ANNUAL REVIEWS

Annual Review of Public Health

Mobile Health (mHealth) in Low- and Middle-Income Countries

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Annu. Rev. Public Health 2022. 43:525–39

First published as a Review in Advance on October 14, 2021

The *Annual Review of Public Health* is online at publhealth.annualreviews.org

https://doi.org/10.1146/annurev-publhealth-052620-093850

Keywords

mobile, mHealth, low- and middle-income countries, LMICs, health services, private sector, governance

Abstract

This article reflects on current trends and proposes new considerations for the future of mobile technologies for health (mHealth). Our focus is predominantly on the value of and concerns with regard to the application of digital health within low- and middle-income countries (LMICs). It is in LMICs and marginalized communities that mHealth (within the wider scope of digital health) could be most useful and valuable. Peer-reviewed literature on mHealth in LMICs provides reassurance of this potential, often reflecting on the ubiquity of mobile phones and ever-increasing connectivity globally, reaching remote or otherwise disengaged populations. Efforts to adapt successful programs for LMIC contexts and populations are only just starting to reap rewards. Private-sector investment in mHealth offers value through enhanced capacity and advances in technology as well as the ability to meet increasing consumer demand for real-time, accessible, convenient, and choice-driven health care options. We examine some of the potential considerations associated with a private-sector investment, questioning whether a core of transparency, local ownership, equity, and safety is likely to be upheld in the current environment of health entrepreneurship.

1. INTRODUCTION

Mobile phones, simple everyday communication devices launched in 1973, have become central to some of the most radical developments in health (2, 5, 7, 39). The use of mobile phones to make calls, send text messages, and access the Internet has transformed the precision and scale of health service delivery in ways that were previously only imaginable. Despite being nearly 30 years in development, mobile health (hereafter, mHealth) has affected countless lives, improving access to preventive health care and supporting patients when they are ill (57, 59, 93). Although younger people in high-income countries (HICs) may not recall the time before mobile devices, for many people across the globe, the shift has been more recent and perhaps more profound or is yet to be realized (24). By 2025, there are expected to be 5.6 billion mobile connections, the majority being smartphones, in the hands of more than two-thirds of the global population (20, 47, 61). In some low-income countries, mobile connections are more reliably accessible than are electricity and clean water (10, 42).

This article examines recent peer-reviewed evidence on mHealth with a focus specifically on its application in low- and middle-income countries (LMICs) (70). As with many novel developments in health, there has been a gradual unfurling of frameworks and tools designed to guide the development and assessments of mHealth interventions (4, 78, 79, 81, 82). We acknowledge the contribution that these have made to the field, particularly considering the emergence of private-sector adaptations of mHealth developed to meet the growing demand for consumer choice and autonomy (62, 63, 66). In this respect, we question the future of mHealth as it increasingly shifts to private-sector entrepreneurs and investors and how these developments serve the most vulnerable, in concert with the aspirations of achieving universal health coverage (51, 53). The World Health Organization (WHO) endorsed a strategic plan for digital health, promoting the wide use of technology-driven health care across all member states (78). Within this context of mHealth as one tool for strengthening health systems, we discuss the space between the delivery of high-quality, affordable, accessible, and appropriate services and the obfuscation of risks and benefits associated with the commodification of mHealth.

2. MOBILE PHONES FOR HEALTH

The basic mobile phone enables phone calls and text (SMS) messages; both functions remain vital to the user experience (14, 58, 59, 77). However, the advent of the smartphone in 2001, with access to Internet data, scales up access to new functionalities, with video streaming, social media, and the ability to send email among the most popular (20, 24, 27). Research on mobile data subscribership estimates approximately 73% penetration of the global market; smartphones are overtaking the classic phone and account for approximately 63% of all phones in use (48).

These figures, variable by region, are testament to the exponential growth in the mobile market; the sheer scale and rapidity of adoption have been quite extraordinary, demonstrating the potential for scale-up of population-level mHealth (9). In the decade since the WHO Report on mHealth (in 2011), the scope of operation and reach has magnified considerably (79). Countries in the Asia-Pacific region, for example, were previously unable to access the 3G networks necessary for many mHealth applications (20). Coverage has now shifted to most regions having over 90% access to a network signal, 53% having access to the Internet in their homes (20, 48). This growth in mobile connectivity (and its subsequent capitalization), scrutinized via forecasting algorithms, was predictable (18). Contingent on access to handsets, cabling, and telecommunications infrastructure, and on increasing digital literacy skills, mobile was an almost certain win for the mobile telecommunications industry (37, 74).

