International Journal on Engineering Technologies and Informatics

Assessing the Impact of Usability from Evaluating Mobile Health Applications

Research Article

Volume 5 Issue 2- 2024

Author Details

Azeezat Busari[1], Tareq Al Jaber[2], Neil Gordon[2] and Zhibao Mian[2]*

[1]*Graduate Student, School of Computer Science, Faculty of Science and Engineering, University of Hull, United Kingdom*
[2]*Lecturer, School of Computer Science, Faculty of Science and Engineering, University of Hull, United Kingdom*

*Corresponding author

Tareq Al Jaber, Lecturer, School of Computer Science, Faculty of Science and Engineering, University of Hull, United Kingdom

Article History

Received: February 26, 2024 Accepted: February 29, 2024 Published: February 29, 2024

Abstract

Software applications that are used to monitor, track, and improve health are called Mobile Health Applications or mHAs. They are developed with or without the help of medical professionals to potentially aid health, achieve health goals and improve lifestyle or behavior. Although mobile Health Applications have been on the market since the advent of mobile applications, the pandemic saw to a 25% increase in the number of mobile health applications available on the app stores. This indicates the growing demand for mHAs. This research was conducted to evaluate the impact of usability of mobile health applications. The dataset used to carry out this research is a review data set of health-condition management focused apps. These apps managed conditions like Diabetes, Depression, Hypertension, etc. System Usability Score, Net Promoter Score, App Ratings, Patient engagement was some of the features that were used to conduct the research. There were low correlations between App's reaction to dangerous information and usability score (0.17), Existence of privacy policy and usability score (-0.032), IOS App Rating and Usability Score (0.053), Android App Rating and Usability Score (-0.029). Patient, Caregiver/Clinicians engagement-based variables like 'does the app makes reference to specific disease guidelines', 'in what way does the app engage patients', 'does the app provide support through social media' showed higher correlations with usability scores and clinical utility. It is recommended that to evaluate the usability of mobile health applications, a combination of usability measuring methods be used.

Keywords: Mobile Health Applications, Usability, System Usability Scores, Patient engagement

Abbreviations: MHAS: Mobile Health Applications; ML4L-HS: Machine Learning for Learning Health Systems; MARS: Mobile App Rating Scale; SUS: System Usability Scale; MCDM: Multi-Criteria Decision-Making

Introduction

Continuous advancement in technology brought about Mobile devices along with other devices that make our lives easier. As these technological devices play a huge role in every part of our lives, mobile devices play a huge role in health. Mobile devices have not only reshaped the way we seek information about our health, track our health and lifestyle, it has also enhanced new forms of doctor-patient interaction, thereby improving access to health significantly. Mobile Health Applications or mHAs are software applications used to provide and monitor health care, manage health data, encourage improvement in lifestyle and behaviour and assist in disease prevention and management. The advent of the pandemic saw a significant increase in the use of mobile health and mobile health applications, leaving the market no longer emerging [1].

According to the IQVIA Institute Digital health trends report published in 2021, over 350,000 mobile health applications are up and running on Google and Apple Play stores, with 25% of that figure of apps added in 2020 alone. While mHAs related to diet, lifestyle, exercising and fitness, or general wellness, are more common, about 46% of the applications available in 2020 are focused on managing a health condition, indicating a shift in the use of mobile apps for clinical-specific

disease management [2]. Mobile health applications can potentially assist their users to improve their health and lifestyle through lifestyle monitoring (as in the case of fitness and women's health apps) and health tracking as in the case of Diabetes management apps that tracks parameters like heart rate and blood pressure [3]. With such a huge number of apps available to consumers worldwide and increasing demand for health condition management apps and the potential impact of using mobile health applications, it is pertinent to examine the usability of such apps and what impact usability might have on over health of consumers.

When considering the quality of software applications (web and mobile apps), usability is of great concern. We want to know the impact of features that have been implemented on the app and how it might affect user experience, and how the user experience might, in turn, determine how long a consumer/user might engage with the application. The International Organization for Standardization defines usability as "*the extent to which specified users can use a system, product or service to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use*" [4].

An app is considered usable if users find it easy to use and can achieve the goals for which they downloaded it. "Ease of use" is not a standalone concept when measuring the usability of mobile applications; other concepts, like learnability, memorability, satisfaction, etc., contribute to the usability of an app [5]. The Interactive Design Foundation [6] lists Effectiveness, Efficiency, Engagement, Error Tolerance, and ease of learning as the main usability factors. However, in addition to these factors, we also want to consider reactivity potential danger to health and data handling when considering the usability of mobile health applications.

