Web-Based Apps in the fight against COVID-19

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Introduction

When and where the first case of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) appeared, remains controversial. However, it has proven to be highly infectious and capable of rapid mutation. Within months, it spread to over 213 countries infecting 21.7 million people and causing 770,000 deaths.

SARS-CoV-2 belongs to a virus family known as Coronaviridae. It is transmitted through minute respiratory droplets produced by coughing, sneezing, or talking in close proximity to one another. Another mode of transmission is by droplets, touching surfaces contaminated with the virus, and touching the face, eyes, or mouth with the contaminated hands. Symptoms of the viral infection appear in 1–14 days and include fever, cough, fatigue, general weakness, sore throat, and muscular pains, while in severe cases it can lead to acute respiratory distress syndrome (ARDS), severe pneumonia, and sepsis (1).

Coronavirus Disease 2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO) on March 11, 2020. Not much is known about the virus, but research is still ongoing, and the search for treatment is underway. Strict standard operating measures (SOPs) are being used in order to limit the spread of the virus until a vaccine is developed. The rapid spread of SARS-CoV-2 has resulted in several difficulties regarding accurate and timely information dissemination, controlling the spread rate, and public health planning. This pandemic has proven to be a unique situation since it was recommended to limit physical interactions to prevent infection (2,3).

Due to the social distancing measures enforced by many countries, it is more difficult for people to receive medical attention quickly and safely. To overcome this problem, be more efficient, and be able to save more lives, the use of artificial intelligence (AI) has been introduced. This has helped promote telehealth and allow patients to receive care in the comfort of their homes and decrease the patient load on the already overflowing hospitals. SARS-CoV-2 is a highly contagious virus, and as health professionals are closely dealing with the affected people, the use of AI has helped to decrease inpatient visits, thereby decreasing the workload and exposure.

Using applications (henceforth referred to as apps) has helped remotely monitor patients while keeping in mind doctor-patient confidentiality and secure communication between them. Contact tracing through the apps has helped identify the 'hotspots' for the virus, track the spread, and contain it (4). These apps can be used in population screening and getting day-to-day updates of the areas where new cases are emerging. The use of apps improves productivity and efficiency in studies with large samples (5).

It is for this reason that web and mobile-based apps are being used during this pandemic situation. Several apps deployed in different areas of the world are being used to accelerate and aid the process of geographical mapping of cases, symptom tracking, contact tracing, assistance with health care visits, and projection of spread and mortality (2-9).

We aim to review and critically assess currently available mobile and web-based applications used in the fight against COVID-19 pandemic. Our goal is to use this information to support the development of the application created by the Larkin Health System: Hispanovida.com. We propose and present proof of the concept and developmental stages of our creation: Hispanovida.com.

Current apps and COVID-19: challenges and opportunities

People, and more importantly, governments, have begun to realize that digital technology can play a very crucial role in the control of this virus. Web and mobile-based apps reach effectively into almost every household and have the potential to connect the public with resources more efficiently than any other system. Currently, contact tracing and public health measures are the only approved methods to control the spread of COVID-19. In that regard, over 45 countries have developed their contact tracing apps, many of them in use before June 2020 (10) (*Table 1*, *Figure 1*). The apps are meant to optimize the process of contact tracing with AI, enabling large-scale contact tracing to be done in a short period, something that is difficult to achieve with limited human resources.

For contact tracing to be effective in controlling the spread of COVID-19, it must ideally be done as soon as an index case starts developing symptoms. However, this information typically reaches the tracers well after the patient tests positive for COVID-19, a little too late to be very useful. The web and mobile-based apps seek to close that distance between symptom onset and contact tracing by eliminating the delays caused by backlogs, human errors, and lack of qualified personnel. A pilot study done in Spain on a contact tracing app-in-development showed that the app identified an average of 6.4 contacts for every virtual positive diagnosis, compared with an average of 3.5 contacts identified by human tracers (11). Some experts believe that for a contact tracing app to be successful, about 60% of the population has to adopt the app. An analysis was done by Sensor Tower, a mobile app-store marketing-intelligence platform, in 13 countries with a population of 20 million or more shows that about 9.3% of their total population has installed government-endorsed COVID-19 contact tracing apps. The highest adoption is of CovidSafe in Australia, with 21.6% of the country installing the app, while the fastest adoption rate belongs to the Corona Warn app in Germany (12).

