"Mobile Health Applications: Development Process, Technologies, Challenges, and Future Scope – A Comprehensive Review"

Jyoti B. Wadekar[1*], Aishwarya S. Dakhore[2], Vaishnavi R. Ghodke[3], Kailash Rathod[4]

1*Asst. Prof. Department of Pharmacognosy, Dr. V.V. Patil Foundation's College of Pharmacy, Vilad Ghat, Ahilyanagar, Maharashtra, India, 41411

2 Research Scholar, Department of Pharmaceutical Quality Assurance, Dr. V.V. Patil Foundation's College of Pharmacy, Vilad Ghat, Ahilyanagar, Maharashtra, India, 414111

3 Research Scholar, Department of Pharmaceutical Quality Assurance, Mangaldeep Institute of Pharmacy, Beedbypass road, Nipani, Chh. Sambhajinagr, Maharashtra, India, 431007

4 Asst. Prof. Mangaldeep Institute of Pharmacy, Beedbypass road, Nipani, Chh. Sambhajinagr, Maharashtra, India, 431007

***Corresponding Author:** Jyoti B. Wadekar

Address: Department of Pharmacognosy, Dr. V.V. Patil Foundation's College of Pharmacy, Vilad Ghat, Ahilyanagar, Maharashtra, India, 414111

Abstract

Rapid advancements in communication technology have spread to medicine also. Particularly, smartphone technology has made medical provisioning through mobile systems a reality. Innovations in mobile software application are potential benefits to the public health since the mobile platforms became more user-friendly, computationally powerful and are affordable. The innovative mobile apps can contribute in clinical consultation complementing face-to-face interaction in the health care at lower risk to the public. We have developed and evaluated mobile app for smartphone on Android platform to facilitate interaction between the patient and doctor where the patient seeks advice, diagnosis and treatment from the doctor from remote places. The Graphic User Interface (GUI) display screens of the smartphones are in corpotated the medical data needed by the clinician to interpret and respond to information.

Keywords - Smartphone; Android; Clinical diagnosis; Doctor app; Patient app

Introduction

It is undeniable that smartphones increasingly become a crucial part of our lives. A significant number of people use smartphone apps for self-management of their health. There are 5 million apps available in two leading app stores Google Play Store (Android) and Apple App Store (iOS). In 2015, 3 billion mobile health apps were downloaded [1]. With such a large availability of apps, the possibility of launching low quality or harmful mobile health apps by some developers may lead to adverse effect for users. For instance, Acne App (iOS) and Acne P (Android) which falsely claimed that blue and red light therapy is an effective acne treatment were removed from the app marketplaces [2].Mobile health apps are increasingly advanced with new technologies; however, they may not have been approved by health care providers or there may be no peer-review systems that exist before releasing these health apps through the app marketplaces. Although the users consider the quality of health apps from user ratings and reviews in the app marketplaces, there is no guarantee whether these reviews are reliable or not

The United States Food and Drug Administration (US FDA) provide guidelines to regulate only mobile medical apps which are intended to be used as an accessory to a regular medical device or to transform a mobile platform into a medical device [4]. However, clinicians and patients are still concerned regarding other types of health apps that, without proper assessment systems, could pose a significant threat to users [5]. Currently, there is a lack of standardized assessment method for mobile health apps. Although there may be some systems, for instance, Synergise [6] and the American Psychiatric Association App Evaluation Model [7], that provide classification criteria of the apps, they only provide assessment guides for mental health apps. Moreover, summative evidences on the criteria for user assessment of health apps are still limited. In order to determine an assessment method for mobile health apps, rigorous and appropriate criteria must be chosen.

Materials and methods

Search strategy:

With the research question: “What are the existing criteria used for assessing quality of mobile health apps?”, 5 databases were searched: PubMed, ScienceDirect, Scopus, Cochrane Central Register of Controlled Trials (CENTRAL) and IEEE Xplore. Grey literature (literature that has not been formally published) was searched from www.ntis.gov, www.mobileactive.org and www.opengrey.eu. The search time window was limited from July 2008 to December 2017 (the first app store launched in July, 2008). The search terms were divided into 5 groups and combined using the Boolean operator AND:

1. (health OR medical OR medication OR medications OR mHealth),

2. (app OR apps OR Application OR Applications),

3. (iOS OR Android),

4. (mobile OR mobiles OR smartphone OR smartphones OR “cell phone” OR “cell phones” OR “mobile device” OR “mobile devices”),

5. (quality OR criteria OR assess* OR evaluate* OR “rating scale” OR checklist OR “content analysis” OR framework).

