Mobile Health : A review of current and emerging evidence

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Received: November 2024. Accepted: December 2024; Published: January / February, 2025.
Citation: Lina Zbaidi, Ikram Olol. Mobile Health : A review of current and emerging evidence. World Family Medicine. January/ February 2025; 23(1): 28-32. DOI: 10.5742/MEWFM.2025.95257874

Abstract

Background: Mobile health (mHealth), a subset of digital health, uses mobile applications, wearables, and monitoring technologies to enhance remote and continuous healthcare services. It aims to revolutionise healthcare through individualised, precise and on-demand care.

Objectives: This review explores current and future applications and potential of mHealth technologies. It examines the rapidly expanding and revolutionary role of mHealth in healthcare delivery and highlights potential barriers and dilemmas.

Methods: A synthesis of recent literature was conducted to provide an overview of mHealth developments, applications, and growing challenges, including data quality, governance, and regulatory gaps.

Results: mHealth applications rapidly expand into multiple health fields, from fitness to mental health and chronic disease. The rapidly evolving mHealth technology promises improved health outcomes through real-time monitoring and tailored interventions. Despite significant advancements, real challenges involving data privacy, accessibility and equity, technology validation, and concerns about commercial influence on governance and regulations further complicate the landscape.

Conclusions: mHealth offers transformative potential for medicine and achieving precise and individualised healthcare. However, addressing data quality, ethical, and governance challenges is critical for sustainable growth and fully realising mHealth's benefits in addressing global healthcare needs.

Key words : Mobile health ,Digital health, Wearables, Remote health monitoring, Digital health applications

An overview of mobile health (digital apps, wearables and remote monitoring)

• **Definition:** Digital health is a diverse field encompassing various technologies targeting or specialising in healthcare (1). Mobile health specialises in wireless or mobile technology, including digital applications, wearables and remote monitoring (2, 3).

• **Aims:** Digital health in general, and mobile technology in particular, aim to improve health outcomes by using technology to advance the prevention, diagnosis and treatment of diseases and health-related conditions (2, 4, 5). Mobile technology distinguishes its services from other digital health by providing remote, continuous or on-demand access and potentially higher consumer control and ownership of their health (3, 6).

The future of mobile health: Scope and potential applications in healthcare delivery

Mobile health is gaining momentum and is in a rapid acceleration mode. The industry is progressively evolving its core products and experimenting with new technology to expand and diversify its market reach (7, 8). Future health care is challenged by an explosion of the world population and pressure on resources, climate change and a global trend for urbanisation, disproportionate increase in the ageing populations in the developed countries, and rising chronic diseases, including mental health and the emergence of novel infectious diseases (9). The future of healthcare relies on the reinvention of traditional delivery models to match the increasing health demands and changing consumer' expectations (9). Mobile health, including digital applications, wearables and remote monitoring, is a promising development in the health information and technology sector (4, 5, 10). Since its introduction, manufacturers' efforts to enhance quality and diversify the product range have been reciprocated by unrelenting consumer interest and technology uptake (11). Mobile health technology has a role in preventing, detecting, diagnosing, and treating health conditions. Mobile technology allows health care to be personalised, adjusted to the consumer's treatment goals, delivered on-demand and delivered outside of the constraints of the traditional health facility (6, 7, 12). Mobile health is expected to continue to improve the accessibility to healthcare, especially for those who already face access problems; for example, vulnerable groups such as people living with mental illness, those who have a terminal illness, or those living remotely would benefit from remote and frequent access (8, 12, 13). Mobile technology allows access to uninterrupted real-time data. The increased amount and diversity of information can improve data quality and clinical decision-making(14). Inception medicine is an emerging field predicting improvements in the early prediction and prevention of diseases based on the algorithmic analysis of mobile health data (6, 14). Implantable devices with chemical and physiological monitoring capabilities could predict and prevent acute events such as cardiac attacks, one of the top mortality causes in modern society (14). Sensor technology also has a role in lifestyle and mental health and well-being monitoring, incorporating data about daily activities, physical movement, food intake, sleep, subjective well-

being and relating the data to vital signs and blood chemistry (10). Health care can be extended beyond the brick-and-mortar health facilities and delivered in a virtual environment, bypassing the constraints of existing delivery models and recouping savings on the traditional costs of buildings, infrastructure and the time and cost of commute and transport (3, 7, 13).

