JTS

The Journal of Transdisciplinary Studies, 8(3): 349-368, 2024
https://doi.org/10.1001/jts.2024.8.3.349

User Experience Design and Improvement Strategies for Chronic Disease Management Digital Healthcare Applications for Older Adults

EunJi Koh[1], Hyojung Jung[2]

[1]Undergraduate Student, College of Health Administration, Dankook University, Korea (koheunji1121@naver.com), First Author
[2]Professor, University of Innovation and Convergence, Dankook University, Korea (hyojung.jung@dankook.ac.kr), Corresponding Author

ARTICLE INFO

Article history:
Received 12 Dec 2024
Revised 24 Dec 2024
Accepted 27 Dec 2024

Keywords:
Accessibility,
Chronic disease management,
Digital healthcare,
Older adult,
Older-adult-friendly design,
User experience (UX) design

ABSTRACT

Increasing life expectancy and the rapid shift toward an aging society have made chronic disease management among older adults a critical social issue. This study aimed to enhance the accessibility and usability of digital healthcare applications by designing user experiences (UX) tailored to the physical, cognitive, and perceptual characteristics of older adult users. The analysis of existing applications identified key improvements, including simplified login, larger icons and text, intuitive interfaces, personalized notifications, and voice support. Reward systems and family engagement features are vital for promoting sustained usage. These findings provide practical guidelines for designing older-adult-friendly digital healthcare applications that enable the self-management of chronic conditions and support healthy aging. Many previous studies lack comprehensive discussions of UX design principles that integrate the physical, cognitive, and perceptual characteristics of older adults. Although there is ongoing research on reward systems, user-friendly interfaces, and data visualization tools to encourage the continued use of digital healthcare applications, holistic design guidelines specifically tailored for older adults remain insufficient. This study addresses these gaps in the literature. This study contributes to improving the quality of life of older adult users and reducing societal healthcare costs by fostering a more inclusive digital healthcare environment.

1. Introduction

The rapid transition to an aging society and the increase in life expectancy have made the management of chronic diseases among older adults a critical challenge facing modern society. According to data from Statistics Korea, South Korea became an aged society in 2017, with 14.2% of its population aged 65 years or older, and is projected to become a super-aged society by

2025, with 20.6% of its population in this age group. These demographic shifts highlight the urgent need for systematic and sustainable solutions to improve health management and quality of life among older adults.

Chronic diseases, in particular, are a significant concern closely tied to the health of older adults and require effective prevention and continuous management. Neglecting chronic disease management not only lowers quality of life but also leads to increased medical expenses and heightened social burdens. However, older adults often face difficulties using traditional healthcare services and digital healthcare applications because of their physical, cognitive, and perceptual characteristics. For example, factors such as small font size, complex interfaces, and unfamiliarity with smart devices are major barriers to accessibility and usability.

Digital healthcare applications have gained attention as essential tools to address these issues. Digital healthcare technologies hold significant potential not only for managing chronic diseases, but also for promoting preventive health management and patient engagement. Features such as simple data input, real-time health monitoring, and personalized notifications encourage users to play a proactive role in managing their health. However, designs that fail to adequately reflect the characteristics of older adults hinder the usability and limit the sustained use of these applications.

This study aimed to propose user experience (UX) design principles and improvement strategies that reflect the physical, cognitive, and perceptual characteristics of older adults. To achieve this, existing digital healthcare applications for chronic disease management were analyzed and UX design principles tailored to older adult users were derived. Ultimately, this study sought to empower older adults to manage their chronic conditions independently and sustainably in digital healthcare environments, thereby improving their quality of life and reducing societal healthcare costs.

To design and improve the UX of digital healthcare applications supporting chronic disease management for older adults, this study set forth the following research questions:

- What are the primary barriers for older adults in using digital healthcare applications?
- What UX design principles are suitable for addressing the characteristics of older adults?
- What features and service elements of digital healthcare applications encourage sustained use by older adults?

These research questions focused on providing practical guidelines for optimizing digital healthcare application designs that consider the specific needs and characteristics of older adults.

2. Theoretical Background and Research Trends

2.1 The potential and barriers of digital healthcare technologies

Digital healthcare technologies hold significant potential not only for managing chronic diseases, but also for promoting preventive health management and patient engagement (Buzina et al., 2024).

Specifically, technologies such as the Internet of Medical Things (IoMT), wearable devices, and smart sensors can contribute to the real-time health monitoring and data-driven management of older adults. For example, wearable devices can track key health metrics, such as heart rate, blood pressure, and blood glucose levels, integrating these data with applications to enable real-time data sharing between users and healthcare providers. These technologies enhance the efficiency of chronic disease management and empower users to understand and manage their health better.

