Adaptive User Interfaces for Personalized Health Informatics Tools: Designing Interfaces That Dynamically Adjust Based on User Preferences and Needs

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Abstract

Background: Adoption of digital health tools in healthcare has been suboptimal in light of its promises to healthcare. This partially can be attributed to lack of personalization, static design, and hence lack of user-centered design approaches. This study aims at exploring users' perceptions toward having Adaptive User Interfaces (AUIs) approach in digital health tools.

Methods: This is a descriptive, survey-based study in which active users of digital health were assessed about their perceptions toward AUIs. The survey was assessing users' needs, functional expectations, adaptability, usability, and trust. Before, ethical approval was achieved conducting the study.

Findings: 137 replies were obtained and the sample was primarily young (66% under 30) and exhibited the level of digital literacy (75% high/very high). Participants indicated that they had positive feelings about embracing the use of AUIs, since they offer personalized recommendations (M = 4.5), health goals (M = 4.5) and the capacity of simplified displays (M = 4.5). Usability was appreciated with emphasis on intuitive design and simplifications (M = 4.6, both). Further, the participants acknowledged the importance of having control over personalization (M = 4.1). Interestingly, trust and acceptance were conditional to improved outcomes and transparency (M = 4.6 and 4.1, consecutively). Nevertheless, some concerns were mentioned over excessive personalization, especially with illiterate users.

Conclusion: Users demonstrated a demand for adaptive, user-centered digital health tools that are intuitive, culturally aligned, and outcome-driven.

Keywords: Adaptive User Interfaces (AUIs), Digital health, User-Centered design, Personalization

1. INTRODUCTION

Information technology has integrated into all industries and into almost all our daily activities. This includes, but is not limited to, smart homes, household appliances, smart cars, and many more [1]. Healthcare is not an exception in many regards, except for being a laggard in adopting IT for care providers and consumers [2]. The reluctant tendency to adopt IT in healthcare has been studied thoroughly. One main contributor is that the design of these systems has not closely considered users' needs and preferences [3]. Thus, the lack of personalized and dynamic designs of IT in healthcare has contributed to improper optimization of IT utility in healthcare [3]. Further to using IT into activities of direct care encounters, it has potential to empower patients beyond the premises of healthcare organization, for example, to monitor and managing chronic diseases, follow up treatment plans, and ensure compliance. Furthermore, it provides a means of connecting healthcare providers with patients diseases remotely [4]. Due to the complexity of these systems, variety in purpose, different technical design and functions, , and the fluency level of users, wide adoption has not been achieved. Another important barrier is the lack of universal standards for developing IT solutions represents another obstacle [5]. One promising solution is the Adaptive User Interfaces (AUIs) approach, which aims to customize layouts, functions based on users' preferences and their levels of digital literacy [6]. AUIs design has enhanced user engagement and satisfaction in one study assessing mHealth usability [6]. As a result, AUIs design has led to wider adoption of digital health in another study [7]. Yet, adopting Adaptive User Interfaces (AUIs) in healthcare can be hindered by internal and external factors, such as users' characteristics, trust, and privacy concerns. While external -system-related - factors such as complexity, functionality, and interoperability standards should also consider when considering AUIs in digital health tools [8]. Therefore, this study aims to explore users' perceptions toward adopting AUIs in healthcare and its role in personalizing tools, and further to have an impact on enhancing patient self-management and engagement.

2. METHODS

This is a descriptive study in which a survey was used to explore users' perceptions of a dynamically adjusted design, where the interface adapts according to the users' preferences and needs. The study sample consists of participants with active interaction using digital health tools for at least four weeks. The interaction should extend beyond merely retrieving and viewing health data, and participants are required to be fluent in English. The minimum required sample size is 150 participants, as determined by a power analysis set at a significance level of 0.05, aiming to achieve 0.8 power to detect a medium effect size.

The survey was constructed by taking over the major constructs of earlier studies and integrating them into a single tool. Particularly, it is based on the User Experience Questionnaire (UEQ) created by Laugwitz, Held, and Schrepp in 2008 [9], and features components of the Technology Acceptance Model (TAM) offered by Davis in 1989 [10]. The survey will start with the questions regarding the demographic data and digital literacy of the participants. The next sections evaluate the perceptions of participants towards usability and their preferences in respect to adaptive interfaces. Further sections look into perceived usability, ease of use, and the intention of the participants to utilize Adaptive User Interface (AUI) digital tools.

