Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Apr 05; 10(F):437-443.
https://doi.org/10.3889/oamjms.2022.8323
eISSN: 1857-9655
**Category:** *F - Review Articles*
**Section:** *Narrative Review Article*

# How Can Mobile Health Technology Improve Usage and Delivery of the COVID-19 Vaccine in Low- and Middle-Income Countries?

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**Edited by:** Eli Djulejic
**Citation:** Elsebaie EH, Fathy MA, Khalifa AK, El-Deen MOS, Alnagdy MA, Elsaidy ST, Fouda AM, Morques KHA, Shehata NM, Salem MR. How Can Mobile Health Technology Improve Usage and Delivery of the COVID-19 Vaccine in Low- and Middle-Income Countries? Open Access Maced J Med Sci. 2022 Apr 05; 10(F):437-443. https://doi.org/10.3889/oamjms.2022.8323
**Keywords:** mHealth, Mobile health; Mobile phone; Coverage; Usage; Delivery; Vaccination; COVID-19
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**Received**: 19-Dec-2021
**Revised:** 16-Jan-2022
**Accepted:** 26-Mar-2022

**Funding:** This research did not receive any financial support
**Competing Interest:** The authors have declared that no competing interests exists


**Abstract**

**BACKGROUND:** Mobile health projects have been implemented worldwide, using mobile phones for record keeping, data collection, or patient communication. Further, mobile health tools have been used to promote behavior change in health workers and/or patients. For example, text message reminders have been shown to increase health-care-seeking behavior or medication adherence in some patients, and mobile data collection and communication tools for health workers have improved follow-up of patients and data reporting.

**METHODS:** This literature review was conducted through a keyword search of the following databases to identify relevant peer-reviewed articles: Google Scholar, PubMed, Embase, and EKB. Keywords used in these searches included mHealth, mobile health, mobile phone, coverage, usage, delivery, vaccination, immunization, and COVID-19.

**RESULTS:** Eleven studies that satisfied the inclusion criteria were included. They examined awareness, applications, challenges, and strengths of Mobile-Health applications. All studies showed some evidence that mHealth intervention had a positive impact on increasing the coverage and use of the COVID-19 vaccine. Bad awareness of people was strongly associated with declines in vaccination intent. The use of mobile applications has made a great revolution in tracking and data gathering about vaccination status. The main limitations were reporting bias and malfunctioning of mobile applications. The main strengths were getting real-time data, improving surveillance, using geographic mapping to monitor populations.

**CONCLUSION:** Growing usage of smartphones and Internet penetration in African countries opens the door to mHealth applications such as health literacy, vaccine supply and control, disease monitoring and intervention, and virtual consultations with health professionals worldwide.

## Introduction

In the recent era of the COVID-19 pandemic, the need for more social distancing and to get the work done without further human presence is highly crucial to eliminate the viral load and, thus, the rate of infection in crowded places in every country globally [1]. Furthermore, the fight against COVID-19 has seen vaccine development moving at a fast pace, with more than 170 different vaccines in trials by November 2020 [2]. While the rollout of the COVID-19 vaccine has implied the first evidence of success, the reality is that this public health emergency is still far from over. Although more than 100 million people worldwide have been vaccinated, several new variants of the virus have emerged in South Africa, Brazil, and the United Kingdom that are more contagious, lethal, and resistant to the original COVID-19 vaccine strains [3]. Moreover, the Low-and Middle-income Countries ("LMIC") are dealing with an already existing immunization crisis, whereby millions of people are exposed to vaccine-preventable diseases such as measles, whooping cough, flu, and polio [2].

Thus, enhancing the speed and efficiency of the vaccine rollout is now even more essential to the global health community's fight to restrain the pandemic. There is a need to monitor individuals' performance and health to report any possible adverse reactions that may happen from the vaccine [4], together with monitoring vital signs, body reactions, and the second booster dose administration. During the COVID-19 pandemic, many cases were treated remotely by physicians from their homes, “Home isolation,” and that helped greatly in decreasing the consistent exposure between doctors, the mild to moderate symptomatic patients, and decreasing the rate of infection in many places, as well as decreasing the hospital burden to encompass the severe cases that needed hospital admission. All of these were done with mobile applications on both Android and IOS systems [5].