The usability of mobile health applications has been evaluated in previous studies. Mobile health apps in different categories, such as general wellness, fitness-focused, women's health, and health condition management, have been investigated worldwide to assess their ease of use, satisfaction and potential to help users achieve their health goals. As there aren't a one-size fits all approach to measuring the usability of mobile health applications, some of these studies have attempted to create a framework that can be used to assess the usability of mobile health applications. A study in India in 2021 by Gupta et al. investigated the usability of mHAs on Type 2 Diabetes Mellitus using multi-criteria decision-making (MCDM) approaches. The apps used in the research were diabetes-management focused, and three popular MCDM techniques were employed in the evaluation exercise. This enabled the mHAs to be ranked based on usability scores obtained by the MCDM techniques. At the end of the study, it was observed that the three MCDM models used showed very similar rankings for the mobile health applications evaluated. Therefore, the researchers proposed using multi-criteria decision-making approaches to assess mobile health applications' usability [7].

In another study of AI-enabled mobile health applications, the International Organisation for Standards (ISO) 9242-11 usability standard was used to evaluate the usability of the mHAs. With high System Usability Scores (SUS) suggesting excellent user satisfaction and experience, Samad Dahri, Al-Athwari and Hussain [8] concluded that using the ISO Standard method to measure usability could provide developers, designers, and researchers a better understanding of mobile health applications. Analysing user reviews on the app store could also give an insight into how usable users perceive apps. In a large-scale analysis of mobile health applications by Haggag et al [9], 5 million user reviews were extracted and analysed. The correlation between user ratings and the impact on different mHAs was assessed, and usability concerns were categorised into 14. Concerns like privacy policies, bugs in apps, logging in and UI/UX were reported. This informed usability of mobile health applications recommendations made by the researchers to developers and designers.

Other frameworks developed to evaluate the usability of mobile health applications include Mobile App Rating Scale (MARS), Health information technology usability evaluation scale, iSYScore Index, etc. Various tools for measuring the usability and quality of mobile health applications have been a result of different interpretations by different researchers and fields [10], and so different aspects of quality and usability are evaluated. Therefore, reviewing these usability validation tools is necessary to ascertain that the tools used evaluate their intended assessment. A study of the psychometric properties of these tools was carried out based on the Consensus-Based Standards for the Selection of Health Measurement Instruments by Muro-Culebras et al. [11]. They found that the most validated usability-focused tools were The Health Information Technology Usability Evaluation Scale and the Measurement Scales for Perceived Usefulness and Perceived Ease of Use. They also found that Mobile App Rating Scale (MARS) was widely used and validated by many mobile Health Applications because it measures app quality.

It has also been revealed that mobile health apps with high usability can result in a higher quality of life (QoL), as in a study conducted by Ebnali, Shah and Mazloumi [12], The effect 3 breast cancer self-management health apps of varying usability scores on quality of life (QoL) were studied against conventional intervention. It was concluded that mHAs with the most patient engagement improved the QoL of their users. Therefore, the impact of the usability of mHA on users cannot be overemphasized.

Materials and Methods

The Dataset

To investigate the impact of usability on mobile health applications (mHAs), a mobile health apps review dataset published by the Machine Learning for Learning Health Systems (ML4LHS) Lab of the University of Michigan was used. It is a review data of from 166 selected mobile health apps focused on managing chronic health conditions like Hypertension, Asthma, Depression, and Diabetes, etc. [13].

These apps were reviewed by clinicians and non-clinicians, and the data of responses to survey questions that measure the usability and quality of the applications were collected. Some of the important features of the dataset include the 10 statement of measuring usability using the System Usability Scale (SUS) formulated by John Brooke [14]. Another is the Net Promoter Score Ratings completed by Clinicians which is the rating of if they would recommend the app for use to their fellow clinicians. Other important features include App ratings for both Android OS and IOS OS of the apps and target population of the mobile health applications. Data cleaning, preprocessing and analysis were done in Jupyter notebook using Python and libraries like pandas and NumPy, seaborn, matplotlib and scikit.

