Journal of Multidisciplinary Healthcare

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REVIEW

A Review of Mobile Applications Available in the App and Google Play Stores Used During the COVID-19 Outbreak

This article was published in the following Dove Press journal:
Journal of Multidisciplinary Healthcare

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Purpose: The objective of this paper was to review the functionalities and effectiveness of the free mobile health applications available in the Google Play and App stores used in Saudi Arabia, Italy, Singapore, the United Kingdom, USA, and India during the COVID-19 outbreak.

Methods: This study adopted a systematic search strategy to identify the free mobile applications available in the App and Google Play stores related to the COVID-19 outbreak. According to the PRISMA flowchart of the search, only 12 applications met the inclusion criterion.

Results: The 12 mobile applications that met the inclusion criterion were: Mawid, Tabaud, Tawakkalna, Sehha, Aarogya setu, TraceTogether, COVID safe, Immuni, COVID symptom study, COVID watch, NHS COVID-19, and PathCheck. The following features and functionalities of the apps were described: app overview (price, ratings, android, iOS, developer/owner, country, status), health tools (user status-risk assessment, self-assessment, E-pass integration, test results reporting, online consultation, contact tracing), learning options (personalized notes, educational resources, COVID-19 information), communication tools (query resolution, appointments, social network, notifications), app design (data visualization, program plan), networking tools (location mapping – GPS, connectivity with other devices), and safety and security options (alerts, data protection). Also, the effectiveness of the apps was analyzed.

Conclusion: The analysis revealed that various applications have been developed for different functions like contact tracing, awareness building, appointment booking, online consultation, etc. However, only a few applications have integrated various functions and features such as self-assessment, consultation, support and access to information. Also, most of the apps are focused on contact tracing, while very few are dedicated to raising awareness and sharing information about the COVID-19 pandemic. Likewise, the majority of applications rely on GPS and Bluetooth technologies for relevant functions. No apps were identified that had built-in social media features. It is suggested to design and develop an integrated mobile health application with most of the features and functionalities analyzed in this study.

Keywords: COVID-19, pandemic, healthcare, m-health, e-health, mobile applications, virtual care, telehealth

Introduction

Since its outbreak in December 2019, the number of COVID-19 cases has been rapidly increasing across the world. As of 21st August 2020, there were more than 226 million of confirmed cases worldwide, including more than 7.9 million deaths.[1]

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http://doi.org/10.2147/JMDH.S285014

The most affected countries were the USA (55 million cases), Brazil (35 million cases), India (29 million cases), the UK (3 million cases), Saudi Arabia (3 million cases), and Italy (2.5 million cases). [1] However, the recovery rates differ significantly across the countries due to various factors such as health interventions, effective planning and methods for managing the outbreak.[2] The COVID-19 outbreak has severely impacted various industries, being the healthcare industry one of the most affected. It faces a severe burden with the allocation of resources, delivering services and containing the spread of the COVID-19 virus.[3–5] In order to minimize the impact of COVID-19 on the healthcare industry, improve the delivery of healthcare services, and facilitate the process of returning to normal life, countries are developing various strategies.

Adopting health interventions using innovative technologies such as mobile health applications integrated with Bluetooth, global positioning system (GPS), artificial intelligence (AI), and machine learning (ML) techniques can significantly improve the delivery of healthcare services remotely while following preventive measures such as social distancing and home quarantine.[6–8] Likewise, telemedicine, virtual software, and virtual care are useful tools of information and communication technologies (ICT) for the remote treatment of COVID-19 patients.[9–11] These digital technologies are universal in scope and minimize the exposure of patients and physicians to the COVID-19 virus. In this regard, the global penetration of ICT around the world related to the smartphone area in 2019 was 3.2 billion users, and it is projected to reach 3.8 billion in 2021.[12]

Consequently, various countries have developed mobile health applications to improve the delivery of healthcare services to contain the spread of the novel coronavirus during the COVID-19 pandemic.[13–21] It is pertinent to point out that in general several of these studies are related to the present investigation. For example, one study indicated that more than 2 million of participants used a free smartphone-based app to report potential symptoms of COVID-19 in the United Kingdom and the USA.[13] Another study used the COVID-19 Symptom Tracker mobile application to collect data on symptoms, risk factors, and clinical outcomes of the COVID-19 pandemic in the United Kingdom and in the USA.[14] Alike, a literature review identified the COVID-19 apps accessible in Canadian application stores at the start of the pandemic.[15] Also, the apps on COVID-19 launched between April 18 and May 5, 2020 in the USA were examined by Ming et al.[20] Likewise, a study investigated the COVID-19 apps used in India.[19] Furthermore, Davalbhakta et al conducted a literature review to detect the COVID-19 apps used in the United States, United Kingdom, and India.[16] Another study identified the COVID-19 applications developed in UK, India, Brazil, Canada, France, Bangladesh, UK, Australia, Spain, Greece, and Vietnam.[17] In a similar way, Singh et al observed the COVID-19 applications utilized in China, Germany, France, Italy, the United Kingdom, Iran, Russia, Spain, the United States, and Turkey.[18] Besides, Rawan et al inspected the use of mobile phone applications for contact tracing during the COVID-19 pandemic in the following 15 countries: Australia, Bahrain, China, Czech Republic, Ghana, Hungary, Iceland, India, Israel, Malaysia, New Zealand, Norway, Saudi Arabia and Singapore.[21]

