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An overview of mobile applications (apps) to support the coronavirus disease-2019 response in India

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***Background & objectives*: The potential benefits of mobile health (mHealth) initiatives to manage the coronavirus disease-2019 (COVID-19) pandemic have been explored. The Government of India, State governments, and healthcare organizations have developed various mobile apps for the containment of COVID-19. This study was aimed to systematically review COVID-19 related mobile apps and highlight gaps to inform the development of future mHealth initiatives.**

***Methods*: Google Play and the Apple app stores were searched using the terms 'COVID-19', 'coronavirus', 'pandemic', and 'epidemic' in the first week of April 2020. A list of COVID-19-specific functions was compiled based on the review of the selected apps, the literature on epidemic surveillance, and national and international media reports. The World Health Organization guideline on Digital Health Interventions was used to classify the app functions under the categories of the general public, health workers, health system managers, and data services.**

***Results*: The search yielded 346 potential COVID-19 apps, of which 50 met the inclusion criteria. Dissemination of untargeted COVID-19-related information on preventative strategies and monitoring the movements of quarantined individuals was the function of 27 (54%) and 19 (32%) apps, respectively. Eight (16%) apps had a contact tracing and hotspot identification function.**

***Interpretation & conclusions*: Our study highlights the current emphasis on the development of self-testing, quarantine monitoring, and contact tracing apps. India's response to COVID-19 can be strengthened by developing comprehensive mHealth solutions for frontline healthcare workers, rapid response teams and public health authorities. Among this unprecedented global health emergency, the Governments must ensure the necessary but least intrusive measures for disease surveillance.**

Key words Contact tracing - COVID-19 - India - mobile apps - mobile health - privacy - telemedicine

The coronavirus disease-2019 (COVID-19) pandemic has spread to >200 countries and territories[1]. In the absence of a specific medical intervention, the world is reliant on public health and social measures to slow or halt the spread of COVID-19. These measures include the promotion of respiratory and hand hygiene, physical distancing for the general population, quarantines for the suspected cases, isolation and contact tracing of the infected individuals, and widespread travel bans. India reported its first case on January 30, 2020. As of May 5, 2020, there were a total of 46,433 active cases and 1568 deaths[2]. The

Government of India imposed a nationwide lockdown on March 24, 2020, and rapidly expanded its testing, contact tracing, and home quarantine efforts. However, an unprecedented flurry of misinformation and fake news leading to panic-driven migration, hysteric buying of masks, medicines, essential household commodities and peddling of unproven treatments[3].

Digital technology innovations are known to present the possibility of improving the efficacy of the health system response to an epidemic[4-6]. The Ebola and Zika virus epidemics have shown the utility of mobile health (mHealth) applications (apps) for improving access to testing, contact tracing, supporting frontline healthcare workers, and raising public awareness[7-9]. Recent evidence underscores the potential of mHealth initiatives for the provision of mental health services to support the patients and healthcare providers in dealing with the psychological impact of the COVID-19 pandemic[10,11]. Contact tracing apps have been a crucial component of COVID-19 response in countries such as China, South Korea, Singapore, the United Kingdom, and Israel[12-14]. However, owing to the collection of users' identifiers and data related to location and Bluetooth interactions, privacy experts have raised concerns over the use of these apps.

The Government of India, launched 'Aarogya Setu' mobile app for the containment of COVID-19, through contact tracing and information dissemination[15]. Further, various State governments and healthcare organizations have developed apps for lockdown enforcement, generating awareness and monitoring of quarantined individuals in India[16]. The present study was aimed to identify and systematically review COVID-19-related mobile apps in India. Another objective was to describe the functions of the apps, map those against the WHO guidelines on Digital Health Interventions and highlight gaps to inform the development of future mHealth initiatives[17].

Material & Methods

The Google Play and the Apple app stores were searched using the terms 'COVID-19', 'coronavirus', 'pandemic', and 'epidemic', individually. In addition, a free-text search was run for COVID-19-related apps using the phrase 'COVID-19 mobile apps in India'. The search was conducted in the first week of April 2020 and updated on May 3, 2020. The preliminary screening of the apps was based on the app titles and full description. The games, apps without English or Hindi language user interface, and apps on infectious disease without a specific focus on COVID-19 were excluded.

A list of COVID-19 specific functions was compiled based on the review of the selected apps, the literature on epidemic surveillance[6,18,19], and national and international media reports[13,20,21]. The WHO guideline on Digital Health Interventions was used to classify the app functions under the categories of the clients (general public), health workers, health system managers and data services[17]. Information related to name, developer, target user group and COVID-19-specific function was abstracted from the selected apps. Frequencies and percentages were used to summarize the information abstracted from the apps.