However, the adoption of these technologies by older adults is hindered by barriers, such as information overload, privacy concerns, and low digital literacy (Almalki et al., 2022). Information overload may arise from complex user interfaces and multistep processes, leading to confusion and eventually abandonment by older users. Privacy concerns, particularly regarding the handling of sensitive health data, reduce trust in digital solutions. Low digital literacy is a major obstacle that prevents older adults from understanding and using new technologies. Addressing these issues requires a user-centered approach that emphasizes an intuitive and simplified design aligned with the needs and capabilities of older adults.

2.2 The need for UX design reflecting older adults' characteristics

Older adults face additional challenges in using digital healthcare applications due to the physical, cognitive, and perceptual changes associated with aging, as well as limited experience with digital technologies. Almalki et al. (2022) categorized barriers to technology adoption into human, technological, organizational, and business dimensions, providing clear factors to consider when designing applications for older adults.

For example, simple login methods such as PINs or biometric authentication significantly enhance accessibility for older users with memory difficulties. Intuitive interfaces that present information step-by-step help users navigate applications more easily. Continuous notifications are critical for compensating memory decline, ensuring timely input of health data, and ensuring adherence to treatment schedules.

Moreover, sensory aids play a crucial role in the design of UX for older adults. Adjustable font sizes, color contrast settings, error-reducing confirmation prompts, and auditory feedback through voice support are essential elements that enhance usability. These design features, which are tailored to the characteristics of older adults, can significantly improve the accessibility and usability of digital healthcare applications.

2.3 Research trends in digital healthcare applications

Previous studies have identified various elements that should be considered when designing digital healthcare applications. Gaiduk et al. (2021) evaluated stress and sleep management technologies for older adults and highlighted their high acceptance owing to their user-friendly designs and automated data input features. Similarly, Buzina et al. (2024) emphasized the role of digital healthcare technologies in enhancing healthcare accessibility and promoting self-management among users.

However, many studies lack comprehensive discussions of UX design principles that integrate

the physical, cognitive, and perceptual characteristics of older adults. Although there is ongoing research on reward systems, user-friendly interfaces, and data visualization tools to encourage the continued use of digital healthcare applications, holistic design guidelines specifically tailored for older adults remain insufficient. This study addresses these gaps in the literature.

2.4 The need for this research

This study proposes UX design principles for digital healthcare applications that reflect the characteristics of older adults. By incorporating the physical, cognitive, and perceptual needs of this demographic, this study sought to enhance the voluntary and sustainable use of applications for chronic disease management. Ultimately, this study aimed to improve the quality of life of older adults while contributing to societal healthcare cost reduction.

Additionally, this study provides practical guidelines for digital healthcare application developers by concretizing a user-centered approach for older adults. This study is expected to establish a new paradigm for age-friendly technology design and contribute to reducing the digital divide.

3. Methods

This study aimed to derive design principles to enhance the UX of digital healthcare applications by addressing the physical, cognitive, and perceptual characteristics of older adults. A systematic research process was undertaken, comprising a literature review, application analysis, user scenario analysis, and expert review. This section outlines our research methods and procedures.

3.1 Literature review

This study commenced with a comprehensive review of the existing research to understand the digital device usage characteristics of older adults and their requirements for chronic disease management. This review focused on identifying the key physical, cognitive, and perceptual limitations that older adults face and explored the role of digital healthcare technologies in overcoming these challenges. This process established the theoretical foundation for the UX design framework used in this study.

3.2 Application analysis

Five digital healthcare applications for chronic disease management, available domestically and internationally, were selected for analysis. The selection process included the following criteria.

- **Inclusion Criteria**: Applications offering free health status monitoring, data management, and notification features or basic features available at no cost.
- **Exclusion Criteria**: Applications restricted to specific insurance providers or those focusing solely

on particular diseases.

Applications were identified using the keyword "chronic disease" in the App Store. Each application was evaluated on the basis of its ability to meet the needs of older adults.

The analysis used a 5-point scale to assess the degree to which the applications addressed physical, cognitive, and perceptual characteristics. The scale is defined as follows:

1 point: Feature absent or minimally implemented.
2 points: Feature present but with significant usability issues.
3 points: Feature adequately implemented but requiring improvements.
4 points: Feature effectively implemented with minor adjustments needed.
5 points: Feature fully optimized for older adults.

Additionally, binary indicators (O/X) were used to identify the presence or absence of specific features such as "easy login methods" or "real-time notifications." The evaluation criteria included intuitive navigation, accessibility, and personalized notifications.

3.3 User scenario analysis

To contextualize the evaluation, user scenarios were created to simulate how older adults would interact with applications in real-life situations. These scenarios highlight key user journeys, such as logging in, entering health data, and interpreting health metrics. This analysis provided insights into the potential pain points and usability challenges specific to older adults.