So where is the evidence that a mobile phone as the conduit for health services is effective, that these benefits are equitable, and that issues of ethics and quality have been safeguarded? Where are the advantages of mHealth being experienced most acutely, and how are mHealth interventions serving LMIC populations? In the early days, mHealth cut its teeth in areas such as behavior change communications: one-way messaging to support behavior change (52, 56–59, 63, 94). Similarly, appointment reminders were logically included with benefits to both consumers and health providers (1, 58, 94). It was representative of a time-saving, direct-to-consumer type of thinking, catching people in the moment of potential action (1, 14). The adaptation of simple one- or two-way messaging interventions has since been extrapolated into an ever-increasing library of adaptations for different contexts (31, 43). There are several possible reasons for this development; first, old modalities of information production and decision making need to change, and people want and need more information in their own hands to make decisions, to exercise autonomy, and to connect with what resources are available when living in remote regions (49, 50). The second ingredient is commerce. The combination of health and technology brings together two quintessential elements of humanity: our complex biology and our need for connection. In terms of economic potential, this transition was like adding salt to potato crisps.

Although mHealth in HICs is becoming increasingly mainstream, evidence of scaled-up, sustained initiatives in LMICs is not as well established. This discrepancy is a likely product of a tendency still toward investment in pilots that fail to reach scale (and are not published) without sustained resourcing owing to a lack of longer-term funding arrangements (13, 31). From the analyses undertaken to date, mHealth in LMICs has been focused largely on two areas: the use of mHealth to support health workers in health service delivery and the use of mHealth to deliver health information directly to consumers and to support behavior change in disease management interventions. However, this is about to change. Large, underserved, and consumer-savvy middle classes in the emerging economies combined with the gaping vacuum in consumer choice for health care during the global severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)/COVID-19 pandemic has only fueled growth in mHealth in LMICs (66).

2.1. mHealth in LMICs

mHealth interventions targeting people with noncommunicable diseases (NCDs) show potential in LMIC settings (68). mHealth programs designed to support engagement in behaviors associated with diabetes, stroke, and cardiovascular disease management have resulted in improved clinical outcomes, health behaviors, and compliance with treatment (12, 29, 32, 34, 64), although not all published studies have shown positive effects (8, 72, 73). mHealth has also been used successfully in the remote monitoring of people with long-term conditions (6, 58, 64) and in the provision of personalized medical advice based on the data received (52). mHealth interventions designed to promote physical activity and healthy diets for NCD prevention have shown promise in LMICs, providing a viable mechanism to improve diet and physical activity behaviors (56, 59). A review of randomized controlled trials (RCTs) on the effectiveness of mHealth interventions on physical activity and diet outcomes in developing countries reported consistent findings with systematic reviews of mHealth interventions carried out in HICs (46).

Significant potential for mHealth in LMICs lies in their reach into most groups, making them ideal for population health approaches. Support for mHealth has been reported for the provision of information and support across diverse areas of health, including oral health (92), smoking cessation (21, 59, 74), and sexual and reproductive health (3, 25, 29, 32, 34), including supporting medication adherence and appointment attendance for HIV treatment (22). In the areas of

maternal and child health, mHealth interventions have been used to provide antenatal and postnatal care at the community level for the purposes of education, data collection, and communication and at the individual level for antenatal care attendance and medication adherence (5, 17, 29).

mHealth has been used effectively for supporting the delivery of health services and care through community health workers, which has included the use of mHealth as job aides, as decision support systems, for data collection, and for feedback and supervision (26, 54, 64, 65). Although the evidence indicates that these interventions are linked to improvements in health care worker performance (2), the complexity of health care delivery, particularly in LMIC settings, and the interplay between human and environmental factors make it challenging to understand the true potential of these interventions (19). Furthermore, few studies on mHealth tools delivered to health workers have assessed the population impact, so the translation of the effectiveness of these tools to health outcomes is not clear. mHealth interventions for health care workers are integrating more complex technologies to enhance aspects such as detection and identification of disease. Although these technologies are promising for increasing the breadth of health care delivery that is available in resource-constrained settings, the barriers of digital literacy, technology issues, and access to network infrastructure prevent these from achieving their potential (19, 24, 38, 40).

