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Smart Care Technology for Self-Management of Diabetes in Older Adults: Applications, Progress, and Barriers

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Abstract: Diabetes mellitus is a serious chronic disease that threatens the health of the elderly. Effective self-management, i.e. continuous daily health management responsibilities undertaken by individuals in the course of disease, including regular medication, blood glucose monitoring, reasonable diet and moderate exercise, is the key to controlling blood glucose, delaying complications and improving quality of life. However, elderly diabetics face many obstacles to self-management. At the physiological level, aging-related cognitive decline, vision deterioration, hearing loss, and reduced hand dexterity impair the frequency and quality of self-management behaviors; At the psychological and cognitive level, some patients have diabetes-related psychological pain, insufficient disease cognition and low self-efficacy; at the social support level, empty nest elderly lack family supervision and emotional support, and patients in rural areas have limited access to medical resources; At the level of health literacy, the health literacy level of elderly patients is generally low, and there are limitations in mastering disease knowledge and treatment programs. Multiple obstacles stack up, making the self-management of elderly diabetic patients at a low level for a long time.

Keywords: Smart Care; Diabetes; Self-management; Digital Health.

1. Introduction

In China, chronic disease patients account for about 19.0% of the total population, and deaths caused by chronic diseases account for 88.5% of the total deaths. Prevention and control of chronic diseases have become an important public health issue in China [1]. According to the International Diabetes Federation (IDF) report in 2025, the number of people with diabetes worldwide has reached 589 million and is expected to increase to 853 million by 2050[2]. The physiological decline and metabolic disorders associated with aging make the elderly the main group with high incidence of chronic non-communicable diseases. Some scholars have conducted research on people over 65 years old. From 2000 to 2019, the prevalence of diabetes increased from 15.5% to 21.9%, and the cancer-related mortality rate of diabetic patients is 1.15 times that of people with normal blood sugar. The cardiovascular disease-related mortality rate is also higher.[3]. In addition, the organ function decreased due to aging, so that the hypoglycemic perception ability decreased, the risk of asymptomatic hypoglycemia and severe hypoglycemia was significantly higher than that of young and middle-aged patients, and the complexity of the disease and the difficulty of management increased exponentially. This study is helpful to expand the nursing theory of elderly diabetes from "function maintenance" to "technology empowerment".

2. Research Questions

2.1. Core Barriers to Self-Management in Elderly Diabetes

Physical decline: cognitive decline (forgetting medication, insulin injection errors), decreased vision (difficulty reading blood glucose meter, insulin dose recognition errors), hearing loss (affecting health information reception), and decreased fine motor ability of hands (affecting blood glucose detection and injection operations) Psychological and cognitive factors: diabetes-related psychological pain, fear of hypoglycemia, low self-efficacy, insufficient disease cognition. Weak social support: empty nest elderly lack daily supervision and emotional support, family caregivers lack ability. Health literacy limitations: limited understanding of diabetes pathology, treatment options, and dietary principles, making it difficult to translate medical advice into daily behavior. Multi-disease coexistence and complex medication: Multiple medication regimens increase the cognitive burden and operational difficulty of medication management.

2.2. Application Barriers, Challenges and Future Directions

Include:

user-level acceptance barriers: technical anxiety, lack of digital literacy, lack of trust in equipment, use motivation decline.

The lack of "aging" design: complex interface, too small font, high charging frequency, cumbersome operation process, lack of voice guidance and other practical problems.

Information islands at the system level: data formats and communication protocols of different devices and platforms are not uniform, which restricts the lack of research evidence for the construction of continuous care networks.

Insufficient research evidence: limitations of short-term, small-sample, single-center studies; lack of long-term follow-up data and cost-effectiveness analysis; large heterogeneity of intervention programs, which is difficult to standardize and popularize.

Ethical and equity issues: data privacy protection, informed consent (especially for older people with cognitive disabilities); digital divide may exacerbate health inequalities within older populations.

3. Technology Application

Smart nursing technology covers continuous glucose monitoring, wearable devices and mobile health applications, artificial intelligence-assisted decision-making, voice interaction, telemedicine and other technical forms. Different technologies have their own emphases in the self-management of diabetes mellitus in the elderly.

