Assessment of quality attributes impacting end-users' experience with mobile health applications in Saudi Arabia: A systematic review and meta-analysis

Mohammed Senitan[1], Abdullah Alotaibi[2]

AFFILIATION
1 Department of Public Health, Faculty of Health Sciences, Saudi Electronic University, Riyadh, Saudi Arabia
2 Pediatric Sleep Disorders Center, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

CORRESPONDENCE TO
Mohammed Senitan. Department of Public Health, Faculty of Health Sciences, Saudi Electronic University, Riyadh, Saudi Arabia. E-mail: malharbi@seu.edu.sa ORCID iD: https://orcid.org/0000-0002-1588-7615

KEYWORDS
mobile health applications, user experience, quality attributes, systematic review, Saudi Arabia, meta-analysis, healthcare usability

Received: 17 August 2024, **Revised:** 25 October 2024, **Accepted:** 20 December 2024

Popul. Med. 2024;6(December):33 https://doi.org/10.18332/popmed/199564

ABSTRACT

INTRODUCTION The exponential growth in smartphone usage has driven the widespread adoption of mobile health (mHealth) applications, offering functionalities such as prescription management, chronic care, fitness tracking, and personal health data management. The success of these apps depends largely on their usability and user satisfaction. This systematic review and meta-analysis aim to evaluate the quality attributes influencing end-user satisfaction and experience with mHealth applications in Saudi Arabia. Additionally, the study seeks to identify underexplored features such as privacy and security, which are critical in healthcare applications.

METHODS A systematic search was conducted across databases including PubMed, Medline, CINAHL, EmBase, Google Scholar, Springer Link, the Saudi Digital Library, the Association of Computing Machinery (ACM) Digital Library, and IEEE Xplore from September to October 2022. Studies published between 2017 and 2022 that evaluated end-users' experiences with mHealth applications in Saudi Arabia were included. Data extraction was performed independently by two reviewers, and the risk of bias was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools. A meta-analysis was conducted on studies reporting satisfaction outcomes, using a random-effects model to account for heterogeneity.

RESULTS A total of 21 studies involving 15727 participants were included in the review. The most commonly evaluated mHealth apps were Tawakkalna, Seha, Mawid, and Tataman. Satisfaction was the most frequently reported attribute (n=9), followed by ease-of-use (n=4), usefulness (n=4), awareness (n=4), acceptability (n=2), learnability (n=2), and efficiency (n=2). Privacy and security concerns were notably underreported. The meta-analysis revealed that younger participants and males had higher satisfaction with mHealth apps, with standardized mean difference (SMD) of 0.30 (95% CI: 0.25–0.36) for age and 0.26 (95% CI: 0.18–0.35) for gender. Both analyses showed high heterogeneity (I^2>90%).

CONCLUSIONS mHealth applications in Saudi Arabia demonstrate high user satisfaction, especially among younger individuals and males. However, critical factors such as privacy and security are rarely mentioned in existing studies, indicating a significant gap in the literature. Future research and app development should prioritize these features to ensure comprehensive usability and user trust in health technologies. Additionally, more attention should be paid to the needs of older users and females to create more inclusive mHealth solutions.

INTRODUCTION

Mobile apps have swiftly expanded globally due to the constantly rising number of smartphone users. In the first quarter of 2021, there were 5.7 million mobile programs available across Google Play and Apple Apps, the two largest app stores. Mobile health applications (mHealth apps) are a subset of these health apps. In the first quarter of 2021, 107000 mHealth applications were available on Google Play and Apple app stores, accounting for about 2% of all mobile apps. According to Statista, the number of smartphone users

increased from 3.668 billion to 6.378 billion between 2016 and 2021, projected to reach 7.516 billion by 2026[1].

mHealth refers to the delivery of healthcare services via mobile devices, such as mobile phones, tablets, wearables, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices, using apps specifically designed for these purposes[2,3]. mHealth apps are increasingly used across various medical specialties and fields, such as patient education, chronic care management, women's health, personal health records, fitness, and nutrition, as well as prescription management[4]. These applications provide users with essential health information, track and store personal data, offer medical advice, facilitate diagnosis and consultations, and notify users of necessary actions.

In Saudi Arabia, the Ministry of Health (MOH) aims to provide high-quality, integrated, and comprehensive healthcare services to the public[5]. As part of this goal, the MOH has adopted eHealth as a key strategy in its transformation plan, designed to improve the delivery of healthcare services in response to the growing demand and rising costs. The MOH's most widely adopted mHealth applications include Tabaud, Tawakkalna, Tatamman, Seha, and Mawid, which support various health functions for the Saudi public[6,7].

Few studies have been conducted to assess the usage of mobile health applications in Saudi Arabia. For example, Almufarij and Alharbi conducted research on the use of mHealth apps during the COVID-19 pandemic and found that while Tawakkalna and Tabaud were widely used, there were concerns about their usability and potential for further enhancement[4]. Another study by Alanzi et al.[8] investigated the adoption of the Seha and Mawid apps, revealing high levels of satisfaction but highlighting a lack of awareness among specific population groups, which limited broader adoption. Similarly, Al-Kahtani et al.[9] examined the usage of the Seha app, finding that many participants were unaware of the app's existence or benefits, despite its capacity to reduce doctor visits and improve healthcare access.

