

Developing a conceptual model for understanding nutritional problems and health-related outcomes among Chinese patients with type 2 diabetes: implications for digital health interventions

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Abstract

Background: It is generally agreed that a healthy diet could promote the management of diabetes, with emerging research indicating the potential delay and prevention of T2DM and its complications. This study used a qualitative method to obtain a first-hand and in-depth understanding of nutritional problems and concerns among patients with type 2 diabetes and explored the negative impacts of insufficient nutrition management on quality of life.

Methods: Twenty-one adult patients with type 2 diabetes participated in a semi structured interview regarding nutritional problems and negative impacts on quality of life. Recordings were transcribed verbatim, and content analysis was used to identify themes.

Results: Four themes emerged from the analysis to represent nutritional problems and negative impacts on quality of life: nutrition literacy, sociocultural aspects of nutrition, behaviours and nutrition management, and negative health-related outcomes .

Conclusions: Considering the nutrition issues and the negative impacts among Chinese patients with type 2 diabetes, digital health intervention was an effective way to improve their health-related outcomes. Personal, social, cultural and religious factors should all be taken into consideration when promoting nutrition knowledge and behaviours.

Introduction

As reported in the tenth edition of the International Diabetes Federation (IDF) Diabetes Atlas 2021, diabetes has aroused global concern due to its high and increasing prevalence. The condition affects 1 in 10 adults, with a total number of 537 million people impacted; this number has been predicted to reach 643 million by 2030 and 783 million by 2045(IDF Diabetes Atlas 10th edition., 2021). In the same report, it reveals that approximately four out of five (81%) diabetes patients live in low- and middle-income countries. Additionally, China occupies the first place with the number of adults with diabetes aged 20–79 years in 2021, with 140.9 million people. This number is almost twice of that in India, with a total number of 74.2 million of the same age group.

Type 2 diabetes (T2DM) accounts for the vast majority (approximately 90%) of diabetes cases worldwide. Numbers continue to rise, with over 350 million adults currently at high risk of developing T2DM. Persistently high blood glucose levels in T2DM have been widely recognized to be related to a number of debilitating complications affecting the heart, kidneys, nerves and eyes and are associated with frequent hospitalizations, premature mortality and reduced quality (Gregg, Sattar, & Ali, 2016).

Emerging research has indicated that T2DM and its complications can be effectively managed through education, support and the adoption of a healthy lifestyle, combined with medication as required (Evert et al., 2013; Ley, Hamdy, Mohan, & Hu, 2014). It is generally agreed that nutritional management combined with regular physical activity is an essential strategy to optimize glycaemic control and reduce long-term

complications (Guo, Huang, Sang, Gao, & Li, 2020; Mijatovic-Vukas et al., 2018). Diabetes self-management education (DSME) is prevalent as it has been shown to improve glycaemic control, lower long-term morbidity and all-cause mortality, increase insulin sensitivity and decrease the risk of foot ulcers (Chrvala, Sherr, & Lipman, 2016; He et al., 2017; Young et al., 2017).

Nutrition management is an important part in diabetes self-management education. Although several consensus reports and guidelines on diabetic nutrition management have been published in the USA (American Diabetes Association., 2020; Dyson et al., 2018; Evert et al., 2014; Inzucchi et al., 2015; Jia et al., 2019), the effectiveness and benefits of nutrition care on diabetic management in China are still limited. The barriers for this may be due to differences in dietary choices and eating habits among patients from different cultural backgrounds. For example, people in China prefer a high-carbohydrate and low-fat diet compared to people in Western countries, who prefer a diet higher in protein and fat, such as a ketogenic diet (Bolla, Caretto, Laurenzi, Scavini, & Piemonti, 2019; Zhang, Monro, & Venn, 2018). This requires more culturally specific and targeted nutrition advice, which eventually improves intervention adherence. Second, a shortage of trained diabetic specialists may reduce professional monitoring of patients' nutrition behaviours (Raaijmakers et al., 2013). Consequently, patients often fail to obtain feedback from health care workers immediately (Yin, Kong, & Chan, 2016). Digital health interventions (DHI) may be an effective solution to overcome the barriers associated with attending DSME and diabetic nutrition management. It bridges between patients and diabetic specialists for the potential of delivery DSME at multiple locations at convenient times in attractive and tailored formats.