On the other hand, as the world is grappling with the COVID-19 virus, its increasing strains and mutation capabilities are leading to new challenges for governments and research communities. In this regard, the number of patients worldwide is increasing with the second wave of the COVID-19 outbreak and many countries are re-implementing closures and curfews to prevent transmission. In addition, non-adherence to social distancing regulations, security and privacy concerns, the high level of asymptomatic cases, etc., suggest that COVID19 mobile applications should be integrated with new features, which are not only focused on the management of COVID-19, but also in providing information on health services such as diagnosis, consultation, treatment, norms, regulations, and so on. These apps can be effective in raising awareness of preventive strategies like social distancing, hand washing, and in storing information on health-related issues and contact tracing.[21,22]

It is pertinent to mention that most of the studies focused on the goals and approaches of developing mobile applications, quality, and technology advances were conducted in the early days of the COVID-19 pandemic.[15,16,20,22,23] As there is a rapid progression in the nature of the pandemic, with new symptoms and cases, and new emerging technologies, there is a need for a worldwide regular review of mobile applications. Although there are studies focused on the analysis of the features and functionalities, their evaluations are restricted to the general features of the apps such as usability and ease of use, but did not include COVID-19 specific functionalities and features.[17,18] In general, there is a limited research evaluating the mobile applications used for the COVID-19 outbreak.[15,17]

Therefore, to address these gaps it is necessary to review and evaluate the various features, functionalities, and effectiveness of these mobile applications on the light of the COVID-19 new challenges. Concerning this issue, the findings of this paper may have positive implications for medical practitioners, application developers, social communities, scientific institutions, and technological organizations. A comprehensive review of various COVID-19 related mobile applications can help app developers understand the drawbacks of current applications, and also help integrate various functionalities and innovative technologies to develop future apps. Similarly, medical practitioners can also review various applications, and suggest the most effective app for the patients, enabling them to better control their health and adopt COVID-19 mitigation strategies by increasing awareness through mobile applications. By referring the effective application, healthcare operations such as diagnosis, consultation can be managed online, which not only saves time and money, but also helps prevent the COVID-19 transmission by reducing travel.

In this sense, the main objective of this paper was to review the functionalities and effectiveness of the most common free mobile health applications available in the Google Play and App stores used in Saudi Arabia, Italy, Singapore, the United Kingdom, USA, and India during the COVID-19 outbreak.

Methods

Identification of Mobile Applications

This study adopted a systematic search strategy to identify the free mobile applications related to the COVID-19 outbreak available in the App and Google Play stores. Keywords such as COVID, track, trace, COVID safe, appointments, and COVID information were used in this search. The search was conducted in August 2020.

Inclusion and Exclusion Criteria

The following inclusion criterion was used to choose the applications accessible in the mentioned stores: 1) the applications had to be free of cost and had to be launched and updated during the COVID-19 outbreak for the management of COVID-19; 2) the applications had to be launched and supported by the governments of the selected countries; 3) to simplify the search, seven countries were chosen where the number of patients of COVID-19 ranged from high (India and the USA) to medium (Saudi Arabia, Italy, and the UK) and low (Singapore and Australia). The applications that did not meet these requirements were excluded.

Research Question

The research question was:

What are the functionalities and effectiveness of the most common free mobile health applications available in the Google Play and App stores used in Saudi Arabia, Italy, Singapore, the United Kingdom, USA, and India during the COVID-19 outbreak?

Description of the Search

Figure 1 describes the PRISMA flowchart of the systematic search. This figure suggests that 141 applications met the search keywords. Then, the initial search identified 26 potential applications that could be considered in this study. After applying the inclusion and exclusion criteria, it was observed that only 12 applications met the inclusion criterion. The applications that met the inclusion criterion were analyzed and their features and functions were evaluated from the following perspectives.