These studies underscore the growing role of mHealth apps in healthcare delivery but also reveal persistent challenges, such as limited awareness and usability issues. Additionally, the studies do not fully address the technical and non-technical factors that influence user satisfaction, nor do they explore critical issues like privacy and security. This study seeks to fill these gaps by evaluating the quality attributes that impact the user experience of mHealth applications in Saudi Arabia, including privacy and security concerns, which are often underexplored.

This systematic review aims to: 1) identify the technical and non-technical characteristics of mobile health applications that affect user satisfaction and overall experience; 2) define the components of an effective, patient-centered mHealth app experience; and 3) discuss mHealth application shortcomings from the perspective of end-users.

METHODS

Study design

This study follows the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 and the Joanna Briggs Institute (JBI) critical appraisal tools for systematic reviews[10,11]. The systematic review was conducted to evaluate the experience of end-users with mobile health applications in Saudi Arabia, assessing studies published between 2017 and 2022. The review was not registered in a systematic review database.

Information sources and search strategy

In September and October 2022, we conducted a comprehensive search of multiple electronic databases, including PubMed, Medline, CINAHL, Embase, Google Scholar, Springer Link, the Saudi Digital Library (SDL), the Association of Computing Machinery (ACM) Digital Library, and IEEE Xplore. The search was restricted to peer-reviewed articles published in English, focusing on studies from 2017 to 2022.

The following search terms were used in various combinations:

- [attributes OR determinants OR factors OR characteristics]
- [mobile health applications OR mHealth applications OR m-health applications]
- [satisfaction OR experience OR patients' experience OR patients' satisfaction]
- [Saudi Arabia]

To ensure a comprehensive review, we supplemented the database search with reference tracking and manual searches to identify any additional relevant studies. The complete search strategy, including the filters and limits applied for each database, is provided in the Supplementary file.

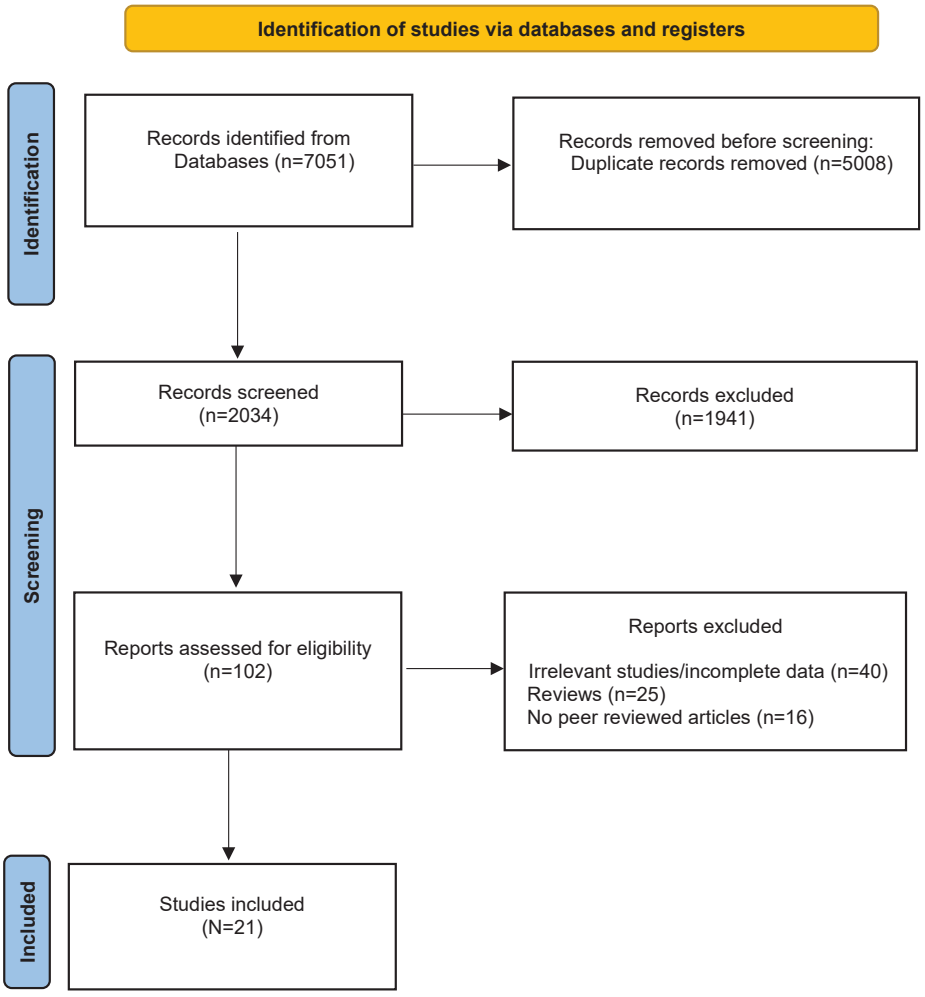
Study selection

Figure 1 illustrates the selection process according to PRISMA guidelines. A total of 7051 records were identified across all searched databases. After removing 5008 duplicate records, 2034 titles and abstracts were screened for relevance. Of these, 1941 records were excluded based on inclusion and exclusion criteria. The remaining 102 full-text articles were reviewed in detail by the principal author (MS) and co-author (AA), and 21 studies were ultimately included in this systematic review. These studies are referenced as follows: [4, 8, 9, 12–29]. Additionally, three of these studies were included in the meta-analyses. These studies are referenced as follows: [8, 9, 17].