To properly analyze the data, the features were grouped as in Table 1 after data had been cleaned. The 10 statements of the System Usability Scale (SUS) ranked from 1(strongly disagree) to 5(strongly agree) [15] were grouped together to calculate the System Usability Scale Score, The Net Promoter Score was grouped as a measure of Clinical Utility, The Ratings of the Apps from the store, Patient engagement style, app reaction when dangerous information is entered, etc. The System Usability Scale Score is calculated using responses from 10 Likert ratings completed by a user of an app after a period. The following process is used computing a SUS scores:

i. Subtract 1 from the user's Likert ratings for odd-numbered items or questions.

ii. Subtract the user's Likert ratings from 5 for even-numbered items.

iii. Each item score will range from 0 to 4.

iv. Sum the numbers and multiply the total by 2.5.

v. This calculation will provide a range of possible SUS scores from 0 to 100.

Table 1: Dataset Variables Groupings for Usability Evaluation.

Group	Features under group
System Usability Score	I think that I would like to use this app frequently
	I found the app unnecessarily complex
	I thought the app was easy to use
	I think that I would need the support of a technical person to be able to use this app
	I found the various functions in this app were well integrated
	I thought there was too much inconsistency in this app
	I would imagine that most people would learn to use this app very quickly
	I found the app very cumbersome to use
	I felt very confident using the app
	I needed to learn a lot of things before I could get going with this app
Patient Engagement	In what ways does the app engage patients
	Does the app reward the user for engaging with the app or achieving health goals
	Does the app engage users through social media If so how
	Does the app appropriately warn users caregivers or clinicians when dangerous information is entered
	How does the app handle communication or sharing of information with CAREGIVERS
	How does the app handle communication or sharing of information with CLINICIANS
Privacy Policy	Does the app have a privacy policy
	Does the app developer provider user information to others individually or in aggregate
	Does the app claim to meet the standard of HIPAA compliance
Net Promoter Score	How likely is it that you would recommend this app to a friend or colleague
App's Reactivity to Dangerous Information	Does the app appropriately warn users caregivers or clinicians when dangerous information is entered?

Columns containing responses from which patient engagement could be measured were also selected into a new data frame and encoded for easy analysis and visualization. The dataset also captured the Net Promoter Score which measures how likely a person can recommend a product to another since clinician reviewers completed this column [16], it was grouped as a "clinical utility" variable. Other features were grouped into variables that enabled further analysis and visualizations. Another important variable is the target population. For easier readability of some of the values in the columns, appropriate renaming of values was done, and values were replaced as necessary. Columns that were deemed unnecessary to the analysis were also dropped. After the features were grouped into smaller features, relationships between each target population and patient engagement, usability and app rating, target population and apps reactivity to danger were analyzed and plotted into visualizations.

The groupings can be found the Table 1

Results

Evaluating Usability and Possible Dependencies

Usability Score was calculated from evaluating the ratings from the 10 statements of John Brooke's System Usability Scale (SUS). All the apps had a usability score between 35 and 100. 57% of all the app reviewed showed excellent usability score. The distribution can be viewed in the boxplot in Figure 1.

The Operating Systems (OS) of the apps were evenly distributed amongst the usability scores too. There was a weak relationship between the app rating score for both IOS and android and the usability scores of the apps as apps with app rating of 4 had varying usability score between 35 and 100. When evaluating the relationship between Target population of the apps and usability score, it was observed that over 60% of the apps in each population category had usability score of over 82.5%. The relationship between usability score and android app rating was slightly negative. Relationship between usability score and IOS Average rating, however, was slightly positive [Figure 2].

In observing the relationship between App reactivity to danger and Usability Score, it was observed that Apps reacting to Danger has no effect on the Usability Score. It also can be observed that apps with usability scores of between 35 and 72 do not react when dangerous information is entered. This can be viewed in the distribution visualized below [Figure 3]. Existence of in app advertisement was also evaluated against the usability scores. As can be seen in the figure below, most apps without in app advertisement have a high usability score range between 82.5 and 100. App with no advertising however showed a usability score between 35 and 60 [Figure 4].