The survey was posted online, and a pilot test was applied to 12 participants. The aim of the pilot was to determine the clarity of the questionnaire, its validity, and internal consistency. The outcomes showed good percentages, with clarity rated satisfactory, and Cronbach's alpha was above 0.7, thus justifying the reliability of the tool.

Participants were recruited by sending invitation emails with a direct link to the survey. Also, a QR code that directed to the survey was distributed via multiple channels to make it more accessible. All the respondents were provided with informed consent beforehand. The questionnaire was meant to take around 10 minutes. The participants were assured that all the answers would be anonymous and that only aggregated data would be analyzed.

The study had the ethical approval of the Institutional Review Board of the King Abdullah International Medical Research Center (KAIMRC) under approval number NRR25/023/5.

3. RESULTS

The study was able to gather 146 responses. After the analysis of the data, 137 surveys were considered to be complete and included into the final analysis. Less than 50% response rates were eliminated to preserve the quality of data and to attain the analytical validity.

The demographic features of the participants are shown in TABLE 1. Of the respondents, 75 (55%) were male. Most respondents were below 30 years of age (81 respondents, 66%), with 22 (16%) between 30 to 35 years and 24 (18%) aged above 35 years. Concerning education level, 75 respondents (55%) had a bachelor degree. Regarding digital literacy, 75% said they had high or very high digital skills.

The majority of the respondents reported frequent use of digital health tools, with 84% stating that they used mobile health (mHealth) applications on a daily or several times a week or once a week. Conversely, 11% indicated that they use it occasionally, and only 5% said they use such tools once in a while. The respondents also expressed high confidence and familiarity with technology; they scored their confidence in using technology at 4.4 and their familiarity with exploring health applications at 4.3 on a five-point Likert scale.

Additional responses are explained in TABLE 2. In the domain related to user needs and expectations, the capacity of the system to provide personalized recommendations (M = 4.5) was well appreciated by the respondents, followed by the capacity of the design to adapt to the changing health needs (M = 4.4), as well as the capacity to support personalized self-management (M = 4.4). This was accompanied by the capability of the system to adapt depending on the behaviour or status of the user (M = 4.3). Finally, the respondents noted that they were not satisfied with fixed interfaces (M = 4.1), which means that they would prefer dynamic and responsive systems.

In the domain of functional expectations for adaptive features, the ability to provide simplified displays received the highest endorsement from respondents (M = 4.5), followed by task-specific adaptations (M = 4.4) and adjustments based on interaction history (M = 4.4). Furthermore, participants appreciated the ability to offer personalized menus and context-sensitive notifications (M = 4.3 and 4.1, respectively), which contributes to the need for Adaptive User Interface (AUI) digital tools.

Table 1: Demographics of Repondents and Digital Health Use

Attributes	Reponses	Frequency	Percent	
Age	18–24	52	38%	Median Age: 26
	25–29	39	28%	
	30–34	22	16%	
	35–39	12	9%	
	40+	12	9%	
Gender	Male	75	55%	
	Female	62	45%	
Education Level	High School	14	10%	Median = 2.0 Bachelor's degree (the typical respondent holds a Bachelor).
	Bachelor	75	55%	
	Master	34	25%	
	Doctorate	7	5%	
	Other	7	5%	
Digital Literacy Level	Very High:	45	33%	Median: 3.0/4 (High)
	High	58	42%	
	Moderate	27	20%	
	Low	7	5%	
mHealth App Usage Frequency	Daily:	52	38%	Median: 4.0/5 (Several times/week)
	Several times/week	44	32%	
	Weekly:	19	14%	
	Occasionally	15	11%	
	Rarely	7	5%	
Confidence using technology		4.4		1–5 Likert scale
Comfort with exploring health apps		4.3		1–5 Likert scale

In the subsequent domain, preferences for adaptivity, participants underscored the importance of designing system capabilities in alignment with individual health goals (M = 4.5), followed by the ability to choose their display preferences and behavior-based learning mechanisms (M = 4.4 and 4.3, respectively). According to the participants, adaptivity should also take into account users' cognitive and physical needs (M = 4.3). Nevertheless, the participants preferred to have control over the personalization settings and, further, to have the ability to disable adaptivity features when they want (M = 4.1, for both).

