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Original Article

Design Framework for mHealth Applications in Chronic Disease Self-Management: Strategies and Requirements

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Abstract

Background: Chronic diseases have been identified as global challenges to public health. Although the self-management of these diseases is critical, it is not always facilitated by conventional health systems. The adoption of mobile health (mHealth) solutions holds great promise for perpetual monitoring and patient engagement in controlling such diseases. According to evidence, most developed applications have not been highly successful in yielding desirable results. Therefore, this study proposed a novel framework for developing personalized mHealth systems that facilitate self-management among individuals with chronic conditions.

Materials and Methods: A multi-step method incorporating qualitative research techniques was employed. First, a narrative literature review was conducted to assess existing work and identify framework-related issues. Semi-structured interviews were also performed with experts in clinical, technical, and behavioral domains to refine the framework requirements for use in the design process. Validations with patients and medical practitioners were conducted to evaluate the clarity and appropriateness of the framework. Ultimately, the data were synthesized using thematic analysis techniques.

Results: The four major themes were personalization and adaptive support, engagement behavior, clinical and technical interfacing, and ethics and trustworthiness. In addition, the themes encompassed the personalization of interventions, interaction features, interfacing capabilities with other systems in clinical settings, and privacy requirements. It was revealed that the users were concerned about ease of use and data management.

Conclusion: Overall, the framework offers an evidence-based and patient-centric paradigm for developing clinically relevant, ethical, and scalable mHealth solutions to help mitigate the burden of chronic diseases worldwide.

Keywords: Mobile health, Chronic disease, Personal management, Framework

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Introduction

Chronic diseases, such as diabetes, hypertension, and obesity, remain a major global health problem, accounting for a large proportion of mortality and morbidity worldwide.[1] The increase in life expectancy is leading to multiple comorbidities, thereby increasing the need for ongoing monitoring and self-management.[2,3] Nonetheless, conventional medical services are often unable to provide ongoing patient management services; this phenomenon is even more common in resource-poor settings. In this regard, mobile health (mHealth) services have recently introduced new approaches to service delivery to provide continuous monitoring, assist in self-management practices, and improve patient-provider communication.[4-6]

It should be noted that the effectiveness of mHealth solutions has remained inconsistent despite their rapid adoption. Many applications have not been based on behavioral theory, lacked personalization features, and have not been integrated with traditional clinical systems.[2,7-9] Thus, several models have been developed to address these challenges and guide the development and evaluation of mHealth solutions. One of the main models is the Chronic Diseases mHealth App Intervention Design Framework, which was developed by Morita et al.[10] The mentioned model combines clinical and behavioral science knowledge to guide a systematic development process in order to deliver scalable chronic disease interventions.[10] Although this model is highly useful, it mainly provides information from a clinical/behavioral perspective while not presenting relevant data on co-design approaches and long-term engagement strategies.

Another area of research revolves around privacy and ethics. For example, Wachtler et al highlight issues with current privacy models that are inadequate to protect sensitive biomedical data collected from mHealth platforms and propose a new privacy framework specifically for chronic disease management.[11] These

articles have drawn attention to a gap in the research; although some models have focused on distinct domains, such as clinical relevance, privacy issues, and interoperability separately, there is still no comprehensive study that combines medical knowledge and ethics.

Furthermore, a limited body of research has addressed these issues, either through repeated contact with experts for feedback or direct user feedback. According to empirical findings, a failure to incorporate patient and expert inputs during formative development phases culminates in usability challenges and compromised long-term engagement.[2,8-13] However, the evidence base remains underdeveloped regarding key aspects such as personalization, motivational design, and the formulation of an overarching framework to unite these concepts. Given these limitations, the present study aims to develop an integrated and multidimensional framework for designing mHealth applications in the self-management of chronic diseases. A combination of literature review, expert advice in clinical, technical, and behavioral domains, and user-centered validation with patients and physicians has been used for this purpose.

This approach aims to fill these gaps by providing a framework for designing scalable and user-friendly mHealth solutions.