Results

A total of 346 potential COVID-19 apps were identified, of which 50 met our inclusion criteria. Fig. 1 provides an overview of the app selection process. The excluded apps were general infectious disease apps not focused on COVID-19 (n=141), games (n=87), or did not have an English or Hindi user interface (n=42) (Supplemetary Table for details).

All the apps selected were free to download, with no in-app purchase options/requirements. State health/municipal departments were the launching agencies for 41 (82%) of the existing COVID-19 apps in India. Private/non-government developers and the Government of India launched seven (14%) and two (4%) apps, respectively. Fig. 2 provides information about the target users of the apps. Two-thirds of the apps (n=34) were developed for the general public, 19 (38%) for quarantined individuals or foreign travellers currently residing in the Indian States, and two (4%) for caregivers. One (2%) app each was

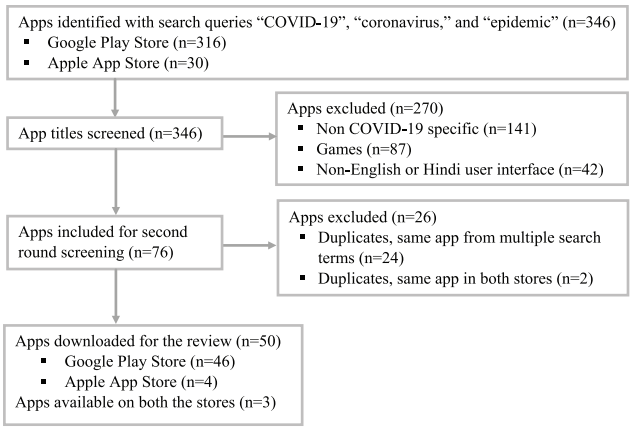

Fig. 1. Screening process flowchart.

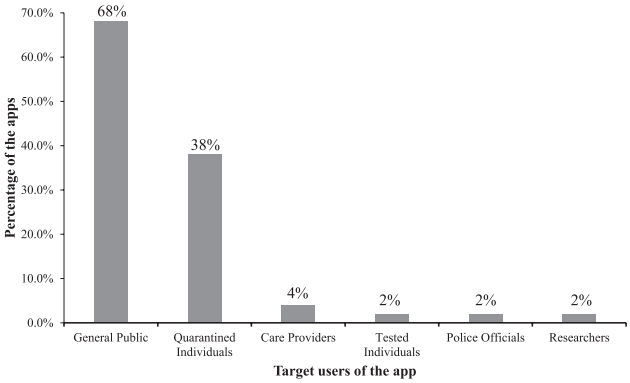

Fig. 2. Target users of the COVID-19 apps in India (n=50).

designed for tested individuals, police officials, and researchers, respectively.

The Table lists the functions of the selected COVID-19 apps and maps these against the WHO guideline recommendations on digital health interventions for health systems strengthening. Dissemination of untargeted COVID-related information on preventative strategies was the function of 27 (54%) apps. Nineteen (38%) apps were developed to monitor the movements of quarantined individuals. On-demand information services through chatbots or telephonic helplines were available only in 19 (38%) apps. Fifteen apps (30%) provided users with a self-risk assessment function based on a set of screening questions related to their symptoms, occupations, travel history, and contact history. Information on the availability of COVID-19 testing facilities was available in six (12%) apps. Four (8%) apps had a provision for booking teleconsultation or testing appointments. The availability of an electronic pass for movement during the lockdown was the only health workforce-specific function available in four (8%) apps. In terms of the data for health managers and policy decisions, nine (18%) apps provide aggregation and visualization of the State governments' data related to confirmed cases and deaths. Eight (16%) apps had a contact tracing and hotspot identification function.

Discussion

It was found that governments, including the Union government and 22 State and Union Territories, invested in the development of mobile apps to deal with this crisis. While there were differences in the State-specific information in the apps developed by different States, the system architecture and many of the functionalities, including self-testing, quarantine monitoring and contact tracing, were common between these State-level apps. The Ministry of Electronics and Information Technology, Government of India, has taken proactive measures to promote the installation and usage of the *Aarogya Setu* app, which is currently available in 11 Indian languages[22]. The penetration of the app is critical to the success of the technology-enabled contact tracing. Evidence suggests that 70 per cent of the population should have the app installed for the digital contact tracing efforts to be effective[23]. The current technological plurality in the absence of robust data exchange mechanisms and Centre-State coordination, can be detrimental for technology-assisted contact tracing in a heterogeneous country like India, especially once the lockdown ends and free movement of people starts. Overcoming this challenge requires the State and the Union Government to ensure the mass installation of a single contact tracing app collaboratively. In contrast, the State-specific apps would still be a vital medium of providing context-specific information and supporting local health systems.