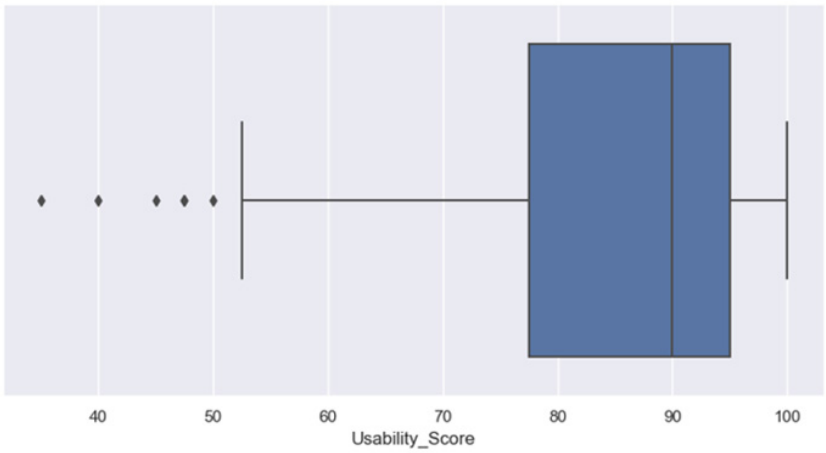

Figure1: Boxplot Showing the Distribution of Usability Score in The Data.

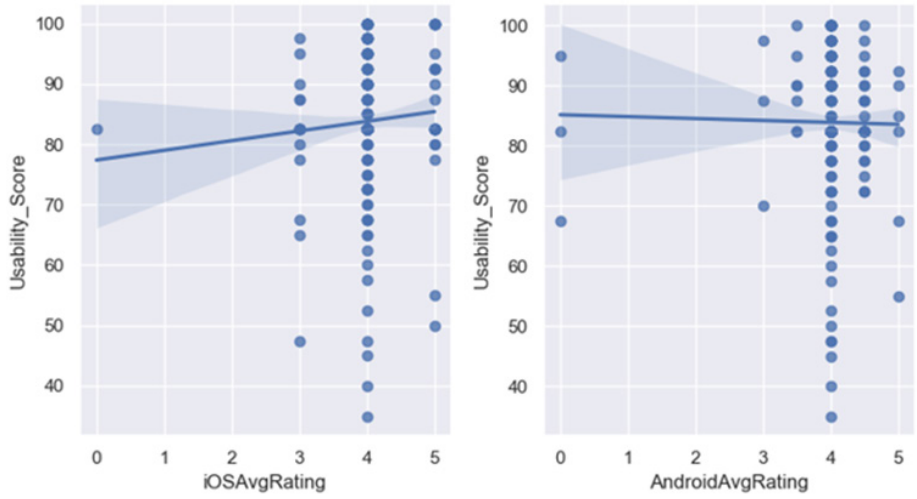

Figure 2: Relationship between Usability Score and IOS Rating and Android App Rating.

Figure 3: Apps Reactivity to danger of Apps and Usability Score.

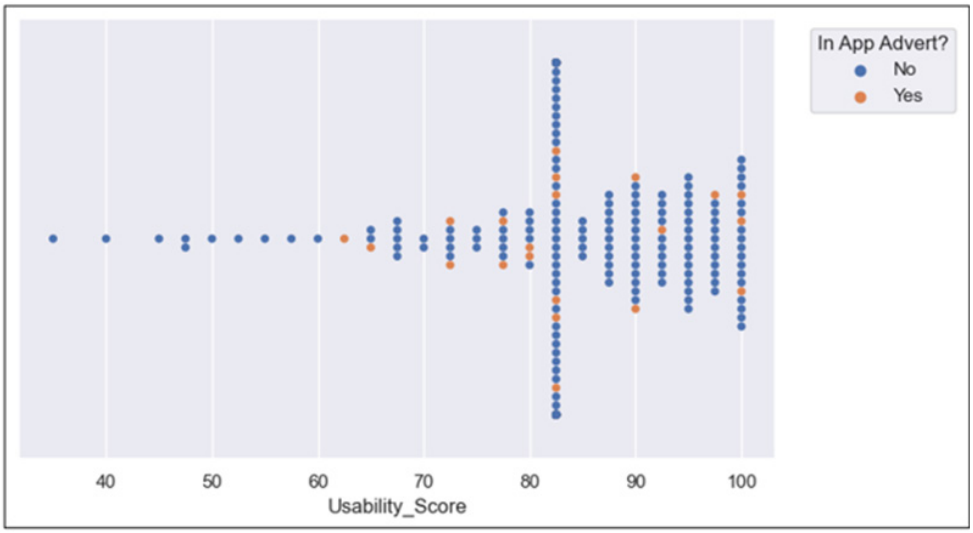

Figure 4: In App Advertisement and Usability Score.