However, a combination of operational challenges, supply chain gaps, inconsistent access, the lack of reliable vaccine-related data and patient records at the administration level, as well as the difficulty of serving remote communities, has significantly slowed the velocity of the rollout everywhere from the United States and Europe to developing countries [2], [3].

Advanced technology, especially in the field of Mobile Health “mHealth,” has been proposed as a potential solution to many of the challenges that developing countries face, including workforce shortages, lack of health information, limited training for health workers, and difficulty tracking patients. Mobile health projects have been implemented all over the world, using mobile phones for record keeping, data collection, or patient communication [6]. Further, mobile health tools have been used to promote behavior change in health workers and/or patients. For example, text message reminders have been shown to increase health-care-seeking behavior or medication adherence in some patients, and mobile data collection and communication tools for health workers have improved follow-up of patients and data reporting [7], [8], [9].

## Study and design

### Information sources

This literature review was conducted through a keyword search of the following databases to identify relevant peer-reviewed articles: Google Scholar, PubMed, Embase, and EKB. Keywords used in these searches included mHealth, mobile health, mobile phone, coverage, usage, delivery, vaccination, immunization, and COVID-19.

### Inclusion criteria

To be included in the review, the article had to meet the following inclusion criteria:

1. Evaluating an mHealth intervention targeted at increasing vaccination rates for COVID-19
2. Implemented in a low- or middle-income country LMIC
3. Included measurement of process, health, or quality-of-care outcomes
4. Included exploratory studies
5. A peer-reviewed article
6. Available in English
7. Published between January 1, 2020, and present.

These criteria were selected to ensure that the included studies will examine outcomes of mHealth interventions on vaccination coverage. Low-, middle-, or high-income status for countries was determined using the World Bank’s 2014 classification, which is based on estimates of the gross national income per capita for the previous year [10]. In addition, the inclusion of only peer-reviewed articles helped to ensure that higher-quality studies were examined. The review was limited to studies available in English, though this is a limitation of this review, and future reviews should include additional languages, if feasible. Finally, studies only included those that were published after 2020, as COVID-19 did not exist before that time.

### Study selection and data collection

The database searches were undertaken by two researchers (Author 1 and Author 2) between March 10, 2021, and April 10, 2021. Subsequent review of the results was undertaken by one researcher (Author 1). The resulting articles were first screened by title, then by abstract, and finally by full text to progressively eliminate articles not meeting the inclusion criteria. Two systematic reviews of mHealth research were identified in the results, so the included articles and reference lists of these reviews were all examined to ensure a systematic search. Finally, the references of all included articles were reviewed as well. The database searches identified 47 articles initially. After removing duplicates, 32 records remained. Each of these records was screened by title and abstract (if necessary), and 10 records were excluded after this preliminary review. The full text of the remaining 22 articles was reviewed to determine if they met the inclusion criteria. Eleven of the articles were excluded, and the reasons for exclusion included: Eight studies being conducted in a high-income country and three studies not studying an mHealth intervention. The other 11 articles that were excluded were mHealth literature reviews that did not identify any new articles for review.

### Synthesis of results

The primary author extracted information from included articles for tabulation in an Excel spreadsheet. The information extracted included type of study, summary conclusions, methods used, intervention studied, health issue(s) studied, outcomes measured, sample size, intervention frequency, effectiveness of intervention, study location, clinical characteristics/setting, mHealth tools used, and project name (if any).

## Results

Most articles examined awareness, applications, challenges, and strengths of Mobile-Health applications and gave recommendations for future mHealth programs and suggested further research. The characteristics and key outcomes of each included study are listed in (Table 1).

### *Characteristics of the studies*

In total, 11 studies satisfied the inclusion criteria. Of these, 2 were review articles of 150 studies on the application of digital technologies in the public-health and 10 studies on the usage of telemedicine in Africa. About 45.4% of the articles were on the applications of mHealth; 36.3% articles were on the challenges facing mHealth studied, 18% studied disadvantages and 17.6% sent educational messages to patients using SMS. The frequency of these interventions varied widely; educational messages were sent on schedules ranging from daily to twice per week. Some studies specified that appointment reminders were sent frequently, and others did not specify.