Quality appraisal of included studies

The Joanna Briggs Institute (JBI) critical appraisal tools were employed to evaluate the methodological quality of the included studies. These tools assess aspects such as appropriateness of study design, recruitment methods, measurement validity, and control for confounding variables.

Figure 1. PRISMA flow diagram illustrating the study selection process for a systematic review on mHealth applications in Saudi Arabia



Each study was assessed independently by two reviewers, with disagreements resolved by a third reviewer.

Inclusion and exclusion criteria

The inclusion criteria for this review were as follows: peer-reviewed articles evaluating mobile health applications (mHealth) in Saudi Arabia, studies focusing on end-user satisfaction, experience, and other related quality attributes, research employing quantitative, qualitative, or mixed-method approaches, and articles published between 2017 and 2022 in English. Conversely, studies were excluded if they did not directly relate to mobile health applications, such as those focused solely on broader eHealth modalities, or if they were non-peer-reviewed literature (e.g. reviews, blogs, book chapters, website content). Articles published before 2017 or in languages other than English were also excluded.

For synthesis, studies were grouped based on the specific mHealth applications they addressed, the methodologies employed (e.g. quantitative vs qualitative), and the user experience factors they reported (e.g. satisfaction, ease-of-use).

Data extraction and risk of bias assessment

Data extraction was independently performed by two reviewers (MS and AA) using Microsoft Excel 365. The data extracted included study design, sample size, key user experience attributes (e.g. satisfaction, ease-of-use), and demographic characteristics of participants. In cases of disagreement during data extraction, a third independent reviewer was consulted for resolution.

Risk of bias in the included studies was independently assessed by the two reviewers using the Joanna Briggs Institute (JBI) critical appraisal tools for systematic reviews[10]. Studies were evaluated based on factors such as appropriateness of study design, recruitment methods, measurement validity, and control for confounding variables. Any discrepancies in the risk of bias assessments were

resolved through discussion or with input from a third reviewer. The results of this assessment are summarized in a risk of bias table, classifying each study as having high, low, or unclear risk of bias.

Definitions of data items

For the purposes of this systematic review, we defined the following key outcomes related to end-user experiences with mHealth apps in Saudi Arabia:

- Satisfaction: Users' overall satisfaction with the application.
- Ease-of-use: How easily participants could navigate and operate the app.
- Usefulness: The perceived value of the app in supporting health-related activities.
- Awareness: The extent of users' knowledge about the app before use.
- Acceptability: Whether participants were willing to adopt and continue using the app.
- Learnability: How quickly users could learn to operate the app.
- Reliability: Whether the app functioned consistently without technical problems.
- Efficiency: The app's ability to help users achieve health goals efficiently.
- Flexibility: How well the app adapted to users' specific needs.
- Errors/technical issues: Reports of technical problems encountered by users.

Data synthesis and statistical analysis

For the quantitative analysis, a meta-analysis was conducted using Review Manager 5.4 with a 95% confidence interval[12]. Given the anticipated heterogeneity among studies, a random-effects model was applied. The heterogeneity was assessed using the I^2 statistic, with values of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively.

Forest plots were generated to visualize the overall effect sizes and heterogeneity across the included studies. The meta-analysis focused on studies assessing satisfaction with mobile health applications in Saudi Arabia. Sensitivity analyses were performed to assess the robustness of the findings, particularly in cases where high heterogeneity was observed. Funnel plots were also generated to assess potential publication bias.

RESULTS

Baseline characteristics of included studies

Table 1 presents the baseline characteristics of the selected studies. These studies included a total of 15727 participants, with sample sizes ranging from 106 to 5008 participants. The majority of the studies utilized a cross-sectional design and employed a structured questionnaire or interviews to collect data on the quality attributes of mobile health applications (mHealth apps)[4,8,9,12,13,17]. Study settings included healthcare

Table 1. Demographic characteristics of selected studies on mHealth applications in Saudi Arabia

No.	Authors	Applications	Sample size	Findings
1	Almufarij and Alharbi[4]	Tawakklna Tabaud Seha Mawid Tataman	878	Tawakklna (96%) was the most popular and often used app, followed by Tabaud (68.6%), Seha (64.2%), Mawid (61.4%), and Tataman (56.4%). The five apps had very high levels of satisfaction, which is indicated by the median satisfaction rating of 4.5, which ranges between 4.3 and 4.6.
2	Alanzi et al.[8]	Mawid	1993	The majority of the participants mentioned possible advantages of using the application, and 82.1% of the participants described MAWID as an easy-to-use tool.
3	Al Ali et al.[12]	Mawid app	146	The application was thought to be simple to use by 65.8% of the participants.
4	Alharbi[13]	mHealth app Mawid	916	On knowledge scores, there were significant impacts of gender, age, marital status, occupation, income, and area ($p<0.05$). Greater agreement that the Mawid app enhances access to health services is predicted by higher knowledge scores ($p<0.001$). People who agree that the Mawid app makes it easier to access care are expected to be more likely to use it ($p<0.001$). The likelihood of utilizing the app is anticipated to be higher among people who visit primary health centers more frequently ($p<0.001$).
5	Alanzi[14]	mHealth apps in post-COVID-19 times	318	The satisfaction levels with mHealth applications are high.