The adoption of contact tracing apps is not as much as we would like, for several reasons. There has been a lot of controversy relating to privacy, battery usage, effectiveness, between others. Hamagen (Israel), HealthCode (China), and Smittestopp (Denmark) are some apps that identify and store the users' locations through a global positioning system (GPS) or global system for mobile communication (GSM) tracking. If they test positive, other app users whose locations crossed with the index case are informed about their exposure and advised accordingly. The location data is usually collected centrally by the government. Such apps have been criticized for their privacy invasion, resulting in many uninstalling the apps and some of them being pulled from the market (13). The HealthCode, China's digital system used in the control of the pandemic, goes a step further by tracking the app users' movements using QR codes to ensure that positive cases are effectively isolated (14). Similarly, Russia's app Social Monitoring app requires COVID positive patients to take photos of themselves to prove they are self-isolating at home; failure to do so incurs a fine of about $56 (15). The aforementioned imposed restrictions have been difficult for many.

To protect the users' privacy, other app developers have used Bluetooth technology, which allows phones to record close contacts with other app users. When a user tests positive, they receive a code from the health department, which allows them to inform close contacts through the app about their exposure anonymously. Among these apps are Immuni (Italy), CovidTracker (Ireland), and SwissCovid (Switzerland). Because of their pro-privacy protocol, they have a high acceptance rate. On Google Play, their estimated installs are more than 500,000 each and their reviews more than 3/5. However, several apps that use Bluetooth also centrally collect users' data location for contact tracing, such as Trace Together (Singapore), which has led to similar conflict with those apps.

To ensure the privacy protection of users, a research team from École Polytechnique fédérale de Lausanne (EPFL) and Eidgenössische Technische Hochschule Zürich (ETHZ), Switzerland has developed Decentralised Privacy-Preserving Proximity Tracing (DP3T), an open protocol for COVID-19 proximity tracing using Bluetooth Low Energy functionality on mobile devices that ensures personal data and computation stays entirely on an individual's phone. The Swiss COVID (Switzerland) and Ketju (Finland) apps are developed using this protocol, which has been endorsed by about 300 scientists in over 25 countries. The decentralized approach is embraced widely and is promoted by the tech companies, Apple and Google. Apple and Google have teamed up to create a contact tracing Application Programming Interface (API), which is based heavily on the DP3T protocol. The API is meant to be used by app developers to create decentralized