Eligibility criteria:

The inclusion criteria were:

1. The studies that related to the evaluation or assessment of mobile health apps (any apps that intend to provide disease management, health and fitness, health information and other health-related apps),

2. The target groups of the apps were patients or general users,

3. The full texts of the studies were published in English. On the other hand, the exclusion criteria were:

a). The studies that focused on the effectiveness or or development of the apps without quality assessment by users,

b). The studies that allowed only the developers to assess the apps,

c). The studies that adopted the quality assessment tools from previously published studies without adaptation.

Selection process

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines to complete a list of final studies. The studies were identified, screened, and selected based on specific inclusion and exclusion criteria by two independent reviewers (SI and WH). First, all studies were screened based on titles and abstracts. The abstracts that met the inclusion criteria (focusing on types of apps and target groups) were included. If the abstracts did not provide sufficient information, the full texts of articles were assessed according to the eligibility criteria by both reviewers. Disagreement was resolved by discussion. Reference lists and citations of included studies were screened to identify additional relevant studies. The data from included studies were extracted and analyzed to generate the quality assessment criteria.

Data extraction

The data extraction forms were developed based on the PICO frame work . The extracted data included: general characteristics of the studies, characteristics of mobile health apps, the procedure for quality assessment and the quality assessment criteria of mobile health apps. Data entered was automatically stored in an online spreadsheet and assessed for agreement by two reviewers. In the case of disagreement, consensus was established based on face to face discussion or on acquiring feedback from an external reviewer.

Classification of the quality assessment criteria

The quality assessment criteria of mobile health apps extracted from the studies were classified by two reviewers. Disease specific quality assessment criteria were excluded. The criteria were then independently classified from identified sources using two steps:

1. The quality assessment criteria usedin each study were grouped based on the similarity of the area or duplicated meaning of assessment. This provided the themes of assessment criteria.
2. All the themes of assessment criteria were grouped into the same quality domain. All discrepancies were resolved by discussion.

Risk of bias of included studies

The included studies were evaluated for their quality and risk of bias using a checklist. The checklist consisted of 8 questions with 8 as the maximum score where higher score represents lower risk of bias and higher quality of the study. The quality of each study was rated according to the corresponding items on the checklist. The 8 questions were: consideration of the data collection time frame, the apps were fully downloaded for consideration based on its content , the clarity method of appraisal the app's quality, the clarity describe the methodology taken to search for appropriate apps, the clarity of the inclusion and exclusion criteria for app selection, the clarity identify the country where the search was conducted, definition of the targeted groups of users and provision of a list of the apps .

QUALITY OF APP CONTENT OR CONTENT-INDEPENDENT EVALUATION?

The app download page should ideally include sufficient information for the average consumer to judge the quality of the app prior to download. However, in reality, the purpose of the description is to convince the consumer to download the app and to pay for it if it is not free. In our previous study that investigated pro-smoking apps in the Apple app store and Google Play, many pro-smoking apps claimed that they can help to quit smoking; some extensively exaggerated efficacyclaims.9 Without looking at the content of the apps, it is difficult to know if they contain the content defined in the description page. Some studies included in our analysis used medical professional involvement or mentioned an evidence base in the app description as a proxy for quality. Although there are obvious benefits to having health professionals' involvement in the development of health-related apps, without downloading the app it is difficult to assess whether this exists in reality and to what extent such input is in-clued in the app.

MISSING OPPORTUNITY

The studies included in this review have systematically reviewe dall the available apps in various app stores for a specific health-related domain. However, the majority (60%) did not provide a list of the identified apps or at least a list of the high-quality apps. In addition to that, a list of reviewed apps is good transparent methodology; a list of the identified high- and/or low-quality apps may be of great value to healthcare professionals and health consumers. Al-

though the list might be outdated later, disseminating such information with the last app update date might be one of the objectives for studies that evaluate the quality of health-related apps. Moreover, this may motivate app publishers to improve their app content.