Continued

Table 1. Continued

No.	Authors	Applications	Sample size	Findings
6	Al-Kahtani et al.[9]	Seha	419	88.5% of those who participated in the study as a whole did not utilize the Seha application. The ability to reach a general practitioner at any time was the biggest perceivable benefit among users of the application. The top motives for non-users were the opportunity to call a general practitioner at any time (25%) and fewer trips to the doctor (23%), whereas the biggest obstacle to use it was not being aware of it.
7	Al Ansari et al.[15]	mHealth apps	195	25.1% and 21.0% of the participants overall were overweight and obese, respectively. Most people worked out infrequently (32.3%) and three to four times per week (29.2%). More than 80% of users either agreed or strongly agreed that it was easy for them to learn how to use the application, and 55.9% of users felt that the application they use serves all fitness levels. More than 70% of users agreed or strongly agreed that the app improved their understanding of exercises and physical activity, and more than 90% would suggest the app to others.
8	Alsaad et al.[16]	Mobile app (self-medication app)	1226	47.6% of the participants were found to be willing to utilize a self-medication app, according to the assessment. This readiness was strongly correlated with the consumer's perception of self-medication and their status as a patient with a chronic illness.
9	Aldhahir et al.[17]	Seha	5008	C with 576 users (58%), consulting a doctor was the service that was most frequently used. Respondents strongly agreed 538 (54%) that they would suggest Seha to others and 402 (41%) that Seha was simple to use. Lack of awareness of the program and its advantages was the main obstacle to using Seha, accounting for 1556 (35%). Tawakkalna was the ministry of health mobile health app that was used the most overall, with 2170 (48%).
10	Bitar et al.[18]	Ana Alsukary	378	The outcomes demonstrated how practical and user-friendly the created tool is. Ana Alsukary, according to caregivers, can help a number of kids comprehend their diabetic condition and change their lifestyles accordingly.
11	Dawood and Alkadi[19]	Sehhaty	106	With 76.36% overall happiness, the report offers compelling proof that the Sehhaty application has a high acceptance rate among users. Despite the fact that 44.34% of participants enjoyed using the Sehhaty app, 68.87% of participants preferred in-person visits.
12	Alharbi et al.[20]	Seha	528	This study offered proof that the Seha app enhanced Saudi Arabia's healthcare delivery system. Users of the app reported superior health outcomes in terms of perceived accessibility to healthcare services, contentment with those services, and system effectiveness as shown by the quantity of doctor visits necessary. Age, gender, the typical source of care, and technological issues all seemed to have an impact on how the app was used.
13	Aljohani and Chandran[21]	mHealth apps	343	The findings also demonstrate that, in Saudi Arabia, behavioral intention to embrace mHealth apps is significantly influenced by healthcare authority enforcement, even more so than by technological aspects.
14	Allam et al.[22]	mHealth apps Tawakkolna Tabauod Tetamman Sehhaty Mawid Sehha	350	To address COVID-19 by releasing creative services, the Minister of Health released Absher, Najez, Muqeem, E'tamarna, Tawakklanah, and the Application. The use of e-government is secure, according to a rising majority of people.
15	Alsaleh et al.[23]	Sehha	362	The research revealed that COVID-19 helped the majority of doctors have a better telehealth experience. Physicians in general (67.6%) expressed satisfaction with Sehha.

Continued

Table 1. Continued

No.	Authors	Applications	Sample size	Findings
16	Alharbi et al.[24]	Health apps	658	Health applications created by the Saudi Ministry of Health were not widely used by patients in Jazan who had been diagnosed with chronic ailments. This suggests a need to promote usage of these health applications, especially among patients with chronic illnesses, and to take use restriction into consideration for older patients with lower levels of education.
17	Alessa et al.[25]	Commercially available app (Cora Health)	30	Ten individuals in total completed trial 1. The study discovered that the app's usability was average and that participants needed some time to become comfortable with it before they could use it effectively. A few usability problems with the app's accessibility and navigation were found, and the majority of users failed to finish a few tasks. 20 patients in all, with a mean age of 51.6 (SD=11.7) years, finished trial 2. The software was generally deemed to be acceptable and simple to use in Study 2; however, some comparable usability concerns were discovered.
18	Alsahali[26]	Telemedicine apps Tawakkalna Sehhaty, Mawid, Wasfaty, Tabaud, Tetamman	68	The maximum possible score was 75, with a mean total score of 58.25 (SD=10.44) for attitudes and beliefs concerning the ideas and advantages of telehealth and telemedicine apps.
19	Alshathri et al.[27]	Mobile app MyFitnessPal StepsApp Pedometer Soarrate Fitbit	1074	30% (7/23) of the apps obtained a quality mean score of ≥4 (out of 5), and 30% (7/23) did not achieve the acceptability level of ≥3. The overall average Mobile App Rating Scale quality of apps was acceptable. Users of the apps wished the free apps they could download included a feature that would let them speak with a specialist. The quality and functionality of the majority of weight-management applications vary, despite their abundance and accessibility.
20	Rafiullah and David[28]	Health apps	355	More than one-third of those polled said the health applications were extremely simple to comprehend, with an equal percentage saying that some training was either required or helpful.
21	Atallah et al.[29]	mHealth apps	376	64% of people are clearly interested in tracking and monitoring their own sadness and anxiety using their own phones.