The evidence for mHealth programs in LMICs has come largely from small studies with short follow-up periods, resulting in questions about their sustainability and impact. A collaboration between researchers and the private sector has provided evidence of real-world implementation of an mHealth physical activity program (16). More than 69,000 participants, 92% being from developing countries, took part in a study of the 100-day Stepathlon program and found positive impacts on physical activity outcomes (16).

In line with evidence from HICs, much of the evidence for mHealth in LMICs has utilized the SMS modality. Even within SMS interventions, the heterogeneity of intervention dosage, duration, content, and functionality limits understanding of successful features. Therefore, despite the positive outcomes reported from mHealth interventions in LMICs, drawing conclusions on the effectiveness of mHealth interventions is still challenging owing to the small number of studies along with the lack of consistency in intervention type and outcome measures. Although the evidence of effectiveness of these interventions and tools is far from conclusive, the acceptability of mHealth as a modality for health intervention and support in LMICs is well established (1, 8, 23, 45, 67), which arguably warrants their continued use and development.

Efforts to provide guidance to stakeholders regarding the design, implementation, and evaluation of mHealth interventions (4, 9, 41) emerged in response to the somewhat erratic experimentation in the field. The newly released WHO Digital Health Strategy (2020–2025), the product of resolutions from the United Nations General Assembly and the World Health Assembly, with consultation from across member states, identifies priority areas for WHO investment (78, 79). Although it addresses the full spectrum of digital modalities, several core principles remain relevant for mHealth in LMICs, in particular, the need for a sound regulatory framework for activities based on capacity building, equity, ethics, accountability, and governance (35, 78, 79). Prior to the WHO Digital Health Strategy, allied initiatives such as the 2016 Monitoring and Evaluation for Digital Interventions (78) provided a pragmatic, whole-of-life-cycle (from prototype to national implementation) guide to implementers. The guide characterized the rising concerns regarding the proliferation and adaptation of digital initiatives that were not being subject to the same level of scrutiny as were other interventions. Many were being developed in isolation from local government involvement, without assurance of future support, exhausting enthusiasm for the "potential for mHealth" (55). Contrary to the potential, the majority, despite producing positive outcomes, were at risk of overlooking the importance of integration, alignment with national health sector plans, resources, and governance (35). The practice of disaggregated problem solving is arguably

one of many expressions of what Chigudu (11) describes as the colonial practice of global health problem-solving. This approach sidesteps the importance of culture, history, and politics as an inconvenient truth about why things do not necessarily work as intended.

The Be He@lthy Be Mobile (BHBM) program, a collaboration between the International Telecommunications Union and the WHO, established in 2012, provides support for governments on the mechanics of effective implementation and scale-up of mHealth initiatives (81). The program focuses on the development of handbooks designed to foster skill development and on the collaboration between the government and public sector to implement practical steps for scale-up (82). To date, BHBM has launched mCessation (or mTobaccoCessation) (83), mDiabetes (85), mHypertension (90), mTB-Tobacco (88), mDementia (91), mAging (87), mCervical Cancer (84), and mBreathefreely (for asthma and chronic obstructive pulmonary disease) (86). A handbook to guide the development of creating personas to enhance engagement in mHealth is also available (89). Handbooks are designed to be practical user guides to cover key areas, including the context (operations management), content (message development or adaptation), recruitment, technologies interface, evaluation, and monitoring. Regardless of whether an mCessation program is to be developed from scratch, or adapted from a prevalidated version, BHBM's approach reflects that any mHealth initiative is doomed without early, consistent, and appropriate effort to build whole-system capabilities and commitment from the implementers [government or public-private partnerships (PPPs)] to promote the longer-term benefits (41).