3.1. Continuous Glucose Monitoring Technology

Continuous glucose monitoring (CGM) monitors the glucose concentration of interstitial fluid in real time through subcutaneous sensors, which can continuously record the trend of blood glucose fluctuation for 24 hours, eliminating the pain of repeated blood sampling by traditional fingertip blood glucose monitoring. CGM can not only provide real-time blood glucose values, but also generate new management indicators such as time within glucose target range (TIR) and glucose coefficient of variation, providing an unprecedented data base for refined blood glucose management in elderly diabetic patients.

3.1.1. Facilitating Self-Management

The core value of CGM is to transform "hidden glucose fluctuations" into "visual data maps." Patients can view real-time blood glucose values and trends through mobile phones or readers, thus directly correlating behaviors such as diet, exercise, medication, etc. with blood glucose responses. Qualitative research shows that older type 2 diabetics see CGM as a "valuable tool for gaining insight into internal processes in the body" and that this deeper understanding significantly improves their diabetes self-management behaviors. In addition, CGM can effectively identify asymptomatic hypoglycemia, a particularly common and dangerous clinical situation among elderly diabetic patients, and its acceptance and effectiveness among the elderly population. A Korean study that included older patients with type 2 diabetes showed compliance with CGM in the elderly population of 81%. In terms of glycemic control, systematic reviews and meta-analyses of non-insulin treated patients with type 2 diabetes have shown that CGM has a positive effect on improving glycemic control. The real-time feedback mechanism of CGM enables patients to take timely intervention measures to control the disease, and can effectively predict or diagnose the metabolic status of elderly diabetic patients according to blood glucose concentration.

3.1.2. Limitations and Challenges

Elderly people face special barriers to CGM use: sensor wear may cause skin irritation, equipment operation has certain requirements for digital literacy, equipment costs are high, and some are not covered by medical insurance. In addition, some studies suggest that CGM has a significant effect on mean blood glucose reduction in patients under 60 years of age, but the effect may be weakened in patients aged 60 and older, suggesting that the use of CGM in elderly people needs to be accompanied by more adequate education and support.

3.2. Wearables and Mobile Health Apps

Wearables and mobile health (mHealth) apps are the most widely used combination of smart care technologies. With the advancement of science and technology, wearable devices have gradually developed into multifunctional electronic technology products, with the function of human body data collection, and have begun to be used in the direction of medical supplies to record the wearer's pulse, ECG, heart rate, blood lipids, blood pressure and other health data as well as exercise status and sleep quality in daily life[4]. Mobile health applications provide data visualization, medication reminders, health education, online consultation and other functions through smart phone APP or Weixin Mini Programs. In terms of home-based continuing care, Wu et al. continuously and in real time monitored the lifestyle and indoor environmental factors of patients with chronic obstructive pulmonary disease by applying integrated home air quality sensing devices, 5G-based smartphone applications and wearable devices, and recorded the monitored data. It is convenient for medical staff to make real-time adjustments to the treatment and care procedures for patients, and also provides reliable data for establishing predictive models in the later stage [5].

3.2.1. Promotion of Self-management

Wearable devices and mobile health applications can improve the self-management of elderly diabetes mainly through the following mechanisms: firstly, behavior self-monitoring devices convert abstract physical activity into specific numbers, so that patients can objectively assess their own exercise standards; secondly, the external reminder and urging APP's timed medication reminder function directly targets the core pain points caused by memory loss of the elderly; Third, data-driven health decision-making The data accumulated over time can help patients identify patterns between behavior and blood sugar, and then adjust diet and exercise programs.

3.2.2. Evidence of Intervention Effect

Health coaching technology combined with wearable devices on the impact of glycolipid metabolism and self-management behavior in patients with type 2 diabetes Studies have shown that combined interventions can effectively improve patients 'metabolic indicators and self-management behavior. A randomized controlled study of hospital-community blood glucose cloud management model included 239 elderly patients with type 2 diabetes. The intervention group was managed by blood glucose cloud management mobile phone software. The results showed that this model could significantly improve the self-management ability of elderly diabetes patients. The application of smart wearable devices in home exercise rehabilitation of coronary heart disease with diabetes also initially confirmed its feasibility in promoting regular exercise. In the exercise management dimension, a mixed-approach study of older patients with type 2 diabetes demonstrated that technology-assisted lifestyle self-monitoring was feasible and associated with improvements in HbA1c.

3.2.3. Limitations and Challenges

The elderly face multiple obstacles in using wearable devices and mobile health applications: "uncomfortable aging" design problems such as excessive device charging frequency, small interface fonts, and complex operation processes are common; some elderly people have technical anxiety and insufficient trust in device accuracy. In addition, the digital literacy of rural elderly patients and patients with low education level is generally low, and the problem of technology accessibility is particularly prominent.