IMPROVING THE METHODOLOGIES USED TO ASSESSTHE QUALITY OF HEALTH-RELATED APPS

The poor methodologies used in this review highlight the need to create a systematic health-related app evaluation framework. We propose that best evidence or recommended guidelines should be used to predefine and assess app content. The predefined list in the study of Abrom et al.11 was adapted from a list created to evaluate content of smoking cessation Internet Web sites. This highlights that existing criteria to evaluate Web site content can be adapted to evaluate smartphone apps providing they originate from evidence-based health guidelines and recommendations, as was the case in the study of Huck vale et al.12 Without efficacious, strategic methods to censor the quality of information in health-related apps, their use-fulness may be inhibited. Furthermore, the wide dissemination of low-quality medical information may be harmful to consumers as it may promote the adoption of negative health behaviours, such as smoking, and may misinform users. Finally, assessing the usability of the functions that are based on the predefined list is important to measure ease of use for consumers.

As the health-related app industry continues to grow and new updates of old apps continue to be released, there is a need to assess and reassess their content. Adopting a systematic approach, based on the suggestions of this review, allows efforts to assess app quality to be standardized. As a result, the overall assessment of health-related apps may be more easily regulated, allowing consumers of health apps to make better choices in which apps they choose to purchase.

Thus, it is recommended for future health-related apps quality reviews to report the elements in this study quality check list, to use a systematic evaluation approach based on the actual downloaded app content, to provide a list of the reviewed apps including the last update date, and to avoid using consumer ratings or reviews to judge app quality.

Limitations

While the original search strategy to identify app-quality rating criteria was conducted using guidelines for a systematic review, few peer-reviewed journal articles were identified. As a result, the search strategy was expanded to include conference proceedings and Internet resources, which may not have been as extensively peer reviewed. Suggested guidelines for scale-development were followed , whereby a qualitative analysis of existing research was conducted to extract app-quality criteria and then develop app-quality categories, subcategories, MARS items, and their anchor ratings via a thematic review and expert panel ratings. Despite these efforts, and the corrections made after piloting the scale, two MARS items on the functionality subscale (ease of use and navigation) achieved only moderate levels of interrater reliability (ICC =50). These items have been revised and are being tested.

Researchers are yet to test the impact of the mental health apps included in this study. As a result, the MARS item evidence base was not rated for any of the apps in the current study and its performance has not been tested. It is hoped that as the evidence base for health apps develops, the applicability of this MARS item will be tested.

Future Research

Future research is required to determine the suitability and reliability of the MARS across multiple health and other app domains, as well as its applicability in the sphere of app development. The association of the app quality total and subscale scores with the concepts of user experience, quality of experience, and quality of service requires further investigation.

Future refinements of MARS terminology and additional items are likely to be required, as the functionality of mobile apps progresses. It is hoped the current version of the MARS provides mHealth app-developers with a checklist of criteria for ensuring the design of high-quality apps.

The MARS could also be utilized to provide quantitative information on the quality of medical apps as part of recent medical app peer-review initiatives, such as that launched by JMIR mHealth and health.

With some modification, the MARS may also inform the development and quality rating of health-related websites. While the MARS was designed to be utilized by experts in the mHealth field, a simpler version of the scale, “MARS-app user”, based on the original MARS, was developed in consultation with youth agencies and young people for the purposes of obtaining user feedback on app quality and satisfaction. The MARS-app user version is currently being piloted. It is available upon request from the corresponding author.

Future research is also required to determine how to best evaluate the safety of mHealth apps in terms of the quality of the health information contained in the apps and the privacy and security of user information . Su recently suggested that assessment of the security and integrity of mHealth apps should include exploration of open-source developer codes for potential malicious functions.

Classification Category

The classification category collected descriptive information on the app (eg, price, platform, rating) as well as its technical aspects (eg, log-in, password-protection, sharing capabilities).

