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Enhancing mHealth Applications through User-Centred Design: A Conceptual Framework for Improved Healthcare Accessibility and User Experience

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ABSTRACT

The rapid growth of mobile health (mHealth) applications offers significant opportunities to improve healthcare delivery. However, the success of these applications largely depends on their alignment with user needs and preferences. This study introduces a conceptual framework cantered around User-Centred Design (UCD) to enhance mHealth applications by prioritizing user experience and accessibility. By focusing on UCD principles, the framework addresses key aspects such as usability, behavioural control, and the influence of subjective norms on user adoption. The framework was developed through qualitative interviews with nine experts from medical and IT fields, each possessing over 15 years of experience. Their insights helped refine the framework to ensure it meets the diverse needs of mHealth users. The UCD approach ensures that the application interface is intuitive, engaging, and tailored to users' expectations, thereby increasing user satisfaction and adoption rates. By integrating UCD into the mHealth application design process, this framework provides a structured approach to creating more accessible and user-friendly healthcare solutions. This focus on UCD is essential for overcoming the barriers to mHealth adoption, ensuring that applications are not only functional but also resonate with users on a personal level. The proposed framework lays the groundwork for future innovations in mHealth, driving the development of applications that are both effective and widely accepted by users.

1. INTRODUCTION

The emergence of mobile health (mHealth) applications signifies a significant change in the delivery and accessibility of healthcare services. Due to the extensive use of smartphones and mobile devices, mHealth applications have the capacity to greatly enhance healthcare results by granting patients convenient access to medical information, enabling remote monitoring, and facilitating immediate communication with healthcare providers. Although mHealth applications have great promise, their usefulness is frequently hindered by inadequate user experience, resulting in low rates of adoption and less than optimal health results. The efficacy of mHealth applications is contingent upon not only the technological framework and

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clinical substance, but also their capacity to fulfil the requirements and anticipations of users. It is crucial to incorporate User-centred Design (UCD) ideas into the development process of mHealth applications.

2. LITERATURE

2.1 Enhancing mHealth Application with UCD

User-centered design (UCD) is crucial in the creation of mHealth applications as it provides a systematic method that greatly improves usability, engagement, and overall efficacy. UCD, or User-Centered Design, is a design approach that differs from traditional methods by placing a strong emphasis on user experience. Unlike other methodologies that may prioritize technological advancements, UCD actively engages end-users and stakeholders throughout the development process. This ensures that the final product closely aligns with user needs, preferences, and expectations, as supported by Korpershoek et al., (2020) and Cornet et al., (2020). Through frequent and early user engagement, User-Centered Design (UCD) reduces the likelihood of creating applications that, despite their technical sophistication, may not effectively connect with or sufficiently cater to the intended user base.

This technique has demonstrated its effectiveness in several mHealth settings. UCD has had a role in improving women's health by developing user-friendly applications that are easy to use and understand. This has resulted in increased user participation and improved health results Kongjit et al., (2022). UCD has contributed to the development of tools that are better suited to the individual needs of patients in the management of chronic renal disease. This has resulted in improved adherence to treatment regimens and overall disease management Sobrinho et al., (2018). UCD has played a crucial role in developing applications that help users navigate the intricate colorectal cancer screening procedures. As a result, these applications have led to higher rates of participation and early diagnosis, as stated by Griffin et al., (2019).

Nevertheless, despite the multitude of advantages, the implementation of User-Centered Design (UCD) is not devoid of challenges. Successful User-Centered Design (UCD) necessitates strategic timing of stakeholder engagement to guarantee that the input received is pertinent and can be acted upon. In addition, the techniques employed in UCD must be flexible enough to cater to the particular requirements and circumstances of the end-users, a task that can prove challenging in varied and intricate healthcare settings (Mccurdie et al., 2012).

2.2 The Significances of Framework in mHealth

In the context of developing countries, where healthcare challenges are frequently multifaceted and complex, conceptual frameworks are indispensable instruments for the development and execution of effective mHealth solutions. A structured and systematic approach to addressing these challenges is provided by these frameworks, which guide both research and practical applications in the field of mobile health. Conceptual frameworks guarantee that these digital interventions are not only innovative but also interoperable with the broader healthcare infrastructure by establishing clear pathways for the integration of mHealth solutions into existing health systems (Advisory Council, 2020; Mburu et al., 2013). This interoperability is essential for the sustainable deployment and seamless deployment of mHealth applications, particularly in resource-limited settings where healthcare systems are frequently fragmented.

