Digital epidemiological surveillance: the role of mobile applications in identifying positive Covid-19 cases[1]

Vigilancia epidemiológica digital: el rol de las aplicaciones móviles en la identificación de casos positivos para Covid-19

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[1] This article is based on the analysis of eight Ibero-American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Spain, Mexico, and Panama) that are part of the Thematic Network for the Evaluation of Public Management Processes in a Pandemic and Citizen Participation (EVAPROP), affiliated with the Ibero-American Program of Science and Technology (CYTED). EVAPROP's overarching objective is to assess the actions implemented by the Ibero-American National Science, Technology, and Innovation Systems in the field of public health as a response to the COVID-19 pandemic during 2020 and 2021, from the perspective of communication, citizen participation, and social listening. The purpose is to provide insights that improve public-sector communication during future health crises and to promote the democratization of knowledge as a cornerstone for achieving collective well-being (CYTED, 2024, para. 1).

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Abstract

This study examines the use of the earliest mobile applications deployed as a digital epidemiological surveillance strategy for identifying and tracing positive COVID-19 cases. A descriptive case analysis was conducted through the review, evaluation, and critical synthesis of academic and institutional sources. Findings indicate that all applications analyzed began operating in 2020, with most being voluntary. Several countries integrated geolocation (GPS) technology, and data were handled anonymously. Some applications enabled Bluetooth-based contact tracing, employing both centralized and decentralized data-storage architectures. The results show that while these mobile applications stood out for their rapid development, they also generated considerable controversy regarding data governance and privacy. The study concludes that future health-crisis response efforts must incorporate alternative tracking strategies that do not rely exclusively on these types of digital tools.

Keywords

Mobile applications; Coronapps; COVID-19; Technological innovation; Telemedicine; Digital surveillance; Epidemiological surveillance.

Resumen

Se estudia el uso de las primeras aplicaciones móviles empleadas como estrategia de vigilancia epidemiológica digital en la identificación y rastreo de casos positivos para COVID-19. Se llevó a cabo un análisis descriptivo de casos por medio de la revisión, evaluación y síntesis crítica de distintas fuentes académicas e institucionales. Se identificó que todas las aplicaciones analizadas comenzaron a funcionar en el año 2020 y la mayoría de ellas fueron de uso voluntario. Varios países utilizaron la tecnología de geolocalización (GPS) y los datos fueron manejados de manera anónima. Algunas aplicaciones permitieron el seguimiento de contactos por *Bluetooth* y los métodos de almacenamiento de datos fueron tanto centralizados como descentralizados. Se concluye que las aplicaciones móviles empleadas destacaron por su rápido desarrollo, sin embargo, en temas de gobernanza de datos y privacidad presentaron gran controversia. Para el afrontamiento de futuras crisis sanitarias se visualiza la necesidad de identificar nuevas estrategias de rastreo que no dependan exclusivamente de este tipo de dispositivos.

Palabras clave

Aplicaciones móviles; Coronapps; COVID-19; Innovación tecnológica; Telemedicina; Vigilancia digital; Vigilancia epidemiológica.

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Introduction

Since the onset of the COVID-19 pandemic, governments around the world implemented initiatives grounded in Information and Communication Technologies (ICTs) to confront the public-health crisis (Kamalova & Moralejo, 2022). One of the most rapidly executed strategies was the development of mobile-device applications—also referred to as mHealth (mobile health), apps, coronapps, or mobile platforms—designed to manage the risk of infection from the novel coronavirus and to ensure that infected individuals could receive timely care and treatment.

Suárez-Millán (2020) defines applications as "any software program run by a mobile phone to perform a task, display information, facilitate communication, entertain, or provide a service" (p. 33), a definition shared by Fernández-Blanco et al. (2020). However, the implementation of such mobile applications was not universally perceived as positive. As Kamalova and Moralejo (2022) note, various societies expressed collective concern about the impact contact-tracing applications could have on users' right to privacy: "the use of these techniques for tracing entails a series of practical, technical, legal, and ethical considerations and risks that introduce various challenges to their implementation and effectiveness" (p. 217). This social apprehension, according to Arguelles and Amaro (2021), led to renewed global interest in issues related to data governance, understood as the set of rules regulating how public and private actors may use information provided by citizens, as well as the mechanisms that can promote social learning and the appropriation of these emerging ICTs.

Despite the initial mistrust surrounding the deployment of contact-tracing applications, they undeniably offered critical support to the health systems of numerous countries. Among other benefits, they enabled "the visualization of real-time data related to virus transmission, allowing citizens, health personnel, and decision-makers to better understand this health-disease phenomenon" (Giraldo et al., 2021, p. 41). Roig (2021) reinforces this positive assessment, noting that one of the main advantages of implementing these applications was the speed with which users could report symptoms and high-risk contacts. This capability facilitated the tracing and confirmation of potential infection cases and, in general, accelerated epidemiological surveillance processes.

Given this context, and with the aim of structuring the presentation of the reflections outlined in this document, the discussion begins by conceptualizing the terms epidemiological surveillance and digital surveillance. It then describes the methodological considerations and proceeds to detail—through the review, evaluation, and critical synthesis of diverse academic and institutional sources—the characteristics of the first digital epidemiological tracing applications for positive COVID-19 cases used in the eight countries that comprise the EVAPROP/CYTED network (Ibero-American Program of Science and Technology for Development, 2024). The document concludes with final reflections that highlight the lessons learned regarding the use of these applications. This analytical sequence is designed to address the objective of describing the use of the earliest mobile applications implemented as a digital epidemiological surveillance strategy for identifying and tracing positive COVID-19 cases in the eight countries of the EVAPROP/CYTED network (Argentina, Brazil, Chile, Colombia, Costa Rica, Spain, Mexico, and Panama).

Epidemiological surveillance and digital surveillance: two related concepts

During the COVID-19 pandemic, global health systems faced significant challenges related to the collection, analysis, and dissemination of information about what was, at the time, an unprecedented public-health crisis. As part of the response to this critical event, governments and organizations—both public and private—shifted their focus toward developing and adapting digital tools capable of overcoming the limitations of traditional epidemiological surveillance, which lacked the resources needed to collect and process the massive volumes of data associated with SARS-CoV-2 infection (Mason et al., 2022). These technological tools played a fundamental role during the pandemic by streamlining contact-tracing processes, supporting the training of health professionals, contributing to the management and control of positive cases, among other functions. Collectively, these efforts led to the strengthening of an emerging and novel form of epidemiological surveillance: digital surveillance, understood as the use of virtual resources, mobile technology, and big-data processing to complement the protocols and approaches of conventional epidemiological surveillance (Kostkova et al., 2021).

Digital surveillance relies on tools such as social media, mobile applications, and mass text-messaging systems to help control disease outbreaks, support infection-prevention campaigns, disseminate evidence-based information on topics of public-health relevance, and facilitate rapid, remote responses for patients who cannot access formal health services in a timely manner (Kostkova et al., 2021).

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Given the positive impact of ICT integration into the field of epidemiology, the following sections synthesize the concept of epidemiological surveillance and describe the emergence of digital surveillance through the implementation of ICT within traditional epidemiology. The discussion concludes by identifying the advantages, disadvantages, and challenges that the integration of digital-surveillance strategies may pose for health-system operations.

Donelle et al. (2021) define epidemiological surveillance as the systematized and continuous collection of information related to health events, with the objective of analyzing, interpreting, and disseminating relevant information to support decision-making within health systems.

Today, epidemiological surveillance has become indispensable to the health sector because it provides a panoramic understanding of the reality of a particular disease and subsequently informs the individuals responsible for formulating policies and making decisions regarding the management of critical health events (Ibrahim, 2020). Rather than a single unified concept, epidemiological surveillance serves as an umbrella term encompassing numerous mechanisms through which information related to diseases is collected and processed—for example, clinical surveillance, passive surveillance, active surveillance, sentinel surveillance, mortality surveillance, serological surveillance, among many others.