The review of the app functionalities revealed that information dissemination regarding the preventative measures was the primary function of the majority of the existing apps in India. The apps reviewed in this study did not have specific strategies to deal with the infodemic. Only two apps, had a fake news control segment. Several apps had a provision related to teleconsultations. The Ministry of Health and Family Welfare, Government of India, has formally recognized remote consultation through recent 'Telemedicine practice guidelines'[24]. With the growing number of COVID-19 cases, there is an urgent need to create integrated teleconsultation options within these apps to assure quality healthcare services, including those with pre-existing conditions. Another notable finding was that the majority of the apps did not have functionalities to assist the hospitals or healthcare workers. In contrast, frontline hospital workers were using mobile apps to compile clinical notes and track the use of protective equipment and ventilator in the United States[20].

In terms of privacy, all the contact tracing and quarantine monitoring apps reviewed in this study collected user data such as name, phone number, real-time location, and Bluetooth interactions with other app users. While the collection of the location data is essential for mapping hotspots of disease transmission, privacy experts are concerned about this data being a hazard for an individual's privacy and national security. The collection of location data in

Table. Functionalities of the coronavirus disease-19 apps and their comparison with World Health Organization recommendation for digital health interventions (n=50)

WHO recommendations[17]	COVID-19 related functions	n (%)
Clients		
Targeted client communication	Availability of testing services and protective equipment for high-risk population	6 (12.0)
Untargeted client communication	Preventive measures and demystification	27 (54.0)
Client to client communication	Community forums for patients and family members	0 (0.0)
Personal health tracking	Symptom tracker	6 (12.0)
	Self-risk assessment	15 (30.0)
	Quarantine monitoring	19 (38.0)
Citizen based reporting	User feedback on services	2 (4.0)
On-demand information services to clients	Information provision through chatbots or helpline	19 (38.0)
Client financial transactions	Manage out of pocket payment by service users	0 (0.0)
Health workers		
Client identification and registration	Enrol user for health services/clinical care	0 (0.0)
Client health records	Longitudinal tracking of user's health status	0 (0.0)
Health worker decision support	Job-aid for frontline health workers	0 (0.0)
Telemedicine	Teleconsultation and testing appointments	4 (8.0)
Health worker communication	Provider to provider communication	1 (2.0)
Referral coordination	Manage referrals between points of service within the health sector	0 (0.0)
Health worker activity planning and scheduling	Electronic pass for the movement of the health workers during the lockdown	4 (8.0)
Health worker training	Train new and existing healthcare staff	0 (0.0)
Prescription and medication management	-	-
Laboratory and diagnostics imaging management	Testing for COVID-19	0 (0.0)
Health system managers		
Human resource management	Human resource monitoring for hospital staff	0 (0.0)
	Participation/volunteer recruitment	1 (2.0)
Supply chain management	Monitor stock levels of health commodities	0 (0.0)
Public health event notification	Notification of confirmed cases	14 (28.0)
	Contact tracing	8 (16.0)
	Hotspot identification	8 (16.0)
Civil registration and vital statistic	Notification of deaths	13 (26.0)
Health financing	Accepting donations from contributors	4 (8.0)
Equipment and asset management	Monitor status of beds and ventilators	0 (0.0)
Facility management	Priority checklists for facility management	0 (0.0)
Data services		
Data collection, management, and use	Data storage, aggregation and visualization	9 (18.0)
	Prediction on future trends of disease	0 (0.0)
Data coding	-	-
Location mapping	Map location of health facilities	9 (18.0)
	Location data recording or Bluetooth handshakes	19 (38.0)
Data exchange and interoperability	Data exchange across systems	-

South Korea and China has sparked global concerns related to privacy and potential mala fide use of the data[25]. To counter this, countries like Singapore and Argentina are using tracking apps that only collect Bluetooth interaction data to preserve user privacy[26]. To ensure transparency, Singapore and Israel have shared their app source code with researchers for an independent audit[27]. In the absence of a data protection law in India, the Central and State governments need to address these privacy-related concerns to garner public trust that would ensure the deployment of these apps at scale.

This study had a limitation that the user feedback on these apps was not assessed. Despite this limitation, this study has important implications for informing the development of future COVID-19 mHealth initiatives in India. These apps are a medium of disseminating disease-related awareness and knowledge at the population level. In a hysteric environment and a severe shortage of testing facilities, the self-risk assessment function available in the apps may help spot the patients at risk for COVID-19.

