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Development of a Mobile Health Self-Management Platform for Patients with Urinary Calculi Based on the Chronic Disease Self-Management Program Model

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Abstract

Background

Urinary calculi are among the most prevalent urological disorders worldwide, characterized by high recurrence rates that impose substantial clinical and economic burdens. Effective self-management is critical for secondary prevention, yet existing mobile health tools often lack comprehensive, evidence-based, and theory-driven functionality. This study aimed to develop a mobile health self-management platform for patients with urinary calculi based on the Chronic Disease Self-Management Program model.

Methods

The platform was developed through a three-phase process. First, an evidence-based self-management protocol was formulated via a systematic literature review using the PIPOST framework and following the "5S" evidence model, covering major Chinese and international databases from April 2019 to April 2024. Second, the protocol was refined through a two-round Delphi survey involving 15 urological nursing experts. The Delphi survey questionnaires (see Additional files 1 and 2) were developed by the research team based on the preliminary evidence summary and the initial platform protocol. Third, a WeChat mini-program named "Stone-Free Diary" was technically developed according to the finalized protocol.

Results

The evidence synthesis yielded a preliminary summary of self-management interventions. The Delphi survey demonstrated high expert authority with an overall authority coefficient of 0.92 and good consensus with coefficient of variation values not exceeding 0.19. The final protocol comprised three core modules: a Personal Health Profile, a Self-management Execution Module covering fluid intake management, dietary recording and assessment, exercise planning, laboratory monitoring, and double-J stent care, and a Structured Evidence-Based Knowledge Base. The "Stone-Free Diary" mini-program was successfully implemented with all three modules fully functional.

Conclusions

The CDSMP-based platform was systematically developed through rigorous methodology integrating theoretical guidance, evidence-based content, and expert consensus. It represents a scientifically grounded mobile health tool designed to support continuous self-management for urinary calculi patients. Future research should focus on evaluating its clinical effectiveness through well-designed randomized controlled trials.

Background

Urinary calculi are pathological deposits formed by abnormal aggregation of crystalline substances in urine under the influence of various pathogenic factors. Based on their location, they are classified as renal calculi, ureteral calculi, bladder calculi, and urethral calculi [1]. As one of the most common urological disorders, urinary calculi not only show an annually increasingprevalence but also impose a significant clinical burden due to their high recurrence rates [2]. Epidemiological studies indicate that the incidence of urinary calculi in China ranges from 1% to 5%, with one-year recurrence rates of 10% to 14% and ten-year recurrence rates reaching 30% to 70%, positioning China among the three highest prevalence regions globally [1]. These data, derived from recent epidemiological surveys, underscore the urgent need for effective secondary prevention strategies. The high recurrence rate causes persistent physical and psychological harm to patients while simultaneously increasing economic burdens and consuming substantial healthcare resources [3, 4]. Consequently, prevention of stone formation and recurrence has become a priority in urological clinical practice and nursing care.

Existing evidence demonstrates that standardized self-management can reduce the risk of initial stone occurrence by more than 50% and decrease recurrence rates by 46%, highlighting its central role in secondary prevention [5, 6]. However, traditional follow-up models are constrained by temporal and spatial limitations, exhibiting significant deficiencies in management continuity, timeliness, and patient-provider interaction. These limitations make it difficult to support patients in achieving long-term, systematic self-management. In this context, the promotion of the "Internet Plus Healthcare" service model has positioned mobile health, delivered through smartphones and wearable devices, as a promising approach for chronic disease management [7, 8]. Numerous studies have confirmed that mobile health-based self-management interventions can effectively enhance patients' management capabilities and improve disease outcomes across various chronic conditions [9–17].

Regarding theoretical frameworks for chronic disease management, the Chronic Disease Self-Management Program has gained international recognition as an evidence-based health management model. This program systematically helps patients acquire self-management skills, thereby improving the quality of chronic disease management and health outcomes [18]. Bai and colleagues have also emphasized that lifestyle interventions should be strengthened for populations at high risk of chronic diseases, and that scientific, continuous health management can delay disease progression [19].

Although several mobile health applications for urinary calculi management exist internationally, their functions are generally limited, focusing predominantly on single aspects such as fluid intake or dietary management. There remains a lack of comprehensive applications that integrate multidimensional management content based on high-quality evidence. Therefore, this study aimed to combine the core elements of the Chronic Disease Self-Management Program model with mobile internet technology to construct a multifunctional self-management platform for patients with urinary calculi. The platform integrates health education, fluid management, dietary guidance, exercise recommendations, and double-J stent care. It is designed to address the shortcomings of existing management models by

providing technological support for standardized, individualized, and continuous stone prevention and management. This platform has important practical implications for enhancing patients' self-management capacity, reducing stone incidence and recurrence rates, conserving medical resources, and improving patients' quality of life.

