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Subjective Cognitive Patterns of Digital Health Tool Usage Intention Among Patients with Type 2 Diabetes Mellitus: A Q-Methodology Study

Zhao Yuan[1]
the First Hospital of Shanxi Medical University
Shang Linping[1]
the First Hospital of Shanxi Medical University
Tang Shan
the First Hospital of Shanxi Medical University
Li li
the First Hospital of Shanxi Medical University
Lin Yanli[1]
the First Hospital of Shanxi Medical University
Li Yuling[1]
liyuling@163.com
the First Hospital of Shanxi Medical University

Research Article

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Abstract

Objective

This study aimed to explore the internal cognitive structure and identify typical subjective cognitive patterns underlying the intention to use digital health tools (DHTs) among patients with type 2 diabetes mellitus, so as to provide a theoretical basis for formulating precise and personalized promotion and intervention strategies for DHTs.

Methods

Q-methodology was adopted in this research. A total of 36 Q-statements were constructed through semi-structured interviews, literature review, and expert consultation. Thirteen patients with type 2 diabetes mellitus were enrolled as the P-sample and completed forced normal distribution sorting of all statements, with a scoring range from − 5 to + 5. KADE software was used for factor analysis to extract and name the dominant factors.

Results

Three typical subjective cognitive patterns were identified, including the empowerment-oriented type (5 participants), risk-averse type (3 participants), and practical tool-oriented type (3 participants). Significant differences were observed among the three patterns in terms of perceived benefits, risk perception, perceived ease of use, and demands for social support.

Conclusion

Patients with type 2 diabetes mellitus exhibit substantial heterogeneity in their intention to use DHTs, which can be classified into three cognitive patterns with distinct internal logics. Clinical medical staff and digital health product designers should differentiate these cognitive patterns and implement targeted intervention strategies, so as to improve the acceptance rate and sustainable use effect of DHTs among diabetic patients.

Background

Diabetes mellitus has become one of the most severe public health challenges worldwide. According to the 11th edition of the International Diabetes Federation (IDF) Diabetes Atlas, the number of adults aged 20–79 years living with diabetes globally reached 589 million in 2024, accounting for 11.1% of the total population in this age group, and the figure is projected to rise to 853 million by 2050[1]. China bears the heaviest diabetes burden across the globe, with approximately 148 million adult diabetic patients recorded in 2024, ranking first worldwide[1]. Over the past three decades, the prevalence of adult

diabetes in China has surged from 2.5% in 1994 to 13.0% in 2021, accompanied by a remarkable younger-onset trend[2]. Meanwhile, the prevalence of prediabetes is as high as 38.1%, forming a huge potential high-risk population pool.

Currently, the awareness, treatment, and control rates of diabetes in China are merely 36.7%, 32.9% and 16.5% respectively, with more than half of patients undiagnosed or under poor disease management[3]. In 2024, diabetes-related deaths in China exceeded 590,000, and the total economic expenditure reached 169 billion US dollars, imposing a heavy burden on the national healthcare system[1].

As a lifelong chronic disease, effective management of diabetes relies heavily on patients' daily self-management. Digital health tools represented by health management applications, wearable monitoring devices and remote follow-up platforms have great potential to optimize long-term self-management and continue nursing services inside and outside hospitals for diabetic patients. However, the adoption rate and sustained usage rate of DHTs remain relatively low in clinical practice, and an obvious gap exists between technical supply and patients' actual usage willingness[4–5].

Most existing studies are based on classical theoretical frameworks such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), adopting questionnaire surveys to analyze the influence of external variables on behavioral intention. Such quantitative approaches are difficult to deeply reveal patients' subjective construction logic in value trade-offs, risk perception and demand preference[6–7]. Traditional quantitative research is limited in capturing the heterogeneity of group subjective attitudes, while pure qualitative research is susceptible to researchers' subjective bias[8].

Q-methodology is a mixed-methods research approach focusing on human subjectivity, which classifies participants' attitude subtypes objectively through qualitative statement refinement and quantitative factor classification. It is highly suitable for exploring the subjective cognitive differences in health technology acceptance among chronic disease patients[9]. At present, Q-methodology has been widely applied in the fields of chronic disease nursing needs and health technology acceptance, while studies focusing on the subjective typing of DHTs usage intention among diabetic patients remain scarce[10–11].