Table 1 Covid-19 contact tracing apps in use by August 1, 2020

Contact tracing app	Number of downloads	Country	Bluetooth	GPS	GSM	Central data collection	Launch date
CovidSafe	1,000,000+	Australia	Yes	No	No	Yes	April 26, 2020
Stopp Corona	100,000+	Austria	Yes	No	No	No	March, 2020
BeAware Bahrain	100,000+	Bahrain	Yes	No	Yes	Yes	March 31, 2020
Virusafe	10,000+	Bulgaria	No	No	Yes	Yes	April, 2020
HealthCode	–	China	No	Yes	Yes	Yes	Feb 2020
Coronapp	10,000,000+	Colombia	No	Yes	No	Yes	April 20,2020
Covtracer	1,000+	Cyprus	No	Yes	No	Yes	May, 2020
eRouska	100,000+	Czech Republic	Yes	Yes	No	Yes	April 15, 2020
Smittestopp	100,000+	Denmark/Norway	Yes	Yes	Yes	Yes	April, 2020
Ketju	–	Finland	Yes + DP 3T	No	No	No	May, 2020
Stopcovid	1,000,000+	France	Yes	Yes	Yes	No	May, 2020
Stop covid	100,000+	Georgia	Yes	Yes	Yes	No	April 12, 2020
OHIOH app	–	Germany	Yes	Yes	No	Yes	–
CoronaWarn App	5,000,000+	Germany	Yes	No	No	No	June 15, 2020
Beat covid	10,000+	Gibraltar	Yes	No	No	No	June 17, 2020
Coalition app	1,000+	Global	Yes	No	No	No	May, 2020
StayHomeSafe	10,000+	Hong Kong	Yes	Yes	No	Yes	Mar, 2020
Rakning C-19	50,000+	Iceland	No	Yes	No	Yes	May, 2020
Aarogya Setu	100,000,000+	India	Yes	No	No	Yes	April 2, 2020
Mask.ir	–	Iran	No	No	Yes	Yes	May, 2020
Covid tracker	500,000+	Ireland	Yes	No	No	No	May, 2020
HSECovid-19App	500,000+	Ireland	Yes	No	No	Yes	May, 2020
HaMagen	(see HaMagen 2 instead)	Israel	Yes	Yes	Yes	Yes	March, 2020
HaMagen 2	1,000,000+	Israel	Yes	Yes	Yes	Yes	July 28, 2020
Immuni	1,000,000+	Italy	Yes	No	No	No	May, 2020
AMAN	500,000+	Jordan	No	Yes	Yes	Yes	May, 2020
Apturi	50,000+	Latvia	Yes	No	No	No	May, 2020
MyTrace	100,000+	Malaysia	Yes	No	No	Yes	May 3, 2020
CovidRadar (COVID-19MX)	500,000+	Mexico	Yes	No	No	Yes	May, 2020
NZ Covid Tracer	100,000+	New Zealand	No (uses QR codes)	No	No	Yes	May 20, 2020
StopKorona!	50,000+	North Macedonia	Yes	Yes	No	Yes	April, 2020

Table 1 (*continued*)

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Contact tracing app	Number of downloads	Country	Bluetooth	GPS	GSM	Central data collection	Launch date
Stay Safe PH	100,000+	Philippines	No	Yes	Yes	Yes	–
ProteGO-Safe	100,000+	Poland	Yes	No	No	No	April 30, 2020
Ehteraz	1,000,000+	Qatar	Yes	No	Yes	Yes	May, 2020
Social monitoring	–	Russia	No	Yes	No	Yes	–
Tabaud (COVID-19 KSA)	500,000+	Saudi Arabia	Yes	No	No	Yes	April 3, 2020
Trace Together	1,000,000+	Singapore	Yes	No	No	Yes	March 20, 2020
StayHome	(wristband tracking device)	Singapore	Yes	Yes	No	Yes	Aug 10, 2020
Corona100m (Co100)	4000+	South Korea	No	Yes	Yes	–	Mar 12, 2020
SwissCovid	500,000+	Switzerland	Yes + DP 3 T	No	No	No	May, 2020
Hayat Eve Sigar	Web-based?	Turkey	Yes	No	Yes	Yes	April, 2020
TraceCovid	100,000+	UAE	Yes	No	No	Yes	May, 2020
NHS Covid-19 App (NHS 24: Covid-19)	1,000+	UK	Yes	No	No	Yes	May, 2020
Coronavirus UY	100,000+	Uruguay	Yes	No	No	Yes	March 20, 2020
Novid	10,000+	USA	Ultrasound	Yes	No	No	May 11, 2020
Private kits: safe paths	–	USA	No	Yes	No	No (can voluntarily share)	March, 2020
Bluezone	300,000	Vietnam	Yes	No	No	Yes, if positive	April 17, 2020

contact tracing apps that interact using encrypted Bluetooth metadata. Several apps, including COVID Tracker (Ireland), My Trace (Malaysia), Estonia's App (Estonia), have now converted to Apple/Google API. The apps and the digital world are constantly evolving to maximize effectiveness along with safety.

While most apps use either Bluetooth, GPS, or GSM to trace contacts, the Novid app (USA) is unique in the use of ultrasound to detect contacts with submeter accuracy. The ultrasound detection system works in the background when the microphone setting is turned on. It works for the user to identify possible exposure and helps the community by mapping hotspots and recording the trend of the spread of COVID-19 in a community (16). It is yet to be seen how effective this technology turns out.

