistructured interview guide.

We had the following main interview questions for the three types of interviewees about family support: (a) What problems and difficulties do patients have in monitoring blood glucose? (b) Do patients need family support during glucose monitoring? (c) What problems and difficulties do family members have in providing support for patients? (d) What are the reasons why family members cannot provide support for patients? (e) What should be done to improve patients' SMBG behaviour. Each interviewee is interviewed for 30–60 min.

Data analysis

The data were double checked using EpiData V.3.1 (EpiData Association, Denmark, Odense) to ensure the accuracy of the survey results. Data analysis was performed using Stata V.14.0 (Stata Corporation, College Station, Texas, USA). The measurement data of normal distribution are presented as the mean \pm SD. The t-test was used to

compare the differences in factors between patients with diabetes and their families. Two researchers transcribed the interview recordings, and another researcher checked and corrected the transcribed text. The transcribed texts were then summarised.

FsQCA V.3.0 (Fuzzy-Set/Qualitative Comparative Analysis V.3.0, Irvine, California, USA) was used to fit the configuration phenomenon in which conditional factors were interdependent in diabetes SMBG. QCA focus on analysing configuration effects, connecting the complex causal relationship between configuration and outcomes. In fsQCA, each condition (the 10 influencing factors in this study) and outcome (SMBG) is treated as a set, and each case has membership scores in these sets. The process of assigning set membership scores to cases involves calibration.³⁶

This study first examined whether a single condition (including its non-set) constituted a necessary condition for SMBG. In fsQCA, a condition always exists when the outcome occurs, which is necessary for the outcome. Consistency is an important measure of a necessary condition, and when the level of consistency is greater than 0.9, it can reliably be considered a necessary condition for outcomes.³⁶

Configuration analysis attempts to reveal the adequacy of outcomes resulting from different configurations of multiple conditions. In this study, the consistency threshold and frequency threshold were not set directly. However, the reasonable and natural threshold was determined after comprehensive consideration of the best practices of the following two QCA methods: (1) the frequency threshold should include at least 75% of the observed cases³⁷; (2) to reduce the potential contradiction configuration, the minimum value of proportional reduction in inconsistency (PRI) consistency should be ≥ 0.75 . As the existing studies have not reached an agreement on the relationship between the preliminary 10 conditions and SMBG or lack clear theoretical expectations, it is difficult to make a clear counterfactual analysis in this study. Therefore, in producing an intermediate solution, 'being or not being' is chosen when faced with which state of the 10 conditions will improve self-management. This paper reports an intermediate solution supplemented by a simplified solution. The solid circle indicates the existence of the condition. The circle with a cross indicates the absence of the condition, and the blank space indicates a fuzzy state, that is, the condition can exist or be absent. The large circle is the core condition (the condition that exists in both the reduced solution and the intermediate solution), and the small circle is the auxiliary condition (the condition that exists only in the intermediate solution). Additionally, configurations with the same core conditions are grouped and arranged from left to right according to the size of the configuration consistency level. Coverage is an important indicator of empirical correlation in QCA research, reflecting the experiential relevance or importance of configuration, similar to R^2 in regression analysis.³⁸

In this study, a robustness test was carried out using the improved consistency level method. Two criteria for the robustness of QCA results (set relationship states of different configurations and differences in fitting parameters of different configurations) proposed by Schneider and Wagemann³⁶ were used for evaluation.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

RESULTS

Participants

Patient–family member dyads

Among 70 patients, 39 (55.71%) were women, 36 (51.43%) were aged between 60 and 69 years, 15 (21.43%) were over 70 years and 65 (92.86%) were married. In total, 9 (12.86%) patients had no formal education, 18 (25.71%) had only primary education, 24 (34.29%) had primary and secondary education and 13 (18.57%) had high school/vocational high school/technical secondary school education. In total, 56 (80.00%) patients were retired and 34 (48.57%) had an income of ¥3000–6000. In total, 77 patients (38.57%) had type 2 diabetes for about 15 years, and 13 (18.57%) and 17 (24.29%) patients had HbA1c values of 8.0%–8.4% and 8.5%–10.0%, respectively.