3.4 Expert review

The proposed UX design principles and findings were validated using an expert review process to assess their feasibility and applicability. The expert panel was comprised of five members with expertise in digital healthcare and UX design, balanced between academia and industry.

- **Digital Healthcare Expert**: A professor specializing in medical information systems for chronic disease management and a practitioner involved in developing healthcare applications at a healthcare technology company.
- **UX Design Expert**: Professionals with extensive experience in user-centered design and usability testing of digital platforms.

The review process included:

- **Preparation**: The experts were provided with the proposed design principles, evaluation criteria, and user scenario analysis in advance.
- **Individual interviews:** One-on-one interviews were conducted to gather independent feedback

on the feasibility of implementing the proposed principles and to provide suggestions for improvement.
- **Group Discussion**: Facilitating a collaborative discussion to reconcile differing viewpoints and identify consensus recommendations.

The feedback from the expert panel was systematically categorized and analyzed. Suggestions for refining the 5-point scale, ensuring technical feasibility, and enhancing practical implementation were incorporated into the final UX design principles.

3.5 Structured analysis

The structured approach enabled a detailed evaluation of the strengths and weaknesses of each application. Key insights were derived regarding how effectively the applications addressed the physical, cognitive, and perceptual characteristics of older adults. This analysis provided a foundation for proposing actionable UX design improvements tailored to the target demographic.

By employing a rigorous methodological framework, this study ensured the validity and practical applicability of its findings, paving the way for the development of user-friendly digital healthcare applications that empower older adults to manage chronic conditions.

4. Results

4.1 UX design directions considering the characteristics of older adults

Older adults face significant challenges in using general applications owing to aging-related changes in physical, cognitive, and perceptual abilities, as well as a lack of experience with digital devices. This study provided foundational insights for designing UX for older adults by thoroughly analyzing their specific characteristics. The findings for each characteristic are as follows.

4.1.1 Physical characteristics

Physical changes associated with aging impose practical limitations on the operation of digital devices. The key considerations for UX design include slower response times, reduced strength and motor skills, and increased fatigue.

- **Slower Response Times**: As neural transmission speed decreases with age, older adults experience delayed reactions, which can cause confusion when interacting with fast-paced interfaces (e.g., rapid screen transitions or animations). Time-sensitive input fields or autoclosing messages can be particularly burdensome for them (Verhaeghen & Salthouse, 1997).
- **Reduced Motor Skills**: Weak finger strength and unsteady hand movements render touchscreen navigation difficult, particularly for small buttons or closely spaced icons. Larger touch targets and adequately spaced icons are essential for UX design (Charness & Bosman, 1990).
- **Increased Fatigue**: Prolonged use of digital devices leads to a quicker onset of hand and arm

fatigue. Simplified processes that allow users to complete tasks with minimal interactions and short operational steps are required.

4.1.2 Cognitive characteristics

Aging leads to a general decline in cognitive ability, which is evident in information processing and application usage. Design must address issues such as reduced attention span, diminished long-term memory, and difficulties in processing irrelevant information.

- **Reduced Attention Spans**: Older adults have a limited capacity to process information simultaneously. Overwhelming information or complex screen layouts can distract users and cause confusion. A concise design and step-by-step information delivery are effective solutions (Craik & Salthouse, 2008).
- **Declined Memory**: Difficulties in learning and recalling complex application procedures are common. Repetitive feedback and clear usage instructions can mitigate this issue (Park et al., 1996).
- **Difficulty with Irrelevant Information**: Older adults struggle to process information lacking clear purpose or context. For example, scientific terms or jargon may be incomprehensible. Simplifying information and providing concrete examples can enhance its usability.

4.1.3 Perceptual characteristics

Age-related declines in vision, hearing, and touch sensitivity present various challenges for application usage.

- **Visual Impairments**: Decreased near vision makes it difficult to distinguish small text and icons. Low-contrast or overly complex color schemes may cause visual confusion. High-contrast colors, larger texts, and clear icon designs are critical. Important information should be emphasized in bold font and color highlights (Owsley, 2011).
- **Hearing Impairments**: Reduced auditory ability, particularly for high-pitched or soft sounds, necessitates loud and clear auditory feedback for notifications. The combination of auditory feedback with visual aids enhances effectiveness (Gordon-Salant, 2005).
- **Touch Sensitivity Decline**: Reduced tactile sensitivity can decrease the accuracy of touch inputs. Adding confirmation steps for touch inputs or designing larger touch buttons can reduce errors. Additionally, haptic feedback (e.g., vibrations) can inform users of a successful input.

4.1.4 Digital information usage characteristics

Limited experience with digital technology poses significant barriers to older adults learning and using new applications. The key issues include unfamiliarity with terms and concepts, difficulties with complex learning processes, and low adaptability to interfaces.