Materials and Methods

This research employed a multi-stage, iterative method to develop a framework for the integrated design of mHealth solutions for chronic disease self-management. The methodological framework systematically included three sequential but interconnected stages. They were categorized as the (1) evidence synthesis stage, (2) framework development stage through the expert knowledge stage, and (3) framework validation stage, focusing on users.

Stage 1: Narrative Literature Review and Requirement Extraction

A narrative literature review was conducted to explore existing mHealth design frameworks and common design principles, and remaining spaces for innovations in chronic disease management solutions. In addition, a systematic search of the literature was performed using the electronic databases PubMed, Scopus, Web of Science, and Google Scholar for articles published between 2013 and 2024, focusing on some key terms, such as 'mHealth research article framework', 'chronic disease management framework', 'self-management framework solutions', and 'mHealth app design guidelines.'

In total, 87 articles were systematically assessed, of which 42 were selected for further review. The first stage of data analysis involved the use of an inductive thematic coding technique in order to identify initial requirements in terms of personalization, behavioral engagement, interoperability, and ethics. These requirements were then used to inform the initial development of the framework.

Stage 2: Expert Consultation and Framework Development

The revised requirements were developed with the participation of eight experts from clinical (4), software development (3), and behavioral (1) sciences. The method involved conducting two sets of semi-structured interviews (45–60 minutes each) and an online workshop (2 hours). Questions related to clinical capabilities, technical limitations, behavioral approaches, and ethical issues related to health system development were included in these interviews.

Next, transcription and analysis were performed using reflective thematic analysis. Two researchers independently coded the transcripts and then resolved disagreements in order to combine codes into themes. The outcomes of this phase were (1) a set of revised design principles, (2) a framework architecture comprising multiple structured pillars, and (3) a low-fidelity prototype embodying the core components of the framework.

Stage 3: User-Centered Validation and Iterative Improvement

To evaluate the clarity, usability, and practical value of the framework, usability testing sessions were conducted with ten patients suffering from diabetes, hypertension, and asthma, as well as four physicians from ambulatory care departments.

The participants completed task scenarios using the low-fidelity prototype while employing the think-aloud protocol. Observational data were collected from note-taking and follow-up questionnaires. Moreover, examples of usability issues (icons and jargon) and expectations (degree of personalization, visual representation of progress, and privacy issues) were addressed in implementing the improvements.

Additionally, a second version of the framework was developed to enhance clinical relevance and usability. The new version incorporated feedback on personalization, clinician alert prioritization, and data management transparency.

Data Analysis

Qualitative data obtained from all stages underwent thematic content analysis. In addition, an iterative coding process, employing open, axial, and selective methods, facilitated the development of higher-order codes aligned with the final four pillars of the framework. Further, methodological rigor was ensured through the triangulation of literature, expert knowledge, and user feedback, which substantiated the framework's constituent elements. Informed consent was obtained from all participants. It is noteworthy that no personally identifiable data were collected in this study, and confidentiality was strictly maintained throughout the study process.

Results

The development of this framework involved three

complementary steps, each of which provided unique insights into the design of mHealth apps for chronic disease management.

Step 1: Literature Review

Combining evidence from systematic reviews and empirical research elucidated four key priorities for designing mHealth applications related to chronic disease management:

(1) Personalized Feedback and Goal Setting: The role of personalized feedback, contextual goals, and adaptive strategies for improving adherence to treatment has been emphasized in these studies. The use of a number of tools, including artificial intelligence (AI), personalized reminder systems, and context-sensitive reminders (e.g., medication reminders and blood glucose monitoring), has helped improve self-management efforts and adherence to treatment in diabetes and cardiovascular disease.[14-17] Although results vary from person to person, these context-sensitive strategies have consistently had positive effects on engagement.