Additional sections collect information on the target age group of the app (if relevant), as well as information on what aspects of health (including physical health, mental health, well-being) the app targets. These domains may be adapted to include/exclude specific content areas as needed.

The app quality criteria were clustered within the engagement, functionality, aesthetics, information quality, and subjective quality categories, to develop 23 subcategories from which the 23 individual MARS items were developed. Each MARS item used a 5-point scale (1-Inadequate, 2-Poor, 3-Acceptable, 4-Good, 5-Excellent), descriptors for these rating anchors

were written for each item. In cases where an item may not be applicable for all apps, an option of Not applicable was included.

The expert panel scrutinized the MARS items and rating descriptor terminology to ensure appropriate and consistent language was used throughout the scale. Calculating the mean scores of the engagement, functionality, aesthetics, and information quality objective subscales, and an overall mean app quality total score is how the MARS is scored.

Mean scores instead of total scores are used because an item can be rated as Not applicable. Additionally, mean scores are used to provide quality ratings corresponding to the familiar format of star ratings. The subjective quality items can be scored separately as individual items, or a mean subjective quality score. The MARS app classification section is for descriptive purposes only.

How to develop a health phone app:

Great — building a health app is exciting and rewarding, and also requires careful planning because of user safety, privacy, and regulations. Below is a step-by-step, practical guide you can follow from idea → launch → maintenance, with concrete technical suggestions, sample feature lists, security & compliance checks, testing plans, and launch tips.

1) Clarify the idea & purpose

Define the core problem your app solves (e.g., remote patient monitoring, medication reminders, fitness tracking, mental-health CBT tools, clinical decision support).

Target users: patients, clinicians, caregivers, general wellness users? Different users change requirements (e.g., clinicians require audit trails).

Primary value proposition: what makes it unique vs existing apps?

Minimum Viable Product (MVP) features — start narrow and focused.

2) Market & competitor research

i. List similar apps and note features they offer, ratings, complaints.
ii. Identify regulatory classification (some apps are medical devices).
iii. Interview 5–15 potential users for pain points and must-have features.
iv. Decide monetization (free, freemium, subscription, B2B licensing to clinics).

3) Define product requirements (PRD)

Create a short PRD with:

User stories (e.g., “As a diabetic patient I want to log glucose to view trends”).

Feature list: must-have vs nice-to-have.

Nonfunctional requirements: scalability, availability, privacy, offline capability.

Data types collected: PHI (personal health information), sensor data, images.

Integrations: wearables (Apple HealthKit / Google Fit / Bluetooth), EHRs (FHIR), labs.

Sample MVP feature list:

Secure sign-up / login (email / phone + 2FA)

Profile + health history

Core functionality (tracking, reminders, chat with clinician, appointment booking)

Data visualization (graphs/trends)

Notifications (reminders)

Basic analytics & admin dashboard

Export/Share data (PDF, CSV)

4) Regulatory & compliance (critical)

Determine whether your app is a medical device under local law (e.g., FDA in US, CDSCO in India, EU MDR). If it makes clinical claims or diagnoses, risk is higher.

Privacy laws: HIPAA (US), GDPR (EU), local privacy laws (India has evolving privacy rules). Treat health data as sensitive.

Security standards: encryption at rest & in transit, secure authentication, audit logging **Clinical validation:** If clinical outcomes are claimed, plan studies or validation evidence on result legal/compliance early noncompliance can block app distribution Note: local rules vary. Consult a regulatory expert for final classification.

5) UX / UI design & accessibility

Design for clarity and low cognitive load. Health apps must be simple and trustworthy.

Onboarding: quick setup + explain data usage & privacy upfront.

Accessibility: large text, voiceover support, color contrast, screen-reader friendly.

Wireframes → clickable prototype (Figma/Adobe XD). Test prototypes with real users.

Design patterns: health timeline, daily logs, medication cards, emergency contact.

6) Choose platform & tech stack

Options:

Native: Swift (iOS), Kotlin (Android) — best for performance & device integrations.

Cross-platform: Flutter or React Native — faster to ship single codebase.

Backend: Node.js / Python (Django/Fast API) / Java / Go

Database: PostgreSQL (structured), or NoSQL for flexible telemetry; consider time-series DB if lots of sensor data.