These modes of conducting epidemiological surveillance are categorized under what is known as traditional epidemiology (Kostkova et al., 2021), which relies on gathering data through direct interaction with individuals who contract a given disease. However, as Donelle et al. (2021) explain, in recent years governments, academic institutions, and health-sector actors—both public and private—have made increasingly concerted efforts to develop new ICT tools capable of supporting health-care practices globally. These tools include, for instance, mobile contact-tracing applications, geolocation services, mass text-messaging systems, the strategic use of social media platforms such as Twitter, and the analysis of online search records, among others. Collectively, these innovations have contributed to what is now known as digital epidemiological surveillance or digital surveillance.

Kostkova et al. (2021) describe digital surveillance as a form of epidemiological surveillance that incorporates tools not traditionally used in conventional epidemiology—such as those mentioned above—which generate large volumes of information that can be integrated into public-health systems as part of the standard response to disease outbreaks. In this sense, digital surveillance expands traditional epidemiology by incorporating data that would not otherwise be accessible without ICT. However, this complementarity does not imply the replacement of surveillance carried out through traditional methods; instead, its purpose is to broaden their

reach. This relationship can be seen in processes such as active surveillance (targeted searches for cases and disease outbreaks) and passive surveillance (waiting for relevant information to reach health systems, for example through diagnostic reports), both of which can be conducted using traditional strategies or digital tools (ICT-based strategies).

Although it is a relatively recent concept that gained prominence during the SARS-CoV-2 health crisis, Kostkova et al. (2021) note that digital surveillance had already been used to address previous critical health events, such as dengue epidemics in tropical countries. The massive volumes of information collected through applications, websites, tracking devices, and other tools require traditional epidemiological analysis to be incorporated into public-health strategies.

The advantages of mHealth applications within digital surveillance are extensive. According to Kostkova et al. (2021), the use of these apps is highly efficient because, due to technological literacy processes driven by globalization, they have become widely accessible tools. Their availability facilitates access to substantial amounts of information, including data from regions with limited connectivity or scarce resources.

Despite these advantages, incorporating apps into health systems also introduces a series of challenges and risks for users. Sujarwoto et al. (2022) report that the primary challenge for these applications was the appropriate management of privacy permissions regarding the information collected, given that in many cases personal data were provided without anonymization, enabling the identification of infected individuals. Furthermore, Sujarwoto et al. (2022) argue that mobile applications were not designed with health-care workers in mind, as evidenced by the significant number of apps lacking features such as communication tools for health professionals, activity-planning functions, training-program dissemination, systematization of hospital resources, or self-care support for this population.

Although the incorporation of ICT—particularly mobile applications—has contributed meaningfully to the innovation of traditional epidemiology, these tools also present notable disadvantages. First, Kostkova et al. (2021) emphasize that many of these new technologies rely on analyzing internet searches and information gathered from social media, which may bias digital-surveillance results due to limited representativeness and the reporting of false infection cases. Ibrahim (2020) also argues that digital surveillance may compromise the human right to confidentiality and information protection, as it is common for certain applications to collect data

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without users' awareness. Additionally, the misuse of ICT has fueled an "infodemic" marked by the widespread dissemination of false information—a challenge that, to date, has not been effectively or promptly addressed by governments. Compounding these concerns is the argument that unregulated app use disproportionately affects minority groups that lack access to formal health services or digital technologies and that such tools create a "false sense of security" among populations regarding disease management (Donelle et al., 2021).

Methodology

Using a qualitative approach, a case-study design was employed through a descriptive analysis that included the review, evaluation, and critical synthesis of various academic and institutional sources. The central question guiding this study was: What are the characteristics and lessons learned from the first mobile applications used as a digital epidemiological surveillance strategy for identifying or tracing positive COVID-19 cases in the countries that comprise the EVAPROP/CYTED network?

The development of this study followed three clearly defined investigative stages. First, a conceptualization phase established definitions of epidemiological surveillance and digital surveillance, emphasizing the importance of digital tools for data collection and processing during the pandemic. This phase also identified the differences between conventional epidemiological surveillance and digital surveillance, highlighting their complementarity in managing the health crisis.

The second investigative stage—a descriptive analysis—focused on characterizing the mobile applications used in the countries under study by examining factors such as user-data management, transparency in the use of personal information, accessibility, and privacy policies. Several aspects of interest emerged: the launch dates of each application, the cumulative number of downloads, the privacy permissions requested by each platform, the mechanisms used to store collected user data, and the public reception of the application in each country.

Finally, the third stage of the study presented final reflections highlighting the lessons learned from the use of digital epidemiological-tracing applications.

As the central axis of the methodology described above, relevant online bibliographic material—both in Spanish and English—was sought and selected according to the themes of interest, prioritizing sources published in 2020 or later to ensure a reference framework grounded in the best available information. Likewise, for information related to the so-called coronapps, priority was given to sources originating directly from official government websites or affiliated agencies (e.g., ministries of health or their equivalents). Alternative digital sources were not excluded, particularly when data collection from official websites proved impossible or insufficient to characterize each mobile application of interest.

Digital Epidemiological-Tracing Applications for Positive COVID-19 Cases in Countries of the EVAPROP/CYTED Network

The following section describes the first coronapps implemented by the governments of eight countries—Argentina, Brazil, Chile, Colombia, Costa Rica, Spain, Mexico, and Panama—which are part of the EVAPROP/CYTED network (Ibero-American Program of Science and Technology for Development, 2024). These applications are considered fundamental components of the initial immediate response to COVID-19. Although additional digital-surveillance applications may have been developed later in these countries, this article focuses strictly on the pioneering platforms.

ARGENTINA: *CuidAR*

On April 27, 2020, as indicated by the Government of Argentina (2020a), the Secretariat of Public Innovation of the Office of the Chief of Cabinet of Ministers launched the CuidAR application, which replaced the country's earlier official app, Coronavirus Argentina, active for approximately one month. The primary purpose of this new mobile application was to enable users to self-assess COVID-19 symptoms and, based on the results of that self-assessment, generate a Certificado Único Habilitante de Circulación (CUCH)—a single circulation permit certifying that the user was authorized to move about during the pandemic. The application was made available to the Argentine public through Google Play and the App Store and accumulated more than 10 million downloads (Presidency of the Argentine Nation, 2022).

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Use of the application was voluntary for Argentine citizens (Government of Argentina, n.d.-a); however, pursuant to a regulation issued by the Directorate of Migration, the app became mandatory for individuals entering the country from abroad. Upon accessing the app, as explained by the Government of Argentina (n.d.-b), users were required to provide personal information: full name, national identification number, processing number of the DNI, gender, and telephone number. This information was subsequently "managed by the Provincial Emergency Operations Committees (COEPs)" (Government of Argentina, n.d.-b, para. 5).

The personal data collected during user registration were not anonymized, unlike statistical data (e.g., number of self-diagnoses, number of downloads), which were handled anonymously (Government of Argentina, n.d.-c). Regarding geolocation and contact-tracing permissions, the Government of Argentina (2020b) states that the app utilized device-based geolocation but did not employ Bluetooth technology for contact tracing. All information collected through CuidAR was stored centrally in "a database overseen by the Undersecretariat of Open Government and Digital Nation of the Secretariat of Public Innovation of the Office of the Chief of Cabinet of Ministers" (Jefatura de Gabinete de Ministros de Argentina, 2020, p. 6). According to the Government of Argentina (2023), this database was deactivated in March 2023 in accordance with Law 25.326 on Personal Data Protection.