Forty-five percent of the studies were conducted in the USA, 36.3%were conducted in the

**Table 1: Characteristics and key outcomes of the included studies**

| First author and year | Title | Study location | Sample size | Subtitles | Methods used (intervention or tools) | Duration of the study | Study outcomes |
|---|---|---|---|---|---|---|---|
| Loomba *et al*., 2021 | Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA | USA and UK | 8001 | Disadvantage of using mHealth in spreading misinformation about COVID 19 vaccine | Online survey | - | That scientific-sounding misinformation is more strongly associated with declines in vaccination intent |
| Hassounah, M.(2020) | Digital Response During the COVID-19 Pandemic in Saudi Arabia | Saudi Arabia | - | Application of mobile technology | - | - | Digital response to COVID 19 will continue using established electronic learning infrastructure with a promising direction toward wider adoption in the future |
| Okereke, M. (2021) | Applications of telemedicine in the supply and distribution of COVID-19 vaccines in Africa | Africa | 10 articles | Challenges of (telemedicine in Africa) | - | - | Although telemedicine cannot directly replace the traditional physical vaccination process, it can facilitate access in hard-to-reach areas and monitor the supply and distribution of COVID-19 vaccine to the end-users |
| Jadidi, M. 2021 | A two-step vaccination technique to limit COVID-19 spread using mobile data | Iran | 242 | Applications | It was a simulation to test a system that can be used for target vaccination | - | 1% of infected people lead to spread of the infection in case of random vaccination while, the immediately and organized vaccination lead to decrease the rate of the infection by 30% |
| Prescott, G. 2021 | HIT utilization and impact on COVID-19 vaccination | USA | - | Challenges | - | - | The importance of development of an approach to allocate the COVID-19 vaccine and its delivery to individuals at high risk of infection |
| Eisenstadt, M. 2020 | COVID-19 Antibody Test/ Vaccination Certification: There's an App for That | UK | - | Application of mobile technology in (Design of Antibody Test/ Vaccination Certificate) | - | - | Design of antibody test/vaccination certificate app which is both secure and private |
| Budd, J. 2020 | Digital technologies in the public-health response to COVID-19 | UK, Korea, Singapore | 150 review article | Disadvantages | - | - | The COVID-19 pandemic has confirmed not only the need for data sharing but also the need for rigorous evaluation and ethical frameworks with community participation to evolve alongside the emerging field of mobile and digital healthcare. Building public trust through strong communication strategies across all digital channels and demonstrating a commitment to proportionate privacy are imperative147 |
| Mondal, A. 2021 | The importance of community engagement on COVID-19 vaccination strategy: Lessons from two California pilot programs | USA (San Francisco, California) | 15,094 | Challenges | - | - | Community involvement and designing multilingual, youth-focused programs will be contributed in fighting disparities in communities healthcare system which will help in reaching the vaccination targets |
| Kuhn, R. 2021 | COVID-19 vaccine access and attitudes among people experiencing homelessness from pilot mobile phone survey in Los Angeles, CA | USA | 125 | Challenges in vaccine hesitancy | Online survey | Monthly for 3 months | The need for targeted educational and social influenced interventions to increase vaccine acceptance among vulnerable groups |
| Gold, M. S. 2021 | Efficacy of m-Health for the detection of adverse events following immunization – The STARSS randomised control trial | Australia | 6338 | Application of mobile technology (SMS) in surveillance | Sending SMS to evaluate its efficacy and acceptability in measuring of AEFI surveillance | 14 days | Wider use of SMS-based surveillance is particularly relevant at this time since establishing robust and novel pharmacovigilance systems are urgently required to monitor the safety of potential COVID vaccines |
| Teitelman, A, M. 2020 | Vaccipack, A Mobile App to Promote Human Papillomavirus Vaccine Uptake Among Adolescents Aged 11–14 Years: Development and Usability Study | USA | 54 | Application of mobile technology (mobile application) in awareness | - | - | mobile technology, such as mobile application (Vaccipack), may be an acceptable platform for providing information to parents and adolescents and advancing the uptake of important vaccines |

HIT: Health information technology, STARSS: stimulated telephone assisted rapid safety surveillance, AEFI: Adverse events following immunization.