2.2. mHealth: Cautious Optimism

Despite the appeal of text message–based programs (e.g., in 2018, 2.1 million people had signed up for India's mCessation program, and 8.6 million for mDiabetes), the transition to mHealth as an integrated facet within the health system has been comparatively slow in LMICs compared with uptake in HICs (69). One-way and two-way messaging remains the most used modality, with a gradual shift to the use of apps and social network sites (Facebook Messenger, WhatsApp, and WeChat) (59, 70, 76). A major barrier to mHealth implementation in LMICs remains a lack of technical capacity and capability, with technical support being outsourced in some countries, leading to limited potential for sustainability (59). Moreover, local investment, especially when donor investment is backing the initiative, is a critical factor in determining translation from pilot to a domestically funding scaled-up program. This transition, which is part of the broader agenda in global health financing, is likely to have significant implications for the sustainability of other interventions that fall outside primary service goods and services infrastructure until the translation of value (of digital health) is costed, tested, and accepted (as no longer an adjuvant to mainstream health service delivery) (44).

An area of concern that mars the optimism surrounding mHealth is the issue of equity: who gains access and reaps the benefits. Groups with greater access to resources (technical as well as financial capital) are more likely to be early adopters of new technologies (24). However, a recent example is the emerging transition to electric private vehicles in some LMICs (44). To ensure that the benefits to the environment are realized beyond profits for the car manufacturer, the diffusion of innovation is relevant; these drivers extend beyond cost and acknowledge intrinsic values and perceptions of choice (44). Early iterations of mHealth were designed primarily for reminders or to promote greater access to in-the-moment support for behavior change. The imperative is that if delivered at scale, one-off, face-to-face interventions can be offered via mobile technologies (predominantly SMS or via social media), providing savings back to the health system (22). In essence, mHealth in the simplest form (text message) provides relatively economical service delivery, at scale, with the benefits of tailoring and potential real-time accountability.

Whittaker and colleagues (75), in a review of mCessation interventions, described mHealth as increasingly useful in the provision of health information and delivery of health care globally, predicting a continued upward trend in the future application of mobile phone–based support. The authors note that the evidence, while reassuring for interventions delivered in HICs, was less apparent for LMICs. Although the potential value added by mHealth in low-resource settings is considerable, particularly with respect to reminders for medication adherence and messages for behavior change, the evidence of impact in LMICs to date relies on hypothesized benefits of scaled-up delivery. A deeper understanding of the process of adaptation, implementation, evaluation, and ethical considerations is emerging (45, 53). mHealth initiatives delivered within settings where there are fewer resources face a myriad of additional challenges, notably technical capacity; short-term, donor-driven funding; and lack of local investment. If not addressed from the concept development phase, these challenges can undermine the potential benefits. In LMICs where health systems are under-resourced and beholden to unsustainable financing mechanisms, equity of access to mHealth must be considered as part of a complex system (24, 71).

mHealth, unlike other areas of health system–level intervention, namely policy and regulatory measures, relies on the private sector in terms of the information and communications technology infrastructure. Some of the earliest PPPs in health responded to the market void left by governments who were unable to deliver on the fundamentals of care, let alone consumer-driven health commodities or services (92). The PPP has been a foundation of the mHealth model, although it is often not always explicitly acknowledged (30, 92). A review of PPPs in the context of strengthening primary health care recognizes the value of the partnership model, particularly in mHealth, where the government, the funders, telecommunications providers, and the local end users are key stakeholders (92). The voluntary nature of PPPs is also distinctive; there is no moral or legal obligation by the private-sector investor to focus on health outcomes. Private investment in health, especially in LMICs, has been a slow burner, albeit with considerable potential, in market terms. Scale (large), human capital (young, growing populations), relatively weak regulations, and, for many emerging economies, a growing middle class provide a sound foundation for mHealth PPPs to be both trialed and scaled up.

Ethical considerations are often slower to emerge beneath the veneer of optimism and determinism surrounding technologies in health (63). Gómez-Ramírez and colleagues (19) argue in favor of actions, not just considerations, that promote ethical, equity, and social justice implications for mHealth. Kellerman (27) penned a brief for *The Atlantic* on the 2013 mHealth Summit in Washington, DC. Remembering this was a time of boisterous enthusiasm for mHealth, she wrote, "With any luck, these apps, and the host of other personalized digital technologies out there, will let consumers handle as many health problems as they can, safely, on their own, freeing overburdened physicians to devote their time to matters that really do require FDA regulation" (27). In the context of private-sector investment in mHealth, with both established ventures in the digital health space, such as Babylon and 1mg, alongside new start-ups, concerns about accountability, quality, and safety are reasonable. The most obvious and well-described risks relate to the safety and confidentiality of sharing data or personal health information via mobile devices (19).