First, general information related to the applications including price, ratings, platform (Android/iOS), country and status (in use/stopped) was collected.

Second, the purposes of the applications and the services they offered were considered.[24–26] These features included "User Status (risk assessment)": this option indicates whether the user was safe or suspected of being infected; 'Self-Assessment': an option for the user to self-assess the risk of contamination by answering the predesigned questions in the application; 'Test Results Reporting': an option to submit the test results to the relevant authorities; 'Online Consultation': and option to provide e-consultation for COVID support and treatment, and also for other conditions/diseases; 'Contact Tracing': an option to track and trace the user's movement to identify whether they have been in close contact with infected persons/contaminated zones.

Third, the learnability function was analyzed.[27,28] This function includes 'personalized notes': an option for making personal notes on health conditions; 'Education resources': this is an option to access to health educational resources; "COVID-19 information": an option to access to COVID-19 information such as support, point of contact, preventive measures, number of cases in different locations, etc.

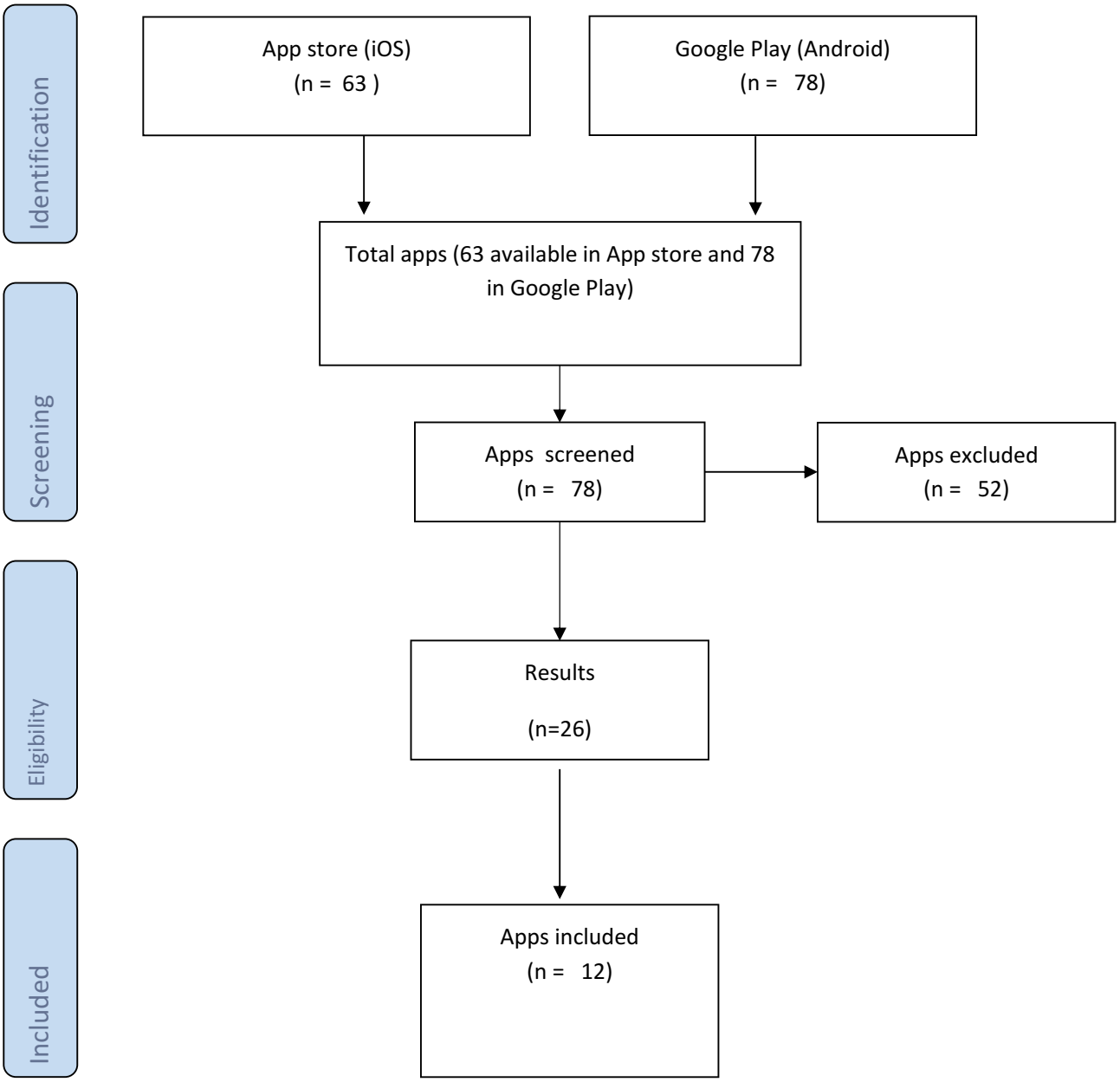

Figure 1 PRISMA flowchart of the search process.