With 56 distinctive ethnic groups, Chinese dietary culture is varied. Cooking styles and eating habits vary among different ethnic populations. Moreover, as the Chinese Nutrition Society recommends in guidelines, Chinese people prefer to consume vegetables instead of meat (Ding et al., 2021; *Acta Nutrimenta Sinica.*, 2021). Thus, dietary and nutritional concerns among Chinese adult patients with type 2 diabetes may differ from those among patients from Western countries. This may increase the difficulties to develop an culturally-appropriate digital health intervention. Therefore, this study adopted a qualitative method to obtain a first-hand and in-depth understanding of nutritional problems and concerns among patients with type 2 diabetes in the context of Chinese culture. A descriptive exploratory qualitative method allowed for the collection of rich narrative data and the understanding of the feelings, thoughts and experiences of the targeted population. The results of this study will imply the development of digital health interventions, and will also assist in the development of culturally tailored and patient-centred nutritional care to promote the management of glycaemia, reduce complications and increase health-related outcomes in this specific population.

Methods

Participants

In-depth face-to-face interviews were conducted between April and July 2021 among adult patients with type 2 diabetes who attended diabetic outpatient clinics at five hospitals in southwestern China. The

participants were purposefully selected based on their demographic characteristics and clinical features to produce a heterogeneous sample. Patients attending diabetic outpatient clinics were invited by their treating dietitian or reception nurse (both independent of the research study). The patients who met the following criteria were invited: (1) met the diagnostic criteria for T2DM according to the 2006 WHO report; (2) had a course of disease of more than 1 year; (3) were aged 18 years and older; (4) were capable of mutual communication and self-expression; and (5) agreed to participate in the study. The exclusion criteria were as follows: (1) had type 1 diabetes and gestational diabetes; (2) were unable to complete the interview due to poor health; (3) had a history of mental disorders; or (4) were diagnosed with cognitive impairment and/or an intellectual disability.

A total of twenty-one participants were recruited. Data saturation was set at the point at which no new data emerged. Saturation of the themes was reached prior to the completion of 19 interviews; however, two more interviews were conducted to ensure a diverse sample considering the participants' demographic characteristics and disease features.

Table 1 presents the demographic and clinical features of the interview participants. The age of the participants ranged from 45 to 77 years old, with a mean of 61.52 (SD: 10.81). The sample included 11 men (52.4%) and 10 women (47.6%). The BMI (kg/m^2) ranged from 16.65 to 34.85. The average number of years of living with T2DM was 10.27 (SD: 5.07). The mean HbA1c (haemoglobin A1c) of the participants was $9.02 \pm 4.42\%$.

Table 1
Characteristics of the participants

Characteristics	N(%)	Characteristics	N(%)
Gender		Years of T2DM	
Female	11 (52.4)	0 ≤ year ≤ 5	4 (19.0)
Male	10 (47.6)	6 ≤ year ≤ 10	10 (47.6)
Age		year > 10	7 (33.3)
20 ≤ age ≤ 40 years old	6 (28.6)	Religion	
41 ≤ age ≤ 60 years old	10 (47.6)	Buddhism	3 (14.3)
> 60 years old	5 (23.8)	Islam	2 (9.5)
Occupation		Christian	1 (4.8)
Retired	9 (42.9)	Not applicable	15 (71.4)
Staff or Farmer	7 (33.3)		
Self-employed	3 (14.3)		
Housewife	2 (9.5)		

Data Collection

Following a review of the literature on nutrition concerns and their impacts on health outcomes such as glycaemic control and quality of life (QoL) among T2DM patients, a semistructured interview guide was developed by the research group (Cheng, Wu, Dawkes, Lim, & Wang, 2019; Mokhtari, Gheshlagh, & Kurdi, 2019). The guide was approved by an advisory group that consisted of senior endocrinologists, charge nurses specializing in diabetes management, and nursing experts in qualitative studies. Interview questions were organized to explore the participants' experience in the following aspects: (1) nutritional concerns and problems; (2) perceived barriers and facilitators affecting nutrition management; (3) health outcomes due to nutrition management and/or nutrition problems; (4) problems with existing health services; and (5) implication for developing a digital health intervention. Table 2 shows the list of the specific questions that the participants were asked.

Table 2
List of the specific questions

Topics	Specific questions for This Topic
Attitudes	<p>How did you feel when you were diagnosed with T2DM?</p> <p>Did you feel you have enough information about nutrition?</p> <p>How did you regard the role of nutrition in T2DM management?</p>
Knowledge	<p>What nutrition for diabetes advice have you been given by clinicians?</p> <p>Where do you seek for diabetes and nutrition information and how accurate is it?</p> <p>What do you want to know about nutrition for diabetes?</p> <p>What foods do you think affect your blood glucose?</p> <p>What foods do you think are healthy or unhealthy?</p>
Behaviors	<p>How did you manage your diabetic dietary?</p> <p>What concerns you raised about nutrition management?</p>
Health-related outcomes & Quality of life	<p>How did feel about your nutrition management?</p> <p>How did T2DM affect your quality of life?</p> <p>How did nutrition management affect your T2DM and health?</p>
Implications for digital health interventions	<p>Have you ever used a digital health intervention to manage diabetes?</p> <p>If we are going to develop a digital health intervention to promote nutrition management, what do you want for the content and design features?</p>

After being given an information sheet and a verbal explanation at the start of each interview, all participants signed the informed consent form. The participants were well informed that their participation would not cause any impact on their treatment and care. A code name was used to protect their privacy and confidentiality and to ensure that each participant could not be identified through the quotations and descriptions.