(2) Behavioral Support and Motivational Strategies: Self-management requires ongoing behavioral support. The presence of some elements, such as badges, leaderboards, challenges, and social interaction associated with gamification techniques, has increased motivation and user engagement.[18] Furthermore, real-time tracking and automated coaching tools improved adherence to self-management across all patient ages, including adolescents and older patients.[19-21]

(3) Clinical and Technical Integration: To ensure operational relevance in medical settings, mHealth solutions should be fully integrated with relevant systems. This will require connectivity to electronic health record systems, sensor-based medical devices (e.g., Bluetooth glucometers and sphygmomanometers), and medical workflows.[22-24]

(4) Ethical and Privacy Concerns: Concerns about privacy have become a common issue regardless of geographic location. Users have demanded greater transparency in data access and storage processes. Accordingly, strong ethics and privacy by design are essential prerequisites for building trust among users in adopting mHealth solutions.[17,25]

Collectively, these results suggest that despite very rapid technological advances in medical care, the long-term use and effectiveness of mHealth technologies in clinical practice heavily depend more on their behavioral designs and reliability than on purely technological advances.[13,22,25-27]

Step 2: Expert Consultation

The study engaged a multidisciplinary panel of eight experts, including healthcare professionals, software developers, and even a behavioral scientist. The experts conducted semi-structured interviews and subsequently convened an online workshop to brainstorm ideas, which substantively advanced the framework's development. This process culminated in a consensus that co-design was the most effective pathway forward. The iterative co-design process and prototyping with a multidisciplinary team proved to be a crucial development component. Furthermore, integrating evidence-based clinical guidelines was fundamental to establishing the application's credibility and user trust. Finally, personalizing the content and ensuring system interoperability are essential prerequisites for sustained adoption.

Divergent priorities emerged across stakeholder groups. Clinicians emphasized clinical accuracy, safety, and regulatory compliance, whereas developers prioritized technical scalability and user experience. Meanwhile, the behavioral scientist focused on sustained motivation and long-term engagement. This diversity in priority highlighted a fundamental tension between rigorous clinical standards and user-centered design principles. The framework evolved into a multi-layered system, structured around three core pillars as advocated by expert feedback; they included (1) grounding all elements in clinical evidence and behavioral theory, (2) incorporating user-centric personalization, and (3) establishing mechanisms for ongoing evaluation. This entire structure is governed by foundational ethical safeguards, principally privacy-by-design and a commitment to equitable access.

Step 3: User-Centered Validation

The initial framework was evaluated with ten patients with chronic conditions and four physicians to assess its practical relevance and usability in real-world contexts.

From a patient perspective, participants clearly expressed a preference for simple and intuitive navigation and the ability to visualize personal health trends (e.g., blood sugar trajectories), and receive context-relevant reminders. While there were concerns about privacy, most patients indicated a willingness to use the app based on the approval of their healthcare providers. Gamification elements, including challenges and goal-oriented features, were particularly popular among younger participants, helping to increase engagement and motivation.

However, physicians emphasized different priorities, including the need for integrated dashboards that presented essential patient information in a unified and accessible manner to support clinical decision-making. Moreover, they indicated the importance of smart alert systems that prioritize essential clinical events, thereby reducing unnecessary interruptions. In addition, physicians expressed interest in tools that could streamline the consultation process without adding workload or complexity to existing workflows.

During prototype testing, both patients and physicians generally found the user interface intuitive and easy to use. However, several areas that needed improvement were identified, including ambiguous iconography and excessive technical jargon. Finally, these issues were incorporated

into subsequent iterations of the framework design.

Integrated Framework

A final design framework for mHealth applications in chronic disease management was developed by leveraging insights from all three phases of the study. The framework was structured around four interdependent pillars that collectively support effective, scalable, and ethical mHealth interventions:

1. Personalization and Adaptive Support: This pillar emphasizes tailoring goals, reminders, and educational content to users' individual profiles. Adaptive mechanisms, powered by AI and behavioral analysis techniques, enable the delivery of context-sensitive guidance that aligns with users' clinical needs and daily routines.

2. Behavioral Engagement Mechanisms: Incorporating motivational strategies (e.g., gamification, social interaction features, and recognition systems) increases user engagement and promotes sustained adherence accordingly. Moreover, these elements are designed to foster self-management behaviors and maintain long-term engagement.