- **Unfamiliar Terminology and Concepts**: Technical terms and concepts commonly used in smart devices may be unfamiliar to older adults; basic terms like “drag” or “swipe” may be confusing.

A simple language and intuitive iconography are essential (Czaja et al., 2006).

- **Difficulty Adapting to Complex Interfaces**: Older adults adapt more slowly to evolving technologies. Complex interfaces or multi-layered menus can lead to confusion. Simplified structures and opportunities for repetitive learning can alleviate these challenges (Mitzner et al., 2010).
- **Preference for Flat Menus**: Older adults prefer straightforward, flat menu structures because nested menus complicate navigation and understanding. Interfaces should enable users to locate the desired information quickly and efficiently.

Considering these physical, cognitive, perceptual, and digital information usage characteristics, the findings of this study offer essential directions for designing digital healthcare applications that are accessible and user-friendly for older adults. This approach not only supports better usability, but also promotes sustained engagement in managing chronic conditions.

4.2 Derivation of UX design principles for older adults and expert review

The UX design principles proposed in this study were refined based on feedback from an expert review group of digital healthcare and UX design professionals. The expert reviews focused on assessing the feasibility and practical applicability of the proposed improvements.

4.2.1 Expert feedback from digital healthcare specialists

Digital healthcare experts provided insights into the functional requirements and technical feasibility of the features essential for chronic disease management applications. For example:

- **Voice Support Function**: Experts noted that while technically feasible, the implementation of voice support could face challenges related to data processing speed and system responsiveness.
- **Reward Systems and Family Engagement Features**: These features, proposed to enhance user motivation and sustained engagement, were received positively. However, the experts recommended more detailed design plans that consider older adults' psychological motivation mechanisms.

4.2.2 Expert feedback from UX design specialists

The UX design specialists evaluated the suitability of the proposed design elements for older adult users. The positive feedback included the following:

- **Large Icons and Intuitive Interfaces**: These are effective for improving accessibility and usability for older adults.
- **Simplified Information Delivery**: Concise and clear information presentation is essential for reducing the cognitive load and enhancing comprehension.

However, some suggestions have been flagged as being less applicable or overly complex when

applied to specific user scenarios. For instance:

- **Touch Error Mitigation through Confirmation Processes**: While valuable, experts advised the selective implementation of such processes to maintain a streamlined user experience. Overuse can unintentionally complicate interactions.

4.2.3 Final UX design principles for older adults

Based on expert feedback, the following guidelines were finalized to optimize the application of the UX design for older adults:

- **Enhancing Accessibility**:

Use large, high-contrast icons with adequate spacing.
Provide customizable font sizes and themes to address diverse visual needs.

- **Simplifying Information and Interactions**:

Present key information in concise formats and step-by-step flows.
Use familiar terms and avoid unnecessary technical jargon.

- **Improving Interaction Reliability**:

Minimize errors through larger touch targets and optional confirmation steps for critical actions.
Offer haptic feedback and visual confirmations to enhance input confidence.

- **Supporting Sustained Engagement**:

Integrate reward systems, such as points or badges, to encourage continuous use.
Enable family members to participate by sharing health data and providing motivational feedback.

- **Leveraging Voice and Visual Feedback**:

Include voice support for navigation and data input.
Pair auditory feedback with visual cues for clarity.

- **Promoting Ease of Learning and Adaptation**:

Provide tutorial modes and repetitive feedback for new users.
Use video guides and help sections to support self-paced learning.

These principles balance theoretical insights with practical applicability and offer a comprehensive framework for designing digital healthcare applications tailored to the needs of older adults. By incorporating these principles, developers can create applications that are accessible and engaging, thereby ensuring sustainable use and effective chronic disease management for older adult users.

Table 1. Application of UX design principles for older adults: A practical guide

Older Adult Characteristics	Considerations	Application Guide
Physical Characteristics	Physical Ability	- Enable simplified login processes (e.g., biometric authentication) - Introduce touch confirmation mechanisms to reduce errors - Remove time limits on inputs - Design larger buttons with sufficient spacing
Cognitive Characteristics	Cognitive Ability	- Structure content in an intuitive and logical manner - Avoid requiring specialized knowledge to use features - Use concise sentences and provide opportunities for repetitive learning through feedback and tutorials
Perceptual Characteristics	Perceptual Ability	- Provide appropriately sized text and highly readable fonts - Emphasize critical information using contrasting colors and bold highlights - Incorporate large, clear, and intuitive images for easy recognition
Digital Information Usage	Understanding Ability	- Use simple and familiar language - Clearly display normal ranges for health data (e.g., blood pressure) - Include straightforward user guides and on-screen prompts with intuitive assistance
	Learning Ability	- Offer step-by-step learning support for first-time users - Include video links to explain complex features - Provide periodic reminders and help tips to reinforce learning and build user confidence
	Sustained Usage	- Implement a reward system (e.g., points, badges) to motivate consistent use - Offer personalized notifications tailored to user behavior and preferences - Simplify navigation by minimizing menu layers and streamlining user pathways