Fourth, the communication strategies were analyzed. These strategies include the following functions: "Query resolution": clearing the doubts and issues of the citizens by answering their queries; "Appointments": enable citizens to book appointments in hospitals through apps; "Social Networking": enable users to share their details and status using social networking apps; and "Notifications": allow users to receive notifications about app updates, medicine reminders, news and any updates related to COVID-19.

Fifth, the app design features were examined. These features included the options: "Data Visualization": this option permits to do a graphical representation of the data; and "ProgramPlan": an option for a pre-defined plan of treatment or preventive procedure which can be followed and tracked by users.

Sixth, networking technologies included in the apps such as GPS location tracking, Bluetooth and WiFi technologies were analyzed.[29]

Finally, the safety and security features of the apps were investigated.[26,30] These features included: "Alerts": this function alert users about any risk or contamination; "Data Protection": indicates the level of risk associated

with the user's data, identified as high, medium and low levels depending on the data protection policies relevant to different applications. Data Protection: indicates the level of risk associated with the user's data, identified as high, medium and low levels depending on the data protection policies relevant to different applications. High-risk category includes the threat to personal data such as passwords, bank information, email content, other accounts data, biometrics, location tracking, personal chats, and so on; medium risk category includes threat to data such as browser history, frequency of texts or calls, device ID, names of Wi-Fi connected devices, calendar information, etc.; and low-risk category includes threat to normal data such as education data, bookmarks, call duration, internet connectivity, duration of exercise, and so forth.

Results

Features and Functionalities of the Mobile Applications

Table 1 shows the features and functionalities of the 12 mobile applications that met the inclusion criterion: Mawid, Tabaud, Tawakkalna, Sehha, Aarogya setu, TraceTogether, COVID safe, Immuni, COVID symptom study, COVID watch, NHS COVID-19, and PathCheck. The table describes the following features of the apps: app overview (price, ratings, android, iOS, developer/owner, country, status), health tools (user status-risk assessment, self-assessment, E-pass integration, test results reporting, online consultation, contact tracing), learning options (personalised notes, educational resources, COVID-19 information), communication tools (query resolution, appointments, social network, notifications), app design (data visualisation, program plan), networking tools (location mapping-GPS, connectivity with other devices), and safety and security options (alerts, data protection).

Description of the Applications

Mawid App

The Mawid application is a central appointment system provided by the Ministry of Health, Saudi Arabia. The application can be used by patients to book, change and reschedule their appointments, and also for managing their referral appointments, across 2400 primary care centres in Saudi Arabia. Using the GPS and the maps feature enabled in the application, patients can view the primary care centres nearest to their location. They can select any primary care centre and book appointments at their convenience. The application also alerts the user if an earlier slot for an appointment is available, which can help patients if they require an early appointment.[30] The application is enabled with the self-assessment feature for COVID-19, and it offers a consultation window to the public. Patients need to enter information such as their travel history and symptoms, and answer other relevant questions in the application for the self-assessment test. At its launch in May 2019, the application was integrated in 98% of hospitals and primary care centres, and linked to more than 6.5 million registered users.[31] The application has provided consultation services for more than half a million people and more than 250,000 self-assessment tests have been recorded since the COVID-19 outbreak in Saudi Arabia.[32,33] Although initially developed as part of a promotion of digital health, the Mawid application has been very effective in delivering healthcare services during the COVID-19 outbreak.

Tabaud App

In relation to the Tabaud application, it was developed to achieve health and safety goals by controlling the COVID-19 outbreak and limiting the spread of novel coronavirus, in order to ease the restrictions on social and business activities in Saudi Arabia.[34] The application is mainly designed for contact tracing, as it notifies users when they come into close contact with other registered infected persons using the same application. This application uses Google Apple API for contact tracing, which strictly protects the privacy and security of the users. Accordingly, the application does not use location mapping, but it relies on Bluetooth technology for detecting any nearby smartphones using the same application. If a user updates their status in the application as infected, this information is then sent to the Ministry of Health for confirmation. If the information is confirmed by the ministry, then all smartphone users with the Tabaud application who have been close to the infected person during the 14-day period prior to the infection will receive a notification to take the necessary precautions.[34] In addition, the application also analyses how close other smartphones were to the infected person, which helps to analyse vulnerability and the risk of contamination. In addition, it allows users to identify their risk of infection. However, the identity of the persons is hidden and anonymity is maintained by transferring the disguised identifier data of the person during communication with other smartphone applications, thus adopting stringent privacy policies. Over 15,000 positive cases have been reported by patients through the application

