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Innovative Research on Community Diabetes Health Management Service Models Based on Smart Blood Glucose Monitoring Sensor Technology

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Abstract: With the ongoing rise in population ageing and diabetes prevalence, the traditional hospital-centric disease management model is proving inadequate. This study focuses on innovative explorations in health management and care models, aiming to establish a novel diabetes health management service framework centered on smart blood glucose monitoring sensor technology, deeply integrating community and home settings. The paper first analyses opportunities and challenges in technological advancement and social services, highlighting the advantages of technologies such as continuous glucose monitoring in terms of data continuity and real-time capability, alongside cost, standardization, and talent bottlenecks encountered during community implementation. Subsequently, the paper systematically proposes an integrated "device-platform-service-talent" quadruple framework. It elaborates on how technological innovation can drive the development of elderly care services and industries, while exploring pathways for localizing internationally advanced concepts and technologies. Finally, the study proposes innovative strategies for talent development models and content to ensure the effective operation of this framework. This aims to cultivate a professional workforce with composite capabilities in technology, healthcare, and management, thereby providing theoretical reference and a practical blueprint for addressing chronic disease challenges and constructing a smart health and elderly care service system.

Keywords: Smart blood glucose monitoring sensor technology; Community diabetes management; Continuous glucose monitoring; Smart elderly care

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1. Introduction

Diabetes, as a typical chronic condition, requires effective management through long-term, continuous data monitoring and lifestyle interventions [1]. However, the existing healthcare service system in our country faces a structural contradiction of prioritizing treatment over management. Upon discharge, patients returning to their

communities and households often find themselves in a management vacuum. Traditional finger-prick blood glucose monitors can only provide discrete point-in-time data, failing to reflect the full-day trend of blood glucose fluctuations, and patient compliance remains poor.

According to the *Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes*, China has a substantial diabetic population with a concerning management situation. The guidelines emphasize the need to enhance blood glucose monitoring and comprehensive management [2], yet traditional management approaches struggle to achieve this objective.

Concurrently, technological advancements have presented us with unprecedented opportunities. Smart glucose monitoring sensor technologies, exemplified by continuous glucose monitoring, enable painless, minute-by-minute collection of interstitial fluid glucose concentrations. This generates dynamic glucose profiles, providing the foundational data for refined, personalized management and serving as the basis for realizing cutting-edge international concepts such as the artificial pancreas [3]. Smart blood glucose monitoring sensors, primarily continuous glucose monitoring (CGM) systems, represent the cutting edge of diabetes management. These sensors continuously monitor blood glucose levels around the clock, providing real-time data on glucose fluctuations. Unlike traditional finger-prick blood glucose testing methods, CGM delivers a continuous data stream that comprehensively reflects glucose trends. These systems can be worn for days or weeks, transmitting data to a receiver or smartphone for analysis.

Domestic empirical research has demonstrated that CGM effectively enhances the management efficacy and safety of elderly diabetic patients in home settings [4]. However, the core challenge currently faced is how to transform this advanced technology from a “high-end tool” within hospitals into an “accessible means” for community and home healthcare services, how to integrate it organically into existing social service systems, and how to foster new forms of elderly care services and industries. It is against this backdrop that this study seeks to explore an innovative pathway for community health management service models enabled by technology.

2. Overview of smart blood glucose monitoring sensors

2.1. Working principle of the smart blood glucose monitoring sensor

Smart glucose sensors (such as CGM systems) indirectly measure glucose concentration in interstitial fluid by inserting a subcutaneous sensor that utilizes glucose oxidase to react with glucose, generating an electrical signal. This electrical signal, proportional to blood glucose levels, is converted into readable data via electrodes, enabling real-time monitoring of glucose fluctuations. The data is transmitted via Bluetooth or wireless to receiving devices such as smartphones or cloud platforms for analysis and monitoring by patients and clinicians. CGM provides continuous glucose data, capturing postprandial peaks and nocturnal hypoglycemia whilst delivering real-time alerts to help patients avoid dangerous fluctuations. It enhances treatment precision and timeliness through remote monitoring.