Table 2. Application of UX design principles for older adults: Detailed guide

Consideration	Review Criteria	Description
Physical Ability	Ease of Login	Supports simple login methods such as PIN or biometric authentication.
	Touch Confirmation	Provides a confirmation dialog for data input to reduce errors.
	Error Recovery for Touch Inputs	Ensures easy error correction and recovery with options to reset or navigate back to the home screen.
	Icon Spacing	Maintains sufficient spacing between icons to improve touch accuracy.
	No Time Limit	Removes time constraints for data input and task completion.
Cognitive Ability	Intuitive Content Display	Presents key features and information in an intuitive and user-friendly manner.
	Concise Information	Ensures that sentences are short, clear, and easy to understand.
	No Specialized Knowledge Required	Avoids technical terms or the need for complex knowledge to use the application.
	Structured Information Search	Organizes information in a structured and easily navigable way.
	Consistent Notifications	Offers notifications to encourage consistent engagement with the application.
Perceptual Ability	Font Size	Ensures text size is appropriate for older adults to read comfortably.
	Font Readability	Uses legible fonts that are visually easy to read.
	Highlighting Important Information	Clearly emphasizes key information with color or style.
	Checkbox Size	Designs checkboxes to be large and easy to use.
	Large and Intuitive Images	Provides images that facilitate easy comprehension of information.
	Graph Readability	Designs visually clear graphs that make data comparison intuitive.
	Voice Support	Includes voice commands and feedback functionality.

Table 2. Cont.

Consideration	Review Criteria	Description
Understanding Ability	Simple Language Usage	Uses simple and familiar terms instead of technical jargon.
	Clear Usage Instructions	Provides straightforward and intuitive guides for using the application.
	Normal Range Information	Offers clear indications of normal ranges for health data (e.g., blood pressure).
	Visual Resources	Delivers information through graphs, images, and other visual aids.
Learning Ability	Educational Video Links	Provides links to educational content or videos related to health management.
	Information for Each Section	Ensures users can easily access additional information for specific features or sections.
Sustained Usage	Reward System	Implements point accrual or reward programs to motivate consistent usage.

4.3 Analysis of chronic disease management applications for older adults

This study evaluated five chronic disease management applications (A, B, C, D, E) available domestically and internationally, reflecting the physical, cognitive, and perceptual characteristics of older adults, as well as their digital information usage needs. The evaluation criteria were designed to enhance older adult-friendly UX. The analysis focused on how well each application met the needs of the older adults in terms of physical, cognitive, and perceptual ability, and sustained usability. The key details of the evaluated applications are as follows.

Table 3. Overview and key features of the five applications

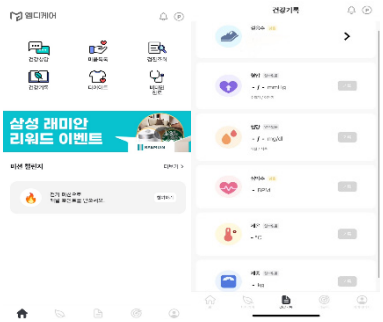
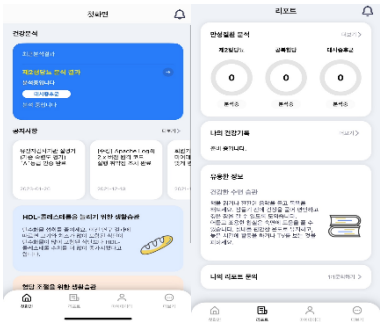
Application	Introduction	Key Features and Functions
A	Data-driven premium health management application 	- Personalized health management with a dedicated coordinator (unlimited health consultations and bi-monthly regular consultations) - Step tracking and real-time health monitoring based on data - Family health management support - Remote medical consultation services (MDTalk)
B	Simplified and efficient chronic disease management application 	- Automatic transfer of health records through hospital integration - Simple data visualization with graphs - 1:1 messaging with primary care physicians - Health checkup records and key health metrics - Remote medical consultation services

Table 3. Cont.

Application	Introduction	Key Features and Functions
C	Digital chronic disease care application offering a platform for patient-physician interaction 	- Blood sugar and blood pressure tracking - Regular intraocular pressure (IOP) monitoring - Communication and consultation with specialists - Medication reminders and tracking - Meal and exercise journaling
D	AI-powered personalized healthcare application for chronic disease management 	- ECG monitoring: Rhythm analysis for arrhythmias, tachycardia, and bradycardia - Blood pressure, blood sugar, body temperature, and weight tracking - Health data extraction and Excel download for specific periods
E	Healthcare MyData-based chronic disease management application 	- Type 2 diabetes management and recommendations for diet and sleep habits - Health status analysis reports - MyData score to evaluate data utilization and currency - User-driven health data access, storage, and service integration

The analysis of cases A through E revealed that while each application reflects certain characteristics of older adults, there are areas requiring improvement. The detailed analysis results are summarized in the following table.