Table 2. Key usability and quality attributes of mHealth applications evaluated across studies in Saudi Arabia

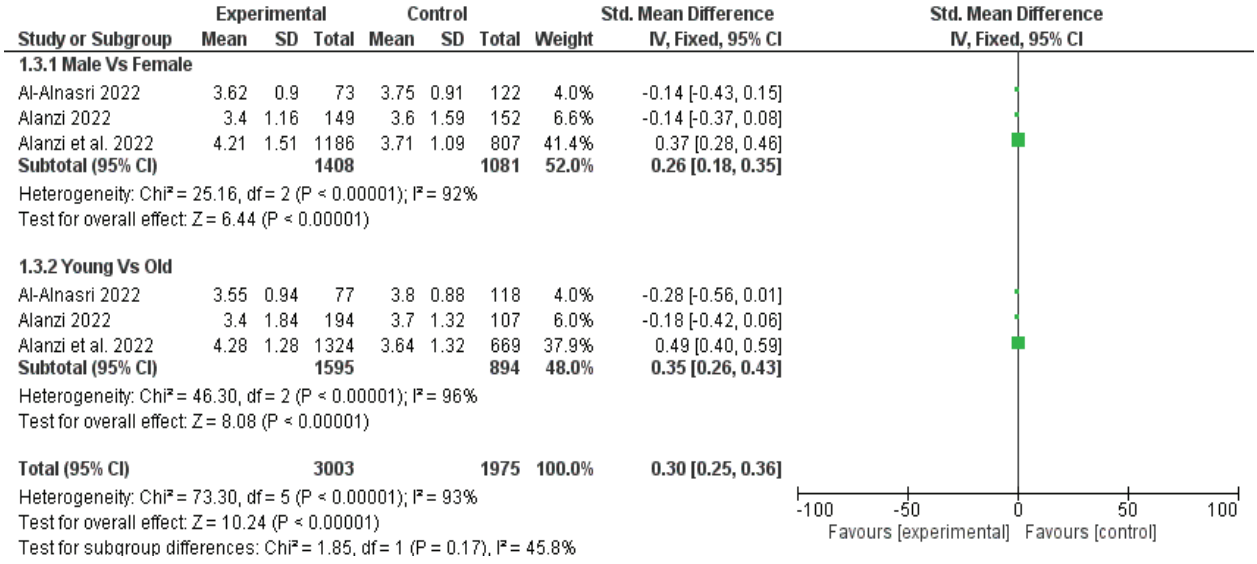
Attributes	References
Satisfaction	4, 8, 10, 11, 15, 17, 18, 20, 21
Ease-of-use	8, 9, 11, 20
Usefulness	13, 15, 20, 23
Awareness	12, 13, 22, 24
Acceptability	18, 25
Learnability	13, 14
Reliability	19, 20
Efficiency	18
Flexibility	9
Errors/technical issues	18

environments such as hospitals, clinics, and public health initiatives within Saudi Arabia[4,9,13,15,20], spanning a duration range 1–3 years[4,8,12]. The table also provides information on the study designs, duration range, and the measurement tools used in the assessments. Quality assessment details, as outlined in the Methods section, are provided for each study to ensure transparency regarding the methodological rigor, the outcomes of which are presented in Supplementary file.

Quality attributes assessed

Table 2 outlines the key quality attributes evaluated across the studies. Satisfaction (n=9) was the most frequently assessed attribute[4,8,10,11,15,17,18,20,21], followed by ease-of-use (n=4)[8,9,11,20], usefulness (n=4)[13,15,20,23], awareness (n=4)[12,13,22,24], acceptability (n=2)[18,25], learnability (n=2)[13,14], reliability (n=2)[19,20], efficiency (n=1)[18], flexibility (n=1)[9], and errors/technical issues (n=1)[18]. These attributes were measured

Figure 2. Forest plot comparing satisfaction rates by gender and age in mHealth application use in Saudi Arabia



using standardized scales or qualitative feedback, depending on the study design. These results demonstrate the breadth of usability factors being considered in relation to mHealth apps in Saudi Arabia, with satisfaction being a predominant focus across the studies.

Meta-analysis results

Three studies were selected for meta-analysis based on their consistent measurement of satisfaction and the comparability of tools used across different population subgroups (e.g. gender, age), these were: Alanzi et al.[8], Al-Kahtani et al.[9], and Aldhahir et al.[17]. Studies lacking consistent outcome measures or reporting missing data were excluded from the meta-analysis.

The meta-analysis included a total of 9567 male participants and 6160 female participants. Males reported slightly higher satisfaction with mHealth apps than females, with a standardized mean difference (SMD) of 0.26 (95% CI: 0.18–0.35). This finding demonstrated a small but statistically significant effect size (Z=6.44, p<0.00001), with a high level of heterogeneity across studies (I^2=92%, p<0.00001) (Figure 2).

In addition to the gender comparison, the above three studies also compared satisfaction between younger (<40 years) and older (>40 years) participants. The mean difference in satisfaction between these age groups was 0.30 (95% CI: 0.25–0.36), indicating that younger participants expressed higher satisfaction with mHealth apps than older participants. A high degree of heterogeneity was observed in these studies as well (I^2=96%, p<0.00001). Despite the significant individual results, the overall subgroup differences were not statistically significant (p=0.17).