Regarding the benefits identified through the use of the application, the Government of Argentina (2020b) reports that more than 40 million circulation permits were issued through CuidAR, streamlining the process significantly. Likewise, the Government of Argentina (2020b) states that "more than 36.9 thousand self-diagnoses with symptoms compatible with COVID-19 were reported, which enabled detection, care, and monitoring of those individuals by the health system" (para. 3), demonstrating the app's effectiveness as an epidemiological-surveillance tool. Based on the volume of diagnoses, the Argentine government subsequently developed a Help Desk to monitor real-time COVID-19 inquiries, handling more than 500,000 requests (Government of Argentina, 2020b).

BRAZIL: *CORONAVÍRUS SUS*

Brazil's Open University of the Unified Health System (UNA-SUS, 2020) notes that "with the aim of facilitating access to information on COVID-19 and combating the spread of false news, the Ministry of Health developed applications containing prevention tips and symptom descriptions" (para. 1), among which is the Coronavírus SUS app. Its launch occurred on March 14, 2020, for both Android and iOS devices. The Government of Brazil (2020) describes the application as a platform designed to "raise public awareness about coronavirus (COVID-19) by providing

information on a variety of topics such as symptoms, preventive measures, recommended actions in cases of suspected infection, a map showing nearby health facilities, among others" (para. 1), emphasizing its educational purpose as opposed to the epidemiological-surveillance functions incorporated into applications deployed in other countries.

According to the app's page on Google Play (Serviços e Informações do Brasil, 2020), the platform has more than 10 million downloads. Its description notes that it requests geolocation and Bluetooth permissions to perform contact tracing; however, it does not require any form of personal identification to access the application, as it does not include a user-registration system. Beyond these features, available information about the app is scarce: no official documents summarize its findings or demonstrated benefits, and users cannot access terms and conditions for Coronavírus SUS. Therefore, it remains uncertain whether geolocation data were stored centrally or in a decentralized manner.

CHILE: *CORONAPP*

As indicated by the Division of Social Organizations of the Government of Chile (2020), on April 16, 2020, Chilean President Sebastián Piñera announced via Twitter the launch of the CoronApp application for Android and iOS devices. Through this app, "users can review all news related to the virus, the measures decreed by authorities, and even self-evaluate their symptoms if they suspect a possible infection" (Division of Social Organizations, 2020, para. 2). The Council for Transparency (2020) states that the app was developed by the Ministry of Health with support from Amazon and Google (Nájera & Ricaurte, 2020).

Nájera and Ricaurte (2020) report that as of June 2020, CoronApp had more than 100,000 downloads; because the application can no longer be accessed through the App Store or Google Play at the time of writing, no updated figure is available. Individuals who downloaded the app were required to provide the following personal data for registration (Angel, 2020): identification number, email address (optional), telephone number, full name, age, and community. Because the application was voluntary, CoronApp stated that these data would not be anonymized but emphasized their responsible use. One of its features, Ayuda Vecina, requested geolocation permissions; however, as noted by Angel (2020), the app did not perform Bluetooth-based contact tracing.

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The data collected by the app were stored centrally in a private cloud on Amazon Web Services (AWS), according to Weidenslaufer et al. (2020), and CoronApp declared that data could be retained for up to 15 years in certain cases—an atypically long retention period given that similar applications generally stored data for around 30 days. In addition, Angel (2020) states that no official government website explained how the data collected by the application would be processed, which led to public distrust regarding its use: "if the Ministry of Health is neither using nor leveraging the value of the data the application collects, it is unclear why users are required to provide so much identifying information when registering" (Angel, 2020, para. 1). Pogrebinschi (2021), in an analysis for the organization Innovations for Democracy in Latin America, notes that to date, the information collected by CoronApp has not been used in any public policy or similar document.

COLOMBIA: *CORONAPP-COLOMBIA*

On April 7, 2020, Colombia's Ministry of Health and Social Protection (MinSalud, 2020) launched the CoronApp-Colombia mobile application on Android and iOS platforms, one day after the first COVID-19 case was officially reported. The app was initially promoted as an informational and self-diagnostic tool. In the words of the Minister of Information and Communication Technologies at the time, Sylvia Constaín: "CoronApp Colombia is a tool that will be very important because, on the one hand, it will provide us with updated information on how the virus is evolving in Colombia, and additionally, it will help us manage our symptoms" (Ministry of Information and Communication Technologies [MinTIC], 2020, para. 3). The application is no longer available through Apple or Android stores because, according to Nájera and Ricaurte (2020), "after the contact-tracing functionality experienced failures, it had to be removed and replaced by the service offered jointly by Apple and Google" (p. 15).

According to MinTIC (2020), CoronApp-Colombia offered a platform through which the Government of Colombia disseminated national COVID-19 statistics, including confirmed and recovered cases, broken down by departments and localities. The app also included a map of nearby medical centers and helplines and provided prevention recommendations.

As noted earlier, the app also collected self-reported data from citizens regarding symptoms and potential positive cases; to register, the application requested the user's first and last name, identification number, mobile number, symptoms experienced by the user or their family members, and their location, among other information (Ríos-Villafañe, 2020). Furthermore,

the app used geolocation and Bluetooth to inform users of possible risk contacts with infected individuals (Fernández-Sosa et al., 2020), and the collected data were stored centrally (Giraldo et al., 2021). CoronApp-Colombia also had the particular feature of tracking the user's location during quarantine if they reported flu-like COVID-19 symptoms.

With the information collected from the application, "the government can obtain a real-time national overview of the emergence of symptoms and specific locations that may trigger alerts about virus spread" (MinTIC, 2020, para. 19). The government asserted that the collected data would remain anonymous. Gil-Torres et al. (2020) estimate that during 2020, the app was downloaded more than 27 million times, likely due in part to a support campaign offering "1GB of data and 100 call minutes to all users who reported their symptoms" (p. 339). Despite this large number of downloads—also boosted by the government mandate requiring the app (Giraldo et al., 2021)—it is estimated that Colombia had only 57.3 smartphones capable of running the app per 100 inhabitants, limiting its effectiveness (Ríos-Villafañe, 2020).

Regarding the government's use of the collected data, Ríos-Villafañe (2020) states that "the National Institute of Health did not receive the data obtained by the application, which results in a failure to fulfill its role in defending public health" (p. 22). Giraldo et al. (2021) add that due to the improper handling of information, the centralized data storage, and the government's inability to deliver on its promise of providing 1GB of data and 100 call minutes to those completing the self-diagnostic questionnaire, the app was poorly received by the Colombian public, hindering its consolidation as a useful epidemiological-surveillance tool in the country.

COSTA RICA: *EXPEDIENTE DIGITAL ÚNICO EN SALUD (EDUS) / (UNIFIED DIGITAL HEALTH RECORD)*

Before being understood solely as a mobile application, Cabello-Cano (2020) notes that EDUS within the Costa Rican health system is "the repository of patient data in digital format (…) whose main purpose is to continuously, efficiently, and comprehensively support the provision of health care services" (p. 33). It was officially implemented in Costa Rica on September 27, 2013, under Law 9162 on the Unified Health Record (EDUS). Beginning in 2015, EDUS was deployed as an official mobile application of the Costa Rican Social Security Fund (CCSS), as

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stated by the International Social Security Association (2024): "to expand access and coverage of Costa Rica's health services, enabling insured individuals to better understand the information contained within their clinical profiles" (para. 1).

On March 26, 2020, shortly after the emergence of the COVID-19 pandemic, the CCSS updated the EDUS application to allow users to determine their risk level regarding the new disease. This service was available both to individuals with registered accounts and those without one (May, 2020). As indicated on the official EDUS website (CCSS, 2022), the application can be downloaded from the Google Play Store, Apple Store, and App Gallery; according to the Play Store (CCSS, 2023), it has accumulated more than one million downloads. Use of the application is voluntary, and in accordance with its privacy policy (CCSS, 2021), the personal data collected (marital status, educational attainment, occupation, telephone numbers, email address, home and work information, and social contacts) are handled confidentially.