Clinical Utility

In the evaluation of clinical utility which is the likelihood of a clinician to recommend the app to another clinician, over 160 apps had a clinical utility score of 5. This means that a clinical reviewer would recommend over 160 of the apps reviewed to another clinician for use. Clinical Utility was evenly distributed across all Operating system (OS) of the apps reviewed. Clinical Utility drops slightly as usability score increases. Clinical Utility increases slightly with increase in IOS App rating, while Clinical Utility increases greatly with increase in Android App rating [Figure 5].

Patient Engagement

Patient Engagement functionality is the ways by which the apps engage with its users. Some of the apps Alerts Patients, Display information, Enables Communication with family caregiver or clinicians. Others provide medication guidance, records information, or provide information that are educational to the users. The patient engagement functionalities are: 'Alerts patients, 'Displays information', 'Enables communication with family or clinician', 'None of the above', 'Provides Guidance', 'Provides educational information', 'Records information', 'Social media app support?'.

It was observed that app with high usability had all 7 of the 8 patient engagement functionalities. Indicating that patient engagement functionality in health condition management app is correlated with usability. Apps targeting Diabetes and Depression/bipolar disorders were observed to have most of the patient engagement functionalities [Figure 6].

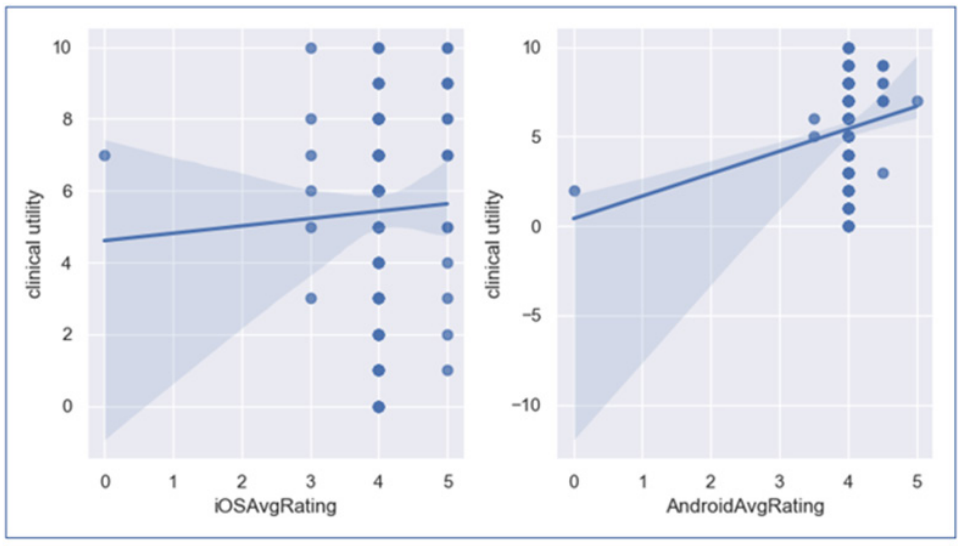

Figure 5: Relationships between IOS App Rating, Android App and Clinical Utility.

Privacy, Patient Involvement, Client Involvement in App Development

As seen in the chart, apps that had patient and clinicians' involvement in development had high usability scores. This is an indication that patient and clinicians can improve usability scores [Figure 7]. Apps with great usability have been shown to have Privacy policies and HIPAA compliance. This suggests that having app privacy policies and compliance with HIPAA can aid the usability of mobile health applications.

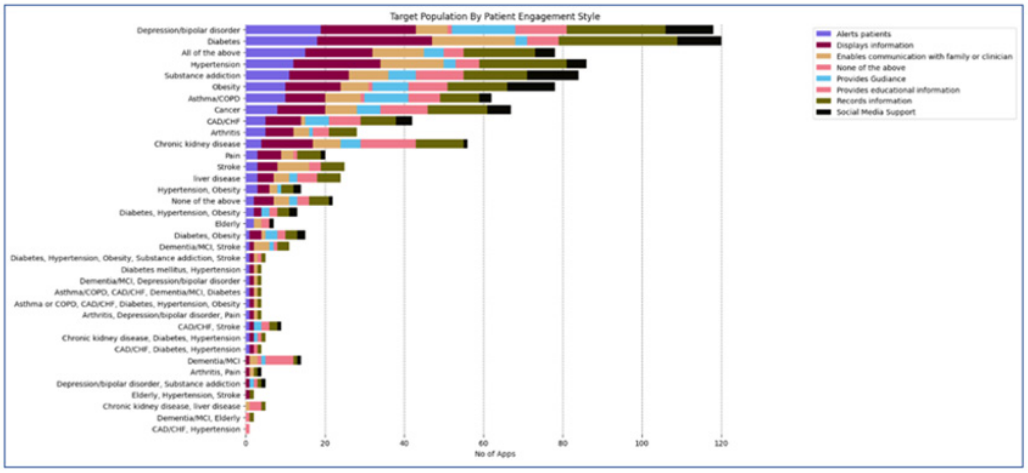

Figure 6: Target Population by Engagement Style.