UK, 9% were conducted in Africa, 9% were conducted in Saudi Arabia, 9% were conducted in Iran, 9% were conducted in Asian countries, and 9% were conducted in Australia. All included studies were published from January 1, 2020, to present.

### Findings

All studies showed some evidence that the mHealth intervention implemented had a positive impact on increasing the coverage and use of the COVID-19 vaccine. However, the quality of the studies varied, and some of these outcomes cannot be conclusively attributed to the mHealth intervention that was implemented from these studies alone.

#### *Awareness*

According to a study [11], the widespread acceptance of a vaccine for coronavirus will be the next major step in fighting the COVID-19 pandemic, but achieving high uptake will be a challenge and maybe impeded by online misinformation. Loomba *et al*. conducted a randomized controlled trial in the UK and the USA to quantify how exposure to online misinformation around COVID-19 vaccines affects the intent of vaccination to protect oneself or others. In both countries, fewer people would “definitely” take a vaccine than is likely required for herd immunity, and that, relative to factual information, recent misinformation induced a decline in the intent of 6.2% points (95$^{th}$ percentile interval 3.9–8.5) in the UK and 6.4% points (95$^{th}$ percentile interval 4.0–8.8) in the USA among those who stated that they would definitely accept a vaccine. They also find that some sociodemographic groups are differentially impacted by exposure to misinformation. Finally, they show that scientific-sounding misinformation is more strongly associated with declines in vaccination intent.

#### *Applications*

There has been a noticeable paradigm shift all around the world in the use of telemedicine and mobile technology during the COVID-19 pandemic, either in contact, tracing using mobile applications which depend on mobile Global Positioning System (GPS), WIFI and Bluetooth (Tabaud App-Saudi Arabia, Aarogya Setu App-India, Trace Together App-Singapore, Immuno App-Italy, NHS COVID-19 App-UK, and COVID). Even in post-vaccination follow-up, mobile technology has been used most noticeably by the launching of the CDC V-Safe App, which is a self-reporting App for vaccination side effects [12].

In the era of technology, mobile applications have made a great revolution in tracking and data gathering. Now, these apps are used for surveillance of vaccinated patients looking for adverse effects and collecting data daily and weekly by using surveys about what vaccinated patients feel. The main purpose of these apps is to collect data to report adverse events. The app developers should give feedback to patients to monitor the adverse effects and to feel safe. They should be more widely available for all people to control the spread of the virus [13].

Because of the worldwide spread of the coronavirus, the limitation of resources and the limitation of face-to-face contact, there are new ways to reach a large number of people to provide the knowledge and the way to take the vaccine by giving the location of the nearest medical center. Even with the presence of internet access constraints in African countries, they could use the SMS service to send all data about the location and the date of the vaccination to the patients. These services just assist the health-care system [14].

The main problem facing the spread of vaccination and could lead to the failure of the vaccination process is misinformation on social media. That could be more dangerous than the virus itself and could lead to the spread of COVID-19 around the world, more deaths, and destroy the vaccination campaigns. Thus, policymakers should place restrictions on the misinformation that is published due to its effects on people. They should support campaigns that represent the true information about the vaccine and how it will reduce the spread of the coronavirus by using SMS services and social media using mobile technology [11].

The effective cooperation between the government and the private sector could provide a great opportunity to publish accurate, effective, and true information about vaccination, reporting infections that would lead the community to be secure. Furthermore, to prevent virus spread, how to deal with infectious people and provide critical care. This cooperation is provided in Saudi Arabia through SMS services, social media, and websites. These available infrastructures that are provided by the cooperation between the government and the private sector lead to these significant results [15].

According to a recent study conducted in Iran by Jadidi, M *et al*.,2021. In this study, they used mobile technology to collect the data and used metrics that will lead to the differentiation between random vaccination and organized vaccination, which is a contact tracing network, representing a weighted graph. This provides huge data that is used to measure the outcome of organized vaccination using the available mobile technology. It traces the individuals that are taking vaccines or that are infected and going to the hospital. This provides huge data to control the spread of Corona virus.