Table 4. Detailed analysis of applications A to E

Evaluation Criteria	Item	A	B	C	D	E
Physical Ability	Ease of Login	X	○	X	X	○
	Touch Confirmation	X	X	○	X	X
	Error Recovery for Touch Inputs	○	○	○	○	○
	Icon Spacing Appropriateness	○	○	○	○	○
	No Time Limits	X	X	X	X	X
Cognitive Ability	Intuitive Content Understanding	○	○	X	○	X
	Information Sentence Length	5	4	2	5	2
	No Specialized Knowledge Required	X	X	X	X	○
	Depth of Information Search	2	4	4	2	1
	Consistent Notifications	X	○	○	X	X
Perceptual Ability	Font Size	2	5	5	4	2
	Font Readability	5	5	3	5	5
	Highlighting Important Information	○	X	X	X	X
	Checkbox Size	4	5	3	5	1
	Large and Intuitive Images	3	4	3	4	2
	Graph Readability	○	X	X	X	X
	Voice Support	X	X	X	X	X
Understanding Ability	Simple Language Usage	○	○	○	○	X
	Clear Usage Instructions	X	X	X	○	○
	Normal Range Information Provided	○	○	X	○	X
	Visual Resources Provided	○	○	X	○	X
Learning Ability	Educational Video Links	X	○	X	X	X
	Additional Information Availability	X	X	X	X	X
Sustained Usability	Reward System	○	X	X	X	○

4.3.1 Reflection of physical characteristics

To address the physical limitations of older adults, features such as simple login methods, touch-error prevention mechanisms, and appropriate icon placement are essential. The evaluation results for the physical ability aspect of each application were as follows.

First, regarding the provision of simple login features, applications B and E supported PIN codes and biometric authentication, significantly improving initial accessibility. In contrast, applications A, C, and D relied on the traditional ID-password method, which may cause difficulties for older users. Repeated login failures can lead to frustration and eventual abandonment of the application.

Second, application C provided a confirmation dialog before saving data, effectively reducing input errors. This reconfirmation process minimizes errors and correction effort. However, other applications lack this feature, which potentially causes inconvenience to users during data entry.

Finally, all five applications implemented adequately spaced icon placement, reduced screen clutter, and enhanced touch accuracy. This fundamental design element was executed appropriately across all applications, contributing to better user experience.

4.3.2 Reflection of cognitive characteristics

An intuitive interface and information delivery system that accommodates the cognitive characteristics of older adults are critical factors in determining application usability.

First, in terms of providing intuitive content, applications B and D clearly guided the key features on the home screen and offered intuitively designed interfaces. In contrast, applications E and C presented overly complex home screens with small fonts, which could hinder older users from understanding or navigating the features effectively.

Second, regarding consistent notification features, applications B and C included reminders to prompt users to regularly input data. This effectively compensates for memory decline among older adults and enhances the continuity of chronic disease management. However, applications A, D, and E either lacked this feature entirely or provided it only at a limited capacity.

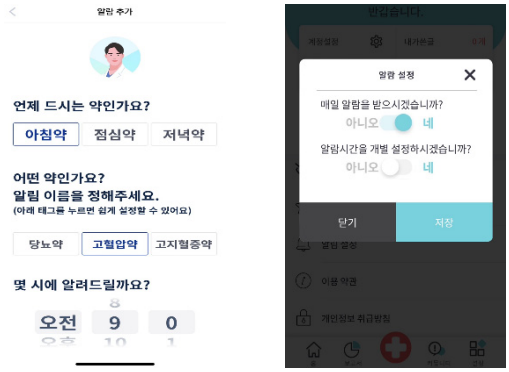


Fig. 1. Example of continuous notification features

Regarding the requirement for specialized knowledge, application E focused on a specific condition (Type 2 diabetes), requiring users to use health checkup records and understand disease-specific terminology. Considering the typically low health literacy of older adults, this structure significantly limits accessibility and poses a substantial barrier to its use.

Fig. 2. Emphasis on key information and graph readability

4.3.3 Reflection of perceptual characteristics

An interface design that compensates for the age-related decline in vision, hearing, and tactile sensitivity is a critical factor in determining the success of an application.

In terms of font size and readability, applications B and D featured larger text and highly legible fonts, allowing older users to easily read and understand the information. In contrast, applications A and E used relatively smaller fonts with lower readability, which diminished accessibility for older users.