All interviews were conducted by the authors, who were not involved in the participants' treatment and care. The interviews were organized in a waiting room to promote privacy and comfort. Semistructured face-to-face interviews were conducted one-on-one at a time convenient for the participants, and they were audio-recorded.

During the interview, a variety of techniques, such as communication skills, clarification probes and field notes, were adopted to promote data collection. Communication skills such as reflective listening promoted the participants' desire to talk and their sense of being respected. Emotional changes and body language were observed during the interview, supplemented by field notes. Field notes allowed researchers to document participants' nonverbal cues while minimizing interruptions to the flow of their

narratives. Clarification questions (e.g., "could you please talk more about..." or "what did you mean by...") were asked to encourage in-depth descriptions of the participants' feelings and thoughts. Interviews varied in duration from 30 to 60 minutes. After the interview, the participants were provided with a verbal summary of the interview within two weeks, and they were given opportunities to modify and clarify their interpretations.

Demographic and clinical data were collected according to the patient records, including age, sex, body mass index (BMI), occupation, religion, years with T2DM, family support and glycated haemoglobin levels (HbA1c).

Data Analysis

The interview recordings were listened to repeatedly and transcribed verbatim. Each transcript was double-checked by both the interviewer and the participant for accuracy. Field notes (e.g., pauses, tears in eyes, facial expressions and overall mood) were also added to the transcripts. No software was used in the data analysis.

Four phases of the thematic analysis approach were used by the analysis team (Braun & Clarke, 2008; Buetow, 2010). The four phases included being familiar with the data by repetitive reading of the interview transcripts multiple times; generating initial codes from the transcripts by identifying interesting, convergent and divergent features within the data; categorizing the codes into themes and the identification of relationships among the different codes; and reviewing and cross-checking the themes. Both bottom-up (inductive) and top-down (theoretical) approaches were adopted when generating themes. Inductive reasoning allowed the codes and themes to emerge through repetitive review of the transcripts, while deductive reasoning allowed a further examination of the themes in relation to the interview guide and the existing findings.

For the bottom-up analysis, after the first four interviews, an initial codebook was developed by the research team. Then, two of the authors, W.Y. and Z.Y., independently coded the remaining transcripts and added additional codes as appropriate. The interpretation of the codes was then discussed, and the themes were chosen by these two researchers until an agreement was reached based on consensus negotiation. In the final stage, in a top-down manner, the themes were redefined, and additional themes were developed, with comparisons to previous findings in the literature and our interview guide to ensure adequate coverage of all of the specific topics this study addressed. To improve the rigour of the findings, the themes were cross-checked and agreed upon by all authors. The authors have different educational backgrounds (diabetes, nutrition, nursing, sociology).

Ethical approval

The ethics of the study protocol was approved by the medical ethics committee of Southwest Hospital, the First Affiliated Hospital of Army Medical University, Chongqing, China. All selected hospitals were requested to follow ethical approval, and this study was conducted in accordance with The Code of

Ethics of the World Medical Association (Declaration of Helsinki). All participants provided informed written consent.

Results

Four themes emerged from the analysis to represent nutritional problems and negative impacts on the quality of life among Chinese patients with type 2 diabetes: nutrition literacy, sociocultural aspects of nutrition, behaviours and nutrition management, and negative impacts of poor nutrition management. Table 3 shows a list of themes and subthemes with the accompanying % proportions.

Table 3
List of the proportions of each theme and sub-theme

Themes & Sub-Themes	Number (percent, %)
Theme: Nutrition literacy	12(57.1)
Insufficient information provision	10(47.6)
Non-practical or over-theorized knowledge	7(33.3)
Inaccurate information	11(52.4)
Theme: Socio-cultural aspects of nutrition	17(81.0)
Family responsibility	6(28.6)
Family knowledge and awareness	3(14.3)
Social role stress	8(38.1)
Culture and religion	7(33.3)
Theme: Behaviors and nutrition management	18(85.7)
Low efficacy in management	7(33.3)
Poor treatment adherence	9(42.9)
Insufficient information seeking	15(71.4)
Theme: Negative impacts of poor nutrition management	16(76.2)
Psychological stress	11(52.4)
Poor glucose control	3(14.3)
Diabetic complications	4(19.0)
Reduced quality of life	14(66.7)

Theme 1: Nutrition literacy

Subtheme 1: Insufficient information provision

Almost 48% of the total respondents complained of insufficient knowledge and nutritional education. This was partially related to the Chinese health care system, in which doctors and nurses were fully occupied with therapies and operations and were too busy to provide nutrition knowledge. In the Chinese culture of hospital admission, the referral system is not well developed. Patients have full access to each level of hospital. Every patient can visit a tertiary hospital at any time. Therefore, a great number of patients access tertiary hospitals, and every doctor in their outpatient clinics may treat over one hundred patients per day.

