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REVIEW

A comprehensive review on the impacts of mobile health and its interventions in improving public health

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Mobile health (mHealth), wearable technology, telehealth and telemedicine, and customized medicine are some of the subfields that fall under the umbrella of digital health. The use of portable wireless devices to send, store, analyze, and retrieve real-time and non-real-time data between patients and healthcare practitioners is known as mobile health or mHealth. A significant number of clinical and evidence-based research initiatives employ mobile health systems, which are mostly smartphone applications. In addition to providing the population with factual health information, mobile health information supports the messages conveyed by healthcare professionals. This study focuses on the characteristics, benefits, and milestones of mobile health technology and applications in supporting diagnostics and clinical decision-making; apps supporting behavior modification to enhance adherence to prescribed treatment paths; digital therapeutic apps; and apps primarily intended to provide disease-related education are the several categories into which mHealth is discussed.

Keywords: mhealth, mobile health, health, digital health technology, smartphones, wearables

Introduction

Digital health encompasses several different areas, including wearable technologies, telehealth and telemedicine, mobile health (mHealth), and personalized medicine. Digital technology has been driving a revolution in health care, from artificial intelligence and machine learning to mobile medical apps and software that assist doctors' daily clinical decisions. Digital health technologies provide tremendous opportunities for advancing individual healthcare delivery and helping us identify and treat diseases more specifically (1).

Numerous limits of the supposedly "transformative" powers of the "digital health" applications created in the wake of the COVID-19 pandemic were made evident by the latest outbreak of the virus and its catastrophic effects on human health, society, the economy, and public health. To facilitate better healthcare delivery and connection, mobile health is an auxiliary concept linked to smartphones' computational and technical characteristics (1).

The first scientist to develop and invent the term "m-Health" is Robert Istepanian, who is regarded as one of the foremost experts and pioneers of mobile healthcare (2). In this compilation, the World Health Organization (WHO) characterized mHealth as "medical and public health practices facilitated by mobile technologies, including smartphones, Personal Digital Assistants (PDAs), patient monitoring devices, and other wireless devices (3–5).

For over 10 years, a multitude of mobile health systems, primarily focused on smartphone applications, were used in a substantial number of clinical and evidence-based research projects carried out all over the world. Computers and the internet, sensors, and communication systems are the main pillars of mHealth (6, 7).

Sensitive patient information may now be protected and recorded via mobile health applications, a type of automated

healthcare solution. Healthcare cloud computing has made it possible to retain information, making it readily available through mHealth solutions for future reference to pertinent patient data. With virtual care choices on mHealth platforms, a bigger patient population may be handled. This is a major contributing reason to the mHealth technology boom (8). Global healthcare delivery might change as a result of mHealth, the application of mobile and wireless technology to promote the accomplishment of health goals (3).

From the standpoint of the developing world, even though smartphones and other mobile technologies are widely used in these nations, the much-heralded advantages of mHealth systems and their market-driven applications—which aim to address the numerous healthcare issues in the world's poorest regions, including bridging care gaps, improving health inequality, and many other issues—remain largely modest and unachievable (1, 9).

There are enormous number of applications available: According to digital health consulting business research2guidance, 325,000 mHealth applications were accessible for download from app stores as of 2017. In the previous year, 36% of Americans utilized the internet or a mobile app to compare healthcare providers, with 51% of millennials being the most likely to do so, according to a 2018 consumer study conducted by health insurer United HealthCare Providers Inc. (10).

A Deloitte survey of 624 doctors and 4530 healthcare consumers revealed that half of the participants tracked their health information using wearables and other technology and that they shared it with their doctor in 53% of cases. Furthermore, 46% of respondents to an Accenture consumer study said they managed their health using a smartphone or tablet, up from 36% in 2016. Moreover, 36% of respondents—up from 30% in 2016—said technology was crucial for managing health. 90% of respondents said they would be comfortable with their doctor receiving information from their wearables (10–11).

The Food and Drug Administration (FDA) of the United States is among the organizations that have increased their availability of standards for evaluating mHealth solutions in recent years. Evaluation criteria cover a wide variety of aspects, such as cost, usability, authenticity of the material or intervention, compliance with privacy regulations, data security, and interoperability with current processes and infrastructure. Emerging initiatives are being made to support these criteria, such as Express Scripts proposed digital health formulary, which is a list of authorized digital health technologies to help payers and customers (12).

mHealth systems provide a variety of services and applications, such as (13–14):

- Mobile telemedicine: used for virtual consultations, patient data storage, and exchange.
- Customized vital sign monitoring, now improved via wearable device connectivity.
- Location-based medical services to guarantee the provision of information pertinent to the area.
- Responding to and managing emergencies.
- Widespread availability of medical information.