Among 70 family members, the average age was 47.09±1.48 years. The main family members are the spouses (28.57%) and daughters-in-law (28.57%). In total, 43 (61.43%) family members were females. Almost half of the patients (45.72%) had an educational level of undergraduate or above. In total, 45 (64.29%) family members had a chronic disease. The sociodemographic and clinical characteristics of the patients and their family members are shown in table 1.

Health providers

A total of 23 health providers were interviewed. Six health providers were from the general hospital (doctors (n=2), and nurses (n=4)). In total, 11 health providers were from 3 community health centres (general practitioners (n=2), public health practitioners (n=5) and nurses (n=4)). Six health providers were from three district Centres for Disease Control and Prevention (vice directors of the centre (n=2) and public health practitioners (n=4)).

Semistructured interview

Different self-management behaviours require different family support, and some self-management behaviours require the help of family members

I don't need to be reminded to take my medication, but I don't know how to take my own blood glucose, and I don't even use the blood glucose meter that I bought at home. (A patient)

Patients need help from their family members, but they are reluctant to actively seek help.

I often can't control my blood sugar, and I can't measure it. I wish someone would help to supervise me.

Table 1 Characteristics of the patients and their family members

| Participants | Characteristics | |
|-------------------------------|---------------------------------|------------|
| Patients with type 2 diabetes | | |
| | Age, n (%) | |
| | <60 | 19 (27.14) |
| | 60–69 | 36 (51.43) |
| | ≥70 | 15 (21.43) |
| | Marriage, n (%) | |
| | Married | 65 (92.86) |
| | Divorce | 1 (1.43) |
| | Widowed | 4 (5.71) |
| | Education, n (%) | |
| | No formal education | 9 (12.86) |
| | Primary school | 18 (25.71) |
| | Junior school | 24 (34.29) |
| | Senior school | 13 (18.57) |
| | College or above | 6 (8.57) |
| | Career, n (%) | |
| | Employment | 11 (15.71) |
| | Retirement | 56 (80.00) |
| | Unemployment | 3 (4.29) |
| | Average household income, n (%) | |
| | <3000 | 7 (10.00) |
| | ~3000 | 34 (48.57) |
| | ~6000 | 19 (27.14) |
| | >9000 | 10 (14.29) |
| | Duration of diabetes, n (%) | |
| | 0–5 | 8 (11.43) |
| | 6–9 | 12 (17.14) |
| | 10–14 | 23 (32.86) |
| | ~15 | 27 (38.57) |
| | HbA1c (%), n (%) | |
| | 7.0–7.4 | 23 (32.86) |
| | 7.5–7.9 | 17 (24.29) |
| | 8.0–8.4 | 13 (18.57) |
| | ~8.5 | 17 (24.29) |
| Family members | | |
| | Age, n (%) | |
| | ~20 | 3 (4.29) |
| | ~30 | 21 (30.00) |
| | ~40 | 22 (31.43) |
| | ~50 | 9 (12.86) |
| | ~60 | 15 (21.43) |
| | Identification, n (%) | |
| | Spouse | 20 (28.57) |

Continued

Table 1 Continued

| Participants | Characteristics | |
|--------------|---------------------------|------------|
| | Son | 17 (24.29) |
| | Daughter | 7 (10.00) |
| | Daughter-in-law | 20 (28.57) |
| | Son-in-law | 1 (1.43) |
| | Grandson or granddaughter | 5 (7.14) |
| | Education, n (%) | |
| | Primary school | 9 (12.86) |
| | Junior school | 13 (18.57) |
| | Senior school | 16 (22.86) |
| | College or above | 32 (45.72) |
| | Chronic disease, n (%) | |
| | Yes | 45 (64.29) |
| | No | 25 (35.71) |

Measurement data are presented as means (SD), and categorical data are presented as numbers (%).
HbA1c, glycosylated haemoglobin.