Methods

Phase 1: Evidence-based development of the self-management protocol

To establish a solid theoretical and evidence-based foundation for platform construction, a systematic literature review was conducted following established evidence synthesis methods. Guided by the PIPOST framework, a structured research question was formulated to ensure clarity and focus. The PIPOST framework, which considers Population, Intervention, Professional, Outcome, Setting, and Type of evidence, was used to structure the research question. The "5S" model guides searches from synthesized sources (systems, summaries, synopses, syntheses, studies) downward to ensure comprehensive coverage of high-level evidence. A comprehensive literature search was then performed following the "5S" evidence model, progressing systematically from synthesized evidence sources downward.

The search covered major Chinese academic databases including CNKI, WanFang Data, and VIP, as well as international databases including PubMed, Embase, CINAHL, and the Cochrane Library. The search period spanned from April 2019 to April 2024. Search terms were employed in both Chinese and English languages, including terms such as urinary calculi, kidney stones, self-management, patient education, clinical guidelines, and their corresponding Chinese equivalents. The search specifically targeted clinical guidelines, systematic reviews, meta-analyses, and expert consensus documents pertaining to the self-management of urinary calculi.

Two researchers who had received systematic training in evidence-based methodology independently performed literature screening, methodological quality assessment, and data extraction. After completing quality evaluation of all included documents, self-management intervention measures were systematically extracted. The extracted evidence was then integrated and synthesized to create a preliminary evidence summary for urinary calculi patient self-management, providing an evidence base for subsequent structured intervention protocol development.

Following the evidence synthesis, a multidisciplinary research team consisting of urologists and senior nursing experts was assembled. This team drew upon the synthesized evidence summary combined with their collective clinical expertise to formulate the initial platform framework through multiple rounds of in-depth discussion. The framework was structured around three core elements derived from the Chronic Disease Self-Management Program model: enhancing self-management abilities, strengthening problem-solving capacities, and facilitating informed decision support. This developmental phase

resulted in the first draft of the platform protocol, which was organized into three core components: a Personal Health Profile, a Self-management Execution Module encompassing fluid intake management, dietary recording and assessment, exercise planning, laboratory index monitoring, and double-J stent maintenance, and a Structured Clinical Knowledge Base.

Phase 2: Refinement of the protocol using the Delphi method

To enhance the scientific validity, professional relevance, and clinical applicability of the platform protocol, a two-round Delphi expert consultation was conducted. Fifteen experts specializing in urological nursing were invited to participate. The Delphi survey questionnaires (see Additional files 1 and 2) were developed by the research team based on the preliminary evidence summary and the initial platform protocol. Questionnaires were designed to evaluate the importance and feasibility of each item within the preliminary protocol using a five-point Likert scale, and open-ended suggestions were solicited for modification. The experts engaged in in-depth discussion and revision of each content item within the platform knowledge base over two rounds of review.

All fifteen questionnaires were distributed and returned in both rounds, resulting in a one hundred percent effective response rate. The experts' familiarity with the study topic was scored at 0.87, and the overall authority coefficient was calculated as 0.92, indicating that the experts possessed high professional authority and thorough understanding of the research subject. The coefficient of variation was used to assess the degree of consensus among experts. In the first round, coefficient of variation values for importance scores ranged from 0 to 0.19, and for feasibility scores from 0.05 to 0.16. In the second round, coefficient of variation ranges were 0 to 0.19 for importance and 0.09 to 0.19 for feasibility, reflecting convergence of expert opinions toward consensus. Based on the suggestions received during the consultations, the research team systematically optimized and integrated the protocol content, culminating in the final version of the Urinary Calculi Patient Self-Management Mobile Health Program (Fig. 1), which served as the direct blueprint for platform development.

Phase 3: Technical implementation and preliminary development

During this phase, the research team collaborated with a professional software development team to systematically translate the previous research findings into a functional technical prototype. A WeChat mini-program named "Stone-Free Diary" was developed accordingly. Regarding technical architecture, the mini-program backend was constructed using the Java programming language in conjunction with the Spring Boot framework, with MySQL selected as the database management system. Data interaction and encapsulation were handled through RESTful APIs. The frontend was developed based on the native WeChat mini-program framework, balancing user interaction experience with cross-platform compatibility.