Sensitivity analyses

Sensitivity analyses were conducted to assess the robustness of the meta-analysis results. Studies with a higher risk of bias were excluded, and the key findings remained stable, confirming that the results are reliable despite variations in study quality. This analysis suggests that the observed differences in satisfaction between males and females, as well as younger and older users, are consistent across the included studies.

DISCUSSION

This systematic review and meta-analysis evaluated the quality attributes influencing user satisfaction with mobile health (mHealth) applications in Saudi Arabia. The study's objectives included identifying key usability characteristics that affect user experience, examining demographic variations in satisfaction, and addressing potential gaps such as privacy and security concerns in app design and implementation. Key findings indicated that satisfaction, ease-of-use, and awareness are the most frequently addressed usability attributes, with significant differences observed between male and female users and between younger and older age groups. The novelty of this study lies in its comprehensive evaluation of mHealth usability attributes specific to the Saudi Arabian context, highlighting both widely adopted applications and unexplored areas such as privacy and security[1,4,8].

In alignment with the study objectives, the findings demonstrate that mHealth applications in Saudi Arabia, such as Tawakkalna, Tabaud, Seha, Mawid, Tataman, Ana Alsukary, and Sehhaty, were instrumental in delivering healthcare services, particularly during the COVID-19

pandemic. Previous studies indicate that Tawakkalna and Tabaud were among the most widely recognized and used apps, underscoring the government's role in supporting healthcare access via digital means[4,6,8]. The prominent use of these applications during the pandemic suggests that mHealth can effectively bridge healthcare access gaps, as seen in similar international contexts.

For instance, the adoption of mHealth applications for public health monitoring and contact tracing during the pandemic was also widely reported in the UAE and the United States, where user satisfaction was similarly driven by the perceived usefulness and accessibility of these apps[26,30,31]. This review identified satisfaction as the most commonly evaluated attribute across studies, followed by usefulness, awareness, and ease-of-use. These findings align with the previous research that emphasized satisfaction as a primary determinant of mHealth app success, particularly in environments where user engagement is critical for maintaining continuity in healthcare services[32].

A notable finding was the emphasis on learnability, or the ease with which users can navigate and understand an app. This attribute was crucial given the varying levels of technology understanding among users, and it mirrors findings from other studies conducted in different healthcare settings, such as those assessing the usability of telemedicine and digital health platforms[30,33]. In contrast, less focus was placed on attributes such as flexibility and technical issues, which may suggest that app developers prioritize core usability features over customizability and error reduction, potentially due to limited user feedback mechanisms[32].

International comparisons provide insight into the broader applicability of these findings. For example, studies conducted in the United States and Dubai found that high satisfaction levels with healthcare applications were attributed to the ease-of-access, streamlined interfaces, and integration with healthcare providers, paralleling our findings regarding mHealth app adoption in Saudi Arabia[30,33]. Similar trends were observed in the UAE, where digital health platforms demonstrated high usability and patient satisfaction, emphasizing the critical role of mHealth in both high- and low-resource settings[26]. While these findings illustrate a global trend toward digital health adoption, differences in demographic usage patterns and satisfaction levels highlight the need for culturally specific adaptations in app design to ensure broader acceptance and utility[1,8,18].

Our meta-analysis of three studies revealed notable demographic variations, with males and younger users reporting significantly higher satisfaction levels with mHealth apps than females and older users. Although younger users may have greater familiarity with digital interfaces, further investigation into gender-based satisfaction differences is warranted. One possible explanation could be the higher technology acceptance and comfort among younger users, as well as different user expectations and tech literacy levels, which can impact overall satisfaction. Additionally, males may exhibit higher satisfaction levels due to gender-specific preferences or perceptions of health-related technologies, as has been reported in studies of other healthcare platforms[31,32,34]. This demographic discrepancy underlines the importance of designing mHealth applications that accommodate diverse user preferences and abilities to maximize engagement and effectiveness[30,35].

Despite the critical nature of privacy and security in health-related technologies, these attributes were underreported in the studies reviewed. This could reflect an assumption by users and developers alike that privacy and security are inherent features, or perhaps the rapid deployment of mHealth apps during the COVID-19 pandemic limited the opportunity for comprehensive security assessments. Addressing this gap is essential, as privacy concerns have been shown to significantly influence user trust and engagement in health technologies[26,31]. Future studies should incorporate explicit evaluations of privacy and security attributes, ensuring that these remain at the forefront of mHealth app development and implementation to mitigate user concerns and safeguard data integrity[1,5,35].

Strengths and limitations

This study benefits from a comprehensive approach, combining systematic review and meta-analysis methods to provide a nuanced understanding of mHealth app usability in Saudi Arabia. The use of rigorous quality appraisal tools, such as the JBI guidelines, facilitated the assessment of study quality and helped ensure that only high-quality studies were included, thereby enhancing the reliability of the findings.

However, several limitations should be acknowledged. These include potential bias from self-reported data and limited generalizability of findings due to the small sample size in the meta-analysis. Additionally, the high heterogeneity observed suggests that results should be interpreted with caution, as variations in study design, population demographics, and measurement tools may have influenced the reported outcomes. Furthermore, the majority of studies evaluated applications using questionnaires and interviews rather than automated, scientific, and systematic methodologies. Future usability studies on the development of mobile applications should incorporate these methodologies to improve evaluation rigor.