According to Fernández-Sosa et al. (2020), EDUS does not use geolocation or contact-tracing permissions. However, its privacy policy (CCSS, 2021) does not specify whether the collected data are stored centrally or in a decentralized format. From Cabello-Cano's (2020) perspective, the EDUS platform has been well received by the Costa Rican population and has proven to be a beneficial tool that has expanded the reach of the national health-care system.

Furthermore, Cabello-Cano (2020) reports that EDUS was evaluated by the Sulá Batsú R.L. Cooperative (an organization independent from the CCSS) across various dimensions, such as user experience and perceptions of health-care personnel regarding the system's efficiency. Overall, the evaluation results were positive, concluding that "modernization has been very important, but with regard to the development of the application, it is still necessary to address digital divides, as not all of the population is aware of it, and therefore does not use it" (Cabello-Cano, 2020, p. 95). Although EDUS continues to face challenges and areas for improvement, Cabello-Cano (2020) emphasizes that it "is a program with international prestige and one of its most important recognitions is the United Nations Public Service Award 2019, granted by the United Nations" (p. 18).

SPAIN: *RADAR COVID*

The Radar COVID application is described by the Government of Spain (2020) as "a mobile application developed to help control the spread of COVID-19 by identifying potential close contacts of confirmed cases through Bluetooth technology" (p. 3). Kamalova and Moralejo (2022)

explain that the application was launched as a pilot project on the island of La Gomera on June 23, 2020, and subsequently, in August of the same year, the Spanish government promoted its adoption across multiple Autonomous Communities. This process was completed on October 14, 2020, when both Madrid and Catalonia joined Radar COVID. Rodríguez et al. (2021) specify that the application was developed using the Exposure Notification System (ENS) created by Apple and Google, which facilitated distribution through their digital stores. According to the official application site (Government of Spain, 2022), it was downloaded more than eight million times, representing a penetration rate of 21 percent of the Spanish population.

According to the Spanish Ministry of Health (2020), Radar COVID uses only low-energy Bluetooth technology for contact tracing and does not request geolocation permissions at any point. Roig (2021) states that the application was entirely voluntary for the Spanish population, and Kamalova and Moralejo (2022) note that the collected data were stored in a decentralized manner. Regarding anonymity of sensitive information, the Government of Spain (2020) states: "the application does not collect any data that would allow your identity to be traced. For example, it will not ask for, and cannot know, your name, surname, address, telephone number, or email address" (p. 17), and that "all data stored on the device (codes exchanged with other mobile phones) are deleted after 14 days" (p. 17). In other words, no mechanism existed through which users could be identified.

Regarding public reception, Kamalova and Moralejo (2022) note that "according to various studies, privacy was one of the main concerns of citizens regarding the adoption of the application" (p. 218), as the Spanish population is characterized by high degrees of uncertainty avoidance— that is, a reluctance to engage with phenomena perceived as untrustworthy. This contributed to weak public uptake of the app, likely compounded by the fact that, during the early weeks of the rollout, the Ministry of Health "did not offer a detailed report on monitoring mechanisms beyond what was included in the privacy policies" (Carrasco, 2021, p. 5), generating doubts about transparency and the potential misuse of personal data. Additionally, the application's privacy policies "were not accessible to the public in the repository, and access was denied to journalists, citizens, and civil society, citing possible changes and future general publication" (Carrasco, 2021, p. 5).

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A final point to analyze regarding Radar COVID is its overall effectiveness as a digital epidemiological tracing tool. According to Roig (2021), the application shows significant shortcomings in this regard, due primarily to the limited adoption of the app among the Spanish population. Roig (2021) notes that "the limited use of the application to date—October 2021—with only 2–4% of positive cases reported, partially mitigates this vulnerability" (p. 533). Carrasco (2021) shares this view regarding the ineffectiveness of Radar COVID, arguing that:

> No consolidated information has been provided regarding how many people were detected through the tracing tools, nor have statistical data been offered concerning the cost and efficiency of the solution, even though this aspect is mentioned in the technical document on the implementation procedure of Radar COVID under the section on operational evaluation. Initially, some territories provided information to promote effectiveness, as in the case of Euskadi, where it was reported that 24 alerts resulted in the quarantine of three individuals. However, this information has not been updated periodically, nor is there a dedicated section for it on the app's website. (p. 9)

These shortcomings in the management of data collected by Radar COVID generated distrust and weak adoption among the Spanish population. In Spain's particular case, it is relevant to recall that health competencies are decentralized; the role of the central government is to coordinate the various regional health authorities. This helps explain why only some Autonomous Communities adopted Radar COVID and, consequently, the app's limited penetration nationwide.

MEXICO: *COVID-19MX*

According to the terms and conditions of the COVID-19MX application (Government of Mexico, n.d.), this digital tool "provides access to official, accurate, and timely information; enables users to perform a symptom self-assessment to identify possible COVID-19 infection; facilitates interaction with authorities for follow-up and care; and allows users to view the availability of COVID-19 hospital services" (para. 2). As explained by Saldaña (2020), the Mexican government introduced the app on April 1, 2020, during an evening press conference on official channels, with the objective that it serve as "a means for the exchange of information between health authorities and the population," stated Ricardo Cortés, Director General of Health Promotion at the Ministry of Health (para. 2). As of April 2023, the application had reached one million downloads on Google Play (Ministry of Health MX, 2021).

According to Aguilar (2020), COVID-19MX was developed by Mexico's Ministry of Health, specifically by a team within the Digital Government Unit of the Secretariat of Public Administration, with support from the National Council of Science and Technology. The app is free, and its download was never mandated by the government. As listed by Aguilar (2020), its

features include: enabling symptom self-assessment; identifying nearby care centers; a section of frequently asked questions and guidance related to SARS-CoV-2; and direct access to news, press briefings, and statements issued by the Ministry of Health.

On the application page in the Google Play digital store, the Ministry of Health MX (2021) indicates that COVID-19MX uses geolocation permissions to inform users about nearby health resources, with location determined by both network and GPS. The app also requests Bluetooth permissions, but as noted by Fernández-Sosa et al. (2020), it does not perform contact tracing using this feature. Other mandatory information requested upon installation includes age, gender, phone number, state, municipality, and risk factors.

Because use of the application is entirely voluntary, its terms (Government of Mexico, n.d.) state that the information collected is not anonymous, may be shared with third parties as required by the Ministry of Health, and is stored centrally by the Digital Agency for Public Innovation of Mexico City through the Directorate General of Citizen Contact. Regarding the use of these data, the Government of Mexico (n.d.) indicates that they will be used to generate institutional records based on reported suspected or confirmed COVID-19 cases.

As for public reception, Arguelles and Amaro (2021) explain that Mexican citizens generally made limited use of the app, an issue reflected in the low number of downloads relative to the country's population (approximately 126 million inhabitants and only one million downloads). This low rate of interaction between the public and the application may be attributed, according to Arguelles and Amaro (2021), to inadequate government promotion, the app's non-mandatory nature, widespread lack of knowledge about how COVID-19MX functioned, and concerns about its privacy permissions. These factors "have generated various controversies in both academic and political circles regarding data governance, especially concerning how data are generated, stored, and used" (Arguelles & Amaro, 2021, p. 136).

PANAMA: *PROTÉGETE CON SALUD*

The Protégete con Salud application—better known as Protégete Panamá—is a platform implemented by the Panamanian government to monitor individuals who tested positive for COVID-19 (National Authority for Government Innovation [AIG], 2020a). On April 28, 2020, the AIG, together with GBM Panama (a technological innovation and development company),

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announced the creation of Protégete, a tool that "will enable COVID-19–positive patients to maintain effective and direct communication with health specialists, especially during potential emergency situations" (AIG, 2020a, para. 2). Two days later, on April 30, 2020, the mobile application was made available to the Panamanian public exclusively for Android devices; as indicated on its Google Play page (Ministry of Health of Panama, 2023), the app has been downloaded more than 100,000 times. The platform was later also made available for iOS.