The fully functional WeChat mini-program successfully realized the three core modules established during the design and development phase. These modules specifically included comprehensive patient personal health record management, personalized indicator recording with intelligent reminders, and evidence-based structured knowledge delivery, forming an integrated urinary calculi self-management support system. The preliminary completion of this platform provides a reliable technical foundation and tool support for subsequent clinical application and effectiveness evaluation.

Results

The finalized platform protocol

The two-round Delphi process successfully refined the preliminary protocol into a consensus-based final program. The final protocol clearly defines the structure and content of the three core modules, ensuring alignment with Chronic Disease Self-Management Program principles and clinical best practices. Based on expert feedback, the research team systematically optimized the content, resulting in the Urinary Calculi Patient Self-Management Mobile Health Program as the direct basis for platform development.

The developed Stone-Free Diary WeChat mini-program

The technically implemented Stone-Free Diary mini-program is a fully functional mobile health platform with comprehensively integrated features. The platform comprises three core modules:

- Personal Health Profile: This module securely stores patient demographic information, medical history records, stone composition analysis results, and individualized treatment plans. It serves as the foundational data repository that enables personalized subsequent functions.
- Self-management Execution Module: This central module encompasses several sub-functions designed to support daily self-management activities. The Fluid Intake Manager allows patients to set personalized daily water intake goals and receive reminder notifications, tracking their progress toward these targets. The Dietary Guide and Log offers personalized dietary recommendations tailored to the specific type of urinary stone, such as providing low-oxalate dietary advice for patients with calcium oxalate stones and low-purine guidance for those with uric acid stones, while also enabling systematic recording of daily food intake for self-monitoring. The Health Metrics Monitor facilitates the recording of key laboratory values including urine pH and twenty-four hour urine volume, and supports ongoing monitoring of patient-reported symptoms. The Double-J Stent Care Guide offers specialized guidance for patients with indwelling stents, covering infection prevention strategies, hematuria monitoring protocols, recognition of signs indicating stent displacement, and clear indicators for seeking urgent medical care.
- Structured Evidence-Based Knowledge Base: This module delivers reliable, up-to-date educational content on disease knowledge, prevention strategies, medication information, and lifestyle modifications directly to the user's smartphone through both push notifications and a searchable

library interface. All content is derived from the evidence summary developed during the initial phase.

The platform's design intentionally operationalizes core Chronic Disease Self-Management Program constructs into specific functional features. Key constructs such as goal-setting are exemplified through personalized daily water intake targets. Self-monitoring is enabled through comprehensive tracking logs for fluid intake, dietary consumption, laboratory values, and symptoms. Performance feedback is provided through visualizations of completion rates and data trends over time. These elements are systematically embedded within the platform to enhance users' self-efficacy and problem-solving skills. The alignment between platform functions and theoretical constructs is summarized in Table 1.

Table 1 Core functional modules of the Stone-Free Diary mini-program and their alignment with Chronic Disease Self-Management Program constructs

Module or Sub-function	Description	Primary CDSMP Constructs Addressed
Personal Health Profile	Secures patient demographics, medical history, stone composition, and treatment plans	Self-management skill enhancement through personalized context
Fluid Intake Manager	Allows setting and tracking daily water intake goals with reminder notifications	Goal-setting and Self-monitoring
Dietary Guide and Log	Provides personalized dietary recommendations based on stone type and enables systematic food intake recording	Tailored information for decision support and Self-monitoring
Health Metrics Monitor	Facilitates recording of key laboratory values such as urine pH and supports symptom tracking	Self-monitoring and Problem identification
Double-J Stent Care Guide	Offers structured guidance on post-procedural care, complication signs, and emergency indicators	Problem-solving and Access to tailored information
Structured Evidence-Based Knowledge Base	Delivers reliable, push-notified Delivers reliable educational content on disease knowledge, prevention, and lifestyle	Informed decision support and Self-efficacy enhancement through knowledge

Discussion

This study reports the systematic development of an evidence-based mobile health self-management platform for patients with urinary calculi, guided by the Chronic Disease Self-Management Program framework. The resulting platform, named Stone-Free Diary, represents a significant advancement in addressing the limitations of currently available tools by integrating multiple core self-management functions into a single coherent system, underpinned by both expert consensus and contemporary scientific evidence. Compared to existing urinary calculi management applications that focus primarily

on fluid intake tracking, our platform offers a more comprehensive approach by integrating dietary guidance based on stone composition, structured double-J stent care, and theory-driven behavioral change features.