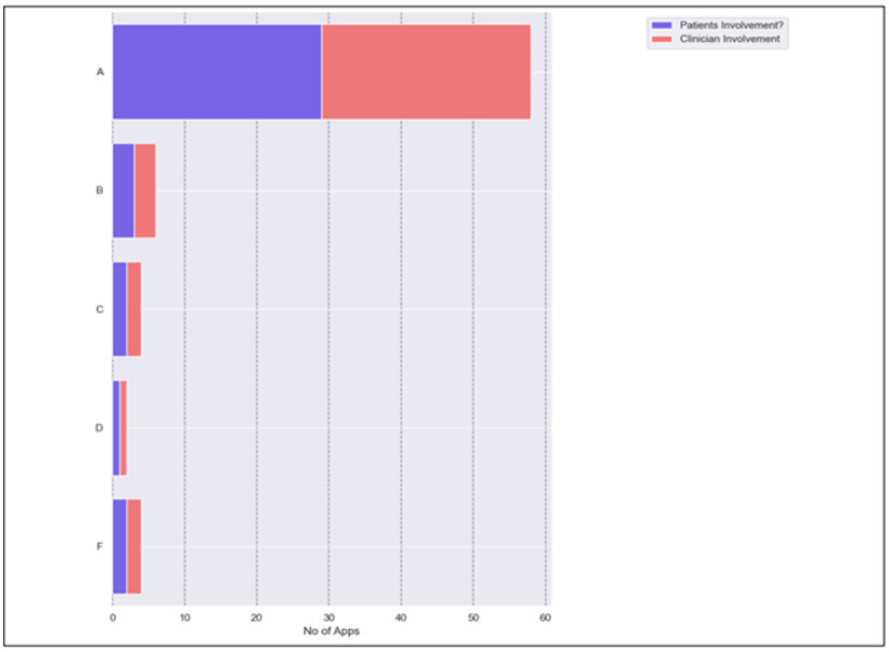

Figure 7: Graph showing Usability vs Patient and Clinicians involvement in app development.

Discussion

This research was conducted to evaluate the impact of evaluating Usability of Health Condition management Mobile Health Applications. Previously, different ways have been used to measure the usability of mobile health applications and its impact. In evaluating Apps Ratings on app store, in-app advertisement, existence of patient engagement, and apps reactivity when dangerous information is entered were the features checked against usability and clinical utility, App ratings of android and IOS in correlation with Usability Scores also showed some negatives. This is suggesting that there is no relationship between App ratings of these mobile health applications and the usability scores of the applications. Therefore App ratings on the store are not a measure of usability of the mobile health applications examined in this research. This agrees with research conducted by [17], where it was found that app ratings are not related to usability scores.

This research also showed that clinicians were more likely to recommend mHAs that had privacy policies and compliance, suggesting privacy and compliance as important features when measuring usability of mHAs [18].

The measure of the app reaction when dangerous information is entered showed a positive relationship with usability score when evaluated. This suggests that app reactivity to danger is an important feature to predict the usability scores of mobile health applications. It indicates that users of health-condition management apps consider apps reactivity to danger an important feature when developing these apps.

Presence of privacy policy in apps doesn't suggest increase in usability scores too. Clinical Utility (Net Promoter Score) however indicates a correlation with presence of privacy policy in these apps (0.43). This is to suggest that clinicians were more likely to recommend apps with privacy policy to other clinicians. Apps targeted at users with Diabetes and Depression/Bipolar disorder showed the most of all patient engagement functionality. Patients with Hypertension and Heart diseases however have the least of all patient engagement functional functionality.

While examining the correlations between the features included in this dataset, Patient engagement, with a correlation of 0.017 with usability score, App references to specific disease guidelines with correlation of 0.27 with usability score, and does app warn caregivers/

clinicians when dangerous information is entered with a correlation of 0.18 with the usability score, are features that can be improved to enhance the overall usability of the mobile health applications examined in this research.