"The health care workers only gave me an insulin pump and said nothing more. There were no doctors or nurses telling me about how to control my diet and did not discuss with me about what to eat and what not to eat in detail." (P12)

"The diabetic clinic was so crowded with patients. After waiting for at least 2 hours, I finally met the doctor. However, the doctor 'kicked me out' of his office within two minutes because many other patients were still waiting for him or her. I did not have a chance to ask about diabetic food in detail." (P05)

Subtheme 2: Nonpractical or overtheorized knowledge

Although educated by the health care workers, 23.8% of the total participants complained that the nutritional knowledge they were given was too broad and too superficial. They still expressed difficulties with the application of this information to daily meals because they did not know how to accurately control their diet and precisely calculate calories.

Moreover, 33.3% of the participants mentioned overtheorized knowledge. According to the traditional algorithm and theory provided by health-care workers, the amount and frequency of food intake were complex and difficult to calculate.

"I have no idea of what high-quality protein is. Tofu? Seafood? There are thousands of kinds of food. I am truly confused of what we could eat and what we could not." (P21)

"As the doctors and nurses said, according to guidelines and theories on diabetes, my meals were required to be carefully controlled by calculating the precise amount of overall food intake. That means you need to understand the calories of each kind of food, and you need to weigh the precise amount of the food, and then you need to make some calculations. These calculations are beyond my understanding as an older person. So I just quit."(P04)

Subtheme 3: Inaccurate information

Moreover, inaccurate knowledge was mentioned by 52.4% of the participants. There were some misunderstandings and incorrect perceptions of diabetic nutrition. For example, some diabetic patients thought they were not supposed to eat any kind of fruit.

"Diabetic patients cannot eat any fruit because all fruits contain sugar. One of my friends, who had diabetes for over 10 years, told me to cut back on any sweet, especially fruit. We believe that blood sugar would rise immediately after eating fruits and vegetables." (P01)

"I had an old friend who brought me two bottles of bee honey. He told me that honey was not high in sugar and was good for health with no side effects to diabetes. Therefore, I ate rice gruel and steamed bread with a spoonful of honey every day. However, as a result, my blood sugar went up high immediately." (P03)

Theme 2: Sociocultural aspects of nutrition

Subtheme 1: Family responsibility

Most patients with type 2 diabetes were living with family members, and it was generally recognized that family support was a key to successful diabetic self-care. Food acts as an important bridge connecting family members; therefore, patients' nutritional habits were greatly impacted by their family members. Approximately 28.6% of the respondents mentioned that they were willing to sacrifice themselves for their family. In other words, they gave priority to the nutritional needs of their children or other family members over their own. If there was a conflict between the therapeutic diet and the family's dietary preferences, the patients would go against the diabetic diet and consider their family's eating habits.

"I am a diabetic patient, but at the same time, I am also a mother. If I reduce the amount of the oil and sugar too much when cooking, my son won't eat the food because it is not tasty. In addition, my son needs enough energy for growing up. I could not require him to eat a diabetic diet along with me. That is not fair for him. Therefore, I cook and eat normal foods with my son; I rely on medicine to help me control the glucose." (P13)

Subtheme 2: Family knowledge and awareness

A total of 14.3% of the patients suggested that their family members also needed to master essential knowledge about diabetic nutrition. If family members lack relevant knowledge, they may fail to support patient diet control.

"My son is very kind to me. He always bought me a full box of fruit. There was a time that he sent me many mangoes by Federal Express. The mangoes were so large in size, I could only eat a half of one. However, it was wasteful to throw away the rest of the mango, so I ate the whole mango. In addition, I still have a full box of mangoes waiting for me to eat. I told my son not to buy so many fruits because I have diabetes; but he still does because he loves me." (P11)

Subtheme 3: Social role stress

Over 38% of the interviewees discussed that stress from multiple social roles may affect diet management and blood sugar control. Patients often ignored their own dietary needs because of their

responsibilities to family and work. For example, female diabetic patients were busy with family care while working at the same time, so they had no time to take care of their own diet control. Male diabetic patients complained about more pressure from work and social interactions, so they chose to give up their diabetic diet.