Health technology designers and their investors have been responding to a gulf between what health consumers need and what is available in the mainstream market. Entrepreneurship has flourished in a context where the traditional reactive model of health care design and delivery has failed. Market-oriented health technology designers anticipate the impacts of demographic and economic changes alongside a growing emphasis on individual responsibility for health. However, designers of new apps may not be subject to the same expectations of accountability for, transparency in, and sustainability of their services as are health providers (9).

Commercial investment in digital health is a logical development, as waiting for government investment to scale up high-performing pilots could stymie potentially lifesaving or life-improving interventions (13). However, private-sector investment brings with it a series of complexities. Adherence to ethical, quality, and safety standards may be less straightforward and visible and therefore less attributable and accountable. Private-sector externalities, costs that are associated with both production and consumption, are outsourced and therefore not always accountable. For example, a company that designed and marketed an app to promote self-monitoring of blood pressure may produce both positive effects (e.g., increased self-regulation of stress, change in diet, improved blood pressure) and negative effects (e.g., hypervigilance on heart rate, increased anxiety, increase in primary care visits) and is unlikely to be accountable for the latter, the primary impact being loss of sales. Where the field is lagging is in comprehensive reporting on the implications of mHealth interventions with respect to the quality of products and accountability measures (15, 33). For populations least able to access health resources, mHealth interventions should be at little to no expense, accessible, and of the highest possible quality (52, 92).

Private-sector companies investing in technologies for health are less likely to publish their development or adaptation processes, evaluation models, or outcomes in peer-reviewed journals. The rise of consumer-driven health (i.e., the consumerization of health) has slowly started to turn toward the pressing need for greater equity in health care access, with niche markets emerging with respect to underserved populations within HICs. The role of the PPP is critical; few investors want to take risks on research and development for digital health tools designed for the people who are least able to pay.

3. FUTURE OF INVESTMENT IN mHEALTH

So how have mHealth initiatives, designed to increase access, autonomy, and consumer choice in health, benefited populations in LMICs? To date, advances in and benefits from an increased investment in mHealth products have favored both product design and capacity development in HICs, most notably countries in Europe and the United States. Evidence described earlier in this chapter is a testament to the growing place of mHealth as a core public health tool, with COVID-19 forcing the hand of digitally reticent governments and health organizations to update and upskill (11). Yet, evidence of scaled-up initiatives being accessible to the poorest is lacking. LMICs typically face additional challenges with building and retaining the technical capabilities necessary to drive and sustain mHealth (62). Access to training and retention of qualified staff remain chronic issues in LMICs. The Pacific Islands region's attempt to stymie the flow of qualified workers to New Zealand and Australia is futile in the face of ever-increasing demands for services.

Global health financing has been undergoing a radical transformation in the past few years; spending on health in LMICs has been proportionally greater than that of HICs. Spending on health in LMICs, and low-income countries (LICs) in particular, is still lower overall than that in HICs (13). As countries transition from low income to lower-middle income, or middle income to upper-middle income, contributions from donor assistance for health decrease. LICs receive on average 27% of their health spending from donors, whereas in lower-middle-income countries, this amount drops to approximately 3%. Alternative models such as community-based or social insurance schemes are increasing, with 129 of the WHO member states having some form of health insurance scheme in place (13). Domestic spending on health is gradually increasing, and, with this increase, personal expenditure on health is decreasing. In describing these transitions, the WHO *Global Spending on Health 2020* report (80) confirms the convergence of health spending between middle-income countries and HICs, with greater public and out-of-pocket spending on health. What does this transition mean for promoting equitable access to health services, in

particular primary health services, alongside actions to strengthen fragile and under-resourced health systems? One outcome of this upward transition in country-level gross national product is the growing middle class, the sector of a population that is increasingly recognized as a key market for personal investment in health. LMICs, with their growing middle class, are highly attractive to digital health options. In general, large economies with a growing middle class, hungry for consumer choices in health services available elsewhere, offer considerable opportunity for digital health providers.