However, I am afraid my son is too busy to bother him, and I don't talk to him about my diabetes. (A patient)

The existing community diabetes management is actually doing everything that can be done, such as follow-up visits, health talks and so on, but the problem is that the patients do not take the initiative. (A public health practitioner)

Family members lack the knowledge, skills and awareness to support the patient, they do not know how to measure blood glucose, or they believe that the patient's blood glucose is well controlled and does not need their help

My son, a Chinese medicine doctor, does not know about diabetes and does not know as much as I do. For example, his knowledge of diabetes, knowledge of complications, and how to monitor blood sugar is not as good as I know. (A patient)

How should people with diabetes exercise to control their diet? I don't know much about this and I don't usually pay much attention to it. (A wife)

The patient has no symptoms, hence the family members think the patient's blood sugar is well controlled, so they don't think the patient will have complications. (A nurse)

Doctors should educate patients and family members together and tell them straightforwardly what they should do to control patients' blood sugar

We are too old to remember that much. I don't want to know what diabetes is. Why do I have to do this to control blood sugar? I wish the doctor would just tell

Table 2 Diabetes self-management behaviours scores

| Dimensions | Range | Score ($\bar{x} \pm s$) | $\frac{\bar{x}}{Max} \times 100\%$ |
|------------|-------|---------------------------|------------------------------------|
| Smoking | 0–1 | 0.74±0.44 | 74% |
| Diet | 0–7 | 4.19±1.58 | 60% |
| Exercise | 0–7 | 3.76±1.96 | 54% |
| Foot care | 0–7 | 1.61±2.57 | 23% |
| SMBG | 0–7 | 1.37±1.80 | 20% |

'Max' refers to the maximum of score for each dimension.
SMBG, self-monitoring of blood glucose.;

me what I should do to control his blood sugar. (A wife)

Family support is important for patients to control their blood sugar and to adhere to self-management behaviours. There are two types of family members: those who like to ask and those who do not care about anything. However, family members do not have a wealth of knowledge and skills in the field of diabetes health and should be educated in the future. (A doctor)

Diabetes self-management behaviours scores

Table 2 describes the scores of patients in the five dimensions of diet, exercise, SMBG, foot care and smoking. It is expressed as the average number of days the patients followed self-management behaviours in the past week. SMBG was very poor.

Scores of various factors affecting patients' self-management behaviours

As shown in **table 3**, in terms of diet, exercise or SMBG and positive or negative family support, the family support scores perceived by patients were lower than those perceived by family members. The difference between the family support scores perceived by patients and family members was statistically significant in terms of the dimensions of exercise negative family support, SMBG positive family support and SMBG negative family support ($p=0.001$, $p=0.002$, $p=0.006$).

FsQCA for SMBG behaviour

We first tested whether causal conditions could be considered necessary to influence SMBG in patients with diabetes. We then analysed the sufficient conditions that influenced the SMBG of patients. Considering the necessary condition test, the presence or absence of none of the variables was necessary for self-monitoring patients' blood glucose, as all conformance values were less than 0.90. Next, the combination of conditions for realising self-monitoring of patients' blood glucose (**table 4**) was calculated. To reduce potential contradictory configurations, the minimum value of PRI consistency should be 0.75. The frequency cut-off in the truth table was set at 1, and the consistency cut-offs were set at 0.90 for SMBG (**table 4**). The intermediate solutions of SMBG showed

Table 3 The scores of various factors affecting patients' self-management behaviours ($\bar{x}\pm s$)

| Dimensions | Patients | | Family | | T | P value |
|--------------------------|----------|-----------|--------|-----------|-------|---------|
| | Range | Score | Range | Score | | |
| Knowledge | 0–10 | 6.89±1.76 | 1–4 | 2.44±0.56 | | |
| Self-efficacy | 1–4 | 2.83±0.48 | 1–4 | 1.84±0.85 | | |
| Risk perception | 1–4 | 2.36±0.40 | 1–4 | 2.22±0.56 | | |
| Family positive support* | | | | | | |
| Diet support | 1–5 | 2.73±0.73 | 1–5 | 2.98±0.78 | –1.93 | 0.056 |
| Exercise support | 1–5 | 2.31±1.12 | 1–5 | 2.62±1.01 | –1.71 | 0.091 |
| SMBG support | 1–5 | 1.89±1.21 | 1–5 | 2.54±1.27 | –3.13 | 0.002† |
| Family negative support* | | | | | | |
| Diet support | 1–5 | 2.25±1.00 | 1–5 | 2.41±0.86 | –1.00 | 0.321 |
| Exercise support | 1–5 | 1.60±0.81 | 1–5 | 2.09±0.84 | –3.53 | 0.001† |
| SMBG support | 1–5 | 1.91±0.81 | 1–5 | 2.36±1.09 | –2.78 | 0.006† |

*means that only these items are the same as those of patients and their families, so t-test was only performed for the family support.
 †p<0.05.
 SMBG, self-monitoring of blood glucose.

two (table 4) combinations of causal conditions that could produce effective SMBG.