2.2. Common products and application scenarios of smart blood glucose monitoring sensors

The primary smart glucose monitoring sensors currently available on the market or under development include the Dexcom G6/G7, FreeStyle Libre 2/Libre 3, Eversense E3 (implantable CGM), and Medtronic Guardian Connect. These devices differ in aspects such as monitoring frequency, wear duration, real-time capability, alert functionality, and data interfaces. The Dexcom G7 provides real-time glucose readings every five minutes, while

the FreeStyle Libre 3 delivers near-minute-by-minute readings without requiring calibration. The Eversense implantable sensor can be used for up to 365 days, making it suitable for long-term monitoring. The Medtronic Guardian Connect integrates with insulin pumps to enable automated glucose control. Most contemporary CGM systems incorporate real-time glucose alerts to assist patients in promptly addressing hypoglycemic or hyperglycemic risks. Furthermore, technological advancements are driving ongoing CGM development towards enhanced accuracy, reduced calibration frequency, extended usage cycles, and integration with artificial intelligence algorithms. These innovations aim to improve the precision and convenience of diabetes management.

Smart glucose monitoring devices are not only suitable for traditional daily diabetes management but are also widely applied in hospital clinical monitoring, elderly and home care, gestational diabetes or individuals with significant blood glucose fluctuations, and in conjunction with insulin pumps/closed-loop systems to achieve automated insulin delivery [5]. In the home environment, users can utilize CGM to gain real-time insights into blood glucose fluctuation patterns, guiding dietary choices, exercise routines, and insulin dose adjustments; In hospitals or during hospitalization, it assists healthcare professionals in dynamically monitoring patients' glucose status, proving particularly vital for critically ill, post-operative, or intensive care patients. For individuals experiencing frequent hypoglycemia or pronounced hyperglycemic fluctuations (such as those with Type 1 diabetes, Type 2 diabetes requiring multiple insulin injections, or gestational diabetes), CGM significantly enhances the safety and timeliness of glucose management. Furthermore, integrating CGM with insulin pumps or "artificial pancreas" systems enables closed-loop regulation of glucose monitoring and insulin delivery, substantially improving the precision of glycemic control and convenience of daily life. Additionally, with technological advancements, CGM is increasingly being utilized in broader health management scenarios, including early screening for glucose abnormalities, monitoring metabolic health and enabling preventive interventions, as well as supporting exercise and lifestyle management.

3. Innovative integration of smart sensing technology and health management models

3.1. The transformation of management paradigms through technological empowerment

Smart blood glucose monitoring sensor technology is fundamentally transforming the landscape of diabetes management, shifting it from a traditional, reactive approach to a more proactive, forward-looking paradigm. This shift marks a significant evolution in how diabetes is monitored and managed, providing greater opportunities for precision and personalized care. At the heart of this transformation are three major advancements that are revolutionizing the way both patients and healthcare providers approach glucose control.

First, CGM technology delivers a level of insight that traditional methods, such as periodic finger-stick testing, struggle to achieve. CGM systems continuously track blood glucose levels in real-time, capturing detailed data on glucose fluctuations, including critical events like postprandial (after-meal) glucose peaks and nocturnal hypoglycemia (low blood sugar during sleep). These are often missed or underrepresented by traditional methods, which only offer snapshots at specific moments in time. With CGM, patients and clinicians can better understand glucose patterns, enabling more precise and timely interventions to prevent dangerous highs or lows.

Second, by integrating continuous glucose data with artificial intelligence (AI) algorithms, this technology takes diabetes management a step further [6]. AI can analyze glucose trends, predict potential fluctuations, and offer recommendations tailored to the individual patient. Whether it is suggesting adjustments to diet, exercise routines,

or medication regimens, the technology provides actionable insights that allow for more dynamic, personalized care. This predictive capability empowers patients to take control of their condition by making informed decisions about their health before problems arise, rather than responding to them after the fact.

Third, this innovation breaks down the traditional barriers of healthcare settings. Historically, professional glucose monitoring and management were confined to clinical environments, with patients only receiving guidance during doctor visits or hospitalizations. However, smart glucose monitoring extends the reach of professional care into patients' everyday lives. By enabling continuous, at-home monitoring, this technology provides a bridge between the clinical world and daily living, allowing for seamless integration of health management into normal routines. This makes it possible to achieve more consistent, long-term control over diabetes, as patients receive ongoing support and feedback without the need for frequent hospital visits.

Ultimately, smart blood glucose monitoring technology is ushering in a new era of comprehensive, patient-centered care. It offers not just a tool for better diabetes management, but a complete system that empowers patients to live healthier, more informed lives. With continuous data flow, AI-driven insights, and the ability to break down the walls of traditional care settings, this technology is paving the way for a future where diabetes is managed more effectively and proactively across the entire care journey.

3.2. Building innovative service models: The four-in-one framework

The core of the innovative service model established in this study is as follows:

Intelligent perception layer: Community diabetes patients are equipped with CGM devices, serving as terminals for physiological data collection.