3. Clinical and Technical Integration: Expert consultations indicate the importance of embedding clinical guidelines into the application's functionality and ensuring interoperability with existing healthcare systems. Similarly, seamless integration with electronic health records, medical devices, and clinical workflows enhances the reliability, validity, and clinical utility of the application. It is noteworthy that this alignment is essential to foster trust between users and healthcare providers.

4. Ethics and Trustworthiness: Throughout the discussions, ethical considerations, particularly privacy-based design, data transparency, and equitable access, emerged as essential components that should underpin every aspect of the framework. Ensuring strong ethical safeguards supports user trust and thus contributes to long-term adoption.

Overall, the integrated framework serves as a practical, evidence-based guide for developing mHealth applications that are both user-centered and clinically meaningful. Four pillars, namely, personalization, behavioral engagement, interoperability, and ethical integrity, serve as the foundation for high-quality mHealth design. It should be noted that these components are not complementary features but rather essential requirements for creating digital health tools that are effective, sustainable, and capable of making meaningful improvements in chronic disease self-management. Table 1 provides related key findings.

The proposed framework (Figure 1) integrates four interdependent pillars: personalization, behavioral engagement, clinical/technical integration, and ethics.

Discussion

This study contributed to our understanding of the essential elements involved in designing mHealth applications for individuals managing chronic conditions. By integrating findings from the literature, expert consultations, and user feedback, the proposed framework emphasized four core dimensions: personalization, behavioral engagement, clinical and technical integration, and ethical safeguards. Overall, addressing these dimensions is critical to overcoming persistent challenges in mHealth design, such as low long-term engagement, limited scalability, and the disconnect between technological capabilities and patient needs.

A central finding of this research was the importance of personalization and adaptive support. Consistent with the findings of earlier studies [17,21], the results indicated that tailored interventions, including adaptive reminders and AI-enabled feedback, can significantly enhance user engagement and thus positively influence health outcomes. Feedback from patients further highlighted that personalization must achieve a balance between clinical precision and user simplicity. Practically, this result highlights the design of tools that are both context-aware and intuitive, ensuring that users can engage with complex clinical information without experiencing cognitive burden.

Moreover, behavioral engagement mechanisms emerged as a key determinant of sustained app use. Participants reported that gamification elements (e.g., challenges, visual progress indicators, and social engagement loops) were motivating and helped maintain adherence, which conforms to the findings of previous research.[2,17] Notably, engagement preferences varied by age group. More precisely, younger users responded positively to gamified features, whereas older adults favored clarity, stability, and straightforward functionality. These observations underscore the need for adaptable engagement strategies that encompass diverse user characteristics and situational needs.

Likewise, clinical and technical integration represented another critical requirement. Seamless interoperability with electronic health records and wearable monitoring devices was essential for clinical acceptance.[19,21] Healthcare professionals particularly valued consolidated dashboards and prioritized alert systems that facilitated efficient decision-making while avoiding unnecessary cognitive load. Their concerns regarding potential "data overload" indicate the need for technical solutions that simplify complex information rather than amplifying it.

Ethical and privacy considerations were equally salient. Consistent with the findings of Lee et al, trust was strongly influenced by transparency in data handling and robust privacy protections.[22] While many patients expressed willingness to adopt the application if recommended by their physicians, concerns regarding data confidentiality persisted. Thus, these insights reinforce the necessity of incorporating privacy-by-design principles and ensuring alignment with regulatory standards. Additionally, ethical design must account for issues of digital equity, ensuring that mHealth tools remain accessible to individuals with

Table 1. Summary of Results Across Phases

Phase	Key Findings
Phase 1: Literature review	Personalization, behavioral support (reminders and gamification), interoperability with EHRs, and privacy concerns
Phase 2: Expert consultation	Consensus: Co-design, clinical evidence integration, and personalization Divergence: Clinicians focus on accuracy and compliance; developers emphasize usability and scalability; behavioral scientists stress motivation and sustained engagement.
Phase 3: User validation	Patients: Value reminders, visual progress, and simplicity; concerns about privacy but willingness to adopt if recommended by clinicians. Clinicians prefer dashboards, avoid data overload, and request alert prioritization. Prototype rated intuitive with minor issues.
Integrated framework	Framework with 4 pillars: (1) Personalization and adaptive support, (2) Behavioral engagement, (3) Clinical and technical integration, (4) Ethics and trustworthiness

Note. EHRs: Electronic health records.