Current applications of mobile health

Mobile health use is incrementally but steadily extending into numerous healthcare fields and disciplines (7). Tens of thousands of health applications are available in mobile App Stores, and more are regularly added to the market (15). The production and use of wearables are also growing, with manufacturing companies competing for consumer traction. Consumers have built an expectation for a broader product range and advanced features with every version update.

• **Mental health and well-being:** Mental health was an early adopter of mobile and digital applications. E-mental health programs offer self-guided web- and application-based prevention and treatment programs for common mental health issues (2). Some of these programs offer remote clinician support and supervision of treatment progress (16). The literature supports the efficacy of mobile mental health programs in treating several mental health conditions, such as anxiety and depression (17). Australian-based programs such as This Way Up clinician-supported programs(16), Beyond Blue Smiling mind app for mental health prevention (17) and Black Dog youth mental health well-being digital programs (18) are accessed by thousands yearly. Other uses of mobile technology in mental health are SMS or text messaging for treatment follow-up or well-being checks. The wide use, simplicity and low cost of text messaging make it a practical and low-cost intervention (8).

• **Physical exercise and fitness:** the fitness industry is a pivotal innovator of digital health applications and wearables. As wearables become more popular amongst all age groups, the industry is claiming to offer more advanced models with improved capabilities and health- tracking features (19). Current wearable tracking capabilities include monitoring and recording the type, frequency and amount of movement and physical exercise. It also detects and compares some of the body's physiological parameters, e.g. heart rate and rhythm, during exercise and at rest (19). Wearables are competing to be our preferred and highly-recommended personal trainer and health coach. They can track progress over days, weeks, and months and provide summaries and analyses of cumulative physical movement. They also send regular

reminders and motivating messages to encourage us to move regularly and exercise. Sleep trackers are also featured on some wearables and claim to analyse sleep quality.

• **Cardiovascular health:** globally, cardiovascular disease is one of the top causes of mortality. The disease burden of chronic cardiovascular conditions such as hypertension and heart failure significantly affects the individual's quality of life and exerts pressure on health services (20). The diagnosis and treatment of these conditions benefit from advancements in mobile technology (14, 21). For example, mobile blood pressure monitors improve the accuracy of the diagnosis of hypertension (14). Mobile blood pressure monitors allow continuous 24-hour or more extended measurement periods rather than episodic stents. It also solves the issue of "white-coat hypertension" for patients with increased blood pressure only during medical encounters (14). For heart failure patients, more digital apps are available to simplify some aspects of managing this complex disease. Medication administration apps can help guide patients in managing polypharmacy, especially those with a new diagnosis (21).

The challenges and pitfalls of mobile health

• **Data quality and validity:** A significant share of the marketed mobile technology, digital apps or wearables are manufactured by private commercial enterprises (15). The current laws and regulations are not prescriptive of guidelines or processes to measure data quality and validity (7). There are growing concerns that some commercially available wearables have faulty monitoring features, such as the heart rate and rhythm tracking functions, leading to false results, unnecessary alarm to the consumer and increased use of traditional health resources (15). Health advice and guidance offered by digital apps are often not based on the best available evidence and can divert from acceptable medical practice (15).

• **Data governance:** Data governance is a framework or structure that defines the organisational data guidelines, rules and principles, the authorities issuing the rules and how the rules are communicated and monitored (22). Data governance is a quality assurance tool and an adequate safety and security measure throughout the data life cycle. Good data governance allows organisations to develop an informed approach and deep understanding of the benefits and risks of data (22). Mobile digital health, developed by private companies, is presumed to be subject to the governance structure of the manufacturer. These structures are often unclear and lack representation from key stakeholders representing consumers and the health sector (2, 7, 15, 23).

• **Equality and access:** Access to digital technology requires a minimum of physical resources and individual skills to connect with the information and utilise it for the betterment of health (24). The prerequisites for valid and effective digital access favours the affluent and educated over the socioeconomically disadvantaged (25). Internet and connectivity infrastructure in rural and remote areas complicates access to all digital health services, including mobile health (26). The cost of mobile devices and wearables is another barrier to equal access for all. The digital capability to fully engage and utilise mobile technology is limited for several population groups, such as the elderly and people living with a disability (24, 25).