Some issues were also brought up- especially by older users- over the level of personalization with some of them suggesting that over personalization might be overwhelming to them. This highlights the importance of the adaptive systems in providing flexibility and transparency so that the user does not feel overwhelmed by the personalization functions.

Table 2: Responses of participants on different domains

Domains and attributes	**Mean** (1–5 Likert Scale)
Needs	
Anticipate recommendations which are personalized	4.5
Interfaces must change based on emerging health requirements	4.4
Static interfaces don't meet needs	4.1
Adaptive interfaces support self-management	4.4
Tools should change based on behavior/status	4.3
Functions	
Interface should adjust based on interaction history	4.4
Personalized menus help complete tasks faster	4.3
Context-aware notifications are useful	4.1
Simplified displays improve experience	4.5
Task-specific adaptations improve efficiency	4.4
Preferences for Adaptivity	
Prefer control over personalization	4.1
Want to be notified before changes	4.1
Comfortable with behavior learning	4.3
Choose display preferences	4.4
The interface must be adjusted to health objectives	4.5
Adaptive feedback (audio/visual) increases the interaction	4.2
Navigation should be remembered by App	4.2
Personalization should consider cognitive/physical needs	4.3
Want the option to disable adaptive features	4.1
Usability	
Interface should remain intuitive	4.6
Adaptive interfaces should be easy to learn	4.4
Personalization should simplify, not complicate	4.6
Clear feedback during interaction	4.4
Consistency value between sections of the app	4.5
Acceptance & Trust in Personalization	
Would use personalized app in case of better results	4.6
Open to data sharing to do personalization	4.1
Trust the app to make good decisions	3.9
Personalized tools motivate more frequent use	4.3
Adaptive features improve inclusivity	4.4

Within the sphere of the usability expectations, the focus of the respondents was on the intuitive and user-friendly design. The most highly rated expectations included the intuitive nature of interfaces (M = 4.6) and the simplification of interactions by personalization instead of complicating them (M = 4.6). Such results indicate the evident necessity to make usability central to adaptive interface

design. Besides, respondents emphasized that there was a necessity to be consistent in various parts of the application (M = 4.5), which further supports the importance of a coherent and predictable user experience. It was also highly appreciated that adaptive interfaces should be simple to use (M = 4.4) and that there should be clear feedback when interacting (M = 4.4) with users of different level of technological skills.

On the area of acceptance and trust in personalization, the respondents rated strongly in support of adaptive features especially where such adaptive features are associated with better results. Most reported that they would put in use of personalized applications when they helped in achieving a better health outcome (M = 4.6) which emphasized outcome-driven motivation. Moreover, the respondents stated that personalization makes them more motivated to use the apps (M = 4.3), which implies that adaptive features may have a positive effect on engagement. Also, adaptive features were thought to enhance inclusivity (M = 4.4), which aligns with more general values of accessibility and user-centered design. Moreover, the willingness to share personal information to facilitate personalization was also prominent (M = 4.1) with the described tendency being the most prominent among the younger male respondents.

The usability expectations were judged as the highest in the range of reviewed domains (M = 4.50, 95% CI: 3.51-5.00), which illustrates the role of simplicity, ease of use, and consistency in design. Users always preferred systems that are user friendly and easy to navigate. The domains of User Needs and Functional Expectations were also highly valued (both M = 4.34), and the confidence intervals were at the peak of the scale. These findings show that users are highly interested in the functions of adaptive interfaces, customized experience, which is dependent on the user behavior, and context-based notifications. Acceptance and Trust domain were next in line (M = 4.26, 95% CI: 3.27-5.00), meaning that users tend to be receptive to personalization, particularly when they are demonstrated as enhancing health outcomes.

The average score of preferences toward Adaptivity was slightly less (M = 4.20, 95% CI: 3.63-4.77), which implies more mixed views. On the one hand, the members liked personalization; on the other hand, many noted that they liked to have control over automated features. Certain users, particularly older ones, were afraid of excess personalization and found it essential to have the ability to switch off adaptive features.

The ratings of all domains turned out to be positive, but since there is overlap between the confidence intervals, the differences between them could be not significant. Nevertheless, the trends are evident: usability and practical usefulness are most valued by the users, whereas control, trust, and personalization preferences demand well-considered design to meet the needs of various users.