"I knew I had diabetes, but I was too busy at work to prepare myself a diabetic meal. Moreover, my child was at a key time in the preparation for the college entrance examination, and I spent my rest of time taking care of him. I just ate whatever I could have." (P08)

"Before, when I was working as a manager, I did have diabetes. However, at that time, I had lots of social interactions, with my colleagues, with my clients and with my working partners. We gathered together to eat and drink alcohol. I knew that it was harmful to my diabetes control. However, I had no other choice." (P03)

Subtheme 4: Culture and religion

Given that Chinese culture is generally associated with collectivism and hospitality, it was considered impolite to refuse food and beverages during social gatherings with family and friends. Some patients even worried about stigmatization as a result of their condition. This perception affected these patients' adherence to the nutritional recommendations.

In addition, religion was an important factor that influenced nutritional habits. Two participants reported that they practised the Islamic religion. They mentioned the conflicts between their religious culture and dietary habits.

"When I went to a dinner party, all my friends were eating and drinking. I did not want to look antisocial to them. In addition, I did not want them to know I had diabetes. I just ate as the same way as they did." (P5)

"I only ate meals before sunrise and after sunset. I did not eat anything, and even medicine at daytime. After Ramadan (Islamic holy month of fasting), we had a Corban Festival. We slaughtered sheep and cattle and ate our favourite traditional foods to celebrate. Although this would cause unstable blood sugar, we still followed traditional customs in our religion." (P17)

Theme 3: Behaviours and nutrition management

Subtheme 1: Low efficacy in management

One-third of the participants complained about their low efficacy of self-management. For example, the patient's diet control easily went to two extremes, either excessive restriction of food or no restraints.

"I knew a diabetic diet was important and essential for glucose control. However, I was born to love meat and desserts. I would not feel happy if I quit them. I could not completely change my diet habits. So I just ate whatever I wanted. If my blood glucose level fluctuated, I just took one more pill." (P4)

"I heard that eating fish and meat easily raises blood sugar, so I do not eat any fresh meat, even eggs; I only eat vegetables. One time when I was resident in the hospital, my doctors said that my protein index was low. I assumed that a low protein index was related to my strict restriction on meat." (P08)

Subtheme 2: Poor treatment adherence

Three interviewees complained that they felt it difficult to strictly adhere to meal plans due to changes in lifestyles or work schedules. Moreover, they did not know how to adjust their diet response to these changes.

Although some diabetic patients realized the importance and benefits of a balanced diet for glucose control, one-third of the participants still found it difficult to comply with a diabetic diet. Some type 2 diabetic patients refuse to reduce their fruit intake simply because they do not like it. In addition, some patients do not like to eat vegetables because they feel that the taste is unpleasant and does not conform to their personal taste preferences.

"I work in a police station. Sometimes I fail to eat my meals on time when there is an accident or an emergency. I have to deal with the case before I can eat my meal. The doctors' dietary advice was only suitable for patients living on a regular schedule. It did not suit people like me whose work schedule was not fixed." (P18)

"My husband and I both have diabetes. I adhere to dietary requirements very well, but my husband is obstinate and self-willed. Sometimes he sneaks out to eat ice cream and high-sugar foods. Then, he gets blood glucose fluctuations." (P7)

Subtheme 3: Insufficient information seeking

Diabetics reported high demands for nutrition information since information-seeking behaviours were evident in most participants (71.4%). Respondents discussed a variety of ways they looked for information related to nutrition, including surfing on the internet, talking with other patients, attending health professional lectures, and reading newspapers and cookbooks. However, none of the respondents reported finding a source that was convenient for seeking information about a diabetic diet. One reason was that some nutrition information was too professional to understand for patients. Moreover, complaints about the quality of online information were also raised. For example, information on the internet is explosive and contradictory, and it is difficult for patients to distinguish between true and false information. Third, they also worried about the leakage of personal information while logging into online education platforms.

"I attended many lecturers on nutrition organized by hospitals and communities, and I took notes carefully every time. However, my memory was poor. I could not remember exactly how to eat. It was troublesome and inconvenient to glance over all my notes. So I just gave up the notes and simply ate the same as before." (P15)

"Online information and education were convenient, but we still doubted the reliability of this information. I heard that personal information was leaked and money was cheated on the internet. So I did not think the network was very safe." (P20)

Theme 4: Negative health-related outcomes

Subtheme 1: Psychological stress

Over 52% of interviewees reported high alertness due to worries and fear of hypoglycaemia. They chose to eat extra meals if they felt slightly uncomfortable in case of hypoglycaemia. Sometimes they even completely ignored diet control to avoid hypoglycaemia.