The intention of the application was for individuals infected with the virus to monitor their condition daily with the support of a medical professional through Protégete, while ensuring that the patient complied with mandatory isolation measures (AIG, 2020a). During the first eight weeks of operation, the AIG (2020b) reported that the platform recorded more than 2,300 positive COVID-19 diagnoses across the provinces of Bocas del Toro, Chiriquí, Colón, Herrera, Los Santos, Panamá, Panamá Oeste, and Veraguas. Subsequently, on February 22, 2021, the AIG (2021) announced that the application was ready to enter its second stage of development after establishing an alliance with Apple and Google that enabled the implementation of Bluetooth-based contact tracing, allowing rapid notification of individuals who might have been exposed to the virus.

The AIG (2021) specifies that "at no time will GPS information, location data, identifiers, or access to users' mobile devices or personal information be stored, nor will such data be shared through this service" (para. 8). The Government of Panama (2021a) notes that the use of Protégete Panamá is expressly voluntary and asserts that neither the national government nor Google or Apple can access any personal information entered into the platform, ensuring that such information remained anonymous. Likewise, "the codes generated by the platform, which activate the notification of contacts within the past fifteen days, have an expiration period and are also dissociated from the personal information of the individual who tested positive" (Government of Panama, 2021b, para. 4). As a result, information is essentially stored in a decentralized manner—that is, directly on the user's device. Finally, it was not possible to access any official documents providing information on the public acceptance of the application or on its scope and outcomes.

The following section presents, in Table 1, a comparative summary of the main characteristics of the applications described above as of March 2023.

Table 1

Characteristics of Mobile Applications Used by Eight Countries During the COVID-19 Pandemic

Application Name	Country	Launch Date	Number of Downloads	Voluntary Use	Data Used Anonymously	Uses GPS	Bluetooth Contact Tracing	Type of Data Storage
CuidAR	Argentina	04/27/2020	+10 million	Yes	No	Yes	No	Centralized
Coronavirus SUS	Brazil	03/14/2020	+10 million	Yes	Yes	Yes	Yes	No information
CoronApp	Chile	04/16/2020	+100 thousand	Yes	No	Yes	No	Centralized
CoronApp	Colombia	04/07/2020	+27 million	No	Yes	Yes	Yes	Centralized
EDUS	Costa Rica	03/26/2020*	+1 million	Yes	Yes	No	No	No information
Radar COVID	Spain	10/14/2020	+8 million	Yes	Yes	No	Yes	Decentralized
COVID-19MX	Mexico	04/01/2020	+1 million	Yes	No	Yes	No	Centralized
Protégete con Salud	Panama	04/30/2020	+100 thousand	Yes	Yes	No	Yes	Decentralized

Note. Although EDUS in Costa Rica predates this date, March 26, 2020 marks the update that incorporated COVID-19–related functionalities.

As shown in Table 1, all analyzed applications (Argentina, Brazil, Chile, Colombia, Costa Rica, Spain, Mexico, and Panama) were launched in 2020 and collectively accumulated approximately 58 million downloads. Most were voluntary, with the exception of Colombia. Several countries used geolocation (GPS) technology, except Chile, Costa Rica, and Mexico. Data were handled anonymously in most cases, except in Argentina, Chile, and Mexico. Some applications (Brazil, Colombia, Spain, and Panama) enabled Bluetooth-based contact tracing, and data-storage methods varied between centralized (Argentina, Chile, Colombia, and Mexico) and decentralized systems (Spain and Panama).

Similarly, Table 2 below summarizes the primary contributions and limitations of each mobile application analyzed in this study.

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Table 2

Main Highlights of Mobile Applications Used During the COVID-19 Pandemic

Country	Argentina	Brazil	Chile	Colombia	Costa Rica	Spain	Mexico	Panama
Application	CuidAR	Coronavirus SUS	CoronApp	CoronApp	EDUS	Radar COVID	COVID-19MX	Protégete con Salud
Public–private partnership	No information found	No information found	Yes	No information found	No	Yes	No	Yes
Main highlighted aspects	Used primarily to issue Single Circulation Permits	Did not request any type of personal identification	Collected data could be stored for up to 15 years—an atypically long retention period	If a person reported COVID-19 symptoms, the app monitored their location throughout the quarantine period	Not an application created specifically for the COVID-19 crisis, but rather a digital health platform that expanded its services during the pandemic	Poorly received by the Spanish population due to being perceived as unreliable, largely because of the lack of public access to its privacy policies	Despite requesting Bluetooth permissions, the application did not indicate that it performed contact tracing	It was not possible to access any official documents regarding public acceptance of the application or its scope and achievements
	Well received by the population and considered successful as a digital epidemiological-surveillance tool	Served an educational function	Did not provide information on how the collected data would be used, generating distrust	Its launch was reinforced by a campaign that promised 1 GB of data and 100 call minutes to users who reported their symptoms	The EDUS platform has been well received by the Costa Rican population	Collected data were deleted after 14 days of storage	Not well received by Mexican society, possibly due to inadequate promotion of the application by the Government of Mexico	Intended for individuals infected with the virus to monitor their condition daily with the support of a medical professional
	The database containing the collected information was shut down in March 2023	Limited information available about the application	By 2021, the information collected had not been used in public policies or similar documents	The National Institute of Health did not receive the data obtained by the app	No additional information included	Displayed shortcomings as a digital epidemiological-tracing tool, primarily due to poor adoption by the Spanish population	Generated controversies in academic and political circles regarding data governance	No additional information included

Conclusions

The implementation of ICT in epidemiological-surveillance processes proved to be a highly effective alternative for supervising and managing the COVID-19 crisis compared with more traditional methods. As Sujarwoto et al. (2022) explain, mobile applications emerged as one of the most important ICT tools for executing digital-surveillance protocols. Following a systematic review of applications used during the pandemic, it becomes clear that the adoption of Bluetooth and GPS-based contact-tracing systems is an essential tool for reducing infections during critical health emergencies. Therefore, their implementation is recommended in future disease outbreaks, potentially through a unified national contact-tracing system integrated into local health systems.

The use of applications enabling telemedicine capabilities can serve as a beneficial tool during epidemics or pandemics, especially for patients in quarantine or in hard-to-reach communities, as they not only facilitate access to medical consultations but also provide accurate, evidence-based information on prevention and treatment (Asadzadeh & Kalankesh, 2021).

Although the future of digital epidemiological surveillance appears promising considering the lessons learned during the COVID-19 pandemic, multiple challenges remain for strengthening ICT-based surveillance strategies. First, nations must demonstrate a willingness to collaborate in the development and dissemination of these tools, as many regions still lack the economic resources and digital literacy necessary to adopt such innovative systems for collecting health information (Ibrahim, 2020). It is also necessary to implement digital-surveillance protocols capable of identifying positive cases considered mild or subclinical, since traditional epidemiological surveillance has historically focused only on clinically detected cases—essentially the "tip of the iceberg" (Ibrahim, 2020).

Furthermore, "the rapid deployment of coronaapps in Latin America is a clear sign of existing digitalization capacities related to surveillance" (Aguerre, 2020, p. 8). However, although the development and implementation of these apps occurred at record speed in the analyzed countries (with the exception of Spain), they exhibit significant differences that prevent them from being collectively described as a unified model. As seen in Table 2, the handling of information provided

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by users varied substantially: for example, governments in Argentina, Chile, and Mexico deemed it necessary to use sensitive data in a non-anonymized manner, in contrast to the rest of the countries in this review.