Table 1 Features and Functionalities of Mobile Applications Related to the COVID-19 Pandemic

Feature Type	Features	Mawid	Tabaud	Tawakkalna	Sehha	Aarogya Setu	TraceTogether	COVID Safe	Immuni	COVID Symptom Study	NHS COVID-19	COVID Watch	PathCheck SafePlaces
App Overview	Price	Free	Free	Free	Free	Free	Free	Free	Free	Free	Free	Free	Free
	Rating: Android (No. of Ratings)/iOS (No. of Ratings)	4.5 (80,440)/ 4.5 (8200)	4.3 (7074)/ 4.5 (323)	4.6 (51,611)/ 4.0 (2200)	4.1 (5425)/ 4.3 (492)	4.4 (1.4 million)/ 4.5 (3100)	3.7 (11,065)/2.7 (33)	2.8 (13,696)/ 4.1 (12,100)	2.6 (41,612)/ 3.8 (49)	4.7 (128,037)/4.7 (17,000)	4.0 (89,977)/ 4.7 (707)	4.1 (31)/4.3 (57)	4.1 (74)/4.5 (55)
	Android	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	iOS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Developer/Owner	Ministry of Health	Ministry of Health	Ministry of Health	Ministry of Health	National Informatics Centre	Government Technology Agency	Australian Department of Health	Ministero della Salute	Zoe Global Limited & Kings College	NHS England	Arizona Department of Health Services	PathCheck, Inc.
	Country	Saudi Arabia	Saudi Arabia	Saudi Arabia	Saudi Arabia	India	Singapore	Australia	Italy	UK	UK	USA	USA
	Status	In use	In use	In use	In use	In use	In use	In use	In use	In use	In use	In use	In use
Health Tools	User Status (Risk Assessment)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	Self-Assessment	Yes	No	No	No	Yes	No	No	No	No	Yes	No	Yes
	E-Pass Integration	No	No	Yes	No	Yes	No	No	No	No	No	No	No
	Test Results Reporting	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	Online Consultation	Yes	No	No	Yes	Yes	No	No	No	No	No	No	Yes
	Contact Tracing	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Learning	Personalized Notes	Yes	No	No	Yes	Yes	No	No	No	No	Yes	No	Yes
	Educational Resources	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	Yes
	COVID-19 Information	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes

Communication	Query Resolution	Yes	No	Yes	No	Yes	No	No	No	No	No	Yes	Low Risk
	Appointments	Yes	No	Yes	No	Yes	No	No	Yes	No	No	Yes	Low Risk
	Social Network	No	No	No	No	No	No	No	No	No	No	No	Low Risk
	Notifications	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low Risk
App Design	Data Visualisation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low Risk
	Program Plan	No	Yes	No	Yes	No	Yes	No	No	No	No	No	Low Risk
Networking	Location Mapping (GPS)	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Low Risk
	Connectivity with Other Devices	No	Yes	No	No	Yes	Yes	No	Yes	No	Yes	Yes	Low Risk
Safety & Security	Alerts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low Risk
	Data Protection	Low Risk	Low Risk	Medium Risk	High Risk	Medium Risk	Low Risk	Medium Risk	Low Risk	Low Risk	Medium Risk	Medium Risk	Low Risk

since its launch in June 2020.[35] The application has been effective in contact tracing and limiting the spread of novel coronavirus.

Tawakkalna App

Concerning Tawakkalna, it is the official mobile application approved by the Ministry of Health, Saudi Arabia. The objective of this application is to facilitate the emergency movement of people during lockdown and curfew. In addition, the application provides information about the COVID-19, such as the number of infections in different locations. The application allows Saudi citizens to request travel permits in the case of an emergency during curfew. The application also notifies the users if they are close to infectious or contaminated zones.[36] It is a simulated version of a Chinese application that uses a colour-coded QR to reflect the situation of the user. Green shows that the person is healthy and has permission to travel. Yellow indicates that the person is suspected of having COVID-19 and is not allowed to move. Red indicates that the person is infected, is not allowed to travel, and needs to be in quarantine.[37]

Sehha App

The Sehha mobile application is one of the most innovative mobile health applications being used in Saudi Arabia. The application was developed for providing e-consultations through audio and video modes for users in the comfort of their own homes.[38] The application employs AI technologies, enabling users to receive safe medical information, and enhancing the user's experience during the consultation process. It also features a health assessment tool, where the users need to answer certain questions. Based on the responses, a health score is developed based on a disease or condition and the relevant feedback and precautions are prescribed. The Sehha app is similar to the Mawid app in terms of booking appointments, but it differs from Mawid as it facilitates an e-consultation process. Mawid provides consultations at primary care centres.[39] The Sehha application was identified as being very useful during the COVID-19 outbreak, as it facilitated restrictions on movement.