To address these limitations, future research should expand study populations to include a broader range of participants, enabling a better understanding of the effects of factors such as age, gender, education level, and location on user satisfaction with mHealth apps. Additionally, incorporating direct assessments of privacy and security features will capture a more holistic view of mHealth app usability and effectiveness[8,31,35].

Implications

The findings underscore the need for targeted improvements

in mHealth app design to enhance usability and broaden adoption across demographic groups. Integrating automated usability evaluation techniques, such as real-time analytics and user feedback systems, could provide developers with insights into user behavior and preferences, helping to address usability issues more proactively. Furthermore, incorporating demographic-specific features and enhancing data privacy and security could significantly improve user trust and satisfaction, particularly among groups with lower digital literacy or higher privacy concerns[31,35].

CONCLUSIONS

Mobile health (mHealth) applications are now indispensable tools in healthcare, providing accessible, efficient, and user-friendly options for managing health remotely. This systematic review identified key usability attributes – satisfaction, ease-of-use, utility, awareness, acceptability, learnability, reliability, efficiency, and flexibility – as the primary drivers of user experience among mHealth apps in Saudi Arabia. However, critical factors such as privacy and security, essential to user trust in health-related technologies, were notably underrepresented in the studies reviewed. This gap highlights an area that requires urgent attention in both research and application development. Additionally, this review's meta-analysis revealed demographic differences, with younger users and males reporting higher satisfaction with mHealth applications. To make these technologies accessible and appealing across all demographics, mHealth apps should be designed with inclusivity in mind, accommodating the specific needs of older users and women.

REFERENCES

1. Statista. Mobile app usage - statistics & facts. Accessed December 20, 2024. https://www.statista.com/topics/1002/mobile-app-usage/
2. Aranda-Jan CB, Mohutsiwa-Dibe N, Loukanova S. Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. BMC Public Health. 2014;14:188. doi:10.1186/1471-2458-14-188
3. United Nations Foundation; Vodafone Foundation. mHealth for Development - Mobile Communications for Health. 2009. Accessed December 20, 2024. http://www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/technology/mhealth/mHealth_for_Development_full.pdf
4. Almufarij A, Alharbi A. Perceptions of using mobile health apps (mHealth) during COVID-19 pandemic in Saudi Arabia: a cross-sectional study. J Health Inform Dev Ctries. 2022;16(1):1-16.
5. Ministry of Health of Saudi Arabia. Ministry of Health Portal. Accessed December 20, 2024. https://www.moh.gov.sa/en/Pages/default.aspx
6. Alghamdi SM, Alqahtani JS, Aldhahir AM. Current status of telehealth in Saudi Arabia during COVID-19. J Family Community Med. 2020;27(3):208-211. doi:10.4103/jfcm.JFCM_295_20
7. Junaid A, Siddiqui AA, Saleh A, et al. The potential and practice of telemedicine to empower patient-centered healthcare in Saudi Arabia. Int Med J. 2020;27:151-154.
8. Alanzi TM, Althumairi A, Aljaffary A, et al. Evaluation of the Mawid mobile healthcare application in delivering services during the COVID-19 pandemic in Saudi Arabia. Int Health. 2022;14(2):142-151. doi:10.1093/inthealth/ihab018
9. Al-Kahtani NK, Aljabri D, Alrawiai S, et al. Factors affecting utilization of the e-health "Seha" interactive application for online medical consultation in Saudi Arabia. Risk Manag Healthc Policy. 2022;15:1607-1619. doi:10.2147/RMHP.S349548
10. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71
11. Joanna Briggs Institute. Critical appraisal tools. Accessed December 20, 2024. https://jbi.global/critical-appraisal-tools
12. AlAli E, Al-Dossary R, Al-Rayes S, et al. Evaluation of the patient experience with the Mawid App during the COVID-19 pandemic in Al Hassa, Saudi Arabia. Healthcare (Basel). 2022;10(6):1008. doi:10.3390/healthcare10061008
13. Alharbi A. Knowledge, attitude and practice toward the mHealth app Mawid: a cross-sectional study. Int Health. 2023;15(3):342-350. doi:10.1093/inthealth/ihac062
14. Alanzi TM. Users' satisfaction levels about mHealth applications in post-Covid-19 times in Saudi Arabia. PLoS One. 2022;17(5):e0267002. doi:10.1371/journal.pone.0267002
15. Al Ansari FS, Alfayez A, Alsalman D, et al. Using mobile health applications to enhance physical activity in Saudi Arabia: a cross-sectional study on users' perceptions. Int Health. 2023;15(1):47-55. doi:10.1093/inthealth/ihac008
16. Alsaad HA, Almahdi JS, Alsalameen NA, Alomar FA, Islam MA. Assessment of self-medication practice and the potential to use a mobile app to ensure safe and effective self-medication among the public in Saudi Arabia. Saudi Pharm J. 2022;30(7):927-933. doi:10.1016/j.jsps.2022.05.010
17. Aldhahir AM, Alqahtani JS, Althobiani MA, et al. Current knowledge, satisfaction, and use of e-health mobile application (Seha) among the general population of Saudi Arabia: a cross-sectional study. J Multidiscip Healthc. 2022;15:667-678. doi:10.2147/JMDH.S355093
18. Bitar H, Alfahid A, Alrige M, Abogazah W, Alsanbi N. Ana Alsukary: an android mobile application to support diabetic children and parents in Saudi Arabia. Rev Rom Inf Tech Autom Control. 2022;32(1):73-86. doi:10.33436/v32i1y202206
19. Dawood AM, Alkadi KS. Evaluating usability of telehealth Sehhaty Application used in Saudi Arabia during Covid-19. Stud Health Technol Inform. 2022;295:285-288. doi:10.3233/SHTI220718
20. Alharbi A, Alzuwaed J, Qasem H. Evaluation of e-health (Seha) application: a cross-sectional study in Saudi Arabia. BMC Med Inform Decis Mak. 2021;21(1):103. doi:10.1186/s12911-021-01437-6
21. Aljohani N, Chandran D. Factors affecting the adoption of