Additionally, conceptual frameworks facilitate the exhaustive assessment of mHealth solutions from the viewpoints of numerous stakeholders. This encompasses not only healthcare providers and patients, but also policymakers, developers, and other critical stakeholders in the healthcare ecosystem (Bradway et al., 2017). Conceptual frameworks are essential for the improvement of educational scholarship in medical education, in addition to facilitating the design and implementation of mHealth solutions. These frameworks contribute to the development of a competent and knowledgeable workforce that is capable of utilizing mHealth technologies to enhance patient care by offering a structured approach to understanding and teaching complex concepts in mobile health (Zackoff et al., 2019).

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In addition, conceptual frameworks provide a basis for comprehending patient adoption factors in developing countries, where the adoption of mHealth interventions can be substantially influenced by cultural, social, and economic factors (Addotey-Delove et al., 2020). Frameworks ensure that mHealth solutions are culturally appropriate and accessible to the populations they are intended to serve by integrating these factors into the design and evaluation process.

Below is the overall conceptual framework figure:

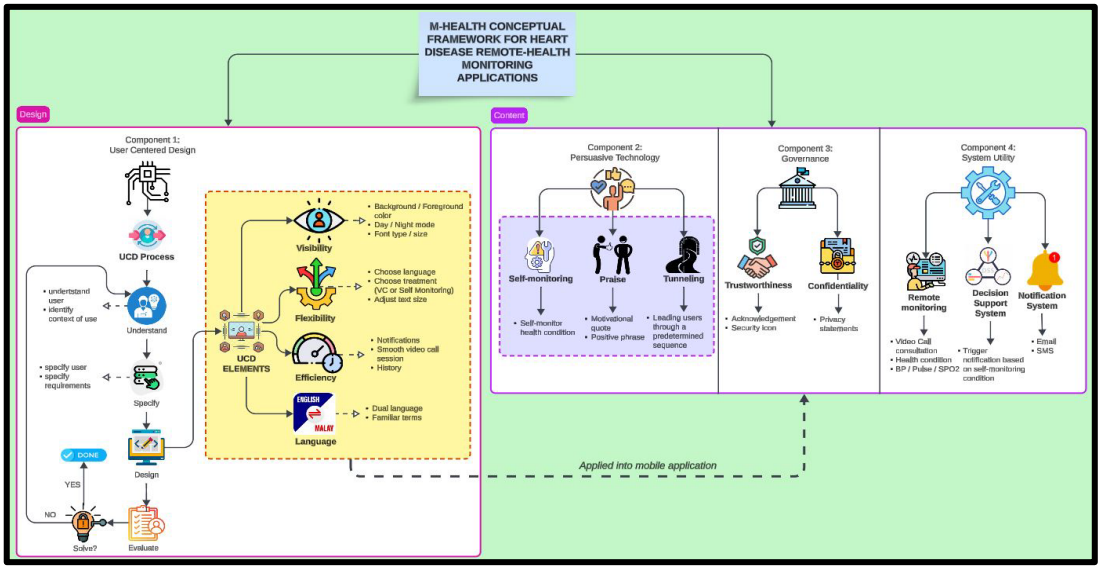

Fig. 1. Overall conceptual framework

2.3 Refining Accessibility to Healthcare with UCD

User-centered design (UCD) techniques play a crucial role in improving healthcare accessibility by actively engaging end-users in the development process. This guarantees that the resultant healthcare systems and solutions are not only easier for users to navigate, but also have long-term viability. UCD, or User-Centered Design, is a method that focuses on meeting the requirements, preferences, and feedback of various users, including patients and healthcare practitioners. By doing so, UCD ensures that digital health solutions are more intuitive and more suited to the specific needs of the people they are intended to benefit. This approach is supported by research conducted by Groos (2023) and Göttgens & Oertelt-Prigione (2021). Adopting this comprehensive strategy is crucial for diminishing health inequalities and promoting fairer availability of healthcare services, thus advancing the overarching objective of attaining universal health coverage.