The total consistency of the analysis of the adequacy of SMBG was higher than the critical value of 0.75, indicating that the results of each condition combination are valid. The two solutions of SMBG (table 4) can explain 42% of patients' SMBG (solution coverage=0.4239, solution

consistency=0.7604). There were two sufficient combinations of conditions. From a single condition (horizontal), the absence of family knowledge and family self-efficacy and the existence of patient's self-efficacy, family members' perceived positive family support, patients' and family members' perceived negative support appeared in all configurations.

In this study, a robustness test was performed using the adjusted consistency level (increased from 0.95 to 0.96). Finally, it was found that the research conclusions of this study were robust.

Table 4 Models of achieving SMBG self-management behaviour in patients with diabetes

| Causal conditions | Path number | |
|---|-------------|--------|
| | 1 | 2 |
| Patient-knowledge | ⊗ | ● |
| Family-knowledge | ⊗ | ⊗ |
| Patient-self-efficacy | ● | ● |
| Family-self-efficacy | ⊗ | ⊗ |
| Patient-risk-perception | ⊗ | ● |
| Family-risk-perception | ⊗ | ● |
| Patient-positive-support | ● | ⊗ |
| Family-positive-support | ● | ● |
| Patient-negative-support | ● | ● |
| Family-negative-support | ● | ● |
| Consistency | 0.8147 | 0.8138 |
| Raw coverage | 0.2964 | 0.3705 |
| Unique coverage | 0.0534 | 0.1275 |
| Solution coverage=0.4239, solution consistency=0.7604 | | |

● = Existence of core condition; ⊗ = Absence of core condition;
 ● = Auxiliary condition existence; ⊗ = Auxiliary condition absence;
 "Space" indicates that the condition may exist or be absent.

DISCUSSION

This study explored the combined effect of diabetes knowledge, family support, self-efficacy and risk perception of patients and their family members on SMBG, providing information for developing targeted intervention measures to control blood glucose better.

We found that SMBG behaviour was characterised by 'multiple complications' and 'all paths lead to the same destination' for participants. Based on the necessity analysis of a single condition of QCA, this study found that no single factor could constitute a necessary condition for SMBG, nor be a sufficient condition. Gulhan Cosansu and Erdogan,²⁰ based on traditional analysis techniques, found that each influencing factor had an interactive effect on patients' self-management behaviours.

We found that knowledge was not an important role in either path. Family support is important to achieve SMBG behaviour. This suggests that family support is needed for patients with and without diabetes knowledge. Further, combined with the interview results, patients need family support to achieve SMBG behaviours, but both patients and family members lack the knowledge and skills.



Therefore, this suggests that we should not focus too much on how to enhance the knowledge of patients and family members, but rather be straightforward in telling patients and family members what they can do to help control the patients' blood glucose.

We also found that regardless of whether the patients in this study had high or low risk perception, they could realise the SMBG through the role of family support. In the two paths of SMBG behaviour, low risk perception with high negative family support perceived by patients and family members to play a key role in path 1; high risk perception is required to play a core role together with high negative family support perceived by patients in path 2. In this study, even in the absence of the internal cause of risk perception, the patient's SMBG could still be changed through the external cause of family support. Other studies suggest that patients' risk perception should be improved,³⁹ but it is difficult.⁴⁰ This study suggests that family support is necessary for the patients with uncontrolled blood glucose. This may be related to the fact that most of the patients in this study were elderly, and measuring blood glucose requires basic skills. In Chinese culture, negative family support such as nagging and complaining instead becomes a means to promote patients to actively engage in SMBG when they do not adopt healthy behaviours, and it can be effective. Positive family support, such as actively helping patients adjust their lifestyles with the results of their blood glucose tests, can also improve patients' self-management behaviours. Usually, patients do not like to follow doctors' instructions regarding healthy lifestyles. As a result, family members will nag them. After nagging, patients will adopt good self-monitoring behaviours with the help of their family members.