Hosting: Cloud (AWS/GCP/Azure). Use managed services for scalability.

APIs: REST or Graph QL. Use standard data models like FHIR for EHR/EHR integrations.

Authentication: OAuth2 / OpenID Connect, plus MFA.

Push notifications: Firebase Cloud Messaging (Android) and Apple Push Notification Service (iOS).

Example stack (balanced):

Mobile: Flutter

Backend: Node.js + Express

DB: PostgreSQL

Auth: Auth0 or custom OAuth2

Hosting: AWS (ECS / Lambda) or managed Kubernetes

Monitoring: Sentry, Prometheus

Analytics: Mix panel / Firebase Analytics

7) Data architecture & security

Separation of PHI from anonymized analytics.

Encryption: TLS for transit; AES-256 for data at rest.

Key management: use cloud KMS (Key Management Service).

Least privilege: role-based access control (RBAC).

Audit logs: immutable logs for sensitive operations.

Data retention & deletion policy and “right to be forgotten”.

Consent: store explicit user consent for data collection & sharing.

Backups & disaster recovery.

8) Build & development workflow

Use Agile: 2-week sprints, backlog, demos.

version control: Git + branching strategy (feature branches, PRs).

CI/CD pipelines for automated builds & tests.

Code review and automated static analysis (linting, SAST).

Containerize services (Docker) for consistency.

9) Testing strategy (very important for health apps)

Unit tests (logic), integration tests (API chains), end-to-end tests (user flows).

Security testing: SAST, DAST, penetration testing.

Usability testing with representative users (observe where users struggle).

Clinical testing: for apps that make clinical claims — pilot studies, clinical validation.

Localization tests if supporting multiple languages.

Accessibility audits (e.g., Voice Over, Talk Back).

Beta testing: TestFlight (iOS), Google Play internal testing.

Testing checklist (quick):

Sign-up/login flows

Data entry and storage correctness

Syncing and offline behaviour

Notification delivery

Permission handling (camera, health, notifications)

Data export & sharing

Error handling and graceful degradation

10) Privacy policy & terms

Write clear user-facing privacy policy describing data collected, purpose, retention, sharing, rights.

11) Integration with devices / standards

Wearables: HealthKit (iOS), Google Fit (Android), Bluetooth LE device protocols.

EHRs: FHIR APIs for sending/receiving clinical data.

Lab results: integration via secure HL7/FHIR channels.

Telemedicine: embed secure video (WebRTC) with encryption.

12) Deployment & app store submission

Prepare app store assets: screenshots, descriptions, privacy policy URL, data usage declaration.

Follow platform rules: e.g., Apple has rules for health/medical apps (permissions, data use).

Prepare a support & safety plan for clinical emergencies (clear disclaimers, escalation paths).

Provide in-app contact for support and bug reporting.

13) Post-launch: monitoring, analytics & ops

Track crash rates, retention, key metrics (DAU/MAU, engagement of core feature).

Monitor backend health (latency, errors).

User feedback loop: in-app feedback, reviews monitoring.

Regularly patch security vulnerabilities and update dependencies.

Maintain documentation and release notes.

14) Clinical & ethical considerations

Provide clear disclaimers: is the app informational or diagnostic?

Avoid providing high-risk medical advice without clinician oversight.

Provide emergency instructions, and design flows to escalate to human help if needed.

Consider bias in data and algorithmic fairness if using models/AI.

15) Example minimal technical design (MVP)

Mobile app (Flutter)

Screens: Onboarding → Home dashboard → Log entry → Trends → Profile → Settings

Backend (REST API)

Endpoints: /signup, /login, /profile, /records, /analytics, /export DB schema (simple)

users(id, name, email, hashed_password, consent_flags, created_at)

records(id, user_id, type, value, unit, timestamp)

meds(id, user_id, name, dose, schedule) Auth

JWT access tokens, refresh tokens, revoke on logoutmSync

When online, app syncs local entries via secure API with conflict resolution by timestamp.

16) Sample privacy & consent phrases (for UI)

“We collect health data (blood glucose, activity) to provide personalized insights. Your data is encrypted and never shared without your permission.”