Contact tracing apps are not the only use of digital technology during this pandemic. Many other apps have been rolled out in the last few months that map out hotspots, connect patients to doctors (telehealth), screen COVID patients, and monitor symptoms, among other functions.

Specific advantages of mobile- and web-based apps during COVID-19

Restrictions in delivering face-to-face patient care led to developing and implementing alternative forms of technology like telemedicine and smartphone apps (17). Smartphone technology with apps to support patient care and surveillance is seen as an extension of telemedicine (17). As the fight against COVID-19 intensifies, many are looking forward to loosening restrictions and lifting of lockdowns. Although there are various ways to support healthcare providers during this time, mobile applications are among the most

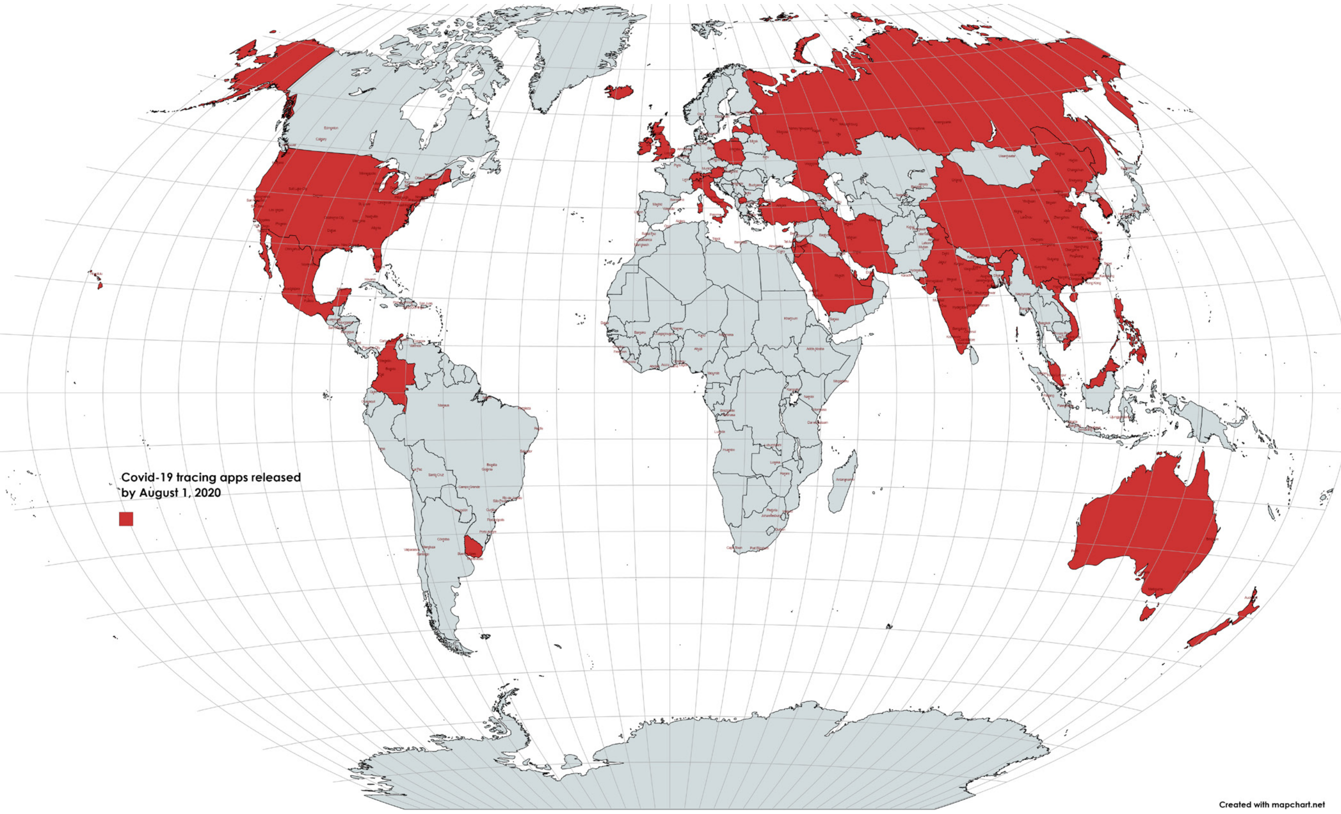

Figure 1 Countries that have released Covid-19 contact tracing apps as of August 1, 2020.