"I have been too anxious to sit down since my diagnosis of diabetes. I am angry with myself because my parents and sisters do not have diabetes. I do not know how I can get this disease. I feel overwhelmed, and I even thought that it might be a punishment from the Gods." (P10)

Diabetes is a chronic and lifelong disease. Long-term self-management and worries about complications cause huge psychological pressure and place a mental burden on patients. Five participants expressed their lack of confidence and low self-efficacy regarding lifelong blood glucose control. This may be because they do not have correct knowledge about the required diet, so they have no idea of how to correctly control their blood glucose. Another reason may be that fluctuations in blood sugar do not provide them with positive feedback or a sense of benefits.

"Through diet control, I could never control the changing patterns in blood sugar, which was always high or always low. I am too tired and bored to monitor the diet and glucose. I want to give up." (P21)

"When my blood sugar is unstable, I often feel upset and particularly sad. Why was it me who got this disease, and why can I not eat sweet food and eat whatever I want, just like my other friends have done." (P06)

Subtheme 2: Poor glucose control

One of the evident impacts of diet is the fluctuation in the blood sugar level. Failing to follow strict diet management may result in poor glucose control.

"When my blood sugar went up slightly higher, my daughter asked me to control my diet first, saying that 'if I did not control my diet well, I would soon get diabetes'. I did not believe it at all, and I still ate dates all day long. As a result, after half a year, my fasting blood sugar reached more than 10." (P14)

Subtheme 3: Diabetic complications

The fluctuating blood sugar caused by uncontrolled diet management may also lead to a variety of diabetes-related complications, such as diabetic nephropathy, diabetic retinopathy, cardiovascular and

cerebrovascular diseases. Complications increase the physical and economic burdens on patients and are closely associated with a decrease in health quality of life.

"Actually, I knew my blood sugar was high five years ago, but I did not take it seriously. I still ate whatever I wanted. Anyway, it did not hurt or itch, until I developed some problems in my eyes. I regretted that I did not listen to the doctor's advice on diet control from the beginning." (P06)

Subtheme 4: Reduced quality of life

The experience of daily insulin injection and the fear of hypoglycaemia and diabetic complications had a negative impact on daily activities and social interactions, eventually resulting in a decrease in quality of life. Two-thirds of the respondents suffered a reduced quality of life when they were too cautious about low blood glucose. They had to prepare candy and nuts in case of hypoglycaemia everywhere they went, including at home, at their workplace and when travelling.

"I cannot accept that I have to take an insulin injection before eating every day; and I cannot bear that I have to take my insulin pen when going out for a long distance. All of these are inconvenient." (P12)

"There is a joke saying that 'it is all right to go out without taking money, but it is bad to go out without candy'. I know the bad feeling of hypoglycaemia, so now I have sugar all over my house. If I do not have a few sweets handy, I'm in a panic." (P09)

Moreover, some participants even mentioned behaviours of avoidance and restrictions on physical exercises and social interactions. The interviewees were overly cautious about hypoglycaemia to the point that they avoided going out and reduced their participation in social gatherings. One respondent even gave up driving due to the potential risks of hypoglycaemia.

"Generally, I seldom go out and travel around because it is very inconvenient that I have to prepare medicine and insulin. In addition, I keep worrying about emergency situations such as hypoglycaemia." (P07)

"I quit driving a car on my own. When I have a hypoglycaemia attack, I shiver and cannot move my body. I am afraid this will place me in a dangerous situation if I am driving." (P08)

Discussion

This qualitative study adopted a one-on-one in-depth interview among 21 patients with type 2 diabetes in the Chinese cultural context, aiming to examine the experience and problems of nutrition management and the negative impacts on quality of life. Four issues of nutrition management were revealed: nutrition literacy, sociocultural aspects of nutrition, behaviours and nutrition management, and negative impacts of poor nutrition management.

Most of our interview participants recognized that dietary control helped them manage their diabetes and obtained psychological and physical benefits. A lack of and inaccuracy of knowledge about diabetes

management were common issues among Chinese patients with T2DM, although health-care professionals have made great efforts to promote nutrition education among diabetic patients. Three issues were mentioned about nutrition education: insufficient, inaccurate, and over-theorized (Fig. 1). More specifically, participants' complaints revolved around the limited time they had to communicate with health-care workers, limited access to nutrition knowledge, and limited understanding of complicated terminology and calculations. Moreover, conflicts have also been raised with regard to the medical and referral systems in China. Patients visited tertiary hospitals without appointments or referrals. Therefore, Chinese diabetic specialists also complained that their great workloads in clinical settings do not allow them to spend enough time providing detailed and precise knowledge and information even though they wish to do so. These results highlighted the need for effective interventions for information provision and training in the context of diabetic care.