Maslow's hierarchy of needs theory divides human needs into five levels: physiological needs, safety needs, love and belonging needs, esteem needs, and self-actualization needs[12]. Diabetic patients' willingness to adopt DHTs essentially reflects the trade-off of health needs at different levels: personal health data privacy corresponds to safety needs, the improvement of self-management ability corresponds to self-actualization needs, and operational simplicity and medical service connection correspond to basic physiological and efficiency needs. Based on Maslow's hierarchy of needs theory, this study adopted Q-methodology to analyze the subjective cognitive patterns of DHTs usage intention among diabetic patients, aiming to provide theoretical support for the formulation of hierarchical and precise clinical intervention and product design strategies.

1 Participants and Methods

1.1 Research Participants

1.1.1 Participants for Q-statement Interviews

Purposive sampling was adopted to recruit outpatients and inpatients with type 2 diabetes mellitus from a tertiary hospital for semi-structured interviews.

Inclusion criteria:

 Aged 18 years and above;

 Clinically diagnosed with type 2 diabetes mellitus for no less than 1 year in accordance with the Guidelines for the Prevention and Treatment of Type 2 Diabetes Mellitus in China (2020 Edition)[2];

 Possessing basic smartphone operating experience;

 Voluntary participation with signed informed consent.

Exclusion criteria:

 Critically ill or unconscious patients unable to cooperate with the interview;

 Patients with language communication or cognitive dysfunction.

A total of 15 patients completed the interviews, including 8 males and 7 females, aged 35–70 years with an average age of (54.6 ± 12.3) years; the disease course ranged from 1 to 15 years. In terms of educational level, 3 patients had primary school education or below, 4 had junior high school education, and 8 had senior high school education or above. This study strictly followed the principles of the Declaration of Helsinki and was approved by the Hospital Ethics Committee (Approval No. KYLL-2025-294). All participants signed written informed consent before enrollment.

1.1.2 Q-sorting Participants (P-sample)

Another 13 patients who met the same inclusion and exclusion criteria were recruited as the P-sample for Q-sorting. In Q-methodology, the sample size of P-sample is usually 1/3 to 1/2 of the number of Q-statements[13]. Finally, 11 valid P-samples were included for statistical analysis.

1.2 Research Methods

1.2.1 Construction of Q-statement Sample

1.2.1.1 Development of Interview Outline

The semi-structured interview outline was formulated based on literature review and expert consultation with three specialists engaged in chronic disease nursing and health informatics:

 What diabetes management apps, wearable monitoring devices and other digital health tools have you known or used?

 What benefits and concerns do you have about using such tools for diabetes management?

 What factors promote or hinder your willingness to try new digital health tools?

 What functions and characteristics do you expect from an ideal diabetes-oriented digital health tool?

1.2.1.2 Data Transcription and Statement Refinement

Each interview lasted no less than 20 minutes. All interview recordings were transcribed into texts verbatim, followed by open coding, statement simplification and deduplication until data saturation with no new viewpoints emerging.

1.2.1.3 Finalization of Q-sample

Three experts in related fields were invited to review, delete and revise the initial statements. Ultimately, 36 representative Q-statements were finalized, covering multiple dimensions including perceived benefit, perceived risk, ease of use demand, social influence, external support and emotional psychology. All 36 statements were randomly coded and made into Q-cards for subsequent sorting.For specific details, refer to Table 1.

Table 1

Q-statements on patients' intention to use digital health tools among type 2 diabetes mellitus patients

ID	Q-statement
Q1	Using digital health tools makes me gain a stronger sense of control over my condition
Q2	I am concerned that my blood glucose and other health data may be leaked or used for commercial purposes
Q3	I am willing to try these tools as long as their operation is simple and intuitive
Q4	No matter how much information the tool provides, it cannot replace face-to-face communication with doctors
Q5	I am more willing to use the tools if they can reduce hospital visits and medical costs
Q6	I expect the tool to automatically provide dietary and exercise adjustment suggestions based on my blood glucose data
Q7	I worry that inaccurate device measurements may mislead my disease management decisions
Q8	I feel more supported if family members or friends can view my health data and give reminders via the tool
Q9	Learning to use new tools costs too much time and energy, and I prefer traditional paper records
Q10	I hope disease management can be more interesting with game-like challenges and rewards in the tool
Q11	I will only try the tools officially recommended by doctors or nurses
Q12	I worry about additional long-term costs of using digital health tools
Q13	Viewing charts and data of well-controlled blood glucose gives me a strong sense of accomplishment
Q14	I will quickly lose patience if too much manual data entry is required
Q15	I hope the tool can connect with medical insurance information and synchronize data with hospital systems
Q16	Using these tools makes me feel like a modern patient and face the disease more actively
Q17	I am concerned that over-reliance on tools may weaken my ability to judge my own condition
Q18	The reminder function is very useful for people like me who are forgetful
Q19	There is abundant health information online, so there is no need to use dedicated digital health tools
Q20	I hope professional dietitians or health managers can provide guidance through the tool platform
Q21	It frustrates me that I have no one to consult when encountering problems in using the tools