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Supplemetary Table. Details of app developers and functionality assessment of the apps

App Name	State	Target User Group	COVID-19 related app functionalities
Aarogya Setu	Multiple States, developed by Government of India	General public	Preventive measures and demystification, Self-risk assessment, Information provision through chatbots or helpline, Electronic pass for the movement of the health workers, Contact tracing, Accepting donations from contributors, Location data recording or Bluetooth handshakes
COVID-19 Quarantine Monitor Tamil Nadu (official)	Tamil Nadu	Quarantined individuals	Symptom tracker, Quarantine monitoring, Location data recording or Bluetooth handshakes
MP COVID RESPONSE APP	Madhya Pradesh	General public; Hospitals; Government authorities	Preventive measures and demystification, Hotspot identification, Data storage, aggregation, and visualization
COVA Punjab	Punjab	General public	Availability of testing services and protective equipment for high-risk population, Preventive measures and demystification, Self-risk assessment, Information provision through chatbots or helpline, Notification of confirmed cases, Notification of deaths, Data storage, aggregation, and visualization, Map location of health facilities
GoK - Direct Kerala	Kerala	General public	Preventive measures and demystification
Quarantine Watch	Karnataka	Quarantined individuals	Quarantine monitoring, Information provision through chatbots or helpline, Location data recording or Bluetooth handshakes
Test Yourself Goa	Goa	General public	Availability of testing services and protective equipment for high-risk population, Self-risk assessment, Information provision through chatbots or helpline
Jaano	Multiple States	General public	Availability of testing services and protective equipment for high-risk population, Map location of health facilities
Corona Watch	Karnataka	General public	Preventive measures and demystification; Information provision through chatbots or helpline; Contact tracing; Hotspot identification; Data storage; aggregation; and visualization; Map location of health facilities; Location data recording or Bluetooth handshakes
COVID19 Feedback	Multiple States, developed by Government of India	Tested individuals	User feedback on services
Mahakavach	Maharashtra	Quarantined individuals	Quarantine monitoring; Contact tracing; Hotspot identification; Location data recording or Bluetooth handshakes
CoBuddy - Covid19 Tool	Multiple States	General public; Quarantined individuals	Preventive measures and demystification; Quarantine monitoring; Location data recording or Bluetooth handshakes
GCC - Corona Monitoring	Tamil Nadu	Quarantined individuals	Quarantine monitoring; Location data recording or Bluetooth handshakes
KSP Clear Pass Checker	Karnataka	Police officials	Electronic pass for the movement of the health workers
CG Covid-19 ePass	Chhattisgarh	General public	Preventive measures and demystification; Electronic pass for the movement of the health workers
Test Yourself Puducherry	Puducherry	General public	Availability of testing services and protective equipment for high-risk population; Self-risk assessment; Information provision through chatbots or helpline

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App Name	State	Target User Group	COVID-19 related app functionalities
COVID-19 West Bengal Government	West Bengal	Quarantined individuals	Symptom tracker; Quarantine monitoring; Location data recording or Bluetooth handshakes
West Bengal Emergency Fund	West Bengal	General public	Accepting donations from contributors
Kavach	Chhattisgarh	General public	Preventive measures and demystification; Self-risk assessment; Notification of confirmed cases; Contact tracing; Hotspot identification; Notification of deaths; Data storage; aggregation; and visualization; Location data recording or Bluetooth handshakes
SMC COVID-19 Tracker	Gujarat	Quarantined individuals	Quarantine monitoring; Location data recording or Bluetooth handshakes
Niramaya	Madhya Pradesh	General public	Preventive measures and demystification; Self-risk assessment; Information provision through chatbots or helpline; Teleconsultation and testing appointments; Notification of confirmed cases; Notification of deaths
Uttarakhand CV 19 Tracking System	Uttarakhand	General public	Self-risk assessment; Information provision through chatbots or helpline
nCOVID-19 Nagaland - Visitors App	Nagaland	Quarantined individuals	Preventive measures and demystification; Self-risk assessment; Quarantine monitoring; Information provision through chatbots or helpline; Location data recording or Bluetooth handshakes
Corona *Mukt* Himachal	Himachal Pradesh	Quarantined individuals	Quarantine monitoring; Location data recording or Bluetooth handshakes
UP Self- Quarantine App	Uttar Pradesh	Quarantined individuals	Quarantine monitoring; Location data recording or Bluetooth handshakes
Trackmetic-An initiative by Morigaon Police; Assam	Assam	General public	Preventive measures and demystification; Information provision through chatbots or helpline; Contact tracing; Hotspot identification; Data storage; aggregation; and visualization; Map location of health facilities; Location data recording or Bluetooth
COVID-19 Odisha	Odisha	General public	Preventive measures and demystification; Self-risk assessment; Notification of confirmed cases; Contact tracing; Hotspot identification; Notification of deaths; Location data recording or Bluetooth handshakes
RajCovidInfo	Rajasthan	General public	Preventive measures and demystification; Notification of confirmed cases; Notification of deaths; Data storage; aggregation; and visualization
T COVID`19	Telangana	General public	Availability of testing services and protective equipment for high-risk population; Preventive measures and demystification; Self-risk assessment; Information provision through chatbots or helpline; Teleconsultation and testing appointments; Notification of confirmed cases; Notification of deaths; Data storage; aggregation; and visualization; Map location of health facilities
COPE Odisha	Odisha	General public; Quarantined individuals	Preventive measures and demystification; Symptom tracker; Self-risk assessment; Quarantine monitoring; Contact tracing; Hotspot identification; Location data recording or Bluetooth handshakes
Covid Locator	Goa	General public; Quarantined individuals	Quarantine monitoring; Contact tracing; Hotspot identification; Location data recording or Bluetooth handshakes