Milestones in mHealth development

Refer to **Figure 1** for additional information.

Features of mHealth applications

Refer to **Figure 2** for a summary of relevant details (15–19).

Attractive UX/UI design structures

The design of a healthcare application should not just be visually appealing but also effectively communicate the goals and vision of your organization. User Experience and User Interface (UX/UI) is crucial. For optimal outcomes, collaborate with the top mHealth app development firm and adhere to best practices for healthcare UI/UX design.

Medical data protection

Security of customer data is critical because mHealth apps manage sensitive information like medical records and health histories. From the beginning of the mHealth app development process, it is important to prioritize strong data protection measures to guarantee the confidentiality and accuracy of the user data. For an extra degree of protection, think about putting blockchain technology into practice. If you're not familiar with this groundbreaking technology, speak with blockchain development services.

Online video consultation with the experts

In the healthcare sector, ease of use and safety are essential. The mobile health app guarantees that patients can receive real-time medical advice by integrating the capability for online video consultations with medical professionals. Studies show that this feature increases the effectiveness of healthcare applications by enhancing patient experience and providing prompt support.

Health activity tracking

The ability for users to monitor their health and well-being is a helpful feature of healthcare apps. Your app can provide

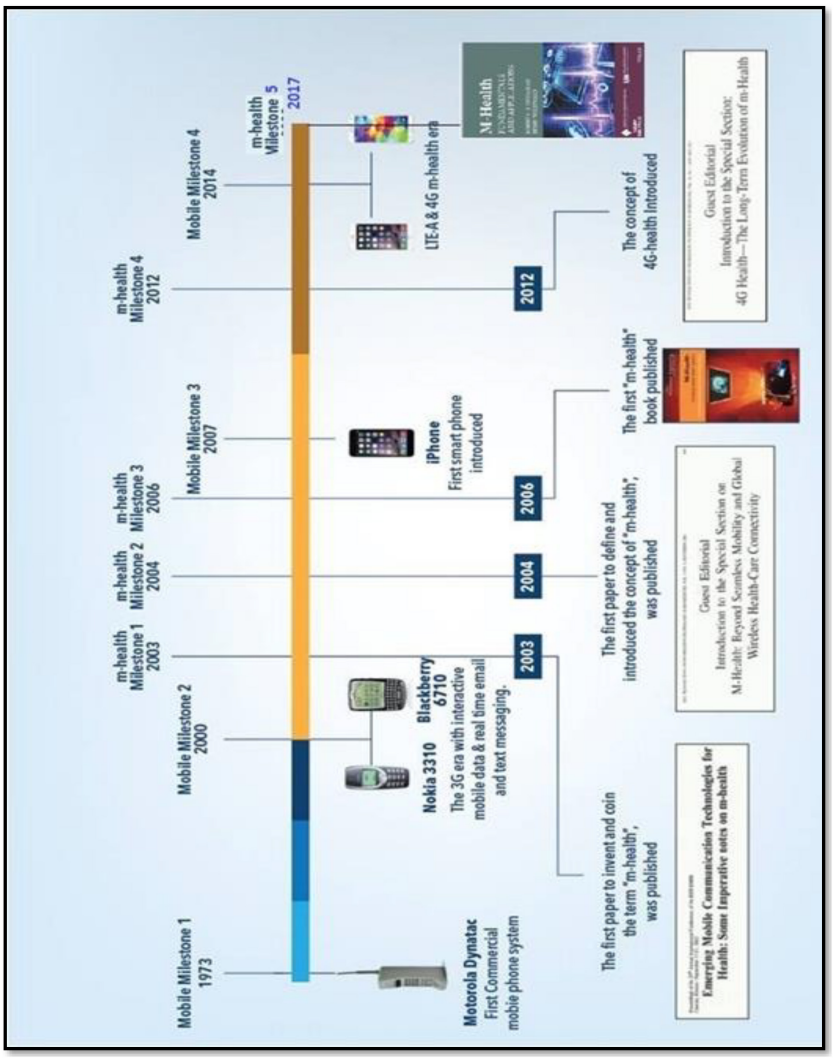

FIGURE 1 | Key milestones in mHealth development (7).

users with insights based on the data they provide, such as their daily blood pressure measurements. Once this data is analyzed, the app can offer recommendations for living a balanced lifestyle.

Indications checking functionality

Advanced functionality can help your healthcare app stand out. Provide a feature that enables users to examine their symptoms to detect possible health issues and provide recommendations for the doctor to obtain a more accurate diagnosis.