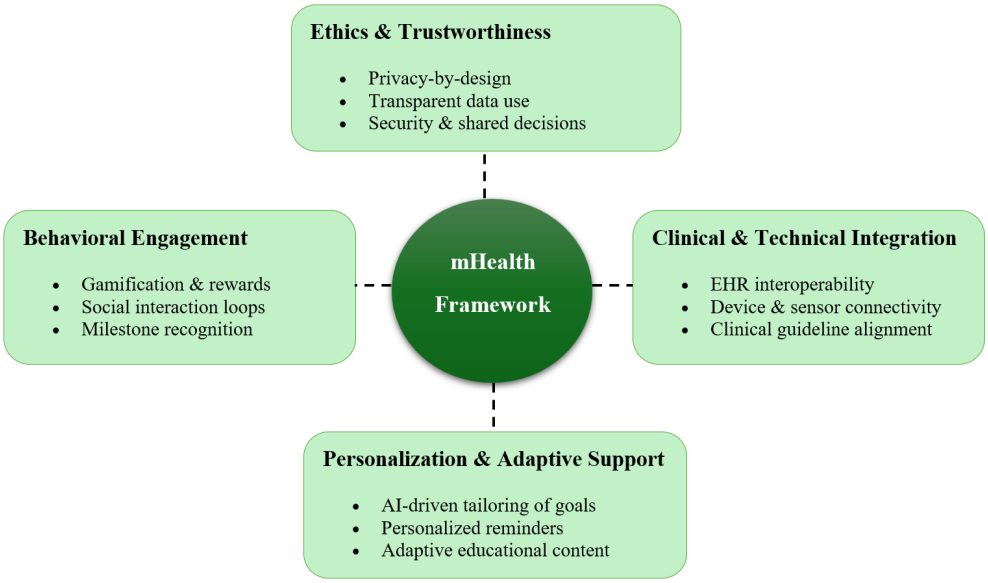

Figure 1. Integrated Design Framework for mHealth Applications in Chronic Disease Management
Note. EHRs: Electronic health records; AI: Artificial intelligence

limited technological skills or restricted access to digital resources.

More broadly, the significance of this study lies in its contribution to bridging the gap between technological development and real-world implementation. Unlike previous frameworks that primarily focused on technical specifications or behavioral elements in isolation, the framework developed in this study integrated clinical, behavioral, and ethical dimensions into a cohesive and practical model. This comprehensive approach positions the framework as a valuable guide for designing next-generation mHealth interventions that are effective, sustainable, and scalable.

Several limitations should be acknowledged. First, the study employed a narrative rather than a systematic literature review, which may introduce selection bias or lead to the omission of relevant studies. In addition, the sample sizes for the expert consultations and user validation were relatively small, limiting the generalizability of the findings. Accordingly, future research should involve larger, more diverse populations and incorporate quantitative evaluation methods in order to further validate and refine the framework. Eventually, longitudinal studies will be essential for assessing the long-term impacts of mHealth applications developed using this framework on clinical outcomes and the quality of life.

Conclusion

In general, the findings of this study increased our understanding of mHealth application design for chronic disease management by proposing an integrated, multi-dimensional framework that unites personalization, behavioral engagement, clinical and technical integration, and ethical safeguards. By addressing both human and technological factors, the framework provides practical guidance for researchers, developers, and healthcare professionals seeking to develop mHealth solutions that are effective and widely adoptable in real-world healthcare systems.

Authors' Contribution

Conceptualization: Pouneh Parvar.
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Project administration: Amirreza Hassanpour.
Supervision: Akbar Jabbari.
Visualization: Akbar Jabbari.
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Writing–review & editing: Akbar Jabbari.

Competing Interests

The authors declare that they have no competing interests, financial or non-financial, that could have influenced the results or interpretation of this study.

Ethical Approval

Not Applicable.

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