The use—or absence—of Bluetooth permissions for contact tracing divided the applications analyzed, with half requiring this permission to operate and the other half not using it. Similarly, regarding geolocation permissions, five out of the eight applications analyzed determined it necessary to implement GPS tracking, despite it being one of the features that generated the greatest public distrust in the societies where these apps were developed. Finally, it is noteworthy that among all the countries analyzed, only Colombia made installation and use of its *CoronApp* mandatory, a factor that may explain both its disproportionately high number of downloads and the public's rejection of the tool (Giraldo et al., 2021)

Although there are significant differences in how each of the eight applications described operates, it is also possible to identify a series of factors common to all of them. Gil-Torres et al. (2020) note that "it is evident that efforts focused on two specific fronts: health and information" (p. 341), and they even argue that Brazil's application, *Coronavirus-SUS*, performed exceptionally well as a source of accurate information for its population, while Argentina's *CuidAR* was a pioneer in the field of telemedicine.

With regard to the benefits obtained after the implementation of the applications analyzed, the literature reveals divergent opinions. On one hand, Kondylakis et al. (2020) assert that although evidence regarding the effectiveness of so-called *coronapps* remains fragmented and further systematic reviews are needed, overall these authors view digital tracing and surveillance applications as an essential resource during the pandemic. The applications supported citizens, health professionals, and decision-makers by reducing the spread of false information during the health crisis, facilitating symptom reporting and follow-up, enabling quarantine monitoring, and moderately reducing the burden on hospitals.

All these positive aspects of *coronapps* should be strengthened if, in the future, mobile applications are again used to control positive cases of an emerging disease (Kondylakis et al., 2020). Their implementation must occur in close coordination with national health systems, since "this type of tool is effective to the extent that it is fully integrated into the public health system, as it is health authorities who input positive cases and determine risk levels" (Arguelles & Amaro, 2021, p. 139).

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In contrast to Kondylakis et al.'s (2020) positive perspective on mobile tracing applications, Pérez-Pacho (2021) argues that most existing applications did not provide direct utility to citizens, as reflected in their short lifespan and low download rates (with the exception of *CoronApp-Colombia*).

The review and analysis conducted reveal multiple reasons that help explain the poor public reception of *coronapps* across Latin American societies and in Spain. First, Roig (2021) questions the choice of smartphones as the sole devices capable of running these applications, arguing that "perhaps for this reason we might first ask whether mobile phones are appropriate as medical tools, given their numerous sensors and the problems arising from this data-collection capacity" (p. 535). Contact tracing, the author suggests, could have been implemented through other means less dependent on this technology and therefore more accessible to populations such as older adults or children, who may struggle to operate smartphones.

Additionally, "tracing applications may end up being used for purposes other than pandemic management once the pandemic has ended" (Roig, 2021, p. 537). In this regard, Argentina stands out from the other analyzed countries as the only one that publicly announced the closure of its *CuidAR* database.

Finally, although *coronapps* were implemented quickly in the midst of a global health crisis and provided substantial support to the governments examined in this study, possible unethical practices concerning transparency and personal-data handling led to a widespread perception among citizens that using these applications placed their privacy at risk. This perception ultimately became the common factor behind their limited adoption.

In conclusion, the mobile applications used as digital epidemiological-surveillance strategies were notable primarily for their rapid development and their variety of information-collection services. However, they sparked considerable controversy regarding data governance and privacy, particularly due to the eventual use of geolocation permissions. As Finol (2021) notes, the concept of transparency has gained increasing prominence in data governance in recent years due to the growth of governmental web portals and their need to collect, store, and process sensitive information—data of vital importance to society. This demand for state transparency has driven the implementation of open-data strategies, whereby "the opening of public information and open government converge as a meeting point between strengthening democracy and good governance" (p. 28). Where such transparency was not perceived in the collection and processing of data from *coronapps*, public adoption was inevitably hindered.

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A health-data governance system capable of generating public trust must meet a minimum set of fundamental criteria, including policies that minimize barriers to data sharing and access, measures to safeguard privacy and information security, timely notification if data are compromised through breaches or misuse, and transparency supported by public-information mechanisms (Vásquez, 2021). All these privacy and security guarantees "must build public trust in how governments handle their data to improve the quality of their lives" (Cabello, 2023, p. 18). The absence of such trust was one of the main obstacles preventing the effective implementation and full utilization of mobile tracing applications during COVID-19. For this reason, future health-crisis responses require greater transparency in data management, as well as the identification of alternative tracing strategies that do not rely exclusively on mobile devices, thus enabling greater public uptake and acceptance.

Authorship contribution statement

Andrés Castillo Vargas, Principal Investigator. Contribution: data collection, data analysis, theoretical framework, manuscript drafting, and final review.

Sebastián Ramírez Estrada, Co-investigator. Contribution: data collection, data analysis, theoretical framework, manuscript drafting, and final review.

Conflict of interest

The authors declare that they have no conflicts of interest with any institution or commercial association of any kind.

References

Aguerre, C. (2020). La delgada y móvil frontera de las Corona-Apps en América Latina. *Análisis Carolina*, (30), 1–8. https://doi.org/10.33960/AC_30.2020

Aguilar, P. (April, 2020). Análisis de la App COVID-19MX. Socialtic. https://socialtic.org/wp-content/uploads/2020/04/Analisis-de-app-COVID-19MX.pdf

Angel, M. (September 20, 2020). *"CoronApp – Chile" | Analysis of the mobile application*. Red Académica Puentech. https://web.archive.org/web/20240417153640/https://puentechlab.com/blog/analisis-aplicacion-coronapp-chile

Arguelles, E., & Amaro, M. (2021). Gobernanza de datos, apropiación y confianza en el uso de aplicaciones de monitoreo en México en el contexto del COVID-19. *Administración Pública y Sociedad (APyS),* (011), 134–155. https://revistas.unc.edu.ar/index.php/APyS/article/view/32781/34256

Asadzadeh, A., & Kalankesh, L. (2021). A scope of mobile health solutions in COVID-19 pandemics. Informatics in Medicine Unlocked, *23*(100558). https://doi.org/10.1016/j.imu.2021.100558

Asociación Internacional de la Seguridad Social [AISS]. (July 10, 2024). Aplicación Expediente Digital Único en Salud (App EDUS). AISS. https://ww1.issa.int/es/gp/197720

Autoridad Nacional para la Innovación Gubernamental [AIG]. (February 22, 2021). Protégete Panamá, nuevo servicio de notificación de exposiciones de contacto Covid-19. AIG. https://aig.gob.pa/protegete-panama-nuevo-servicio-de-notificacion-de-exposiciones-de-contacto-COVID-19/

Autoridad Nacional para la Innovación Gubernamental [AIG]. (April 28, 2020a). Protégete, nuevo aliado digital en la lucha contra el COVID-19 en Panamá. AIG. https://aig.gob.pa/protegete-nuevo-aliado-digital-en-la-lucha-contra-el-COVID-19-en-panama/

Autoridad Nacional para la Innovación Gubernamental [AIG]. (June 25, 2020b). Protégete con Salud alcanza sus primeras ocho semanas de funcionamiento. AIG. https://aig.gob.pa/protegete-con-salud-alcanza-sus-primeras-ocho-semanas-de-funcionamiento/

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Cabello, S. (2023). Análisis de los modelos de gobernanza de datos en el sector público: una mirada desde Bogotá, Buenos Aires, Ciudad de México y São Paulo. Naciones Unidas – CEPAL, Cooperación Alemana a Deutsche Zusammenarbeit. https://repositorio.cepal.org/server/api/core/bitstreams/9e5b987c-9168-4f88-9503-ca05c6d353ce/content

Cabello-Cano, S. (2020). El Expediente Digital Único en Salud de la Caja Costarricense de Seguridad Social. CISS.