Aarogya Setu App

Regarding Aarogya Setu, it is an official mobile application launched by the government of India for tracking the COVID-19 outbreak, and restricting the spread of COVID-19. The application uses both GPS and Bluetooth

technologies for tracking.[40] Similar to Tawakkalna, this app uses Bluetooth technology for communicating with nearby devices and it uses GPS to track the user's location in relation to other smartphone users who have registered as infected and are using the same application. This app also provides additional functions such as self-assessment tests, test reporting, e-permits for travel, COVID-19 related information, information about precautionary methods, online consultations, etc.[41] The app has alerted more than 1.4 million users about the possible risk of contamination and it has helped to generate 697 coronavirus hotspots in the country.[42] However, in relation to the use of the data, some privacy concerns were raised, such as information collection, purpose limitation, data storage, institutional divergence, lack of legislation, transparency and auditability.[43,44] The government subsequently addressed these concerns, and the app is currently being used by the majority.

TraceTogether App

TraceTogether is a contact-tracing mobile application launched by the Singapore government. Similar to the Aarogya Setu application, this app uses Bluetooth technology to identify when a user is in close proximity to an infected person, and it accordingly alerts the user. This app uses anonymous IDs, which are exchanged between smartphones with TraceTogether installed.[45] Privacy and security were given utmost importance when designing the application. The Bluetooth data stored in the smartphones are automatically deleted after 25 days. In addition, the users have the right to delete the data, ensuring high levels of privacy.[44,46]

COVID Safe App

About the COVID Safe application, it is a contact-tracing mobile application launched by the Australian Department of Health. It is the only contact app approved by the Australian government. The purpose of the application is to track the movement of people and to identify whether they have come into close contact with infected people. If they do, the app alerts them. In addition, the health officials will contact and provide the support and information needed.[47] Users can register using a pseudonym in order to protect their identity, and they also give their mobile number. The app should be running in the background. It uses Bluetooth technology for communicating (using digital handshake) with other devices that have installed the COVID Safe application. Information such as date, time and contact numbers is securely encrypted and stored on the phone for 21 days; after this time the users can delete the data. Also, the data stored in the National COVID Safe Data store will be destroyed at the end of the pandemic.[48]

Immuni App

With regard to Immuni it is a contact-tracing app launched by the Italian government in June 2020. This app is similar to other contact-tracing apps; it alerts users if they come into close contact with a person using the same app who has been registered as infected. The unique feature of the application is that it uses Bluetooth low energy technology, ensuring low power utilization. In addition, the application does not collect any personal details such as name, date of birth, address, telephone number, or email address.[49] If two smartphone users with the Immuni app installed come into close contact, their smartphones automatically exchange generated codes. This makes it possible for the application to trace previous contacts if one of the users is diagnosed with the virus. Later, the code is entered into the centralized system by the health authorities with the consent of the patients, and this system is used to alert all other users who have come into close contact (using the code).[50] In addition, the application possesses a multilanguage feature, enabling people of different nationalities to use the application in Italy. The application does not track movements and it only shares the codes for contact tracing. Any data collected and shared with the central server will be deleted by December 31st, 2020.[36]

COVID Symptom Study App

The COVID Symptom Study application was developed by the researchers at King's College London Guys, St Thomas' Hospitals, and Zoe Global Limited, a health technology company. The purpose of this application is to analyse the spread of the virus, identifying high-risk areas in the UK, assessing vulnerable sections of society, and understanding the symptoms linked to underlying health conditions.[51] This app does not provide any information or health advice, but it is intended to collect data from people in order to promote the research related to COVID-19 in the UK, so that better preventive actions can be taken. People can voluntarily participate in the study, and share two types of information on a daily basis. The first part is related to general information, such as age, health information, and any underlying conditions; and the second part is related to the symptoms.[52] More than 4 million people across the UK are voluntarily contributing data to the application, and this has helped to create an

efficient database that can be used for analysing information related to COVID-19.[53]