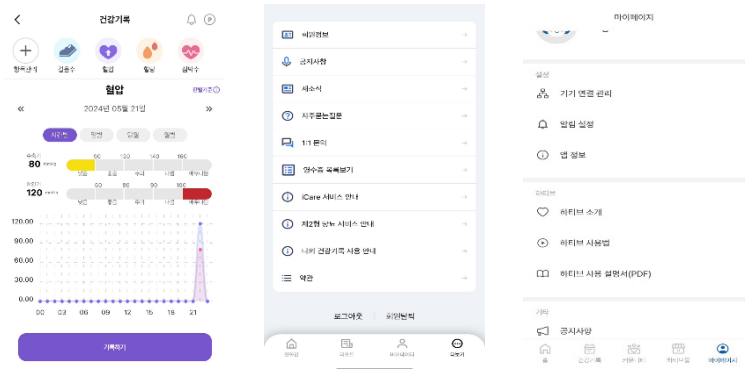


Fig. 3. Example of application usage guide

In terms of graph readability and color emphasis, application A effectively used visual aids by providing graphs that allowed users to compare data over time (e.g., daily and hourly comparisons). It also emphasized key information using colors, enabling users to understand the data intuitively. By contrast, other applications either lack sufficient visual aids or present overly complex visuals, resulting in reduced information clarity and effectiveness.

Fig. 4. Example of providing normal range for health records

Evaluation of the voice-support functionality revealed that none of the applications provided this feature. This indicates a lack of consideration for older adults with hearing impairments, who could benefit from voice assistance, to better understand and use application features.

4.3.4 Reflection of digital information usage characteristics

Chronic disease management requires a long-term perspective, making features that encourage sustained application particularly important.

To enhance the understanding and learning capabilities, some applications effectively support user adaptation by providing simple usage guides and video resources. Although simplifying and streamlining the application content may result in the omission of certain information, linking users to related resources in an accessible manner can significantly improve convenience. For instance, in application B, users could click on a “Health Education” icon to access various video resources related to diabetes management and hypertension testing, enabling them to easily find the information they needed.

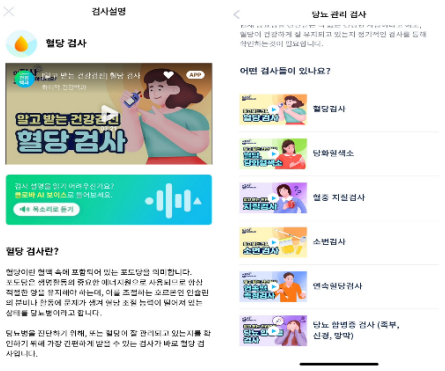


Fig. 5. Example of providing links to related Videos

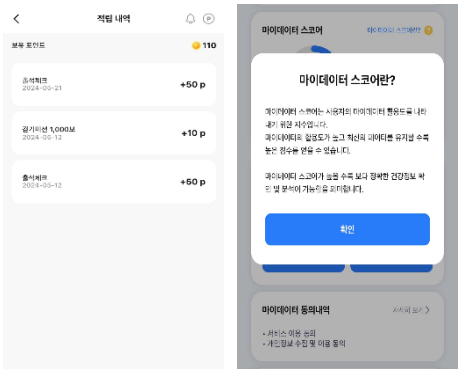


Fig. 6. Example of reward system implementation

The evaluation of the reward system support revealed that application A motivated users by allowing them to accumulate points based on activities, such as step counts and data input. These points can then be used for membership subscriptions to effectively encourage user engagement. Application E adopted the MyData Score system, which increases the frequency of data input and provides more accurate health information. Such reward systems have a positive effect on promoting the long-term use of applications by older adults.

Overall, the evaluation of the reflection of physical characteristics revealed that while most cases satisfied features such as simple login and touch error prevention, adjustments in icon spacing and removal of time limits were often insufficient. Regarding the reflection of cognitive characteristics, intuitive information presentation and the use of simple sentences were effectively implemented in cases B and C. However, some applications required specialized knowledge, indicating a need for improvement. In terms of perceptual characteristics, font size, color contrast, and emphasis on important information were appropriately designed in cases A and B. However, graph readability and the provision of intuitive images were lacking in case E. Finally, concerning the reflection of digital information usage characteristics, case C positively supported learning through video resources and step-by-step guides, whereas cases D and E lacked sufficient learning support features. Furthermore, the reward systems and strategies for encouraging sustained usage are generally inadequate across most cases.

5. Conclusion and Recommendations

This study aimed to evaluate and propose improvement strategies for chronic disease management applications by focusing on the physical, cognitive, perceptual, and digital information usage characteristics of older adults. By analyzing five applications (A, B, C, D, and E), this study identifies the key strengths and areas for improvement, offering actionable insights for future application development.