3.3. Telemedicine and Intelligent Management Platform

Telemedicine breaks the time and space constraints through

information and communication technologies, enabling elderly people with diabetes to receive continuous medical and care services at home.

3.3.1. Innovation of Service Mode

Telemedicine is applied in various forms in the management of diabetes mellitus in the elderly, including video consultation, remote blood glucose monitoring, online health education, electronic health file sharing, etc. Telemedicine has significantly improved access to health care for elderly diabetic patients with mobility difficulties, remote or empty nest living alone.

3.3.2. Evidence of Intervention Effectiveness

A randomized controlled trial of home-based telemedicine interventions based on the Health Belief Model (HBM) showed that the intervention reduced HbA1c by 0.42% and significantly improved self-management skills, self-efficacy, and health beliefs among older people with type 2 diabetes in the community. This study confirms that personalized education and behavioral intervention programs based on health belief models and telemedicine can bring significant benefits to elderly people with type 2 diabetes in the community, providing new ways for chronic disease prevention and management. A study on the effectiveness of an online health system for remote management of type 2 diabetes also confirmed that telemedicine combined with an online health management system was effective in regulating HbA1c, LDL cholesterol, body mass index and blood pressure in patients with type 2 diabetes. At 12 months follow-up, the hybrid (remote + face-to-face) diabetes care model had comparable glucose and lipid outcomes to pure face-to-face care, while improving care access and patient engagement.

3.3.3. Limitations and Challenges

In the age of networking and digitization, older adults have difficulty "integrating digitally", they are unable to use the Internet proficiently, and even the overall awareness and usage of diabetes software is low[6]. It faces problems such as insufficient digital literacy, unbalanced network infrastructure and difficulties in establishing doctor-patient trust. In addition, caregivers in telecare unable to perform physical examinations and may miss some important clinical information.

3.4. Artificial Intelligence Technology

Artificial Intelligence (AI) care, also known as AI care, refers to the use of AI technology to assist and support the care process.[7]With the rapid development of information technology, the application of "Internet +" and AI in nursing provides more convenient and efficient medical services for patients, while improving the work efficiency and professional level of nursing staff[8]. AI algorithms can integrate electronic health records, wearable device data, lifestyle information and other multi-source data to build a "dynamic health portrait" of elderly diabetes patients and predict the risk of hypoglycemia, hyperglycemia and complications. A model for predicting the frailty risk of hospitalized elderly patients with type 2 diabetes based on machine learning and SHAP interpretability provides a new tool for early identification of high-risk patients. Clinical medical applications based on large language models and multimodal models also suggest that AI has potential for non-invasive blood glucose monitoring.

3.4.1. Personalized Intervention Plan Recommendation

AI can recommend personalized diet plan, exercise plan and drug adjustment suggestion according to the patient's blood glucose fluctuation pattern, living habits, medication plan and other characteristics. The intelligent consultation system for diabetes patients is centered on three functional modules of "questionnaire-question and answer-case analysis", and provides intelligent health management support through Weixin Mini Programs.

3.4.2. Clinical Nursing Process Optimization

AI-assisted nursing decision support system can help nurses quickly identify patients who need priority intervention and realize accurate delivery of nursing resources. AI applications in nursing safety management have also received attention, including medication error warning and adverse event prediction.

4. Conclusion

This paper systematically combs the main application directions of intelligent nursing technologies such as continuous glucose monitoring, wearable devices and mobile health applications, telemedicine platforms and artificial intelligence in the field of elderly diabetes self-management. Available evidence suggests that these technologies can help by eliminating the pain and inconvenience of frequent fingertip sampling (CGM), providing medication reminders and health education.(mobile health APP and voice interactive equipment), predicting blood glucose trends and recommending personalized programs (artificial intelligence), breaking space-time restrictions to achieve continuous follow-up (telemedicine platform) and other mechanisms can effectively improve the frequency of blood glucose monitoring, medication compliance, physical activity level and diabetes self-care behavior of elderly patients, thus improving blood glucose control (HbA1c), reducing diabetes-related psychological pain, Demonstrated clear results in enhancing self-efficacy and quality of life. From the perspective of the evolution of technology development, intelligent nursing is undergoing a transformation from "single functional equipment" to "multi-source data fusion platform", from "passive data recording" to "active intelligent intervention".

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