ID	Q-statement
Q22	The interface design and friendliness of the tool affect my long-term usage intention
Q23	I only consider using the tool to provide complete medical records for doctors during follow-up visits
Q24	I feel pressured and out of step with peers if other diabetic patients are using the tools while I do not
Q25	I trust written paper records more than electronic devices for higher reliability and privacy
Q26	I hope the tool can manage not only blood glucose but also integrate blood pressure, weight and other health indicators
Q27	Potential troubles caused by trying new tools make me hesitant to adopt them
Q28	Jointly setting disease management goals with family members can enhance mutual understanding
Q29	Complex tools are not suitable for me due to old age, poor eyesight and inflexible hands
Q30	I will be more confident to use the tools if training courses are held in communities or hospitals
Q31	A peer communication community in the tool can reduce my sense of loneliness in disease management
Q32	Diabetes management mainly depends on self-discipline and living habits, and tools play a decisive role
Q33	I worry that personalized suggestions provided by the tool may be inappropriate and even harmful to my health
Q34	Clear health trend reports provided by the tool are more persuasive than vague personal feelings
Q35	I want to master the use of these tools to better manage my disease and avoid troubling my children
Q36	I will have higher trust in tools certified and recommended by authoritative institutions

1.2.2 Q-sorting Procedure

An 11-point scoring method was adopted, with a forced normal distribution sorting grid set from − 5 (strongly disagree) to + 5 (strongly agree). Researchers explained the connotation of each Q-statement to participants one by one. Participants placed 36 Q-cards into the corresponding grid according to their agreement level and were allowed to adjust the positions repeatedly until final confirmation. After sorting, semi-structured in-depth interviews were conducted focusing on statements with extreme scores (+ 5, − 5) to record participants' reasons and subjective thoughts.

1.2.3 Statistical Analysis

KADE software was used for statistical analysis of Q-methodology data[14]:

 Principal component factor analysis was performed to extract common factors with eigenvalue ≥ 1 and cumulative variance contribution ≥ 40%[15];

 The critical value of factor loading was set at ≥ 0.43. Each included factor should correspond to no less than 2 participants, while samples with cross-factor loading or invalid loading were eliminated[16–17];

 Factor standard Z-scores were calculated, with Z ≥ 1.0 defined as positively recognized statements and Z ≤ − 1.0 as negatively rejected statements[18].

2 Results

2.1 Results of Q-sorting Factor Analysis

Initially, four common factors with eigenvalue ≥ 1 were extracted, with a cumulative variance contribution rate of 69%. After varimax rotation, 2 unrepresentative samples were eliminated. Factor analysis was reperformed on the remaining 11 valid samples, and 3 common factors with eigenvalue ≥ 1 were extracted, explaining 64% of the total variance. The three factors corresponded to 5, 3 and 3 participants respectively.

2.2 Classification and Characteristics of Subjective Cognitive Patterns

2.2.1 Factor 1: Empowerment-oriented Type (n = 5)

This pattern had high loading on statements Q6 (Z = 2.01), Q13 (Z = 1.65) and Q34 (Z = 1.58). Patients in this subtype highly recognized the value of DHTs in providing personalized dietary and exercise suggestions, visualizing blood glucose data and analyzing health trends. They regarded DHTs as an important carrier to improve self-management efficacy and grasp the initiative of disease management, which corresponded to the self-actualization needs in Maslow's theory.