used methods (18). A wide range of countries have launched mobile applications that directly cater to patients who have contracted the virus or have been close to individuals positive for COVID-19 (18). The process of contact tracing is a lucrative way in which contact tracers can accurately identify infected patients and help them quarantine or self-isolate. The process relies on in-person interviews, which is a slow process and very taxing (19). The usage of mobile apps will be beneficial in combating COVID-19 for both patients and health care providers.

Contact tracing apps are at the forefront in identifying patients with a confirmed COVID-19 diagnosis, providing them with instructions on how to go about self-quarantining, monitoring their clinical symptoms as well as alerting friends/family who has been close to them two days before the onset of symptoms (18). There is a new breed of apps to retrace a person's movements to help identify people who might have been infected with the hope of notifying those people at an early stage of the infection to stop the spread of the virus (19). Though efficacy is not yet proven, modeling demonstrates that apps can slow the spread of the virus if enough of the population uses them. A Take-up threshold of 60% of a community can bring this current pandemic under control, according to scientists at the University of Oxford, UK (19). Even if the apps are beneficial, contract tracers are still needed for follow-up interviews. Many protocols have been created by researchers and developers, to promote trust and gain public approval. Privacy-minded protocols use a decentralized approach using phone Bluetooth to send short bursts of data between phones broadcasting transient pseudonyms (19). No identifying or location information is retained in a decentralized approach (19). If executed correctly, it can play a substantial role in both containing and flattening the transmission curve of the virus. AI in the form of mobile applications continues to facilitate the preparedness and detection of COVID-19 positive patients (20). The usage of mobile and web-based applications has the potential to help curb the spread of COVID-19 and, hence, reduce mortality.

Increasing access to online resources broadens a patient's knowledge of their medical conditions. It allows them to access the most up-to-date information, enabling them to make an informed decision on treatment options and better ease with the burden of diseases. They also can share their experiences on treatment outcomes, medication interactions, or other community member's symptoms. These online resources play an essential role in patient education, compliance with treatment and follow-up, and reducing the need for inpatient hospitalization. Digital health addresses the barriers in health care delivery, improves access and affordability, and augments the quality of health care provided. Currently, telemedicine is being put to the test to see if it is safe, efficacious, and a legitimate replacement for in-person visits between physician and patient.

Specific limitations of mobile- and web-based apps during COVID-19

Despite the enumerated advantages of the web- and mobile-based applications, some issues regarding their use were identified, particularly with privacy. Some applications make use of Bluetooth and may allow third parties to view the location of individuals. In other countries where web- and mobile-applications were launched, it enabled tracking of phones (Israel, Taiwan, and Singapore) or access to a patient's travel history (Taiwan) (5,21-23).

One limitation is the lack of access to technology. Many susceptible groups such as the elderly, disabled, homeless, and children are less likely to have a mobile phone and may not be able to use such apps. Not including this population will likely cause an incomplete penetration of the effort to use a contact tracing app (18).

Hispanovida.com App Goals, Advantages, and Possible Limitations

The goals of the web-based apps are to target a large population with accurate information, along with creating self-awareness about the most pertinent signs and symptoms of COVID-19. It is cost-effective and readily accessible. AI would guide in contact-free interaction during the pandemic with improved contact tracing methods, encourage self-quarantine and self-isolation measures leading to prompt mitigation of the spread of the virus. It supports real-time monitoring. This system, in turn, would decrease the emergency room visits and reduce the burden on the already overwhelmed healthcare system. It will aid in the judgment regarding home quarantine versus hospital admission. It will also provide us with the data to help understand the disease's epidemiology in a specific population.

Hispanovida.com used as guidance the risk assessment algorithm created by Ecuavida.com. On August 5, 2020, Ecuavida reported having 15,675 registered users and 25,397 total tests performed. Additionally, they reported having 9,057 users classified as low risk, 3,597 users classified as medium risk, and 12,743 users classified as high risk.