A multidisciplinary team (MDT) including nurse specialists and nutritionists may be a potential solution to promote nutrition education and management. First, T2DM management is complicated since metabolic disorders such as obesity, hypertension and hyperlipidaemia often coexist with T2DM, further heightening the risk of diabetes-related complications. A single health care professional cannot effectively deliver all components of T2DM treatment (Dankoly et al., 2021). An MDT is generally composed of different health care disciplines, usually physicians, nurse practitioners, dietitians, and other health care professionals. They meet together to discuss a patient's health care plan and with each member, contributing to the patient's treatment and care (Tan et al., 2020). McGill et al (McGill et al., 2017) reported successful practices of implementing multidisciplinary team care in T2DM. For example, in a USA Boot Camp study of an integrated health care delivery system, involving a primary care trained nurse practitioner, endocrinology-certified diabetes educator (CDE) and a pharmacist, the results revealed a substantial reduction in HbA1c levels among the Boot Camp participants compared to those who were not enrolled in the Boot Camp (HbA1c declined from 96.94 mmol/mol to 66.56 mmol/mol vs. 95.53 mmol/mol to 87.55 mmol/mol). Second, from the patient's perspective, a desirable MDT requires access to include primary care physicians, specialist endocrinologists, dietitians, nurses and nurse practitioners with diabetes expertise, social workers/case managers and physical therapists. In a recent randomized controlled trial, the intervention arm was multidisciplinary collaborative care. In addition to receiving usual care, patients with uncontrolled type 2 diabetes, polypharmacy and comorbidities were also regularly followed up by pharmacists. The results showed a significant reduction in the mean HbA1c from $8.6\% \pm 1.5\%$ at baseline to $8.1\% \pm 1.3\%$ at 6 months (Siaw et al., 2017).

Another feasible solution is to adopt e-Health technologies and develop mobile apps to assist with nutrition management (Lv et al., 2019). Electronic health (eHealth) and mobile health (mhealth) technologies such as web-based programs and smartphone applications have been demonstrated to be effective in assisting individuals with diabetes self-management behaviours (Rollo et al., 2016). For instance, the mobile app GlucoMan (Denecke et al.) (Schmocker, Zwahlen, & Denecke, 2018) supports data collection, allowing patients to monitor disease-relevant parameters; however, more functions need to be developed regarding nutrition care and dietary management. Gifford et al (Cassar, Denyer, O'Connor, & Gifford, 2018), in their qualitative investigation, identified domains to improve nutrition literacy,

including specific nutrients versus foods, labels and packaging, construction of the diet, knowledge and guidance for healthy eating, understanding of serving and portion sizes, the ability to select healthier foods, and demographics such as belief systems and culture. Consistent with the previous studies, our studies found that patients with T2DM were most interested in food and nutrition therapy. However, participants pointed that most of the current diabetes-related digital technologies addressed all aspects of living with diabetes, including medicine, diet, physical activity, mental health, and social connection. This will distract their attention from nutrition management and improve the difficulties to reach the information they really needed.

As shown in Figure 1, the consequences of knowledge inaccuracy and insufficiency were misunderstanding and negative attitudes towards nutrition management and eventual harmful behaviours such as a lack of adherence to medical treatment. Most current interventions are focused on how to improve relevant knowledge. Nevertheless, according to the knowledge, attitude, and practice (KAP) model (Alidosti et al., 2012), changes in nutrition behaviours go through three continuous processes: acquiring knowledge, producing beliefs, and forming behaviours (Xiong et al., 2020). Diabetic care workers, in addressing both cognitive factors (knowledge) and emotional factors (attitudes and perceptions), can promote effective dietary behaviours.

Most importantly, similar to previously reported results (Frier, 2014; Umpierrez & Korytkowski, 2016), patients themselves brought up the risks of hypoglycaemia as a major concern. Hypoglycaemia is one of most common acute complications in diabetes and may threaten patients' lives. In addition, as our participants reported, hypoglycaemia has also been positively associated with increased rates of mental disorders such as anxiety and depression, deficits in working capabilities, and reduced levels of social interactions. All of these factors will eventually reduce health-related outcomes, including quality of life. Similarly, Orozco-Beltrán et al. reported that nearly half of T2DM patients are rarely or never informed about hypoglycaemia, and fear of hypoglycaemia may contribute to poor adherence to treatment and therefore limit glycaemia control. He and his team even developed and validated a specific questionnaire to assess the impact of hypoglycaemia on the HRQoL of T2DM patients (Win, Fukai, Nyunt, Hyodo, & Linn, 2019).