While John Booke's System Usability Scale has been in used far and wide to evaluate the Usability of a product, In the case of this research, there has been lots of inconsistencies that suggests that using only SUS method of evaluation may not be enough to gauge the usability of health-condition management mobile health applications. To further ascertain the usability ratings of these health-condition management mobile health applications, it is recommended that other ways of measuring usability like Mobile App Rating Scale be used.

Conclusion

In conclusion, the research has investigated the impact of usability on health-condition management focused mobile health applications. The dataset used was a review data of mobile health applications targeting users with health conditions like Depression/Bipolar disorder, Hypertension, Arthritis, Diabetes, etc. System Usability Scale (SUS) Scores, Net Promoter Score (Clinical Utility), App Store Rating per OS and other usability-based features were evaluated, and relationships measured.

Patient, Caregiver/Clinician engagement-based features showed the most correlations with usability scores and clinical utility in this research. App store ratings, presence of in-app advertising showed weak correlations with usability scores however, suggesting that other ways of evaluating usability of mobile health applications should be considered. It is recommended that future work could include exploration of combination of other techniques to measure usability of mobile health applications and mobile health applications that are more general wellness focused could also have their usability evaluated.

References

1. Evenstad L (2021) Covid-19 has led to a 25% increase in health app downloads, research shows. ComputerWeekly.com.
2. (2021) IQVIA Institute. Digital Health Trends 2021 innovation, evidence, regulation, and adoption.
3. Liu P, Astudillo K, Velez D, Kelley L, Cobbs Lomax D, et al. (2020) Use of Mobile Health Applications in Low-Income Populations. Circulation: Cardiovascular Quality and Outcomes 13(9).
4. (2018) International Organization for Standardization. Ergonomics of Human System Interaction: Usability, Definitions and Concepts. ISO International Organization for Standardization.
5. Nielsen J (2012) Usability 101: Introduction to usability. Nielsen Norman Group Nielsen Norman Group.
6. (2019) The 7 Factors that Influence User Experience. The Interaction Design Foundation UX courses.
7. Gupta K, Roy S, Poonia RC, Nayak SR, Kumar R, et al. (2021) Evaluating the Usability of mHealth Applications on Type 2 Diabetes Mellitus Using Various MCDM Methods. Healthcare 21: 10(1): 4.
8. Samad Dahri A, Al Athwari A, Hussain A (2019) Usability Evaluation of Mobile Health Application from AI Perspective in Rural Areas of Pakistan. International Journal of Interactive Mobile Technologies (iJIM) 13(11): 213.
9. Haggag O, Grundy J, Abdelrazek M, Haggag S (2022) A large scale analysis of mHealth app user reviews. Empirical Software Engineering 27(7).
10. Nouri R, R Niakan Kalhori S, Ghazisaeedi M, Marchand G, Yasini M (2018) Criteria for assessing the quality of mHealth apps: a systematic review. Journal of the American Medical Informatics Association 25(8): 1089-1098.
11. Muro Culebras A, Escriche Escuder A, Martin Martin J, Roldan Jimenez C, De Torres I, et al. (2019) Tools for evaluating the content, efficacy, and usability of mHealth applications: a COSMIN systematic review. JMIR mHealth and uHealth 9(12).
12. Ebnali M, Shah M, Mazloumi A (2019) How mHealth Apps with Higher Usability Effects on Patients with Breast Cancer?. Proceedings of the International Symposium on Human Factors and Ergonomics in Health Care 8(1): 81-84.
13. (2015) ML4LHS Lab -Mobile Health Apps Evaluation Dataset.
14. Brooke J (1995) SUS: A quick and dirty usability scale.
15. Bernstein I (2017) Likert Scale-an overview. Science Direct.
16. Reichheld F (2011) The Ultimate Question 2.0 (Revised and Expanded Edition): How Net Promoter Companies Thrive in a Customer-Driven World. Google Books. Harvard Business Review Press.
17. AlBesher AA, Stone RT (2017) The Correlation between Users' Star Rating and Usability on Mobile Applications. World Academy of Science Engineering and Technology International Journal of Computer and Information Engineering 11(5).
18. Aljaber Tareq, Gordon Neil (2018). A Hybrid Evaluation Approach and Guidance for mHealth Education Applications. 282-290.