NHS COVID-19 App

The NHS COVID-19 app was launched by NHS Test and Trace, UK. The app uses Bluetooth low energy technology along with GPS to track the movement of users. This app serves various purposes. Firstly, it alerts a user if they have come into close contact with other registered app users who have tested positive for COVID-19. Secondly, it allows users to report symptoms and book a free test for COVID-19. Thirdly, if users check into a place or venue, it informs them whether a high number of positive cases have been listed there. Fourthly, it allows users to keep track of their self-isolation countdown and to access relevant advice.[54] The app does not store any personal information that can identify a user. However, information such as location tracking, postcode, venue check-in, etc., is collected for track and trace purposes.[55]

COVID Watch App

Concerning the COVID watch application (USA), it was developed by the University of Arizona, supported by the Arizona Department of Health Services. The application is currently being used in the university, and the plan is to roll it out in phases across Arizona. The purpose of the application is to alert users if they come into close contact with any registered infected person using the app. The app uses Bluetooth technology and does not use location tracking.[56] In addition, it does not collect any personal information that can identify the user. The unique feature of the application is that any party or authority could not track who has been informed, and it was one of the first applications to launch an open-source specification.[37,41]

PathCheck App

Finally, the PathCheck application (USA) is a contact-tracing application developed by MIT and TripleBlind, who collaborated to form a newly created non-profit organisation called PathCheck Foundation. The purpose of the application is to integrate both people and health departments in an effort to contain the spread of novel coronavirus by sharing information. The application uses Google Apple Exposure Notification API, which ensures privacy and security for the users' data.[57] The users can store their private location and symptom diaries on their phone. Various health departments are integrated with the app, and the users can select any preferred department to share information and receive services. The goal of PathCheck is to encourage the re-emergence and re-opening of economies and communities.[58]

Discussion

The results of this study related to the applications that were launched and updated during the COVID-19 outbreak for the management of COVID-19 in several countries show that 12 free applications available in the App and Google play stores were launched and supported by the governments and health institutions of India, USA, Saudi Arabia, Italy, UK, Singapore, and Australia. The accessible applications that met the inclusion criteria were: Mawid (Saudi Arabia), Tabaud (Saudi Arabia), Tawakkalna (Saudi Arabia), Sehha (Saudi Arabia), Aarogya Setu (India), TraceTogether (Singapore), COVID Safe (Australia), Immuni (Italia), COVID Symptom Study (UK), NHS COVID-19 (UK), COVID watch (USA), and PathCheck (USA).

All the applications described above can be used by the majority of mobile device users around the world, are free and available on the Android and iOS platforms. However, the functionalities of the applications differed with respect to the health tools available. Ten out of twelve apps (Mawid, Tabaud, Tawakkalna, Aarogya Setu, TraceTogether, COVID Safe, Immuni, NHS COVID-19, COVID Watch, PathCheck SafePlaces) have the feature of assessing the user's status or risk assessment, and they were enabled with the option of reporting test results, which helps to analyze the spread of the virus and alert other users who have been in close contact with the infected person to take preventive measures. Four of the mobile applications (Mawid, Aarogya Setu, NHS COVID-19, and PathCheck SafePlaces) reviewed provided self-assessment tests, with which users can assess their status and access feedback about preventive measures. Two apps (Tawakkalna, Aarogya Setu) out of the twelve provided services for an E-pass or travel permit during the COVID-19 outbreak. In addition, nine out of twelve apps (Tabaud, Tawakkalna, Aarogya Setu, TraceTogether, COVID Safe, Immuni, NHS COVID-19, COVID Watch, and PathCheck SafePlaces) provided a contact-tracing feature. Only one application (Mawid) allowed test reporting, so that users could book an appointment and receive healthcare services, but it was not enabled with contact-tracing features.

Focusing on the integration of health tools, it can be observed that the majority of the apps were enabled with contact tracing, test result reporting and self-assessment, reflecting the primary goal of these applications, which is

to contain the spread of the novel coronavirus. Several studies have reported similar findings, and they suggested that the majority of apps were focused on contact tracing and were available on both Android and iOS platforms.[15,37,38,59] In addition, a few applications such as Mawid, Sehha, Aarogya Setu and PathCheck provided online consultations, facilitating the practice of social distancing and home quarantine procedures, and ensuring continuity in delivering healthcare services for various conditions/diseases. It should be noted that launching different apps for different services such as consultation, awareness (information), contact tracing and travel permits may confuse citizens and create ambiguity over the use of applications for COVID-19.[60] Therefore, a single application integrating several services as in Arogya Setu and PathCheck may benefit citizens by allowing them to access services from a single application.