Data platform layer: Data is transmitted in real time to the cloud-based health management platform via Bluetooth, IoT, and other technologies. The platform handles data storage, cleansing, analysis, and visualization.

Professional service layer: This constitutes the model's core. Community GPs and health managers monitor patient data via the platform, intervening promptly on system alerts and devising dynamic management plans.

User application layer: Patients and family members can view their blood glucose data, receive health reminders and educational information via a mobile app, enhancing self-management capabilities and family collaboration.

This model represents a profound innovation in health management and care delivery, transforming isolated technological devices into an integrated ecosystem of people, technology, processes, and services.

4. The synergistic development of technology applications and the elderly care services industry

4.1. Empowering smart elderly care to enhance the quality of life for older people with diabetes

Diabetes is one of the primary chronic conditions threatening the health and quality of life of the elderly. Applying this model to the field of elderly care services holds significant value. For diabetic individuals living alone or in empty-nest households, the real-time alert functionality of CGM can substantially reduce the risk of acute events such as severe hypoglycemia, delay the onset of complications, and enable them to live more safely and with greater dignity within their communities and homes.

This model furnishes care homes and community day centers with specialized blood glucose management tools and protocols, embedding the medical aspect digitally and intelligently throughout the entire care process. It

represents the practical implementation of the internationally advanced concept of integrated care in China.

4.2. Fostering and driving the development of related industries

The promotion of this model will effectively drive the upgrading of elderly care services and industries, as well as the emergence of new business formats. It will stimulate the research, development, manufacturing, and cost-efficiency improvements of domestic CGM technology. It will foster the emergence of enterprises specializing in the development and operation of cloud platforms dedicated to chronic disease management. A cohort of specialized "third-party health management service companies" may emerge, providing technical platforms and operational service outsourcing to community health centers and elderly care institutions. Under strict conditions of data anonymization and security safeguards, aggregated anonymized data can be utilized for public health research, drug efficacy evaluations, and other purposes, thereby unlocking the value of data.

5. Challenges and responses: Focusing on talent development and content innovation

5.1. Core challenges facing the implementation of the model

Despite its promising prospects, the widespread adoption of this model still faces a series of typical and complex challenges arising from the integration of technological advancement and social services. Firstly, although costs are decreasing, the upfront expense of CGM devices remains a significant barrier for some patients and public health budgets [7]. Secondly, compatibility issues often exist between devices and data platforms from different manufacturers, creating "data silos" that impede the seamless flow and centralized management of information. Finally, the accuracy, stability, and long-term wearability of the devices require ongoing refinement.

Currently, CGM devices and associated remote monitoring services remain excluded from basic medical insurance reimbursement in most regions, constituting one of the foremost bottlenecks to their universal adoption. The absence of sustainable payers hinders the establishment of a commercially viable closed-loop service model.

This represents the most fundamental and urgent challenge. The knowledge structure of existing community healthcare personnel often leans heavily towards traditional diagnosis and treatment, with a widespread lack of capability in interpreting CGM data, operating health information technology platforms, and conducting remote patient management and communication. This shortage of multi-skilled professionals is a key factor constraining the release of technological dividends at the grassroots level.

5.2. Breaking through with innovation in talent development models and content

To support the effective operation of the new model, innovation in talent cultivation approaches and content is imperative. Educational objectives must shift from singular clinical skills towards a composite goal encompassing "clinical competence + data analysis capability + interpersonal communication and empathy + technological application skills." Such professionals may be termed "Digital Health Managers."

Beyond traditional medical curricula, courses such as Introduction to Health IoT Technologies, Health Big Data Analysis and Interpretation, Digital Management Practices for Chronic Diseases, and Application and Guidance of Smart Health Products should be introduced. Employing project-based learning, students should simulate the operation of a community diabetes management program, utilizing real or simulated CGM data platforms for decision-making throughout the process.

Training should not be confined to medical students; it should also encompass large-scale digital skills

enhancement programs for practicing community doctors and nurses. Furthermore, explore extending certain skill training modules to community workers and elderly care attendants.

6. Policy and safeguard system development: The key support for promoting the sustainable development of the model

To successfully transition this innovative model from pilot demonstrations to widespread adoption, it is crucial to establish a comprehensive and resilient external support environment. At the heart of this environment lies the need for pioneering policy frameworks and safeguards, which can only be effectively achieved through top-level design. Such a design must not only be visionary but also practical, ensuring that it fosters a regulatory landscape that is conducive to the model's scalability and long-term success.