In addition to the influence of hypoglycaemia on quality of life, Dr. Zurita-Cruz et al. also reported that QoL in patients with T2DM was modified by multiple factors, including the presence of diabetes distress, medication adherence, depression symptomatology, longer duration of diabetes, use of insulin, marital status, and comorbidities (Wu et al., 2013). This was consistent with our results that marital status and sufficient support from family members in nutrition management could enhance management behaviours, improve the quality of blood glucose control, and eventually promote quality of life. Family support was a great emotional comfort when patients were diagnosed with diabetes or were in a depressed mood. Most patients lived with family members, such as spouses. Family members can play a role in supervision and provide reminders. For example, they can help manage blood glucose, remind patients about consuming diabetic food, and monitor emergencies such as hypoglycaemia. Elderly people whose children were not around could receive help with blood glucose management through

WeChat and telephone. Second, it was found in this study that the dietary preferences and habits of family members restricted patients' compliance with diabetic diets. The lack of awareness of the importance of diet and the lack of knowledge of how to control the diet among family members would be detrimental to the dietary control of the patients. Third, the patients, especially female patients, had to expend time and energy in taking care of their families, which hindered the management of their own diet. Therefore, the patient's family members should be included in nutrition education. In addition, it was suggested that the dietary preferences and habits of the patients' families should also be evaluated, and the influence of family dietary habits should be considered.

Conclusions

This study identified key issues regarding nutrition self-care specific to patients with type 2 diabetes in the Chinese context. Personal, social, cultural and religious factors were also identified within the context of the ecological model. A conceptual model was then developed to illustrate the nutrition problem and its negative impact on health-related outcomes. Considering the nutrition issues and the negative impacts among Chinese patients with type 2 diabetes, digital health intervention was an effective way to mutual communications on nutrition self-care between diabetic specialists and diabetic patients.

Abbreviations

T2DM

type 2 diabetes mellitus

BMI

body mass index

HbA1C

glycated haemoglobin levels

QoL

quality of life

PROM

patient-reported outcomes

MDT

multidisciplinary team

KAP

knowledge attitude and practice

DSM

diabetes self-management

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the medical ethics committees within the hospitals.

Consent for publication

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

None to declare.

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Not applicable.

Authors' contributions

Study design: YW, CM and YZ. Data collection: YW, XY, XG, CM and YZ. Data analysis: YW, XY and YZ. Data interpretation: YW, XY, XG, CM and YZ. Manuscript draft: YW. Manuscript revision: CM and YZ. Manuscript approval: YW, XY, XG, CM and YZ.

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Figures

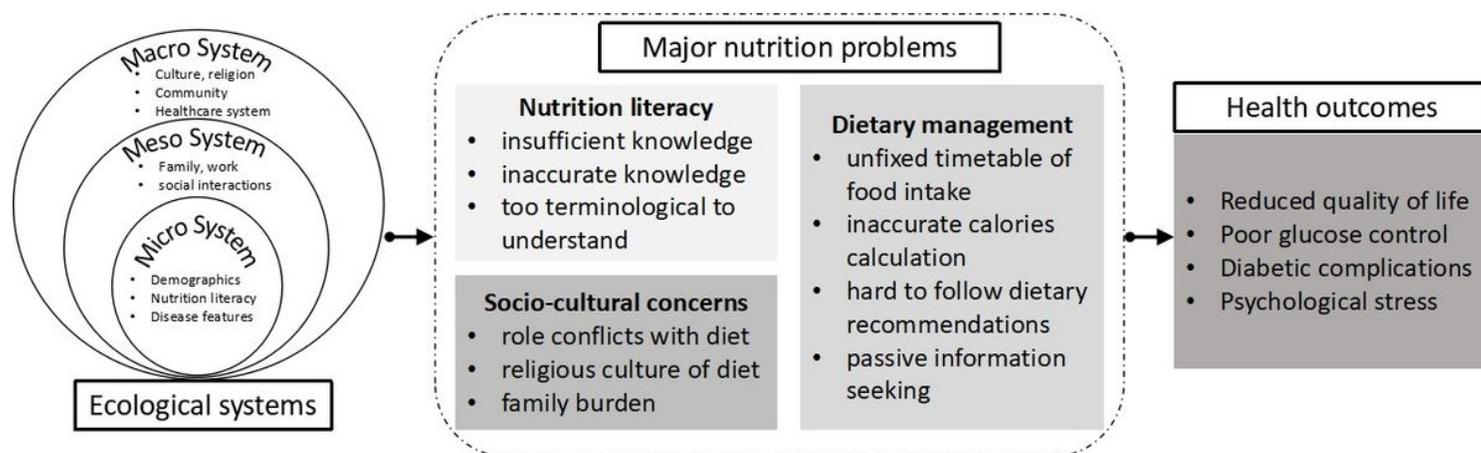


Figure 1

a conceptual model of nutritional problems and its negative impacts on quality of life