2.2.2 Factor 2: Risk-averse Type (n = 3)

High loading statements included Q2 (Z = 1.92), Q7 (Z = 1.58) and Q27 (Z = 1.47). Participants in this subtype mainly focused on health data privacy leakage, device measurement inaccuracy and potential risks of adopting new tools. They held a prudent and conservative attitude towards digital health technologies and gave priority to safety and risk prevention, which conformed to the safety needs in Maslow's theory.

2.2.3 Factor 3: Practical Tool-oriented Type (n = 3)

High loading statements were Q3 (Z = 1.71), Q15 (Z = 1.45) and Q14 (Z = 1.38). Participants held a pragmatic and rational attitude, focusing on operational simplicity, data interconnection between hospital and medical insurance systems, and reducing the burden of manual data entry. They valued the

practicality and efficiency of DHTs, balancing physiological convenience needs and social service adaptation needs.

The representative Q statements and corresponding Z scores of three cognitive patterns are shown in Table 2.

Table 2
Representative positive and negative Q-statements of each cognitive pattern (Z-score)

Factor	Cognitive pattern	Positive statements (Z ≥ 1.0)	Negative statements (Z ≤ − 1.0)
1	Empowerment-oriented	Q6, Q13, Q34, Q1, Q16	Q19, Q32
2	Risk-averse	Q2, Q7, Q27, Q33, Q17	Q10, Q24
3	Practical tool-oriented	Q3, Q15, Q14, Q5, Q18	Q9, Q29

3 Discussion

3.1 Empowerment-Oriented Type: Meeting Self-Achievement Needs and Stimulating Intrinsic Motivation

In this study, patients with an empowerment-oriented approach constituted the largest proportion (5/11). Their core characteristic is viewing digital health tools as "empowerment agents" that enhance self-management capabilities. These patients exhibit strong demand for features such as personalized feedback, data visualization, and trend analysis, hoping the tools will help them "gain a clearer understanding of their health status." This aligns closely with Maslow's hierarchy of needs, where patients seek not only basic information but also personal growth and improved problem-solving abilities through the tools [12]. Previous research has demonstrated that digital interventions providing personalized feedback and a sense of achievement significantly improve self-management adherence among diabetic patients [19–20]. Therefore, product design for empowerment-oriented patients should focus on developing features such as in-depth data analysis, visual reports, goal-setting, and reward mechanisms. In clinical implementation, emphasis should be placed on how the tools help patients "take ownership of their health," thereby stimulating their intrinsic motivation.

3.2 Risk-Avoidance Type: Strengthening Security Needs and Establishing a Trust Foundation

Patients of the risk-avoidance type exhibit heightened sensitivity to data privacy, technical accuracy, and potential negative consequences. Their concerns are not unfounded—existing studies report frequent data breaches in health apps [21], and the measurement accuracy of certain devices is questionable. Maslow's hierarchy of needs theory indicates that security needs rank second only to physiological needs; individuals only pursue higher-level needs when their safety is assured [12]. Therefore, for risk-

avoidance patients, intervention strategies should prioritize addressing trust issues: On one hand, tool developers should mitigate privacy risks through transparent privacy policies, end-to-end encryption, and localized storage technologies; on the other hand, healthcare professionals should proactively explain the security mechanisms of the tools to patients and recommend products certified by authoritative institutions (e.g., approved by the National Medical Products Administration or recommended by the Diabetes Branch of the Chinese Medical Association) [2]. Additionally, offering free trial periods or offline experience opportunities can help alleviate patient concerns [22].

3.3 Practical Tool Type: Balancing ease of use and integration, meeting efficiency requirements

Practical tool-oriented patients adopt a pragmatic attitude, focusing most on the ease of use, cost-effectiveness, and integration with existing medical services of the tools. These patients usually have limited time or lack patience for technical operations, and they hope that the tools are "not troublesome and truly useful". This preference intersects with both the physiological needs (such as saving time and energy) and the esteem needs (such as improving efficiency and gaining recognition) in Maslow's hierarchy of needs [12]. Notably, in this study, practical tool-oriented patients had a more prominent demand for "connection with the medical insurance system" and "synchronization with the hospital system", suggesting that the current fragmentation between digital health tools and the existing medical system is a significant barrier to adoption [22–23]. Therefore, at the policy-making level, efforts should be made to promote the interconnection of regional health information platforms to enable automatic integration of home-based patient data with electronic health records. At the product design level, user experience should be optimized, manual input should be reduced, and convenient input methods such as voice and photo capture should be supported. Additionally, exploring the inclusion of tool usage costs in medical insurance reimbursement is also recommended.