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App Name	State	Target User Group	COVID-19 related app functionalities
COVID CARE	Arunachal Pradesh	General public; Quarantined individuals	Symptom tracker; Quarantine monitoring; Contact tracing; Hotspot identification; Location data recording or Bluetooth handshakes
Corona-Care	Multiple States	Quarantined individuals	Symptom tracker; Self-risk assessment; Quarantine monitoring; Information provision through chatbots or helpline; Teleconsultation and testing appointments; Location data recording or Bluetooth handshakes
CoronaFACTS	Multiple States	General public	Preventive measures and demystification; Notification of confirmed cases; Notification of deaths; Data storage; aggregation; and visualization
COVID-19!	Multiple states	General public	Preventive measures and demystification; Notification of confirmed cases; Notification of deaths; Data storage; aggregation; and visualization
BMC Combat Covid19	Maharashtra	Quarantined individuals	Quarantine monitoring; Information provision through chatbots or helpline; Data storage; aggregation; and visualization; Location data recording or Bluetooth handshakes
COVID-19 Care Tamil Nadu - (Official)	Tamil Nadu	General public; Quarantined individuals	Preventive measures and demystification; Self-risk assessment; Quarantine monitoring; Notification of confirmed cases; Hotspot identification; Notification of deaths; Accepting donations from contributors
T COVID'19	Telangana	General public	Availability of testing services and protective equipment for high-risk population; Preventive measures and demystification; Information provision through chatbots or helpline; Teleconsultation and testing appointments; Notification of confirmed cases; Accepting donations from contributors; Map location of health facilities
Haryana *Sahayak*	Haryana	General public	Preventive measures and demystification; Self-risk assessment; Notification of confirmed cases; Notification of deaths; Map location of health facilities
Trackmetic - (*Niramoy*) by Morigaon Police; Assam	Assam	General public	Preventive measures and demystification; Information provision through chatbots or helpline
NMC COVID-19	Maharashtra	General public	Preventive measures and demystification; Information provision through chatbots or helpline; Map location of health facilities
Sahaaya Setuve	Karnataka	General public	User feedback on services; Participation/volunteer recruitment
House Quarantine AP Police	Andhra Pradesh	Quarantined individuals	Preventive measures and demystification; Quarantine monitoring
Ayush Kavach	Uttar Pradesh	General public	Preventive measures and demystification; Information provision through chatbots or helpline
Telangana Covid19 Tracker	Telangana	Quarantined individuals	Quarantine monitoring
RajCop Citizen	Rajasthan	General public	Electronic pass for the movement of the health workers
Fight Covid	Maharastra	Quarantined individuals	Quarantine monitoring
Odisha COVID Dashboard	Odisha	General public	Preventive measures and demystification; Self-risk assessment; Notification of confirmed cases; Notification of deaths; Map location of health facilities

Contd...

App Name	State	Target User Group	COVID-19 related app functionalities
COVID19Connnect	Multiple States	General public; Researchers	Preventive measures and demystification; Information provision through chatbots or helpline; Provider to provider communication; Notification of confirmed cases; Notification of deaths; Map location of health facilities
WashKaro	Multiple States	General public	Preventive measures and demystification; Symptom tracker; Information provision through chatbots or helpline; Notification of confirmed cases; Notification of deaths