Different scholars have different views on the role of different family support.⁴¹ Some of them believe that both positive family support and negative family support will affect the self-management behaviours of patients with diabetes. However, this study found that negative family support plays a crucial role, which may be due to the unsatisfactory realisation of SMBG behaviour in patients.

SMBG was very poor, which is consistent with previous studies.⁴² SMBG behaviour is different from diet and exercise behaviour. This may be associated with older patients, gradual memory loss and multiple chronic complications. Therefore, it is difficult for patients to master and understand the complex knowledge of SMBG. This needs the support and help of family members. Pamungkas *et al*'s systematic review⁴³ found that positive family support is associated with the patients persisting in exercise. In addition, Nansseu *et al*⁴² found that among some self-management behaviours that are difficult to adhere to, the relationship between family members' negative family support for patients and self-management behaviours is the most critical. This also explains why negative family support plays a core role in the QCA results.

Similar to other studies,^{44 45} patients and their family members have different perceptions of family support.

In this study, perceived family support by patients is more important than perceived family support by family members. There are two possible reasons for the discrepancy: either the family members provided family support, but the behaviours did not meet the patient's expectations for this family support behaviour or did not match the patient's desired family support behaviour. The family members overestimated their own family support behaviour. The goal of family support is to enhance patients' self-monitoring behaviour of blood glucose. When patients feel that there is useful support for them, they will naturally take the initiative to adopt self-management behaviours. It suggests that family members should pay more attention to patients' perceptions, the methods and effectiveness of family support.

Our study has some limitations. First, this study was a cross-sectional study, and the subjects were all patients with a long course of diabetes in a certain community and they had at least one family member. Thus, the study's conclusions could not be generalised to the whole population. Second, the study was conducted in Shanghai, which is a more developed city, and all the patients were registered in the community health centre system, limiting the generalisability of the results. Finally, attitudes are the mediating variable in the KAB model,¹⁷ which could not be analysed by the QCA method.

CONCLUSION

By looking for pathways to achieve patient's SMBG behaviour, this study found two critical pathways to achieve the desired behaviour change. Thus, whether the risk perception is high or low, good behaviours can be achieved by strengthening family support, suggesting that we need to build based on path analysis when developing community intervention technologies. Moreover, negative family support plays a crucial role on SMBG. Patients' perceived family support is more important than family members' perceived support, suggesting that family members should improve their support to improve patients' perception of family support. In future studies, the scope of the study population can be expanded. Based on the conclusions of this study, it can provide information to enhance self-management behaviours and develop targeted interventions for people with poor glycaemic control through the role of family support.

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Demographic characteristics of the patients and family members

Demographic characteristics of the patients

| Question | Answer |
|--|--|
| 1. What is your gender? | ①Male, ②Female |
| 2. How old are you now? | Years |
| 3. What is your marital status? | ①Married, ②Divorce, ③Widowed, ④Unmarried |
| 4. What is your education background? | ①no formal education, ②Primary school, ③Junior school, ④Senior school, ⑤College or above |
| 5. What's your occupation? | ①Employment, ②Retirement, ③Unemployment |
| 6. What is the average monthly household income? | |
| 7. How long is your diabetes duration? | Years |

Demographic characteristics of the family members

| Question | Answer |
|---|---|
| 1. How old are you now? | Years |
| 2. What is your relationship with patients? | ①Spouse, ②Son, ③Daughter, ④Daughter-in-law, ⑤Brother or sister, ⑥Son-in-law, ⑦Grandson or granddaughter |
| 3. What is your gender? | ①Male, ②Female |
| 4. What is your education background? | ①no formal education, ②Primary school, ③Junior school, ④Senior school, ⑤College or above |
| 5. Do you suffer from chronic illnesses? | ①Yes, ②No |