3.4 The heterogeneity of cognitive patterns calls for differentiated strategies.

The three cognitive patterns identified in this study share similarities with the findings of the research on the functional exercise needs of patients with PICC catheters after breast cancer surgery [10] and the study on the preferences of family caregivers of dementia patients for virtual care support [11]: the needs for health support among patients with chronic diseases and their caregivers show significant heterogeneity. For instance, in the breast cancer study, information support need type, full-cycle management need type, and emotional support need type were identified [10]; in the dementia caregiver study, basic need type, self-help acquisition type, multi-party collaboration type, and communication and sharing type were discovered [11]. Additionally, the supportive care needs of patients with PICC catheters also exhibit multi-dimensional characteristics [24]. Although the specific dimensions differ, they all indicate that a one-size-fits-all intervention strategy is difficult to meet the needs of all patients. Therefore, in clinical practice, medical staff should quickly identify the cognitive pattern type of patients through brief assessment tools and provide personalized recommendations and support accordingly.

For example, recommend powerful APPs to empowerment-oriented patients, emphasize safety certification to risk-averse patients, and recommend user-friendly products that integrate well with hospital systems to practical tool-oriented patients.

3.5 Dynamic and Staged Support for Cognitive Patterns

The cognitive patterns of patients are not static and may change with the progression of the disease, technological experience, and life circumstances. For instance, newly diagnosed patients may be more risk-averse due to a lack of information, but as they accumulate experience in disease management and enhance their self-efficacy, they may gradually shift towards an empowerment-oriented approach. This dynamic nature is consistent with the findings in studies on patients with PICC catheters after breast cancer surgery, which revealed differences in behavioral and psychological characteristics at different stages of catheter use [10], and in studies on dementia caregivers, which showed a correlation between the duration of care and preference types [11]. Therefore, it is recommended to establish a dynamic assessment mechanism to reevaluate patients' cognitive patterns at different stages, such as the initial contact, mid-term use, and long-term maintenance, and adjust support strategies accordingly. For example, in the initial stage, high-touch, high-support guidance (such as face-to-face teaching or video tutorials) can be provided; during the proficient stage, more in-depth functional exploration and community support can be offered.

3.6 Insights for Product Design and Policy Formulation

The results of this study provide specific guidance for the design and promotion of digital health tools [23]: (1) Modular design: The tool should offer customizable functional modules, allowing users to turn on or off certain functions (such as data analysis, social sharing, privacy protection mode) according to their own preferences. (2) Hierarchical promotion strategy: Different communication styles and recommendation paths should be adopted for patients with different cognitive patterns. (3) Strengthened supervision and certification: Establish an authoritative digital health tool certification system to alleviate the widespread concerns about privacy and security. (4) Promote data interoperability: Accelerate the standardization construction of medical and health information to achieve seamless connection between patients' home data and electronic health records.

4 Conclusion

Based on Q-methodology, this study identified three stable subjective cognitive patterns of DHTs usage intention among type 2 diabetes mellitus patients, namely empowerment-oriented type, risk-averse type and practical tool-oriented type. The three patterns presented significant heterogeneity in perceived benefits, risk concerns, ease of use demands and social support expectations. Clinical medical staff, health managers and digital health designers should fully respect individual cognitive differences and implement classified and precise intervention and product optimization strategies. Future studies are suggested to expand the sample size and conduct longitudinal follow-up research to explore the

dynamic evolution law of cognitive patterns, providing more empirical evidence for constructing an intelligent and precise home management system for diabetic patients.

Abbreviations

DHTs
Digital health tools
IDF
International Diabetes Federation
TAM
Technology Acceptance Model
UTAUT
Unified Theory of Acceptance and Use of Technology
Q-methodology
Q methodology
P-sample
Participant sample

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the First Hospital of Shanxi Medical University (Approval No. KYLL-2025-294). Written informed consent to participate was obtained from all individual participants included in this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YL Li and LP Shang designed the study. Y Zhao and YL Lin performed data curation and screening. Y Zhao and L Li conducted formal analysis. Y Zhao wrote the original draft. L Li and Sh Tang reviewed and edited the manuscript. All authors read and approved the final manuscript.

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