A principal methodological strength of this work lies in its structured, multi-phase development approach. The initial evidence synthesis phase ensured that all recommended self-management strategies were derived from high-quality guidelines and research, thereby establishing a credible foundation for the platform's content and maximizing its potential effectiveness. The systematic literature review, covering both Chinese and international databases over a five-year period, ensured comprehensive capture of the most recent evidence. The subsequent two-round Delphi survey, characterized by high expert authority with an overall authority coefficient of 0.92 and strong consensus demonstrated by coefficient of variation values consistently below 0.19, rigorously validated the clinical relevance, feasibility, and acceptability of the proposed platform structure. This multi-stage iterative process enhances the scientific rigor of the platform and its readiness for implementation in real-world clinical practice.

The Stone-Free Diary platform incorporates several design innovations aligned with contemporary principles of chronic disease care. By leveraging mobile internet technology, it facilitates continuous hospital-to-home care, effectively bridging the critical gap often present in episodic clinic-based follow-up models. The platform addresses the practical need for ongoing support after hospital discharge through features such as medication reminders, fluid intake monitoring, and symptom recording functions. Particularly noteworthy is the dedicated module for double-J stent management, which provides structured guidance covering infection prevention, hematuria monitoring, stent displacement recognition, and clear indicators for emergency consultation. This module addresses a frequent source of patient anxiety and potential complications, offering systematic support for preventing and managing stent-related adverse events.

Furthermore, the platform enables personalized and precise management through its evidence-based knowledge base content. By delivering dietary and lifestyle recommendations tailored to the patient's specific stone composition, the platform moves beyond generic health advice to individualized actionable plans. For instance, patients with calcium oxalate stones receive recommendations to limit high-oxalate food intake while maintaining adequate calcium consumption, whereas those with uric acid stones receive emphasis on low-purine dietary approaches and urine alkalization measures. This precision management strategy, based on stone composition characteristics, significantly enhances the clinical applicability of health guidance and may improve patient adherence and subsequent outcomes.

The platform also integrates and visually presents multi-dimensional patient data through its personal health record system. By combining patient demographic information, laboratory values, dietary records, and physical activity data, the system not only records individual data points but also displays trends over time through graphical representations. These visualizations help both patients and healthcare providers intuitively understand disease control status. For example, dynamic monitoring of urine pH

facilitates assessment of urine alkalization therapy effectiveness, while twenty-four hour urine volume records objectively reflect the adequacy of fluid intake. Such functions provide important reference information for patient self-management and physician treatment decisions.

A key aspect of the platform's design is the explicit translation of core Chronic Disease Self-Management Program constructs into functional features. Through personalized goal-setting exemplified by gradually increasing daily water intake targets, combined with timely feedback mechanisms, the platform enhances patients' self-efficacy. By enabling patients to achieve progressively challenging goals and providing immediate feedback on their performance, the platform builds mastery experiences—a key source of self-efficacy according to Bandura's theory. Structured complication recognition and management protocols strengthen patients' problem-solving abilities. Individualized knowledge delivery based on patient characteristics supports self-decision making. This theory-driven design transforms the platform from a mere information recording tool into an active behavioral intervention instrument that promotes sustainable behavior change.

From a medical informatics perspective, the platform demonstrates several features consistent with successful digital health interventions. The integration of structured knowledge delivery with personalized self-management support represents a promising approach to addressing the complex needs of patients requiring ongoing management. The modular design facilitates future enhancements and potential integration with existing healthcare information systems. The platform's architecture, utilizing contemporary web technologies and cloud-based infrastructure, ensures scalability and maintainability while protecting patient data security and privacy.

Limitations and future directions

This study reports the completion of the platform's development phase. The primary limitation is that its effectiveness in improving patient outcomes remains to be empirically tested. Specific outcomes requiring investigation include enhancement of self-management behaviors, improvement of metabolic parameters, reduction of stone recurrence rates, increase in quality of life, and decrease in healthcare costs. Additionally, while the platform was developed with input from clinical experts through the Delphi process, direct patient involvement in the design phase was limited. Future iterations should incorporate user-centered design methods to optimize usability and acceptance based on patient feedback. The platform was developed within the WeChat ecosystem, which, while widely adopted in China, may limit its generalizability to populations in regions where WeChat is less prevalent. Future adaptations for other platforms could enhance international applicability.