Investigation of diabetes self-management behavior and its influencing factors

PATIENT KNOWLEDGE

| Question | Answer | Score |
|---|------------------------------|---------------------------------------|
| 1. Diabetes can be cured | ① True, ② False, ③ Unknow | ① True=1, ② False=0, ③ Unknow=0 |
| 2. Parents suffer from diabetes. children are susceptible to diabetes | ① True, ② False, ③ Unknow | |
| 3. According to the food exchange method of diabetic diet treatment, 1 medium-sized apple is approximately equivalent to the total energy of 1 serving of rice (about 25g).so in order to eat more apples, you can eat less rice. | ① True, ② False, ③ Unknow | |
| 4. The blood glucose monitoring results show that the blood sugar is too high, and the patient can increase the amount of medicine by himself. | ① True, ② False, ③ Unknow | |
| 5. As long as you keep taking hypoglycemic drugs and keep your blood sugar stable. you don't need to control your diet. | ① True, ② False, ③ Unknow | |
| 6. For diabetic patients, exercise with greater energy consumption is more suitable for patients. | ① True, ② False, ③ Unknow | |
| 7. The patient goes to the hospital for monitoring regularly, so there is no need for self-monitoring at home. | ① True, ② False, ③ Unknow | |
| 8. Diabetics have high blood sugar. hypoglycemia is unlikely. | ① True, ② False, ③ Unknow | |
| 9. When hypoglycemia occurs, the individual must have symptoms such as palpitation, cold sweats, and pale complexion. | ① True, ② False, ③ Unknow | |
| 10. Diabetes patients do not need to perform fundus examination if blood sugar control is up to standard. | ① True, ② False, ③ Unknow | |

FAMILY KNOWLEDGE

| Question | Answer | Score |
|--|---------------------------------|---------------------------------------|
| basic knowledge | | |
| 1. Diabetes is a common chronic disease, but it usually can not be cured. | ① True, ② False, ③ Unknow | ① True=1, ② False=0, ③ Unknow=0 |
| 2. The dietary treatment of diabetes is mainly to control the intake of sugar or staple food (rice, flour, etc.) | ① True, ② False, ③ Unknow | |

| | | |
|--|--|---------------------------------------|
| 3. Exercise for diabetics is best to start after 1 hour after meals. | ①True, ②False, ③Unknow | |
| 4. Patients with diabetes who have normal fasting glucose measurements do not need to be measured after meals. | ①True, ②False, ③Unknow | |
| Complications knowledge | | |
| 1. What do you think of your understanding of the complications of diabetes? | ①Cardiovascular disease ②Retinopathy ③Diabetic foot ④Neuropathy ⑤Hypoglycemia coma ⑥Ketoacidosis ⑦Diabetic nephropathy ⑧Hyperosmolar nonketotic diabetic coma ⑨Lactic acidosis | ①≤2=1, ②3~4=2, ③5~6=3, ④≥7=4 |

*The total score of family knowledge is the sum of basic knowledge and complication knowledge and then take the average score. The value ranges from 1 to 4.

PATIENT-SELF-EFFICACY

| Question | Answer | Score |
|--|--|---|
| 1. My own efforts can help control my risks of getting diabetes complications. | ① Strongly agree, ② Agree, ③ Disagree, ④ Strongly disagree | ① Strongly agree=4, ② Agree=3, ③ Disagree=2, ④ Strongly disagree=1 |
| 2. If I make a good effort to control the risks of diabetes complications, I am much less likely to get complications. | ① Strongly agree, ② Agree, ③ Disagree, ④ Strongly disagree | ① Strongly agree=4, ② Agree=3, ③ Disagree=2, ④ Strongly disagree=1 |
| 3. I feel that I have little control over risks to my health. | ① Strongly agree, ② Agree, ③ Disagree, ④ Strongly disagree | ① Strongly agree=1, ② Agree=2, ③ Disagree=3, ④ Strongly disagree=4 |
| 4. If I am going to get complications from diabetes, there is not much I can do about it. | ① Strongly agree, ② Agree, ③ Disagree, ④ Strongly disagree | ① Strongly agree=1, ② Agree=2, ③ Disagree=3, ④ Strongly disagree=4 |

* Patients' self-efficacy refers to their ability to control diabetes and its complications, similar to personal risk control. These items are adopted from Risk Perception Survey–Diabetes Mellitus Scale.

FAMILY-SELF-EFFICACY

| Question | Answer | Score |
|--------------------------------|-------------------|---------------------|
| 1. You are concerned about the | ① Strongly agree, | ① Strongly agree=4, |

| | | |
|---|---|---|
| complications of diabetes in your family and are willing to take positive action to help her. | ②Agree, ③Disagree, ④Strongly disagree | ②Agree=3, ③Disagree=2, ④Strongly disagree=1 |
|---|---|---|

* The self-efficacy of family members expressed their willingness to help patients, showing a strong motivation.