Consent checkbox: “I agree to the Privacy Policy and allow the app to store and process my health data.”

17) Team & roles you’ll need

Product manager / founder

UX/UI designer

Mobile developer(s)

Backend developer(s)

QA / testing engineer

DevOps / SRE

Security / compliance advisor

clinical advisor (if clinical claims)

18) Costs & timeline (what to avoid)

I won’t give specific time estimates (projects vary hugely), but plan for core phases: discovery, design, MVP development, testing, regulatory/clinical validation, and launch. Costs depend on team location, complexity, and regulatory needs. Always budget for ongoing maintenance and security.

19) Launch & growth tips

Start with a focused pilot group (clinics, patient groups) to gather real feedback.

Publish case studies / validated outcomes to build trust.

Offer clinician dashboards or clinician partnerships if B2B.

Use content marketing (blogs, webinars) and PR targeted to healthcare communities.

20) Quick checklist before you ship

Privacy policy & Terms published

Data encryption in transit & at rest

Authentication + MFA enabled

Consent captured & stored

Thorough testing (security, usability, device compatibility)

App store guidelines followed

Support & incident response plan ready

Logging & monitoring enabled

If you want, I can now:

draft a one-page PRD for your specific app idea,

create an MVP feature list and wireframe in Figma-style steps,

produce example API schemas and a starter DB schema,

or give code snippets (Flutter or React Native) for a login + data entry flow.

Tell me which of those you want me to produce right away and I'll generate it.

COST OF APP DEVELOPMENT

Calculating the cost of App Development is one of the most important parts of a project proposal. It varies based on a lot of factors which we will discuss now. However, there is a clear difference in the cost when an individual or a freelancer does the app compared to asking an App Development Company to do the same. Both have their own advantages and disadvantages, but we choose based on the context of the app and the customer. It is not possible to calculate an exact amount as the cost of app development; rather, only an estimate can be drawn based on the requirements given. It is not possible to determine the rate by just taking one factor into consideration and should look for various factors that influence that amount. We will see a few factors that need to be considered before heading for a cost determination. These characteristics determine the worth of the App

• Functionality/Purpose of the App

• Native or Cross Platform App Development

• Third Party Integrations • Complexity of the Visual Interface and Code

• Consumption of Hardware Features such as Camera, Bluetooth, NFC, etc.

• Maintenance Plan for the App

The business of Apps website states that a Simple App can be charged anywhere from $40,000 to $60,000, a Medium Complexity App can be charged anywhere between $61,000 to $120,000 and a Complex App Development can be in the range of $120,000+ in the US. It also states that it would cost approximately $90,000 per year to have an App Development team can be recognized as Project Manager, Team Lead, Developer, Back End Developer, Designer and Tester. All these roles are needed for an organization that plans on delivering the app, whereas a freelancer will take up apps that are not so complicated that need many work hours to complete the given app. Depending on the complexity of the app, the number of people and work load for each will change, and so does the cost that the app will demand.

CONCLUSION

The Mobile App Development Industry is a Young Player in the market and has already crossed the revenue that other IT or IT Enabled Industry has procured. This Industry has evolved and grown drastically in a short period of time and has got people who would have never thought of using software in their entire life and are now experts in using a Smart Phone and all the essential Apps that the phone has to offer. It is safe to say that a Mobile Phone is now not only used for its actual purpose of calling and sending SMS but a lot more than that [43]. The number of new users joining Apple or Google to activate a new device is constantly growing every day. India has taken advantage of this industry to put itself as a country of fast-growing App Users and App Developers in the world. Apart from that, India has also contributed to be the third largest country from which the revenue from apps have been phenomenal.

This industry has made way for India to be a world leader in not just consuming apps, but also developing them. India has also become a preferred country to invest in app development globally. We have discussed in detail how this industry is and will be. Since we cannot see a decline in the usage of mobile phones in our day-to-day life, we can also be sure that the App Development Industry is going to thrive in the upcoming days. If it focuses on utilizing the recent trends in IT appropriately and delivering Apps that are not going to be just a remake of existing apps, then the Mobile App Development Industry will keep growing in the upcoming years.

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