By prioritizing inclusivity in the design of digital health solutions, there is a great potential to greatly diminish disparities in healthcare accessibility. This is especially crucial in heterogeneous populations where social, cultural, and geographic obstacles frequently restrict the availability of vital healthcare services. By customizing digital health platforms to cater to the requirements of marginalized communities, these solutions can assist in closing the disparity between various population groups, guaranteeing equal access to high-quality healthcare for all individuals (Henni et al., 2022; van de Vijver et al., 2023).

Community health initiatives, mobile clinics, and telemedicine are all instances of how UCD can be utilized to enhance accessibility to primary healthcare services in remote regions. These tactics enable healthcare providers to access people that would otherwise be geographically or socially disconnected from

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the healthcare system, guaranteeing that patients receive prompt and suitable medical attention. By integrating user feedback and local expertise into the development of these services, they can be more precisely customized to address the distinct requirements of rural communities, ultimately resulting in improved health outcomes (Gizaw et al., 2022).

Furthermore, the implementation of user-centered design in digital mobile health platforms can greatly enhance the effectiveness and openness of healthcare delivery. These platforms facilitate the process of obtaining healthcare services, alleviate administrative difficulties, and empower patients with more control over their health information (Huisman et al., 2022). The outcome is an enhanced healthcare system that is more receptive and open, catering to the requirements of its users, resulting in heightened patient satisfaction and confidence

2.4 Cultivating UX with UCD

User-Centered Design (UCD) has continually demonstrated its efficacy in improving user experience (UX) on many digital platforms. UCD approaches prioritize the inclusion of users in the design process, ensuring that the produced products are both functional and closely aligned with user expectations and preferences. Research has demonstrated that this technique significantly enhances user happiness and usability, making it an essential strategy in the creation of websites, mobile applications, and other digital tools (Muktamar B et al., 2023; Sukamto et al., 2020).

Research has unequivocally proven the efficacy of UCD across multiple areas, showcasing its adaptability and significant influence. UCD has played a crucial role in developing user interfaces for educational websites that improve learning experiences by increasing the accessibility and engagement of educational content. Likewise, digital psychological interventions that utilize User-Centered Design (UCD) principles have demonstrated increased user engagement and efficacy. These interventions are customized to address the unique requirements of their intended recipients (Al-Sa'di & McPhee, 2021; Dominguez-Rodriguez & De La Rosa-Gómez, 2022). Furthermore, within the domain of virtual reality (VR), UCD methodologies have resulted in the creation of interfaces that are more immersive and user-friendly, leading to notable enhancements in user performance and overall experience (Karakaya et al., 2022).

The UCD process generally consists of four main stages: analysis, design, evaluation, and implementation. During the study phase, designers collect comprehensive data regarding the users, their requirements, and the specific environment in which the product will be utilized. Subsequently, the design phase ensues, during which preliminary concepts and prototypes are formulated, drawing upon the acquired insights. The assessment step entails conducting tests with actual users to gain input that influences later modifications. During the deployment stage, the improved product is introduced and closely monitored to ensure it meets the expectations of the users (Hartawan, 2022; Multazam et al., 2020).

UCD's primary advantage rests in its iterative nature, wherein user feedback is consistently incorporated into the design process. This continuous improvement process contributes to the development of interfaces that are not only easier to understand but also more gratifying to utilize. Empirical research substantiates the effectiveness of User-Centered Design (UCD) in enhancing different User Experience (UX) measures, including usability, productivity, and user contentment. Research has demonstrated that products created with User-Centered Design (UCD) principles tend to experience higher rates of adoption and receive more favourable user ratings, thereby emphasizing the concrete advantages of this approach (Husseniy et al., 2021).

3. METHODOLOGY

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The UCD component within the mHealth framework was developed and validated using a qualitative research approach. The selection of this strategy was based on its capacity to offer comprehensive insights and meticulous feedback from participants. The process comprised the subsequent steps

3.1 Selection of participants

Nine experts were chosen for their vast expertise in the disciplines of medical science and information technology. Every expert possessed more than 15 years of professional experience and was acknowledged for their significant contributions to their respective professions. The selection criteria guaranteed that the input offered was of a high caliber, demonstrating competence and credibility.