The policy frameworks should address several key areas, including clear regulations for technology deployment, data security, privacy protection, and user safety. Furthermore, they must provide adequate incentives for early adoption while ensuring that these incentives are aligned with long-term sustainability goals. It is also essential that the frameworks offer flexibility to adapt to the evolving nature of technology, market conditions, and societal needs.

Beyond the legal and regulatory aspects, the external support environment must include institutional mechanisms to facilitate collaboration across government bodies, industry stakeholders, and academic institutions. Such partnerships will ensure that the model is not only well-supported from a policy perspective but also continuously refined through ongoing research, innovation, and feedback loops [8]. Moreover, international cooperation and alignment with global standards should be a priority to promote cross-border adoption and ensure interoperability in diverse market contexts.

In summary, the transition to widespread adoption hinges on creating a robust support structure grounded in strong policy design and the active involvement of multiple stakeholders. Through this approach, the model can scale effectively, be safeguarded against potential risks, and ultimately achieve its full potential across different sectors and regions.

6.1. Exploring diverse payment mechanisms

Payment issues remain the core bottleneck constraining the widespread adoption of inclusive technologies [9]. To overcome this impasse, it is recommended to systematically submit evidence-based cost-benefit analyses grounded in real-world research to healthcare regulatory authorities. These analyses should utilize evidence-based medical data to clearly demonstrate the long-term healthcare cost savings delivered by digital health technologies such as CGM in reducing the incidence of severe complications and decreasing emergency hospital admissions. Efforts should focus on incorporating CGM monitoring consumables and associated digital health management services into outpatient special chronic disease reimbursement catalogues. Concurrently, explore value-based payment schemes linked to health outcomes, establishing dynamic pricing mechanisms tied to clinical efficacy.

Beyond basic medical coverage, commercial insurers should be guided to develop bespoke insurance products integrating innovative health management models. These products could standardize coverage for CGM devices and consumables, data analysis and interpretation services, and remote physician supervision, with differentiated premium pricing to meet the needs of populations with varying risk profiles. Actively explore Public-Private Partnership (PPP) models to support the development of smart community health stations, deploying integrated

diagnostic equipment in primary care facilities to provide convenient digital health screening services for residents.

Concurrently, establish diversified funding mechanisms, encouraging charitable organizations to establish dedicated assistance funds offering equipment purchase subsidies or cost-sharing schemes for low-income diabetes patients. Support pharmaceutical enterprises in implementing corporate social responsibility initiatives through Patient Assistance Programs (PAPs), thereby forming a multi-tiered protection system where "the government provides basic coverage, commercial insurance supplements this, and charitable organizations provide a safety net" [10]. Simultaneously, establish regional diabetes prevention and treatment effectiveness evaluation and incentive funds to reward medical teams achieving population health improvements through digital health technologies, thereby fostering a sustainable new ecosystem for smart diabetes prevention and management.

6.2. Establishing unified technical standards and data security specifications

To ensure the delivery of high-quality services and the robust protection of sensitive information, it is imperative for industry associations to assume a leadership role. They must proactively convene stakeholders—including manufacturers, healthcare providers, and IT experts—to establish a comprehensive framework of industry-wide technical standards, unified data interface specifications, and standardized service process protocols for the application of CGM devices in community health management.

The primary objective of this standardization is to guarantee seamless interoperability. This ensures that CGM equipment from different manufacturers can be effortlessly integrated with various health information platforms at all levels, from community clinics to regional and national health databases, thereby preventing technological silos and facilitating comprehensive care.

Concurrently, strict adherence to data protection regulations, such as the Personal Information Protection Law, is non-negotiable [11]. This must be reinforced by the establishment of end-to-end security management systems that govern the entire lifecycle of health data. These systems must explicitly address and mitigate risks associated with data collection, secure transmission, encrypted storage, authorized utilization, and proper anonymization processes.

Furthermore, it is critical to define clear and legally sound boundaries regarding data ownership and usage rights. Policies must transparently specify who can access the data, for what purposes, and under what conditions. This clarity is fundamental to building public trust, safeguarding patients' privacy rights, and ensuring that the immense value of health data is harnessed ethically and responsibly for individual and public health benefits.

6.3. Promoting multisectoral coordination and ecosystem development

The successful implementation of this integrated health management model necessitates a concerted, multi-stakeholder approach that transcends the capacity of the health sector alone. A siloed effort is insufficient to address the complex challenges at the intersection of technology, healthcare, and public policy. Therefore, it is imperative for the Department of Health and Wellness to assume a strong leadership role, establishing a high-level interdepartmental task force. This entity would be responsible for orchestrating collaboration with key partners, including Medical Insurance for reimbursement reform, Industry and Information Technology for manufacturing and digital infrastructure, Civil Affairs for community mobilization and social support, and Data Management authorities for governance and security.