Private-sector health care entrepreneurs are well embedded within health service provision in LMICs. What does the arrival of private investors (as distinct even from PPPs) in mHealth signal in terms of requirements for accountability, ethical practice, and data security? The digital health regulatory architecture has provided little structure, to date, aside from guidelines and tools for implementation and evaluation. However, the private sector with its fundamental ethos and comparative market-driven expertise is well placed to decipher economic opportunity from need.

The Pathways to Progress initiative, funded by the Bill and Melinda Gates Foundation, with representatives from the World Bank, government, technology, and business, is concerned that the lack of scale-up of initiatives in LMICs will impede progress toward universal health coverage. These hold-ups are seen not only as inequitable, but as an opportunity lost given the demands and potential investment available for mobile contributions to health. The comparatively slow rollout of mHealth in LMICs should raise concerns about equitable benefits. Those living in the poorest communities should be prioritized to gain access. A mantra in New Zealand states that what is good for Māori (the indigenous population) is going to be good for all in New Zealand. mHealth, or any other digital health system, needs to be designed on the basis of the values and priorities of the most disadvantaged in order for equity to be realized.

In the context of mHealth, creating practical solutions to address problems that require connecting people to services they need at a lower cost, without compromising on quality, is the ideal. But herein lies the challenge: Should innovative solutions crosscut regulatory measures imposed by policy prescriptions? In LMICs, tech innovation and policy are key to progress in achieving development goals, including access to health for all. The view that digital or technological innovations are more impactful than the grinding pace of policy change is familiar. Despite digital innovations often being built as responsive, agile, and consumer focused, and despite the anticipation of needs remaining a powerful driver to innovations in digital health, good governance is also essential. The faltering responses demonstrated by many countries to the COVID-19 pandemic are testament to the need for innovation, resourcefulness, and strong governance and regulation (30).

The widespread adoption of smartphones has coincided with the rapid growth of young and socially mobile middle-class populations within LMICs. It has been extremely challenging for countries to adapt colonial and faith-based health care systems to provide modern and cost-effective services for the growing middle classes (43, 60). Private hospitals and services are still out of reach for most of the poor, with out-of-pocket expenditures still representing a significant barrier for those seeking care (13). Deteriorating public hospitals and clinics do not meet the needs, let alone expectations or desires, of citizens increasingly awakened to the existence of modern, private-sector services. Smartphone-based medical consultations, online pharmacies, and lab test booking and results services have emerged in recent years to meet this growing need (66). These companies have received significant international venture capital investment with valuations now in the billions of dollars, demonstrating that international financiers have seen the potential for mHealth and are rapidly investing in this sector (49).

One such service, Babyl, from United Kingdom–based start-up Babylon Health, is now providing remote consultation services and a self-diagnosis app for health care consumers in Rwanda

(49). Babylon Health was started by the UK private health care entrepreneur Ali Parsa in 2013 and has since grown to provide self-diagnosis and general practitioner remote consultation services to patients in the United Kingdom funded by the National Health Service (66). The service has been controversial and disruptive to the general practice sector in the United Kingdom, and concern has been expressed about the security and privacy of the health care data it collects (36). In 2021, Babylon Health will list on the NASDAQ stock exchange (by merging with an existing NASDAQ-listed company) with a market value of US$4.2 billion (15). Much of the excitement around Babylon Health has been the development of an artificial intelligence (AI)-based diagnosis service, whereby consumers can self-diagnose by entering symptoms into a mobile phone app. The potential for such a service is self-evident, especially for communities that have been underserved by existing health care systems (41). Once developed, AI algorithms and apps can scale with almost no marginal cost, in stark contrast to the funding needed to sustainably increase the numbers of nurses, doctors, and allied health professionals. However, many consultations using symptom checker apps result in a recommendation to consult with a health care professional. If the consultation is done through the app, this process may still represent a saving in time and cost for patients (who will not need to travel to the appointment), and a private call-center nurse consultation may be cheaper than a government-provided service. However, if more patients than usual are referred to a public health care service owing to their use of the app, the overall costs to the system may end up being higher. Research is needed to assess the overall cost-effectiveness of using symptom-checker apps and remote teleconsultation services, particularly in health care systems with large underserved populations (44). However, middle-class patients and healthy health care consumers are now adopting such apps at scale, and the implications for health care funders are growing.