Table 1. Experts background and experiences

Expert	Gender	Field	Experiences
	Male	Academician / Fitness Expert	17 years
	Male	Medical Expert (ENT)	15 years
	Male	IT Expert	18 years
	Female	IT Expert	15 years
	Male	Medical Expert (Cardiologist)	31 years
	Male	Academician / Medical Officer (Cardiologist)	18 years
	Female	Medical Expert (Rehab)	27 years
	Female	Medical Expert (Cardiologist)	32 years
	Female	Academician / HCI Expert	24 years

3.2 Data Collection

Semi-Structured Interviews: The main method used to collect data was through semi-structured interviews. This framework facilitated a versatile yet thorough examination of the experts' thoughts and perspectives. The duration of each interview ranged from 60 to 90 minutes, and they were performed either face-to-face or over video conferencing to accommodate the availability of the experts.

The interview questions were created to encompass many facets of the UCD component, such as its indispensability, implementation difficulties, prospective enhancements, and general incorporation within the mHealth framework. Open-ended questions fostered in-depth responses and facilitated the investigation of emergent patterns.

3.3 Data Analysis

The Content Validity Index (CVI) was used to analyse the relevance and importance of each piece in the User-Centered Design (UCD) process. A score for Item-level Content Validity Index (i-CVI) was computed for each element, indicating the percentage of experts who agreed on its relevance. A high i-CVI score signifies a robust consensus and validation of the element.

$$CVR = \frac{Ne - \frac{N}{2}}{\frac{n}{2}}$$

Fig. 1. Content Validity Ratio formula

4. RESULTS AND DISCUSSIONS

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The proposed conceptual framework centered around User-Centered Design (UCD) was rigorously evaluated through qualitative interviews with nine experts from the medical and IT fields. These experts, each with over 15 years of experience, provided in-depth feedback on the framework, helping to validate its components and guiding necessary refinements. The following sections detail the key findings from the expert interviews and discuss their implications for the framework and the broader field of mHealth application development.

Table 2 shows the questions in survey form answered by the experts specifically for User-Centered Design (UCD) component.

Table 2. Question in survey for UCD Component

Scale item	Question
1	This component able to attract user to use the application.
2	This component will increase the visibility of all the function in the application.
3	This component will increase the accessibility to all the functions provided
4	This component will increase the legibility of the application such as text, image and sound.
5	This component will allow users to fully understand all the text in the apps by using appropriate language.
6	This component will support user to search information quickly and easily throughout the application.
7	This component is suitable to be part of this framework.
8	This component is crucial to be part of this framework.

Table 3 presents the results of an evaluation conducted by nine experts on the User-Centered Design (UCD) component of the proposed mHealth framework. Each expert rated eight scale items, which represent different aspects of the UCD component (refer table 2), on a scale from 1 to 5. The "Number Agreement" column indicates the total number of experts who agreed that the item is essential, while the "i-CVI" (Item-Content Validity Index) reflects the proportion of experts who rated the item as essential (with a score of 4 or 5).

Table 3. Response from experts for UCD Component

User Centered Design											
Item description	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6	Panel 7	Panel 8	Panel 9	Number Agreement	i-cvi
Scale Item 1	5	5	4	5	5	5	5	5	5	9	1
Scale Item 2	5	5	4	5	5	5	4	4	5	9	1
Scale Item 3	5	5	4	5	5	5	4	5	4	9	1
Scale Item 4	5	5	4	5	4	4	5	5	4	9	1
Scale Item 5	5	5	4	5	4	4	5	4	4	9	1
Scale Item 6	5	5	4	5	5	4	5	5	5	9	1
Scale Item 7	5	5	4	5	4	5	4	5	5	9	1
Scale Item 8	5	5	4	5	4	5	5	5	5	9	1

4.1 Experts' Validation and Feedback

The expert panel unanimously agreed on the importance of incorporating UCD principles into mHealth application design. They emphasized that the success of mHealth applications hinges on their usability and the extent to which they align with user needs and preferences. The experts highlighted several strengths of the proposed framework:

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i. Holistic Approach: The framework's emphasis on UCD was praised for its comprehensive consideration of user needs throughout the development process. This approach ensures that mHealth applications are not only technically robust but also user-friendly and accessible.
ii. Emphasis on Behavioural Control and Subjective Norms: The inclusion of behavioural control and subjective norms as part of the UCD component was seen as crucial for enhancing user engagement and adoption. These factors are essential for designing applications that users find intuitive and aligned with their daily routines and social contexts.
iii. Iterative Design Process: The experts appreciated the framework's advocacy for an iterative design process, where continuous feedback from users is incorporated into successive iterations of the application. This was seen as vital for addressing evolving user needs and ensuring long-term user satisfaction.