4. DISCUSSION

The aim of the present study was to investigate the needs, functionality, and users preference of adaptive user interfaces in digital health tools. The responses were gathered and processed within the framework of the literature review, user experience concepts, and cultural considerations to come up with a complete picture of the value and essential points of adaptive user interfaces in health applications.

Participants demonstrated that they have a strong expectation of individualized recommendations in relation to their individual health profiles. The high mean rating (4.5) projected this perception, which is the perceived value of individualization when it comes to digital health support. Such results are consistent with the earlier studies indicating that customized content makes users more engaged and satisfied with mHealth apps [11]. In Saudi Arabia, where digital health projects are fast growing, the demand to have individual support is indicative of a developing digital health culture.

Closely associated with personalization was an expectation of adaptive behavior- that is, the interface would change with the changing health needs of the user. Participants rated this point in a relatively high fashion (4.4) where the significance of a system that is responsive to the variations in user condition, behavior or goals is supported. This flexibility has been identified in previous literature to be critical in the management of chronic diseases where health statuses are dynamic and are to be adjusted continuously [12].

A significant segment of the sample was dissatisfied with one-size-fits-all models with a mean of 4.1 showing the limitations of static user interfaces. One of the aspects, which was clearly preferred by the respondents, was the ability to adjust the tools to the behavioral adjustments, which were visible in several items across the questionnaire. The opinion can be related with a comparable study that revealed that Arab users were more inclined to positively react to a system that can adjust both in terms of visual and functional adaptability, to their needs and cultural standards [13].

Among the key themes that were discovered as a result was the need to have self-management support with adaptive interfaces. The perception that these characteristics would enable people to take charge of their own health was high (mean 4.4), which is in line with healthcare paradigm changes to patient-centered care and digital self-care tools. Adaptive feedback and real time interface changes were perceived as the means of enabling this autonomy.

The participants also expressed functional expectations of adaptive design. It is important to note that they embraced the notion that interfaces needed to adapt after their interaction history (mean 4.4), and customized menus to simplify tasks (mean 4.3). These inclinations point to a need of smart systems which undergo learning as the user deploys them, a trend that is also visible at the worldwide level when scholars propose user modeling and context-sensitive computing [14]. Another area of consensus was simplified display structures (mean 4.5), with the point that complexity ought to be abstracted as the interface becomes more customized. Ease of use is also the most important factor in a part of the world that may have different degrees of digital literacy, particularly among the elderly or with less educated users.

Adaptive functionality should however not be at the cost of the user control. Respondents expressed a strong desire to be in control of personalization options (mean 4.1), and desired transparency notified when changes were made to the system (mean 4.1). This is reminiscent of the literature on the topic of algorithmic opacity and the agency loss possible with overly autonomous systems [15]. Although a large number of respondents were satisfied with systems learning based upon their behavior (mean 4.3), they also appreciated the option to override automated choices, turn off the features, or choose their favorite display settings. These findings indicate that there is a two-fold desire: people want to enjoy the advantages of machine learning-driven personalization and feel confident that they are still in control.

Another significant discovery was the value of alignment of health goals, where the users ranked the relevance of adaptive interfaces that help in achieving personal health goals very high (mean 4.5). This flexible goal orientation has been indicated to enhance engagement especially in mHealths that are aimed at weight loss, diabetes management or fitness tracking [16]. And with this, dynamic feedback systems and memory of navigation patterns (mean 4.2 per) were appreciated in terms of efficiency and an uninterrupted user experience.

Surprisingly, the research also showed an underlying fear of the possibility of overwhelming users with excessive personalization. This feature had a relatively low score (mean 3.8) indicating that although users value the level of adaptability, excessive automation can be confusing or burdensome. This implication indicates that balance is essential–an idea also reflected in the usability literature, which cautions against overfitting the interface to behavioral idiosyncrasy which might not be sustained [17].

The best scores in the whole questionnaire appeared on the subject of usability. Intuitive design (mean 4.6), ease of learning (mean 4.4), simplified user experience with personalization (mean 4.6) and interface consistency (mean 4.5) were highly supported. This can be justified by the accepted principles of human-computer interaction (HCI), which emphasizes that intelligent systems are still expected to be guided by conventional principles of usability [18].