Wearable device integration

When wearable device compatibility is integrated into your mHealth app, users can effortlessly track and sync their health data. Users may monitor blood pressure, heart problems, sugar levels, and more with wearable integration. Work with a reliable fitness application development system to include this functionality effortlessly.

Cloud service integration

Cloud storage allows healthcare apps to access user data across devices. From any place, users may safely access their medical records, health photos, and histories. Cloud-enabled healthcare services improve user experience while streamlining data administration.

Blockchain in healthcare

This is a novel technology in the context of developing mHealth applications. Blockchain development services for the healthcare industry contribute to improved app security and patient data in a timely care setting. The technology

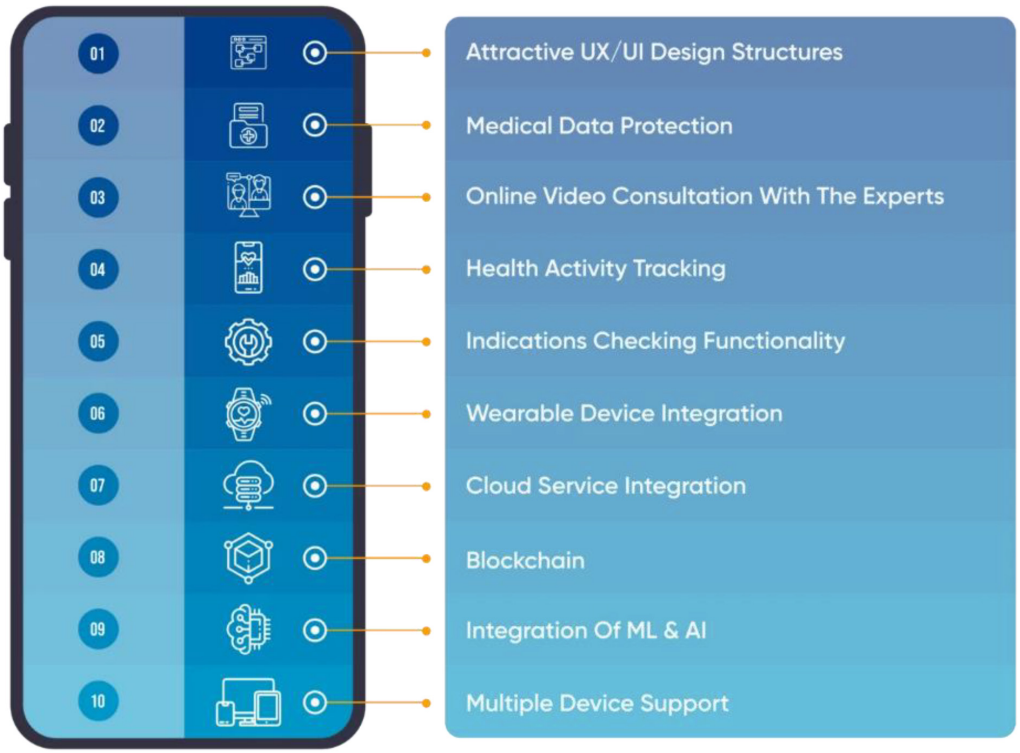

FIGURE 2 | Features of mHealth applications (19).

is based on a cryptography system that, when combined with the other components, ensures that transactions (such as paying for video conferences in advance) are safe and protected from internet threats.

Integration of Machine Learning (ML) and Artificial Intelligence (AI)

Machine learning and artificial intelligence have the power to distribute enormous volumes of data and draw meaningful conclusions from it. These findings have the potential to alert users of mobile healthcare apps to several health concerns sooner.

Professionals can stay on time and get findings with high accuracy by using apps developed with AI and ML for detecting different health conditions. A skilled healthcare mobile app development business can help you boost your ML/AI earnings.

Multiple device support

For access to a wider demographic, ensure that your healthcare app works on a range of devices and platforms. Make sure your software works on all device kinds, regardless of whether you are targeting iOS or Android customers. Ensuring inclusiveness is crucial for ensuring a broad user base to utilize your software.

For specialized apps, consider collaborating with a reputable healthcare app development company to look into cutting-edge features that could help your app stand out from the competition.

Privacy, security, and mobile health policies

Any app should take privacy and security into account, but this is especially relevant for those who gather and distribute user health data. Health Insurance Portability and Accountability Act (HIPAA) rules protect the security and privacy of most individually identifiable health information held by health plans, most healthcare providers, and healthcare clearinghouses. The HIPAA Rules apply to individuals or organizations that create, receive, maintain, or transmit health information for, or provide specific services to, a covered entity. The Office for Civil Rights within the U.S. Department of Health & Human Services enforces the HIPAA Rules. These organizations must notify the HIPAA Rules of any breaches involving health information. It's important to remember that health information kept by anybody who isn't a covered organization or business partner is exempt from the HIPAA Rules (20).