5.1 Summary of findings

5.1.1 Physical abilities

The ability to address physical limitations is fundamental to the application design for older adults. Features such as simple login methods, touch error prevention mechanisms, and appropriately spaced icons have been inconsistently implemented across applications. Applications B and E offered simple login options, such as PIN codes and biometric authentication, which greatly enhanced initial accessibility. Application C included a confirmation step to reduce touch errors, which is a notable step toward improving usability. However, the remaining applications either lack these features entirely, or implement them inadequately, thereby presenting barriers to user engagement.

5.1.2 Cognitive abilities

Simplified interfaces and intuitive guidance are critical for enhancing cognitive usability. Applications B and D effectively guided the users through clear home screens and straightforward layouts, thereby improving their usability. However, applications E and C struggled with overly complex interfaces, small fonts, and the inclusion of features that require specialized knowledge, which reduces accessibility. Furthermore, although some applications provide notification features to engage users and support memory retention, these features are applied inconsistently and require further enhancement.

5.1.3 Perceptual abilities

Addressing visual and auditory needs is vital for supporting older adults' interactions with applications. Applications B and A received higher evaluations for their use of readable font sizes, color emphasis, and visually intuitive graphs, whereas application A stood out for effectively visualizing data through graphs and color highlights. Nevertheless, none of the evaluated applications included voice support, which is a critical feature for overcoming auditory limitations and fostering inclusivity in digital healthcare applications.

5.1.4 Sustained usability

Motivating users to maintain engagement is essential for the long-term success of chronic disease management applications. Applications A and E implemented reward systems to encourage sustained usage: application A used a point-based membership model, whereas application E introduced the MyData Score to motivate consistent health data input. These systems highlight the potential of gamification and personalized feedback in fostering user retention; however, such features remain underused across most applications.

5.2 Design and improvement implications

Based on these findings, the following recommendations are proposed to improve the design of chronic disease management applications tailored to older adults.

5.2.1 Enhance basic accessibility

Design elements such as simple login methods, touch error prevention, and appropriately spaced icons must be considered fundamental to improving accessibility for older adults. These features not only lower barriers to entry, but also ensure a smoother user experience, particularly for individuals with physical limitations. Complex login procedures should be replaced with simplified options such as biometric authentication or one-tap logins.

5.2.2 Develop intuitive and simplified interfaces

An intuitive interface that clearly guides users through key functions on a home screen can significantly enhance the usability. The removal of unnecessary information and maintenance of navigation simplicity can prevent cognitive overload. Applications B and D demonstrate the value of these approaches. Furthermore, consistent and customizable notification systems can address memory-related challenges and promote the continuity of chronic disease management.

5.2.3 Strengthen visual and auditory support

To meet the perceptual needs of older adults, applications should provide clear and accessible visual elements, including larger fonts, intuitive graphs, and color-coded highlights of critical information. Application A serves as an example of an effective implementation. Additionally, voice support features should be prioritized to assist users with auditory limitations and ensure a more inclusive design.

5.2.4 Implement motivation strategies for sustained usability

Reward systems, such as point-based incentives, personalized feedback, and gamification elements, have been shown to be effective in maintaining user engagement. Applications A and E provide examples of successful implementation of these systems. Expanding the adoption of such strategies can encourage older adults to actively participate in health management.

5.2.5 Adopt a comprehensive design approach

This study highlights the need for a holistic approach to application design that integrates the physical, cognitive, and perceptual characteristics. Features such as voice support, consistent notifications, and intuitive interfaces should be standardized across all applications to meet the diverse needs of older adults.

5.3 Contributions and future directions

This study offers practical design guidelines and identifies areas in which chronic disease management

applications can better support older adults. By combining user-centered design principles with actionable recommendations, the findings contribute to the development of more inclusive, effective, and sustainable digital healthcare solutions. Future research should extend these insights by incorporating global case studies and examining the long-term impact of these design principles on health outcomes and user engagement.

By addressing the gaps identified in this study, developers and researchers can pave the way for digital healthcare applications that not only meet the functional needs of older adults, but also empower them to manage their health independently, ultimately improving their quality of life and reducing societal healthcare costs.

Notes

Author Contributions

Koh: Conceptualization, Data Curation, Writing - Original Draft.
Jung: Formal Analysis, Methodology, Supervision, Funding Acquisition.

ORCID

EunJi Koh : https://orcid.org/0009-0004-2302-3990
Hyojung Jung : https://orcid.org/0000-0001-5046-5007

Conflicts of Interest

No author has any other conflict of interest to declare.

Acknowledgments

Following are results of a study on the "Biohealth Convergence and Open Sharing System" Project, supported by the Ministry of Education and National Research Foundation of Korea.

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