m-health applications in Saudi Arabia: impact of healthcare authority enforcement. In: Pacific Asia Conference on Information Systems; 2021.
22. Allam A, AbuAli A, Ghabban F, Ameerbakhsh O, Alfadli I, Alraddadi A. Citizens' satisfaction with e-government mobile services and m-health application during the COVID-19 pandemic in Al-Madinah region. J Serv Sci Manag. 2021;14:636-650. doi:10.4236/jssm.2021.146040
23. Alsaleh MM, Watzlaf VJM, DeAlmeida DR, Saptono A. Evaluation of a telehealth application (Sehha) used during the COVID-19 pandemic in Saudi Arabia: provider experience and satisfaction. Perspect Health Inf Manag. 2021;18(4):1b.
24. Alharbi R, Qadri A, Mahnashi M, et al. Utilization of health applications among patients diagnosed with chronic diseases in Jazan, Saudi Arabia during the COVID-19 pandemic. Patient Prefer Adherence. 2021;15:2063-2070. doi:10.2147/PPA.S329891
25. Alessa T, S Hawley M, Alsulamy N, de Witte L. Using a commercially available app for the self-management of hypertension: acceptance and usability study in Saudi Arabia. JMIR Mhealth Uhealth. 2021;9(2):e24177. doi:10.2196/24177
26. Alsahali S. Awareness, views, perceptions, and beliefs of pharmacy interns regarding digital health in Saudi Arabia: cross-sectional study. JMIR Med Educ. 2021;7(3):e31149. doi:10.2196/31149
27. Alshathri DM, Alhumaimeedy AS, Al-Hudhud G, Alsaleh A, Al-Musharaf S, Aljuraiban GS. Weight management apps in Saudi Arabia: evaluation of features and quality. JMIR Mhealth Uhealth. 2020;8(10):e19844. doi:10.2196/19844
28. Rafiullah M, David SK. Health apps usage and preferences among Saudi patients with diabetes: a survey. Int J Clin Pract. 2019;73(5):e13345. doi:10.1111/ijcp.13345
29. Atallah N, Khalifa M, El Metwally A, Househ M. The prevalence and usage of mobile health applications among mental health patients in Saudi Arabia. Comput Methods Programs Biomed. 2018;156:163-168. doi:10.1016/j.cmpb.2017.12.002
30. AlSuwaidi S, Moonesar IA. UAE resident users' perceptions of healthcare applications from Dubai Health Authority: preliminary insights. Dubai Med J. 2021;4(1):10-17. doi:10.1159/000513489
31. Kabha R, Salameh F, Ahmad AK, El Bahi M, Mustafa H. M-health applications use amongst mobile users in Dubai, UAE. Int J Innov Technol Explor Eng. 2019;9(2):5100-5110. doi:10.35940/ijitee.b6477.129219
32. Alzahrani AS, Gay V, Alturki R, AlGhamdi MJ. Towards understanding the usability attributes of AI-enabled ehealth mobile applications. J Healthc Eng. 2021;2021:5313027. doi:10.1155/2021/5313027
33. Baker DR, Cadet K, Mani S. COVID-19 testing and social determinants of health among disadvantaged Baltimore neighborhoods: a community mobile health clinic outreach model. Popul Health Manag. 2021;24(6):657-663. doi:10.1089/pop.2021.0066
34. Poulsen KA, Millen CM, Lakshman UI, Buttner PG, Roberts LJ. Satisfaction with rural rheumatology telemedicine service. Int J Rheum Dis. 2015;18(3):304-314. doi:10.1111/1756-185X.12491
35. Seto E, Leonard KJ, Cafazzo JA, Barnsley J, Masino C, Ross HJ. Perceptions and experiences of heart failure patients and clinicians on the use of mobile phone-based telemonitoring. J Med Internet Res. 2012;14(1):e25. doi:10.2196/jmir.1912

CONFLICTS OF INTEREST
The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none was reported.

FUNDING
There was no source of funding for this research.

ETHICAL APPROVAL AND INFORMED CONSENT
Ethical approval and informed consent were not required for this study.

DATA AVAILABILITY
All data gathered or analyzed during this study are included in the article, and derived from recognized databases such as PubMed, Medline, CINAHL, Embase, Google Scholar, Springer Link, Saudi Digital Library (SDL), etc. (some databases are open access and some require user subscription). Further enquiries can be directed to the corresponding author.

AUTHORS' CONTRIBUTIONS
MS and AA: study concept and design, literature review and screening of articles, revision of the manuscript. MS: analysis and interpretation of data, drafting of the manuscript. Both authors read and approved the final version of the manuscript.

PROVENANCE AND PEER REVIEW
Not commissioned; externally peer reviewed.