PATIENT-RISK-PERCEPTION

| Question | Answer | Score |
|---|--|--|
| 1. Compared to other people with diabetes of my same age and sex, I am less likely than they are to get diabetes complications. | ①Strongly agree, ②Agree, ③Disagree, ④Strongly disagree | ①Strongly agree=4, ②Agree=3, ③Disagree=2, ④Strongly disagree=1 |
| 2. Compared to other people with diabetes of my same age and sex, I am less likely to have serious health problems. | | |
| 3. I am very concerned about getting diabetes health problems. | ① Strongly agree, ② Agree, ③ Disagree, ④Strongly disagree | ①Strongly agree=4, ②Agree=3, ③Disagree=2, ④Strongly disagree=1 |
| 4. I worry about getting diabetes complications. | ① Strongly agree, ② Agree, ③ Disagree, ④Strongly disagree | ①Strongly agree=4, ②Agree=3, ③Disagree=2, ④Strongly disagree=1 |
| 5. Medical tests (e.g., X-rays, MRI) | ①Almost No Risk, ②Slight Risk, ③Moderate Risk, ④High Risk | ①Almost No Risk=1, ②Slight Risk=2, ③Moderate Risk=3, ④High Risk=4 |
| 6. Violent crime | | |
| 7. Extreme weather (hot or cold) | | |
| 8. Driving/riding in an automobile (car) | | |
| 9. "Street" drugs (illegal drugs) | | |
| 10. Air pollution | | |
| 11. Pesticides | | |
| 12. Household chemicals (cleaners) | | |
| 13. Cigarette smoke from people smoking around you | | |
| 14. Heart attack | | |
| 15. Foot amputation | ②Slight Risk, | ②Slight Risk=2, |
| 16. Cancer | ③Moderate Risk, | ③Moderate Risk=3, |

| | | |
|-------------------------|------------|--------------|
| 17. Vision problems | ④High Risk | ④High Risk=4 |
| 18. High blood pressure | | |
| 17. Numb feet | | |
| 18. Stroke | | |
| 19. Blindness | | |
| 20. Kidney failure | | |

FAMILY-RISK-PERCEPTION

| Question | Answer | Score |
|--|--|---|
| 1.Are you worried about complications for diabetic patients at home. | ① Strongly agree, ② Agree, ③ Disagree, ④Strongly disagree | ①Strongly agree=4, ②Agree=3, ③Disagree=2, ④Strongly disagree=1 |
| 2.Heart attack | ①Almost No Risk, ②Slight Risk, ③Moderate Risk, ④High Risk | ① Almost No Risk=1 , ② Slight Risk=2, ③Moderate Risk=3, ④ High Risk=4 |
| 3. Foot amputation | | |
| 4. Cancer | | |
| 5. Vision problems | | |
| 6. High blood pressure | | |
| 7. Numb feet | | |
| 8. Stroke | | |
| 9. Blindness | | |
| 10. Kidney failure | | |

POSITIVE FAMILY SUPPORT PATIENT PERCEIVED

| Question | Answer | Score |
|--|-----------------------|-------------------------|
| DIET | | |
| 1. Praise you for following your diet. | ①None | ①None=1 |
| 2. Eat at the same time that the patient does. | ②Once a month | ②Once a month=2 |
| | ③Once a week | ③Once a week=3 |
| 3. Buy you things containing sugar to carry with you in case of an insulin reaction. | ④Several times a week | ④Several times a week=4 |
| | ⑤At least once a day | ⑤At least once a day=5 |
| EXERCISE | | |
| 1. Encourage the patient to participate in sports activities. | ①None | ①None=1 |
| 2. Exercise with you. | ②Once a month | ②Once a month=2 |
| | ③Once a week | ③Once a week=3 |
| | ④Several times a week | ④Several times a week=4 |
| | ⑤At least once a day | ⑤At least once a day=5 |
| self-monitoring of blood glucose (SMBG) | | |
| 1. Help you decide if changes should be made based on glucose testing results. | ①None | ①None=1 |
| | ②Once a month | ②Once a month=2 |
| | ③Once a week | ③Once a week=3 |

| | | |
|--|---|---|
| | ④Several times a week ⑤At least once a day | ④Several times a week=4 ⑤At least once a day=5 |
|--|---|---|