Five (Mawid, Sehha, Aarogya Setu, NHS COVID-19, PathCheck SafePlaces) out of the twelve apps provided options for personalised notes. Also, five of them (Sehha, Aarogya Setu, COVID Symptom Study, NHS COVID-19, and PathCheck SafePlaces) apps provided access to health educational resources and COVID-19-related information. With the rapid spread of myths and misinformation about COVID-19 across the world, it is of utmost importance that people are properly educated about COVID-19 and are made aware of precautionary measures, other treatments, and safety procedures.[61] However, due to the functionality of specific applications, access to information is limited to a few applications.

Concentrating on the communication process, four (Mawid, Sehha, Aarogya Setu, PathCheck SafePlaces) out of twelve apps offered options for query resolution and four (Mawid, Sehha, NHS COVID-19, PathCheck SafePlaces) apps offered online booking of appointments. While no apps were identified that enabled a social networking feature, all of the applications reviewed provided notifications.

In addition, all of the applications provided a data visualisation feature with the use of graphics to present health-related information and COVID infections. Half of the reviewed applications (Tabaud, Sehha, Aarogya Setu, COVID Safe, NHS COVID-19, and PathCheck SafePlaces) offered a program plan option, while the other half did not. Similarly, half of the reviewed applications (Mawid, Tawakkalna, Aarogya Setu, TraceTogether, NHS COVID-19, PathCheck SafePlaces) used GPS location tracking features, while the other half (Tabaud, Sehha, COVID Symptom Study, Immuni, COVID Safe, COVID Watch) did not present this feature because of rising privacy concerns. As a result, the majority of the applications, eight out of twelve (Aarogya Setu, TraceTogether, NHS COVID-19, PathCheck SafePlaces, Tabaud, Immuni, COVID Safe, COVID Watch), relied on Bluetooth technology. Bluetooth Low Energy technology is effective and uses low amounts of energy; it can also be very effective for contact tracing in close proximities.[62] Thus, the majority of the applications preferred Bluetooth Low Energy for contact tracing.

Although applications for managing COVID-19 are being launched and used, issues such as privacy, safety, security and data protection remain one of the major concerns.[30,43,44] In view of rising concerns, applications such as TraceTogether, Immuni, COVID Watch, PathCheck, etc. have updated their privacy policy so that they collect no personal information that can reveal identity and they employ clear policies on data usage and destruction.

The main limitation of this work was that some applications for the management of COVID-19 could not be detected in the search due to the keywords used in this process. Another limitation is the fact that this work is not aimed at analyzing the total landscape of mobile phone applications used during the COVID-19 outbreak. Only free applications available in the App and Google Play stores used in India, USA, Saudi Arabia, Italy, UK, Singapore, and Australia were reviewed. Additionally, web-based applications such as COVIDNearYou or Coronaisrael were not included. Similarly, we did not perform a more robust search in publication indexes such as Pubmed, Web of Science, Scopus, or Google Scholar.

Future research can focus on reviewing the technologies, functions and features of the mobile applications dedicated to COVID-19, and publishing findings that can be used by medical practitioners, application developers, and governments to collaborate in the process of containing the spread of the novel coronavirus. Also, it would be interesting to investigate if social networking and innovative technologies such as artificial intelligence (AI), machine learning (ML), and Deep Learning (DL) can be effective in improving various approaches related to COVID-19 management. A previous study suggested that AI, ML, and DL, can be effective in improving various approaches such as treatment, medication, screening, prediction, forecasting, contact tracing, and drug/vaccine

development related to healthcare services and COVID-19 management.[7,8,63]

Conclusion

This study has reviewed the main mobile applications used during the COVID-19 outbreak to provide health care services, contain the spread of the new coronavirus, and facilitate the movement of people during curfews in Saudi Arabia, India, Italy, Singapore, the United Kingdom, United States of America, and Australia. The analysis revealed that various applications have been developed for different functions like contact tracing, raising awareness, appointment booking, online consultation, etc. However, only a few applications such as Arogya Setu and PathCheck have integrated various functions and features such as self-assessment, consultation, support and access to information in a single application, simplifying to the users the access to services. Also, most of the apps are focused on contact tracing, while very few are dedicated to raising awareness and sharing information about COVID-19, which is essential to combat the spread of COVID-19. Likewise, the majority of applications rely on GPS and Bluetooth technologies for contact tracing and other relevant functions. No apps were identified that had built-in social media features. Furthermore, one of the main challenges identified was the lack of an integrated application with most of the features and functionalities analyzed in this study. In this sense, users depended on different applications for medical care, travel, diagnosis, tracking, and awareness, etc. Therefore, an effective solution to solve this problem can be to design and develop an integrated mobile health application, which allows access to all these functions. Using a single application can reduce costs and improve health data management, and decision making.

Disclosure

The author reports no conflicts of interest for this work.

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