Caja Costarricense del Seguro Social [CCSS]. (2023). EDUS, versión 8.2.0 [Mobile application]. Google Play. https://play.google.com/store/apps/details?id=com.ccss.expedienteunico&hl=es_CR&gl=US

Caja Costarricense del Seguro Social [CCSS]. (October 23, 2022). EDUS. CCSS. https://www.ccss.sa.cr/appedus/

Caja Costarricense del Seguro Social [CCSS]. (November 25, 2021). Política de Privacidad. CCSS. https://www.ccss.sa.cr/appedus/pdf/politica.pdf

Carrasco, S. (2021). Aplicaciones de seguimiento en la UE: enseñanzas que extraer para el uso de la tecnología en el futuro en la lucha contra desafíos sociales. El caso español: aplicación Radar Covid. Rights International Spain. https://rightsinternationalspain.org/wp-content/uploads/2022/03/Privacidad-y-App-Radar-Covid-Informe-aplicaciones-de-seguimiento-en-la-UE.pdf

Consejo para la Transparencia. (May 7, 2020). Oficio N. 000675. Communicates information regarding compliance with Law N.19.628 on the protection of private life in the processing of personal and sensitive data collected through the "CoronApp" application (pp. 1–9). Santiago, Chile. https://www.consejotransparencia.cl/wp-content/uploads/2020/05/Oficio-CPLT-675-SEGPRES-SALUD-CORONAPP-07.05.2020.pdf

CYTED. (January 16, 2024). EVAPROP–Red de evaluación de procesos de gestión pública en pandemia y participación ciudadana. https://www.cyted.org/evaprop

División de Organizaciones Sociales [DOS]. (April 23, 2020). Tecnología al servicio de la salud: ¡Gobierno lanzó aplicación móvil "CoronApp"! Ministerio Secretaría General del Gobierno. https://dos.gob.cl/tecnologia-al-servicio-de-la-salud-gobierno-lanzo-aplicacion-movil-coronapp/

Donelle, L., Hall, J., Hiebert, B., Shelley, J., Smith, M. J., Gilliland, J., & Stanley, M. (2021). Digital technology and disease surveillance in the COVID-19 pandemic: A scoping review protocol. BMJ Open, 11(10), e053962. http://dx.doi.org/10.1136/bmjopen-2021-053962

Fernández-Blanco, Y., Fernández-Rigondeaux, Y., Sorí-Gómez, J., & Valenciano-Rivero, B. (2020). Aplicaciones para dispositivos móviles en el enfrentamiento a la COVID-19. *Serie Científica de la Universidad de las Ciencias Informáticas*, *13*(11), 158–165. https://publicaciones.uci.cu/index.php/serie/article/view/675

Fernández-Sosa, J., Aguirre, V., Delía, L., Thomas, P., Corbalán, L., & Pesado, P. (2020). COVID-19: un análisis comparativo de Apps [Conference presentation]. XXVI Congreso Argentino de Ciencias de la Computación (CACIC), Universidad Nacional de La Plata, La Plata, Argentina. https://sedici.unlp.edu.ar/bitstream/handle/10915/114435/Documento_completo.pdf-PDFA.pdf?sequence=1&isAllowed=y

Finol, L. (2021). Transparencia y Gobernanza en la Gestión de la Crisis de COVID-19. *Cuestiones Políticas*, *39*(68), 23–50. https://doi.org/10.46398/cuestpol.3968.01

Gil-Torres, A., Martín-Quevedo, J., Gómez-García, S., & San José-De la Rosa, C. (2020). El coronavirus en el ecosistema de los dispositivos móviles: creadores, discursos y recepción. *Revista Latina de Comunicación Social*, *78*, 329–358. https://www.doi.org/10.4185/RLCS-2020-1480

Giraldo, S., Avilo Lasso, B., Mercado, L. R., Zapata, J. F., & Roncacio Bedoya, A. (2021). Reflexión sobre los límites sociales, políticos y jurídicos a las estrategias de rastreo de contactos epidemiológicos mediante aplicativos móviles. El caso de Medellín (Colombia). *Visioni LatinoAmerican*, (24), 49–55. https://doi.org/10.13137/2035-6633/31195

Gobierno de Argentina. (September 19, 2020b). Cuidar: cuidado y transparencia de un trabajo en sociedad. https://www.argentina.gob.ar/noticias/cuidar-cuidado-y-transparencia-de-un-trabajo-en-sociedad

Gobierno de Argentina. (April 27, 2020a). El Gobierno relanza CUIDAR, la nueva versión de la app coronavirus Argentina. https://www.argentina.gob.ar/noticias/el-gobierno-relanza-cuidar-la-nueva-version-de-la-app-coronavirus-argentina

Gobierno de Argentina. (March 30, 2023). La Secretaría dio de baja los registros de la aplicación Cuidar. https://www.argentina.gob.ar/noticias/la-secretaria-dio-de-baja-los-registros-de-la-aplicacion-cuidar

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Gobierno de Argentina. (n.d.-a). CuidAR. ¿Qué es y para qué sirve? https://www.argentina.gob.ar/jefatura/innovacion-publica/acciones-coronavirus/aplicacion-y-tableros-de-gestion/que-es

Gobierno de Argentina. (n.d.-b). CuidAR. ¿Cómo funciona? https://www.argentina.gob.ar/jefatura/innovacion-publica/acciones-coronavirus/aplicacion-y-tableros-de-gestion/como-funciona

Gobierno de Argentina. (n.d.-c). *CuidAR. Sobre los datos recopilados.* https://www.argentina.gob.ar/jefatura/innovacion-publica/acciones-coronavirus/aplicacion-y-tableros-de-gestion/datos-recopilados

Government of Brazil. (April 3, 2020). *Coronavirus – SUS.* https://www.gov.br/pt-br/apps/coronavirus-sus

Gobierno de España. (2020). *Radar Covid. Utilizando las últimas tecnologías para contener la pandemia COVID-19.* https://radar-resources.s3-eu-west-1.amazonaws.com/documento-APP-RadarCOVID-v4.pdf

Gobierno de España. (September 25, 2022). *Estadísticas.* https://radarcovid.gob.es/estadisticas/descargas-radar

Government of Mexico. (n.d.). *Términos y Condiciones de Uso de la "App COVID-19 CDMX" del Gobierno de la Ciudad de México.* https://app.covid19.cdmx.gob.mx/terms

Gobierno de Panamá. (2021a). *Protégete Panamá.* https://protegete.panamasolidario.gob.pa/?csrt=15499410482745864005

Gobierno de Panamá. (2021b). *Políticas de Privacidad y Tratamiento de Datos Personales de Protégete.* https://protegete.panamasolidario.gob.pa/politicas-de-privacidad.html?csrt=15499410482745864005

Ibrahim, N. (2020). Epidemiologic surveillance for controlling Covid-19 pandemic: Types, challenges and implications. *Journal of Infection and Public Health, 13*(11), 1630–1638. https://doi.org/10.1016/j.jiph.2020.07.019

Jefatura de Gabinete de Ministros de Argentina. (2020). *Términos y Condiciones.* https://www.argentina.gob.ar/sites/default/files/terminos_y_condiciones_aplicacion_cuidar_-_covid_19_-_v5.pdf

Kamalova, S., & Moralejo, A. (2022). El tratamiento periodístico de la privacidad en las aplicaciones de rastreo de COVID-19 en España y Reino Unido. *Dígitos. Revista de Comunicación Digital, 8*, 215–230. https://doi.org/10.7203/rd.v1i8.222

Kondylakis, H., Katehakis, D., Kouroubali, A., Logothetidis, F., Triantafyllidis, A., Kalamaras, I., Votis, K., & Tzovaras, D. (2020). COVID-19 mobile apps: A systematic review of the literature. *Journal of Medical Internet Research, 22*(12), e23170. https://doi.org/10.2196/23170