To reduce the time needed to identify a person under investigation (PUI) for COVID-19 and their rapid isolation, we propose collecting data such as contact information, recent travel history, signs and symptoms, risk factors, close contacts, and lab reports using a web-based app. With the data extracted, we can do a preliminary screening, early identification, improve stratification, tracking, and treatment of possible COVID-19 cases. Such data can be used in the preliminary screening and early identification of possible COVID-19 cases. Thousands of data points are processed through AI frameworks that can evaluate individuals and stratify them into no risk, minimal risk, moderate risk, and high-risk groups. Low risk is advised to continue preventive measures. Medium and high risk is linked to a healthcare provider who will offer support. We enhanced our app by adding services such as contact tracing for medium and high risks, privacy-minded protocols, a virtual chatbot, and translation services. AI and medical apps help patients and physicians access lab tests, medical records, and educational materials. This new way to deliver care will help stratify patients in risk groups to assess their necessities and improve access to the system efficiently.

Furthermore, for contact tracing to be effective in stopping the spread of COVID-19, it must ideally be done as soon as the index case develops symptoms. Hispanovida.com takes on a proactive approach in that it identifies cases early in the disease process and aims to prevent them from progressing to the severe stages of this disease. We seek to reduce the time between symptom onset and contact tracing by eliminating the delays caused by backlogs, human error, and lack of qualified personnel. Due to this, we developed a survey and offered CTS support for any person who would like to be informed and educated about the virus so they can identify initial signs and symptoms and report them on the app early in the course of the infectious period.

Functionality testing was performed by evaluating database and links connection, cookies, submission, and gathering data. Usability and interface testing were done by running the test with an internal team simulating the expected user base and evaluating navigation, content, and server-web interaction. Compatibility and performance testing was done to evaluate if the app is displayed correctly in different browsers. Security testing was performed to develop privacy-minded protocols that use a decentralized approach. Though efficacy is yet to be mapped, modeling demonstrates that the app can slow the spread of the virus if used widely.

The constraints of Bluetooth and GPS technologies can lead to false positive and false negative results, which weaken their effectiveness for contact tracing. Mobile apps exist and run on the device itself. Web-based-apps use an internet browser and can adapt to any device. They are not fundamental to a selective system and instead need to be downloaded or installed. The web-based apps function in the browser, update themselves, do not require app store approval, and launch quickly. Furthermore, Hispanovida.com has been translated to English (Covidriskeval.com), and Haitian Creole (Napviv.com) by Larkin Health Systems. The main goal is to be able to reach a bigger population and have a greater impact.

Limitations to our web-based app include recall bias regarding events that occurred from two days before symptom onset and until the start of self-isolation as this impacts data concerning close contacts and places visited during that period. Also, registering is limited to those who are computer literate and with access to a PC or smartphone. It is important to note that contact tracing is a time-consuming and resource-intensive process. Contact tracers may face users with language barriers or with misconceptions about COVID-19, and these will be accommodated accordingly by presenting information from valid sources and connecting with translation services. Finally, the app will not capture the data of those who are not interested in participating, too ill to register, or who have passed away due to COVID-19 in the interim.

Conclusions

During the COVID-19 pandemic, digital health will prove to be a key in mitigating the spread of the virus. Current literature and the overwhelmed health care system call for the need to integrate digital health with primary care and educate the public on its advantages to enhance healthcare response, surveillance, outbreak prediction, geospatial analysis, and development of accurate curative algorithms in response to the challenges presented by the pandemic. With the data gathered in this review, we were able to enhance our app and address current limitations to improve its efficacy and quality. Thus, Hipanovida.com has potential to boost the current contact tracing apps and enhance the tracking of community transmission of COVID-19 by allowing users to manually record their close contact information in a more personalized way. This could help reduce COVID-19 cases until we have successful widespread vaccination. Our app still has limitations, such as recall bias from users and limited access only by PC or smartphone. The web-based app became fully functional in September 2020.

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