This study was conducted on two different populations using combined metrics like degree centrality and connectivity centrality, a combined metric. This uses two methods: vaccine allocation and targeted vaccination.

Vaccine allocation: this method is used to locate individuals who have been vaccinated or infected while the targeted vaccination is a method that selects individuals randomly to trace the efficacy of the two methods of vaccination. And from this data, we measure that 1% of infected people lead to the spread of the infection in the case of random vaccination. On the other hand, immediate and organized vaccination led to a decrease in the rate of infection by 30% [16]. From this study, we know the benefits provided by health information technology and its impact on reducing the spread of the coronavirus using many ways to collect this data. First from telemedicine, second from medical records, and third from websites. This data could help to target the infected patients and organize the way of vaccination by using a walking system to reduce the waiting list of patients. This will have an impact on reducing the rate of infection and vaccination to reduce the spread of the coronavirus [17].

*Challenges or limitations*

Mobile applications and telehealth communications are a double-edged weapon as they encourage people to report, search, and engage in the delivery of the process and information while being a highly subjective process as well [18]. Each user feels very free to report the symptoms, the signs, or information as they like or understand, and that carries a lot of false data sometimes that may oppose the mass vaccination strategy that countries should be carrying out these days [19].

Though the presence of some disadvantages in the way of mobile applications, like reporting bias, malfunctioning, and late or hard development, it carries a lot of advantages which make it the best modern way to reach everyone through spreading awareness of the importance of valid, accurate data [20] (Kuhn *et al*., 2021). It also reaches anyone at any time in any place, making the data emerging from it highly vast and affirmative to help health-care providers and policymakers know the right numbers and provide the best care they can provide [21] (Gold *et al*., 2021).

*Strengths*

As mobile technology becomes more widely available, its application in m-Health to improve immunization campaigns has expanded as well. Authorities employ M-Health to collect real-time data, improve surveillance using geographic mapping, and monitor populations using cellular phone data [1]. Furthermore, text messaging-based M-Health is effective in modifying HPV vaccination behavior among high-risk populations for cervical cancer in the United States. M-Health has also been used to aid in the acceptance of vaccines and the development of confidence in them. In addition, text messaging-based M-Health was found to be successful in changing behavior toward HPV vaccination among the high-risk population for cervical cancer in the United States, The M-Screening intervention improved HPV vaccine awareness, intent to obtain, and reception significantly. This strategy, which has been shown to reduce the burden of human papillomavirus and cervical cancer in the United States [2], may also hold promise for the ongoing COVID-19 mass vaccination campaign in Africa.

## Discussion

Wide coverage of COVID-19 vaccine in LMIC is fundamental to decrease viral spread. Our literature review was conducted to determine if mobile health technology improves the usage and delivery of COVID-19 vaccination in LMIC. In 2013 a meta-analysis study was conducted in Africa. Information was obtained through a network of active telemedicine practitioners in different African countries using internet communication through E-mail, and available data using internet source. In this study, it was inferred that embracing telemedicine could be a milestone in improving health-care services and making better usage of the available resources in both urban population and rural one. In 2014, 2016 and 2017 there was extensive efforts to study the feasibility and efficacy of mobile health technology in increasing the public awareness towards vaccination [22].

Tablets, unique barcodes and GPS were used to map the community coverage in a reactive oral cholera vaccine campaign in rural Haiti, April–June 2012. Researchers concluded that the usage of M-health is strongly considered in future mass vaccination campaigns.

In 2016, M-Health pilot study was performed using A 7-day text message HPV intervention was developed using a quasi-experimental research design for 30 Korean-American women. Concluded results that M-Health significantly increased the knowledge of HPV with an intent to get vaccinated within one year, and 30% of participants received the first dose of the HPV vaccine [23].

Appointment reminders, mobile phone apps, and prerecorded messages were proven effective in improving vaccination uptake in the 2017 systemic review of ten peer-reviewed studies and 11 studies from white or gray literature. Nine took place in India, three in Pakistan, two each in Malawi and Nigeria, and one each in Bangladesh, Zambia, Zimbabwe, and Kenya.