POSITIVE FAMILY SUPPORT FAMILY PERCEIVED

| Question | Answer | Score |
|--|---|---|
| DIET | | |
| 1. Praise him/her for following your diet. | ①None ②Once a month ③Once a week ④Several times a week ⑤At least once a day | ①None=1 |
| 2. Eat at the same time that the patient does. | | ②Once a month=2 |
| 3. Buy him/her things containing sugar to carry with him/her in case of an insulin reaction. | | ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| EXERCISE | | |
| 1. Encourage the patient to participate in sports activities. | ①None ②Once a month ③Once a week ④Several times a week ⑤At least once a day | ①None=1 |
| 2. Exercise with him/her. | | ②Once a month=2 ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| self-monitoring of blood glucose (SMBG) | | |
| 1. Help him/her decide if changes should be made based on glucose testing results. | ①None ②Once a month ③Once a week ④Several times a week ⑤At least once a day | ①None=1 ②Once a month=2 ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |

NEGATIVE FAMILY SUPPORT PATIENT PERCEIVED

| Question | Answer | Score |
|---|---|--|
| DIET | | |
| 1. Nag you about following your diet. | ①None ②Once a month ③Once a week ④Several times a week ⑤At least once a day | ①None=1 |
| 2. Eat foods that are not part of the patient's diabetic diet. | | ②Once a month=2 ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| EXERCISE | | |
| 1. Criticize you for not exercising regularly. | ①None ②Once a month ③Once a week ④Several times a week ⑤At least once a day | ①None=1 |
| 2. Does your family prefer to let you sleep more than exercise. | | ②Once a month=2 ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| self-monitoring of blood glucose (SMBG) | | |
| 1. Nag you about testing your | ①None | ①None=1 |

| | | |
|--|---|---|
| blood glucose level. | ②Once a month | ②Once a month=2 |
| 2. Criticize you for not recording the results of glucose tests. | ③Once a week ④Several times a week ⑤At least once a day | ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |

NEGATIVE FAMILY SUPPORT FAMILY PERCEIVED

| Question | Answer | Score |
|--|---|---|
| DIET | | |
| 1. Nag him/her about following his/her diet. | ①None ②Once a month | ①None=1 ②Once a month=2 |
| 2. Eat foods that are not part of the patient's diabetic diet. | ③Once a week ④Several times a week ⑤At least once a day | ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| EXERCISE | | |
| 1. Criticize him/her for not exercising regularly. | ①None ②Once a month | ①None=1 ②Once a month=2 |
| 2. Does his/her family prefer to let him/her sleep more than exercise. | ③Once a week ④Several times a week ⑤At least once a day | ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |
| self-monitoring of blood glucose (SMBG) | | |
| 1. Nag him/her about testing his/her blood glucose level. | ①None ②Once a month | ①None=1 ②Once a month=2 |
| 2. Criticize him/her for not recording the results of glucose tests. | ③Once a week ④Several times a week ⑤At least once a day | ③Once a week=3 ④Several times a week=4 ⑤At least once a day=5 |

SELF-MANAGEMENT BEHAVIOR

| Question | Answer | Score |
|---|-----------------|-------|
| 1. How many of the last SEVEN DAYS have you followed a healthful eating plan? | 0 1 2 3 4 5 6 7 | 0~7 |
| 2. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan? | | |
| 3. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables? | | |
| 4. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products? | | |

| | | |
|---|-----------------|-----------------|
| 5. On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking). | | |
| 6. On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work? | 0 1 2 3 4 5 6 7 | 0~7 |
| 7. On how many of the last SEVEN DAYS did you test your blood sugar? | | |
| 8. On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your health care provider? | 0 1 2 3 4 5 6 7 | 0~7 |
| 9. On how many of the last SEVEN DAYS did you check your feet? | | |
| 10. On how many of the last SEVEN DAYS did you inspect the inside of your shoes? | 0 1 2 3 4 5 6 7 | 0~7 |
| 11. Have you smoked a cigarette (even a puff) in the past week? | ①no ②yes | ①no=1 ②yes=0 |