• **Data privacy and security:** The modern view of data is that it is an organisational asset and should be invested in to maximise the benefit for the organisation (7, 23). Personal data collected by mobile health devices and apps include detailed and extensive personal information from name, date of birth and contact details to health information and habits (7, 15, 23). This "gold mine "of data is increasingly attractive for commercial enterprises for traditional purposes such as marketing and to use to feed and develop AI technology capable of understanding and predicting consumer behaviour (23). The fine print privacy policies imposed by companies on consumers are geared towards commercial benefit, allowing companies to use and share consumers' data for financial gain. The vulnerability of consumer and their data remain a significant challenge for mobile technology (23).

• **Professional and consumer attributes and skills needed to use the technology:** Generic digital health apps and wearables are designed with the assumption of a certain level of digital literacy and capability(24). All consumers are expected to have the digital skills, access and capability to use the information and benefit from it to the same level. The assumption that most young people are technology savvy is probably true (11, 25). However, several barriers restrict access for many individuals and population groups. Physical disability, loss of dexterity, hearing or vision obstructs full and equal access to mobile health. Education level, literacy and age, and health determinants also impact digital access (6, 11, 24, 26).

• **The potential impact of the involvement of the corporate sector in healthcare:** The commercialisation of mobile health and the unopposed influence and power of the private sector can potentially compromise the quality and equity of digital healthcare (15, 23). Policy and legislation are lagging in this area, leaving a significant gap in market regulations and risking the loss of consumer power and voice in the absence of protection from governments and health authorities (5, 7). Private enterprises have a long and strong history of innovation, producing and constantly evolving quality products that are highly attuned to consumer demands. However, we cannot ignore that these are commercial enterprises driven mainly by financial gain and health safety, accessibility, and equity are merely secondary agendas (26).

The prospects of mobile digital technology and healthcare delivery in the next decade

Mobile digital health is expected to influence and substantially impact healthcare delivery in the next ten years and the longer term (5, 6, 11). The current use patterns of digital apps and wearables indicate an upward trend of steady expansion and evolution of the mobile health market (6, 7, 11). Advocates and digital optimists are predicting mobile technology to revolutionise

are predicting mobile technology to revolutionise individualised and accurate healthcare, personalise health prevention, diagnosis and management and lay the basis for innovative healthcare models (19). Digital apps, wearables and implantables are predicted to be the catalyst for individualised and accurate healthcare and novel models such as “inception medicine“ (14). In the era of genetic mapping and testing, consumers’ expectations of their healthcare are rapidly changing, and there is a general sense of dissatisfaction with the “one size fits all “healthcare models (3, 7). Mobile health offers technological features capable of continuously monitoring and collecting vital physiological data with the promise of using the data to individualise prevention, diagnosis and treatment plans and, therefore, an overall improvement to individual health outcomes (10). Inception medicine claims to improve the prevention, early intervention and treatment processes through the triangulation of multi-source data from mobile physiological monitoring, genetic testing and AI- enhanced technology (10). However, for mobile health to deliver on its positive forecast for the next decade and maintain the momentum for leading innovative and agile healthcare delivery, it needs to address the defaults in the accuracy, quality and validity of current technological models and operations (7, 15). The “validity “of mobile products is increasingly questionable as more products fail to deliver the results they claim or promise. Digital apps are observed to measure “proxies “in a tick-box fashion rather than pursuing actual and fit-for-purpose indicators (23). Weight loss and fitness apps collect vital signs and physical movement measures, but the evidence for “validity by improving fitness or achieving the desired weight” is lacking (27). Blood glucose and blood pressure monitors display similar deficiencies and a mismatch between the health issue they claim to address and the final health outcome (23, 28). Attention and investment in the scientific rigour of future mobile technology are critical to embedding validity (3). Current regulations and data governance structures must be revised to improve app design and development governance and processes. The industry would benefit from adopting a co-design approach and complementing IT expertise with the perspective and knowledge of health experts and consumer representatives (5, 15, 23). In addition, the next decade will increasingly challenge mobile health to rectify its inherent preference for a generic techno aware and savvy customer typology. Mobile technology is increasingly scrutinised for excluding the socioeconomically and technologically challenged by design, and technology developers are under mounting pressure to produce inclusive technology that contributes rather than halts health equity and advantage. Health equity is mobile technology’s next frontier (26).

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