Late in 2019 was the emerge of the COVID-19 pandemic as a novel virus and rose with it the need for timely and reliable information. Many worldwide countries, implemented lockdown of most public and private services in response to the pandemic and established population movement restrictions nationwide. With the implementation of these strict mitigation regulations, technology and digital solutions have enabled the provision of essential services [24].

On March 3, 2020, the first case of COVID-19 in Saudi Arabia was confirmed, which triggered the developing and launching approximately 19 mobile applications and platforms that serve public health functions and provide health-care services [25].

Mobile health technology usage and delivery of COVID-19 vaccine literature review aiming to determine the effectiveness of Mobile Health tools to increase the coverage and use of COVID-19 vaccine, results showed that countries using Mobile health technology achieve a great results in monitoring, collecting data, patients following up and delivering the correct information about COVID-19 vaccines especially and generally on health issues, and even there are many challenges and disadvantages on using the mobile technology such as malfunctioning and bias reporting, but despite this concerns, mobile technology participate in increasing awareness and increasing people's confidence in the vaccination process starting from vaccine registration, booking vaccination appointment, receiving and finally the vaccine following up process.

The availability of strong mobile technology services in UK and USA promoted advancing with the vaccination process investigating misinformation, reporting of side effects and following Post-COVID vaccination [11]. While in LMIC especially, in African countries, they are facing a great challenge in using mobile technology in the vaccination process, especially with the low availability of internet services pushing them to use SMS services in complying with health services needed and delivering required information about vaccination process [16]. Meanwhile delivering an accurate information about vaccines, prevention and treatment of diseases, especially during pandemics is of great importance as misinformation may lead to dangerous problems [11] than the disease causing, which must be supported by policymakers' decisions in implementing a powerful mobile system using all available communicating techniques. As the case seen in Saudi Arabia, where governmental and private sectors are cooperating to ensure delivering the correct information in the right time to the right person through using websites, SMS services and also social media [12].

Furthermore, mobile technology allowed to improve data collection methods, data follow-up and make the process more organized; for example, vaccinated people or infected people are better-controlling virus spread and decreasing the virus infection rate as happened in Iran, allowing more ease of targeting infected people and control the infection cycle [15], [17]. Furthermore, the results comply with using mobile in the United States to increase the acceptance and changing behaviors of participants toward the vaccine [2].

Previous experience in dealing with pandemics, well-educated people and also the low number of populations show a great impact to use mobile technology as in KSA who, has the experience in dealing with Severe acute respiratory syndrome helped them to implement a powerful mobile system during dealing with COVID pandemic, this also seen in UK and USA who have the required knowledge and capabilities to implement the vaccination process in their already existed Mobile health system while this not found in (LMIC) with their low educations status, poor families income and huge population increasing year after year.

In Egypt, with a lot of information is available online, especially on social media outlets. This information was mostly misleading and powered by panic. The Egyptian Health Ministry was a source of reliable information for both the public and health-care workers, through their website [26] and different verified social media platforms [27]. The ministry of health assigned a hotline number (105) for public information and reporting suspected symptoms, which had a great impact on decreasing the total daily ER and clinic visits from concerned individuals just looking for information. Tele-health in the form of FB posts, SMS messages and different online posts was very useful in educating the public about the importance of social distance and health precautions to limit the spread of the virus.

In 2021, when the COVID-19 vaccines became available The Egyptian health ministry launched a new registration website [28] for all citizens and residents in Egypt to register for the vaccine, on which a detailed consent form is posted explaining all the knowledge available for the vaccine and a stepwise process of how to get vaccinated by using ID number or passport number. Which made the process simple enough and more organized to keep track of the number of people vaccinated in Egypt every day.

SMS messages are sent to the registered individuals directing them to the approved vaccination centered on specific date, to avoid overcrowding and limiting the possible spread of the virus keeping with the recommended health precautions. Another assigned hotline for vaccination information and rescheduling vaccinations appointments was 15335.

## Conclusion

Growing usage of smartphones and internet penetration in African countries opens the door to mHealth applications such as health literacy, vaccine supply and control, disease monitoring and intervention, and virtual consultations with health professionals around the world.

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