Kostkova, P., Saigí-Rubió, F., Eguia, H., Borbolla, D., Verschuuren, M., Hamilton, C., Azzopardi-Muscat, N., & Novillo-Ortiz, D. (2021). Data and digital solutions to support surveillance strategies in the context of the COVID-19 pandemic. *Frontiers in Digital Health, 3*, 707902. https://doi.org/10.3389/fdgth.2021.707902

Ley 25.326 de 2000. Protección de los Datos Personales. (October 30, 2000). D.O. No. 1558. https://servicios.infoleg.gob.ar/infolegInternet/anexos/60000-64999/64790/texact.htm

Ley 9162 de 2013. Expediente digital único de salud. (August 26, 2013). D.O. No. 182. http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_norma.aspx?param1=NRM&nValor1=1&nValor2=75700&nValor3=93998&strTipM=FN

Mason, C., Lazenby, S., Stuhldreher, R., Kimball, M., & Bartlein, R. (2022). Lessons learned from implementing digital health tools to address COVID-19 in LMICs. *Frontiers in Public Health, 10*, 859941. https://doi.org/10.3389/fpubh.2022.859941

May, S. (March 26, 2020). *CCSS actualiza app de Edus para que cada persona conozca su nivel de riesgo por COVID-19.* Delfino. https://delfino.cr/2020/03/ccss-actualiza-app-de-edus-para-que-cada-persona-conozca-su-nivel-de-riesgo-por-COVID-19

Ministerio de Salud de Panamá. (2023). *Protégete Panamá* [Mobile application]. Google Play. https://play.google.com/store/apps/details?id=pa.gob.protegete

Ministerio de Salud y Protección Social [MinSalud]. (April 6, 2020). *Medidas para afrontar la COVID-19 tras un mes de su llegada al país.* https://www.minsalud.gov.co/Paginas/Medidas-para-afrontar-la-COVID-19-tras-un-mes-de-su-llegada-al-pais.aspx

Ministerio de Sanidad. (October 23, 2020). *Procedimiento de implementación de la App Radar COVID como complemento a los sistemas manuales de identificación de contactos.* https://www.sanidad.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov/documentos/COVID19_Procedimiento_RADAR.pdf

Digital epidemiological surveillance: the role of mobile applications in identifying positive Covid-19 cases
Vigilancia epidemiológica digital: el rol de las aplicaciones móviles en la identificación de casos positivos para COVID-19

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Ministerio de Tecnologías de la Información y las Comunicaciones [MinTIC]. (April 14, 2020). *Así funciona CoronApp Colombia, aplicación para detectar y monitorear casos de COVID-19.* Ministerio de Tecnologías de la Información y las Comunicaciones. https://mintic. gov.co/portal/inicio/Sala-de-prensa/MinTIC-en-los-medios/135648:Asi-funciona-Coro-nApp-Colombia-aplicacion-para-detectar-y-monitorear-casos-de-COVID-19

Nájera, J., & Ricaurte, P. (2020). *Tecnologías de interés público: el caso de las coronapps en América Latina.* Centro Latam Digital. https://www.jacobo.org/wp-content/uploads/2021/04/Policy-report_Tecnologi%CC%81as-de-intere%CC%81s-pu%CC%81blico-el-caso-de-las-coronaapps-en-Ame%CC%81rica-Latina.pdf

Pérez-Pacho, J. (2021). *Análisis de apps móviles sobre información, prevención y seguimiento de COVID-19 y desarrollo de una app innovadora en dicho campo* [Bachelor's thesis, Universidad de Valladolid]. Repositorio documental. https://uvadoc.uva.es/bitstream/handle/10324/47169/TFG-G4817.pdf?sequence=1&isAllowed=y

Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo [CYTED]. (January 16, 2024). *EVAPROP–Red de evaluación de procesos de gestión pública en pandemia y participación ciudadana.* CYTED. https://www.cyted.org/evaprop

Pogrebinschi, T. (2021). *CoronApp.* Innovaciones para la Democracia en América Latina. https://latinno.net/es/case/4128/

Presidencia de la Nación Argentina. (2022). *Cuidar COVID-19 Argentina* [Mobile application]. UpToDown. https://cuidar-covid-19-argentina.uptodown.com/android/descargar

Ríos-Villafañe, M. (2020). *La contención de una pandemia en la era digital: la tensión entre el derecho a la intimidad y la salud pública* [Bachelor's thesis, Universidad de los Andes]. Séneca, Repositorio institucional. https://repositorio.uniandes.edu.co/server/api/core/bitstreams/eaa2edc1-feb5-4714-9abb-89b650092119/content

Rodríguez, P., Graña, S., Alvarez-León, E. E., Battaglini, M., Darias, F. J., Hernán, M. A., López, R., Llaneza, P., Martín, M. C., Ramirez-Rubio, O., Romaní, A., Suárez-Rodríguez, B., Sánchez-Monedero, J., Arenas, A., & Lacasa, L. (2021). A population-based controlled experiment assessing the epidemiological impact of digital contact tracing. *Nature Communications, 12*(1), 587. https://doi.org/10.1038/s41467-020-20817-6

Roig, A. (2021). Garantías frente a las aplicaciones de rastreo de contagios en situaciones de pandemia. *Teoría y Realidad Constitucional, 48*, 527–542. https://doi.org/10.5944/trc.48.2021.32260

Saldaña, S. (April 23, 2020). *"COVID-19MX": la app oficial para autodiagnóstico de COVID-19 en México ya está disponible para Android y iOS y así funciona.* Xataka. https://www.xataka.com.mx/medicina-y-salud/COVID-19mx-esta-app-oficial-para-autodiagnostico-COVID-19-mexico-asi-funciona

Secretaría de Salud MX. (2021). *COVID-19MX* [Mobile application]. Google Play. https://play.google.com/store/apps/details?id=mx.gob.www&hl=es_MX

Serviços e Informações do Brasil. (2020). *Coronavírus–SUS.* https://play.google.com/store/apps/details?id=br.gov.datasus.guardioes&hl=en_US

Suárez-Millán, O. J. (2020). *Tecnologías de la información y la comunicación Tic's para la función pública. Caso de estudio Dian* [Specialization thesis, Universidad Nacional Abierta y a Distancia]. https://repository.unad.edu.co/bitstream/handle/10596/34822/oscarjuliosuarezmillan.pdf?sequence=1&isAllowed=y

Sujarwoto, S., Augia, T., Dahlan, H., Sahputri, R., Holipah, H., & Maharani, A. (2022). COVID-19 mobile health apps: An overview of mobile applications in Indonesia. *Frontiers in Public Health, 10*, 879695. https://doi.org/10.3389/fpubh.2022.879695

Universidad Abierta del Sistema Único de Salud [UNA-SUS]. (March 14, 2020). *Ministerio de Salud lanza aplicación sobre el Coronavirus.* https://www.unasus.gov.br/noticia/ministerio-da-saude-disponibiliza-aplicativo-sobre-o-coronavirus

Vásquez, Á. (2021). *Gestión Pública, Serie 88. Apertura y uso de datos para hacer frente al COVID-19 en América Latina.* Naciones Unidas CEPAL. https://repositorio.cepal.org/server/api/core/bitstreams/ec4d0df3-1472-43ce-83ba-acc5d5b85f10/content

Weidenslaufer, C., Meza, M., & Medel, C. (2020). *COVID-19: Uso de apps con rastreo de contactos y respeto a la privacidad.* Biblioteca del Congreso Nacional de Chile. https://obtienearchivo.bcn.cl/obtienearchivo?id=documentos/10221.1/79593/1/boletin_coronavirus_10.1_FINAL.pdf