Therefore, the logical and essential next step is to conduct well-designed randomized controlled trials to evaluate the platform's clinical efficacy and cost-effectiveness. Such trials should employ multicenter designs with adequate sample sizes to detect clinically meaningful differences in key outcomes. Future work should also explore technical enhancements including potential integration with hospital information systems and regional health information platforms for seamless data exchange and

interoperability. Connectivity with wearable devices could enable more objective monitoring of daily physical activity and fluid intake. Exploration of intelligent algorithms incorporating artificial intelligence technologies holds promise for providing more precise, real-time personalized behavior recommendations and risk alerts based on dynamic patient data changes, ultimately achieving dynamic and intelligent health management.

Conclusions

This study successfully developed the Stone-Free Diary, a CDSMP-based mHealth platform for urinary calculi self-management, through rigorous evidence synthesis, expert consensus, and technical implementation. The platform integrates personal health records, self-management tools, and evidence-based knowledge delivery into an accessible WeChat mini-program. It offers a scientifically grounded tool for hospital-to-home collaborative care, with future research needed to validate its clinical effectiveness.

Declarations

Ethics approval and consent to participate

This study protocol was reviewed by the Medical Ethics Committee of The Fifth Affiliated Hospital of Sun Yat-sen University. In accordance with the relevant national regulations (e.g., Measures for Ethical Review of Biomedical Research Involving Humans) and institutional guidelines for studies involving low risk, the committee determined that formal ethics approval was not required and granted an exemption. The study was performed in compliance with the Declaration of Helsinki. All participating experts in the Delphi survey were provided with detailed information about the study purpose and procedures, and all gave their informed consent prior to participation. All responses were collected anonymously and analyzed in aggregate to ensure confidentiality.

Consent for publication

Not applicable as this manuscript does not contain any individual person's data in any form.

Availability of data and materials

The datasets generated and 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

HP contributed to conceptualization, methodology, investigation, and writing of the original draft. WH contributed to methodology, investigation, formal analysis, and writing through review and editing. SZ contributed to methodology, evidence synthesis, quality assessment, evidence extraction, and writing through review and editing. QP contributed to resources, data curation, and project administration. LZ contributed to software development, visualization, and data curation. JF contributed to investigation, resources, and validation. ML contributed to supervision, project administration, and writing through review and editing. DP contributed to supervision, funding acquisition, and writing through review and editing. All authors read and approved the final manuscript.

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Figures

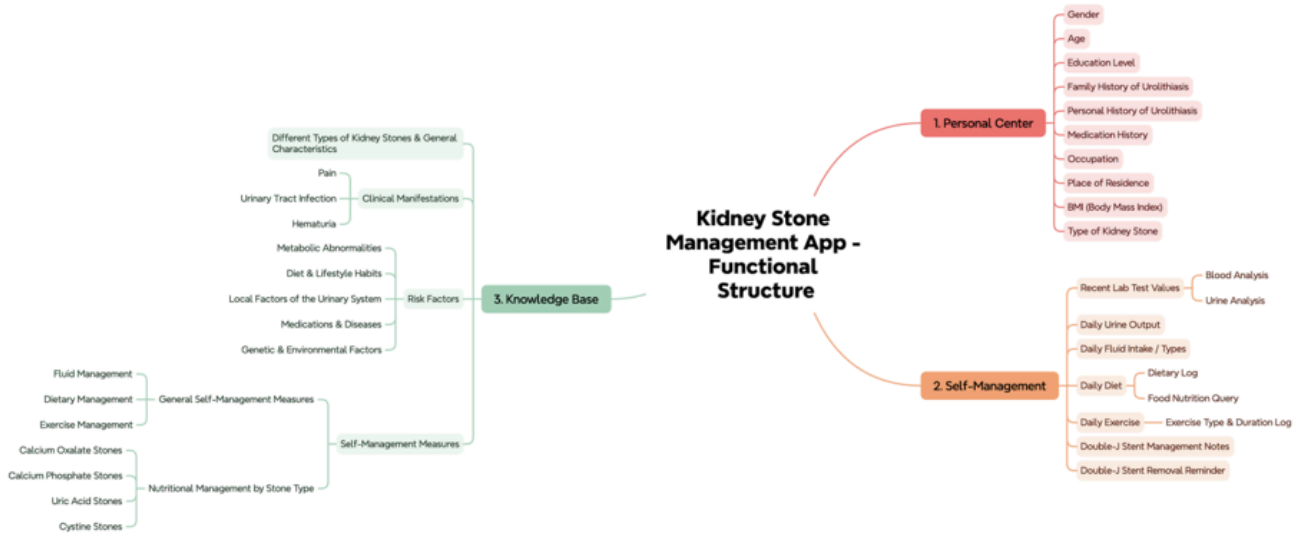


Figure 1

Urinary Calculi Patient Self-Management Mobile Health Program

Supplementary Files

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