When a software function satisfies section 201(h) of the FD&C Act's definition of a device, it is deemed a medical device by the FDA and is governed by FDA device regulations. According to section 201(h) of the FD&C Act,

a software function is a device if it is intended to effectuate any change in the structure or function of the human body, diagnose illnesses or other conditions, cure, mitigate, treat, or prevent disease, or if it is not a software function that is excluded from the definition of a device by the 21st Century Cures Act (20).

The majority of app developers, including those creating health apps, are subject to the Federal Trade Commission (FTC) Act. Section 5 of the FTC Act, which forbids unfair or deceptive acts or practices in or affecting commerce, is enforced by the FTC. This includes rules about the security and privacy of personal data that apps gather, use, store, or exchange, as well as the functionality or safety that applications offer. False advertising for food, medications, equipment, cosmetics, or services in or affecting commerce is prohibited by Section 12 of the FTC Act (20).

The Children's Online Privacy Protection Act (COPPA) applies to anyone running a for-profit website or online service (including mobile applications) that targets children under the age of 13 or that knows for sure that it gathers, utilizes, or discloses personal data from children under the age of 13. Parents have control over the information that operators of websites and online services can gather from their children thanks to the COPPA and the COPPA Rule, which are enforced by the FTC (20).

A more extensive set of instructions for creating a mobile device-based solution is offered by the Clinical Trials Transformation Initiative (CTTI) (12). These guidelines cover the creation of innovative endpoints using mobile device data as well as the design of protocols that employ mobile devices to record data.

The Department of Health in the United Kingdom has delineated a first "Code of Conduct" about data-driven technologies and furnished commissioners with National Health Service (NHS) Digital Assessment Questions (21).

Benefits of mHealth development

The benefits of mHealth and telemedicine adoption are manifold for patients, healthcare organizations, and caregivers, as shown in **Figure 3** (8).

Reduced cancellations

One of the main benefits of mHealth apps is that patients can keep their appointments thanks to the appointment alert function, which also maximizes the use of caregiver hours and prevents cancellations for the healthcare organization.

Medication regularity

The mHealth apps' reminder function, which reminds patients to take their prescription on a regular basis, has this additional strength. Patients' adherence rates will rise as they get timely prescription reminders, and the quality of their care will also improve.

Reduced healthcare expenses

Prescription drugs taken on time, monitoring health via wellness apps, etc., help patients maintain good health and stay less sick. Patients may learn more about managing their chronic illnesses and taking care of themselves with the help of these applications. Their health will improve as a result, and hospital costs will naturally decrease.

Reduced administrative burden

Managing patient data, scheduling follow-ups, paperwork, and other duties call for an additional set of hands from the healthcare company. Mobile health applications' intelligent technology powers each of these procedures.

Medical billing simplified

The use of mobile healthcare services has led to the automation of certain aspects of patient data and medical billing. This lessens the possibility of human mistakes leading to claims being rejected or refused. The healthcare organization's financial line benefits from faster payments.

Caregiving efficiency

Healthcare mobile development promotes prompt and effective patient treatment through the use of medical informatics and practice management systems. The patient experience is improved by the caregiver's easy accessibility thanks to healthcare mobile applications.

Optimized medical data

The patient's medical records are now securely accessible on a secure platform for convenient updating and access thanks to the transfer of medical mHealth data.

Improvement in patient engagement and care

Patients can alter their lifestyle and have a higher chance of successfully managing their chronic diseases if they have a better grasp of their health issues. In addition, patients get access to their medicines, medical histories, and vital signs.

FIGURE 3 | Benefits of mHealth development (8).

Even some smartphone health applications include offline features that let users access medical records.

Enhanced adherence to treatment plans

Patients can adhere to their treatment programs with the aid of the reminder function of mHealth apps. In addition to drugs, proper diet and other treatment-related activities are also necessary.

Increased health literacy and preventive care

The majority of the time, patients are ignorant about their diagnosis and course of therapy. For this, they are entirely reliant on their careers. However, by giving patients access to all relevant health information, mobile health applications can guarantee their level of health literacy.

Conclusion

Thus, mHealth may be used to link medical data, enable diagnostic tests, encourage behavior modification, facilitate decision support in the diagnosis and treatment of a wide range of illnesses, and provide health education. Nevertheless, further study is required to determine the usefulness and cost-effectiveness of mHealth as well as how it might be turned into practical benefits for patients and healthcare consumers.

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