In India, 1mg provides an extensive range of services, including an online pharmacy and lab testing services directly to consumers (**https://www.1mg.com**). 1mg was founded by Indian entrepreneur and ex-McKinsey consultant Prashant Tandon and has received more than US$220 million of investment from US-based funders, including the Bill and Melinda Gates Foundation, and venture capitalists, such as Maverick Ventures and Sequoia Capital (92). 1mg's business model is to act as a digital marketplace. The 1mg website and smartphone application show the prices of drugs and laboratory services from a wide range of providers (as well as offering the services of its own labs). This practice has allowed consumers to avoid overpaying for generic prescriptions and has increased their access to services. This idea has proven extremely popular with India's growing middle class, and the platform claims to have more than 160 million users. 1mg has recently been acquired by Tata Digital, a subsidiary of the Tata Group, an India-based conglomerate with more than US$109 billion in revenue in 2020, securing its future growth as a core consumer service for the Indian middle class alongside air travel, car ownership, hotels, and the other trappings of middle-class life to which Tata provides access (66). The growth of digital health care marketplaces, AI-based self-diagnosis apps, and a plethora of new mHealth apps that replace or transform traditional health care services raises important questions about how and by whom health care services should be provided in the future.

In addition to new entrants such as 1mg and Babyl, mHealth platforms from Google (Android) and Apple (iOS) will likely become an important part of the mHealth landscape in LMICs over time. The Apple Watch and HealthKit developer platform has gradually increased user numbers over the last few years and now includes a wide range of health and fitness tools. The Apple Health app uses the Fast Health Interoperability Resources (FHIR) application programming interface to allow Apple users to view their electronic health record (EHR) information. Google has also been working to develop FHIR-compatible apps and has recently announced the Android FHIR software development kit (SDK) that enables software developers to use the FHIR standard to

develop mHealth apps (**https://github.com/google/android-fhir**). As more LMIC health care organizations adopt standards-based EHR systems, the use case for mHealth apps that integrate EHR data with self-monitoring features is strengthened (45).

Mobile and digital health are no longer the newcomers in the health sector but instead an established, if still adjusting, entity within the constraints of government-led health systems. Much has been achieved that provides both promise and some warning for the future of health delivery that relies on private-sector investment in health. The examples of 1mg and Babylon Health are testament to the scalability of private-sector AI-powered health service platforms, but also to the potential for ethical breaches and erosion of trust (28). Broader issues regarding how the health system, as a complex networked structure, integrates the values offered by mobile and digital health are still not well understood. As academics wrestle with whether mHealth has reduced (or inadvertently exacerbated) inequities in access to health resources, the very drive to innovate and grow new markets continues. More needs to be done to ensure that, in the haste to respond to consumer needs and wants, intrinsic values that underpin the right to affordable, accessible, appropriate, and quality health services remain the ethical benchmark for future advancements. The sharing of mobile data has emerged as a complex issue with the dawn of the COVID-19 pandemic; tracer apps are being widely used as tools for monitoring social mobility and contact tracing (55). As mobile phones become a source of public surveillance, with direct and immediate implications for health security, there is increasing pressure on telecommunications, mobile network operators, and governments to join forces. The importance of the simple mobile phone as a source of data for real-time consumer behavior for public health planning and crisis response cannot be underestimated or, importantly, under-resourced. Regulations are going to be necessary to promote the ethical use of mobile phone data while utilizing its currency in response to public health crises in the future (50, 62).

4. CONCLUSION

We are undoubtedly in the wake of one of the most vociferous shifts in health care but one where the benefits are likely to reach primarily the middle and higher socioeconomic groups unless we deliberately focus our efforts on LMICs. As mobile phones are ubiquitous, portable, reliable, and increasingly accessible, there is great promise and potential for them to influence the democratization of health. However, mHealth also relies on the broader, costly infrastructure of health systems, technology, and industry to come together to add real, long-term value. We need to start working on this effort now, with a view to a more future-focused, technology-enabled health system for LMICs.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Grace Shaw and Abbey Lissaman in the preparation of the manuscript.

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