However, the experts also identified areas where the framework could be further strengthened:

i. Personalization: While the framework emphasizes user-centeredness, the experts suggested that more attention should be given to personalization features. Customizable interfaces and adaptive functionalities were recommended to cater to diverse user groups, including those with varying levels of digital literacy and different health conditions.
ii. Accessibility for Special Needs: The framework could benefit from a more explicit focus on accessibility, particularly for users with disabilities or those from underserved communities. This includes considerations for visual, auditory, and cognitive impairments, as well as cultural and linguistic diversity.
iii. Security and Privacy Considerations: Although not the primary focus of the framework, several experts underscored the importance of integrating security and privacy measures into the UCD process. They argued that ensuring user trust is as critical as enhancing user experience, particularly in healthcare, where sensitive personal information is involved.

4.2 Implications for mHealth Application Development

The expert feedback and the subsequent refinements to the framework have several important implications for mHealth application development:

i. Enhanced User Adoption: By prioritizing UCD, the framework is likely to lead to the development of mHealth applications that are more intuitive and easier to use. This, in turn, can significantly increase user adoption rates, as applications that are designed with the user in mind are more likely to be embraced by their target audience.
ii. Improved Patient Outcomes: Applications that are tailored to user needs and behaviors are more effective in encouraging users to adhere to prescribed health regimens and engage with the application regularly. This can lead to improved health outcomes, as users are more likely to take full advantage of the features and support offered by the application.
iii. Broader Accessibility: The focus on personalization and accessibility ensures that the framework can be applied across diverse healthcare settings, making mHealth applications more inclusive. This is particularly important in ensuring that vulnerable populations, such as the elderly or those with disabilities, can also benefit from the technological advancements in healthcare.

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iv. Trust and Compliance: Incorporating security and privacy considerations into the UCD process, as suggested by the experts, will help build user trust. This is essential for the widespread adoption of mHealth applications, especially those that require users to share sensitive personal health data.

4.3 Addressing Limitations and Future Research

While the framework has shown significant promise, there are some limitations that should be acknowledged:

i. Limited Scope of Expert Feedback: Although the expert panel provided valuable insights, the sample size was relatively small, and the feedback was limited to experts from medical and IT backgrounds. Future research could benefit from a more diverse range of experts, including those from behavioural sciences, patient advocacy groups, and regulatory bodies.
ii. Need for Empirical Validation: The framework has been qualitatively validated through expert interviews, but it has yet to be empirically tested in real-world settings. Future studies should focus on applying the framework in diverse healthcare environments to assess its practical effectiveness and refine it based on user feedback.
iii. Dynamic User Needs: As technology and user expectations continue to evolve, the framework will need to be adaptable to accommodate new developments in mobile technology, healthcare delivery, and user behaviour. Ongoing research and iterative testing will be necessary to ensure that the framework remains relevant and effective.

5. CONCLUSION

The integration of User-Centered Design (UCD) into the development of mHealth applications is crucial for creating solutions that are not only technologically advanced but also user-friendly and effective. The proposed conceptual framework, which has been validated through extensive expert feedback, underscores the importance of prioritizing user needs, behavioural controls, and subjective norms in the design process. By doing so, the framework enhances the likelihood of user adoption, improves patient outcomes, and ensures that mHealth applications are accessible to a diverse range of users, including those with special needs. The framework's holistic approach, which combines elements of usability, personalization, and accessibility, ensures that mHealth applications can be tailored to meet the specific needs of various user groups. Moreover, the integration of security and privacy considerations, as highlighted by the expert panel, addresses the critical issue of trust, which is essential for the widespread adoption of mHealth technologies.

However, the framework is not without its limitations. The feedback was gathered from a relatively small group of experts, and while their insights were invaluable, a broader range of perspectives could further enrich the framework. Additionally, the framework has yet to be empirically validated in real-world settings, which will be an essential step in confirming its effectiveness and identifying any areas for further refinement.

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7. CONFLICT OF INTEREST STATEMENT

The authors declare that they do not have any conflict of interest in the research conducted.

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