Finally, in a question concerning trust and acceptance, participants stated that they would utilize a personalized app in case it enhanced health outcomes (mean 4.6). However, there was a minor reluctance to trust automated decision-making fully (mean 3.9) although overall the respondents were willing to share personal data to be used adaptively (mean 4.1). These reactions highlight one of the cornerstones of digital health the problem of building trust in algorithm systems and ensuring the privacy of users. The Saudi case, when the digital transformation is being actively encouraged by the national policy, becomes more and more favorable to achieve this trust, assuming that the transparency and security are considered as the primary priorities [19].

Finally, the results of this research indicate that the adaptive user interface in mHealth settings is greatly receptive among users in Saudi Arabia, particularly the younger population in the country. Nevertheless, their openness depends on usability, compatibility across cultures and freedom of the user. These factors should be considered by developers and the adaptive systems should be understandable and reliable and empowering. Future mHealth applications may have a transformative role in the changing ecosystem of healthcare in Saudi Arabia by combining the expectations of the users with strong design principles.

According to the findings, the designer must strike a balance between innovation, establishing intelligent personalization and control by the user. Users appreciate a design that keeps changing based on their behavior and preferences and, even more, offer the capability to control the adaptability or override it at their will. The second suggestion is that design must take into account the cultural factor and setting of future users of the digital health tools. Considering that the sample of the study was selected in Saudi Arabia, the choice of design should be based on the preferences of the culture, language, and style of interactions peculiar to the region. This can involve right-to-left design of layouts, use of culturally sensitive icons as well as integration of religiously sensitive content. Third, there should be an endeavor to enhance digital health literacy and user awareness. In spite of the fact that the participants were open to adaptive technologies, their comfort and trust towards such systems can be improved with the increased knowledge in the way personalization

works and what data are being collected and processed. Fourth, mHealth solutions of the future must include adaptive features that allow to support certain health objectives- specifically in such domains as fitness tracking, self-management of chronic diseases, and nutrition tracking. These are the areas that are in line with the Kingdom priorities in relation to the public health and may require scalable digital support. And finally, we suggest that additional empirical research, especially longitudinal or experimental research, should be conducted to determine the actual effects of adaptive interfaces on both health and user interaction and satisfaction. Inclusion of various demographic groups such as older adults, less digital literate, and chronically ill people will be essential to extrapolation of results.

Although this research provides valuable information, it has a number of limitations. To begin with, the sample was very small and only included 137 respondents, which might not be a representative sample of the general Saudi population. As an example, elderly patients and rural/underserved populations were underrepresented, which might restrict the extrapolation of the results. Therefore, in the future, the samples need to incorporate older groups that are less digitally literate. Second, the survey is cross-sectional as it does not allow us to evaluate the extent to which perceptions of adaptive user interfaces might change with time or prolonged use. Adaptive systems are also likely to produce different responses in users when they are implemented over a long period, particularly in situations where health management is involved. Third, the research was based on self-report information, which might be subject to social desirability bias or poor knowledge about adaptive interface functionality. Even though the questionnaire was created in an approachable way, not all the respondents might have comprehended a few technical terms. Fourth, the research failed to compare particular mHealth solutions or physical interface prototype. Rather, it quantified expectations and preferences on a conceptual level. In this way, this requirement-gathering stage will result in the design of particular technical structures and algorithms in the future. The preferences identified in this paper should be validated with the help of A/B testing or usability testing using functional prototypes in a future study. Finally, the research was carried out within a cultural and national setting. Although Saudi Arabia is a unique mix of the technological innovation and cultural heritage, the results cannot be directly applied to other nations that have contrasting digital infrastructure, health care systems, or user demands.

5. CONCLUSION

This paper examined expectations and perceptions of adaptive user interfaces in mHealth applications amongst a sample of young users in Saudi Arabia. The results show that there is a high demand of individualization, responsiveness, and user-oriented adaptivity in digital health platforms. The subjects valued systems that can offer suggestions, are user-friendly, can be integrated with their health objectives, are transparent, and can be customized to manage the design and functionality of the systems. The concept of adaptive User Interfaces integration has a potential in enhancing the health outcome as it may strengthen the engagement of the users.

6. FUNDING

7. CONFLICT OF INTEREST STATEMENT

None declared.

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