The primary mandate of this task force should be to jointly formulate a cohesive national development plan, explicitly aiming to dismantle existing policy barriers and synchronize efforts across sectors. This includes

aligning regulatory frameworks, harmonizing data standards, and creating integrated funding streams to forge a concerted effort that drives systemic progress.

Furthermore, we must actively encourage deep, cross-sector collaboration between healthcare institutions, industrial manufacturers, and information technology companies. This can be fostered by establishing innovation platforms that support joint research and development (R&D) between leading medical centers and high-tech enterprises. The focus of these partnerships should be to co-create and iterate upon context-appropriate solutions—specifically, low-cost, user-friendly, and interoperable products and digital platforms tailored for the unique demands of community health settings and diverse user groups.

To accelerate the transition from innovation to widespread adoption, government and industry should leverage catalytic tools such as public innovation challenges and prize competitions that target specific unmet needs in chronic disease management. Concurrently, the establishment of application demonstration zones in select cities or regions will provide real-world validation, showcase best practices, and create living laboratories for refining these solutions. This multi-pronged strategy is designed to de-risk innovation, stimulate market competition, and ultimately accelerate the emergence and dissemination of scalable, outstanding solutions that benefit the entire population.

7. Comparative analysis of international experience

7.1. Practical experience of the smart diabetes management model in international communities

Within the current global diabetes management landscape, CGM technology has been extensively adopted in community and primary healthcare settings across Europe, the United States, and Japan. This is particularly evident in the daily management of diabetic patients, remote monitoring, and automated treatment systems. European nations, notably the United States [12], have long integrated CGM as a routine management tool for diabetes patients. This enables individuals to monitor blood glucose levels in real time via smart devices, receive immediate feedback, and consequently adjust dietary habits, exercise routines, and medication regimens. Community diabetes management models in these nations typically rely on digital health platforms [13], enabling the sharing of patients' glucose data with healthcare providers for remote monitoring and intervention. Concurrently, the integration of CGM technology with artificial pancreas systems has established a closed-loop management model [14]. This not only facilitates real-time glucose monitoring but also enables automated insulin delivery, enhancing both the safety and convenience of treatment.

7.2. Adaptability and adjustment schemes for the localized application of international experience in China

The localized application of these international experiences in China faces certain challenges. Firstly, regarding policy safeguards, while European and American countries have incorporated CGM devices into their medical insurance reimbursement systems, thereby reducing patients' financial burden, China's medical insurance system currently does not cover such high-end technologies, limiting their widespread adoption among the general population. Secondly, although medical institutions in some cities and regions have begun adopting smart blood glucose monitoring devices, technical support and staff training remain inadequate at primary healthcare facilities. This prevents patients from accessing efficient, continuous health management services at the community level [15]. Moreover, patient acceptance of smart devices constitutes a significant factor in localized implementation, particularly in remote areas where

uptake of digital health and remote monitoring may be lower [16]. Finally, although China's healthcare system is advancing its digital transformation, the uneven distribution of medical resources creates regional disparities in the adoption of smart blood glucose monitoring technologies [17].

Therefore, drawing upon international experience, China must undertake adaptive adjustments in localizing smart blood glucose monitoring technology, taking into account its domestic healthcare policies, market demands, and economic affordability. Enhanced technical support and personnel training for primary healthcare institutions are required, alongside improving patient adherence to digital health technologies. Concurrently, policy measures should be implemented to reduce equipment costs and expand medical insurance coverage, thereby achieving the widespread adoption and universalization of smart blood glucose monitoring technology across China.

8. Conclusion and outlook

This study systematically demonstrates the necessity, feasibility, and implementation pathways for an innovative community diabetes health management service model centered on smart blood glucose monitoring sensor technology. This model represents a robust initiative in response to the "Healthy China" strategy, driving innovation in health management and care models, developing the silver economy, and promoting the advancement of elderly care services and related industries [18]. It has successfully applied internationally advanced concepts and technologies to local contexts, confronting the challenges inherent in integrating technological advancement with social services. Notably, it has creatively proposed solutions for talent development models and content innovation. Looking ahead, as sensing technologies evolve towards non-invasive and minimally invasive approaches, and artificial intelligence algorithms mature further, this model will become increasingly intelligent and inclusive. We can anticipate the comprehensive establishment of a new ecosystem for efficient, human-centered chronic disease management services. This ecosystem will be data-driven, connecting individuals, households, communities, and hospitals.

Disclosure statement

The authors declare no conflict of interest.

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