

Original Research Article

Features and Functionalities of Medical Mobile Applications for the Endemic Phase of COVID-19: Review and Content Analysis

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Article History

Received: 30 November 2022;

Received in Revised Form:

21 December 2022;

Accepted: 26 December 2022;

Available Online: 28 December 2022

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Abstract: The study's objective was to assess the features and content of the COVID-19 mobile applications accessible in the Apple AppStore. A content analysis, comparison, and functionality evaluation of a few COVID-19 related mobile applications was performed. The search for COVID-19 related apps in the iOS AppStore took place between February 1 and March 31, 2022. The mobile applications received a maximum of 7 points (basic feature assessment) and 8 points overall (functionality assessment). The requirements were fully met

by receiving one point. Frequencies from descriptive statistics were used to allude to the applications' features according to the app's basic purpose. A total of 234 applications were recognized using the keywords to explore COVID-19 related mobile applications in Apple AppStore. However, 58 mobile applications (24.8%) relevant to COVID-19 were evaluated. According to the findings of an evaluation of basic aspects of mobile applications, 89.7% require an internet connection, 70.7% have a size of less than 50 MB, 96.6% require no funding, 58.6% include educational content, and 60.3% offer advice from the applications. In terms of score, 41.4% scored three or below, whereas 58.6% scored four or above. Functionality assessment wise, 79.3% included information regarding COVID-19, 12.1% included COVID-19 contact tracing, 17.2% had vaccination status, a health authority maintained 50%, 31.0% included COVID-19 statistics, and 25.8% were able to report ART/PCR test. In terms of score, 91.4% scored three points or less, and 8.6% scored four points or more. This study has discovered several applications that could effectively prevent COVID-19 pandemic spread. Based on the findings, mobile applications that would be recommended are the ones supported by the government health administration of the respective country. App development companies' applications show that competent healthcare personnel was not involved in developing the applications. Online consultation with healthcare professionals might help the public who do not have access to the nearest hospital.

Keywords: health education; mHealth; coronavirus; health system access; infectious disease; essential healthcare services; health emergency preparedness; disaster management

1. Introduction

SARS-CoV-2, also known as coronavirus disease 2019 (COVID-19), has been infecting humans for more than two years, causing extraordinary levels of morbidity and mortality around the world ^[1-3]. According to the World Health Organization (WHO), COVID-19 has caused around 585 million confirmed illnesses and over 6 million deaths worldwide as of August 14th, 2022 ^[4].

As the COVID-19 pandemic spreads, increasing public health attempts to evaluate the viral epidemiology and determine its short and long-term repercussions become increasingly important. New solutions to meet unmet needs are required as the disease progresses and infects people worldwide ^[5]. During the spread of COVID-19, urban lockdowns were established in numerous regions of the world, compelling people to stay at home and limit their activities ^[6]. While its impact on society has evolved regarding behavioural and psychological changes, the trend of using digital media is the most significant change ^[6]. Applications (apps) for mobile health (mHealth) are software that can be described as “integrated into smartphones to enhance health outcomes, health research, and health care services” ^[7]. They are health applications that both patients and healthcare professionals may use and are available on mobile devices ^[8].

According to a WHO's 2011 study, the healthcare industry could take advantage of these benefits by developing mHealth applications to improve patient care ^[8]. In most nations mHealth is quickly becoming one of the most essential instruments for providing emergency medical assistance and patient monitoring ^[9]. The ability for healthcare workers to update patient records at the point of care using mobile devices has reduced the frequency of clerical errors. Healthcare personnel can access these patient records immediately from any location with an internet connection. In addition, mobile technology enables healthcare workers to communicate with one another and their patients at any time, resulting in a reduction in patient load ^[10]. It is critical to collect adequate exposure data, characterize disease burden, and disseminate information that aids in prevention, containment, and contact tracing to support public health initiatives ^[5]. In order to quarantine possibly infected individuals and stop the spread of disease, contact tracing is the process of finding whom the sick individual may have contacted, as well as determining where the disease may have started or who might be the "Patient Zero" in a given location ^[11].

Since WHO declared COVID-19 a global pandemic, the demand for digital tools to enhance public health measures has surged, and it now provides information to assist various stages of the pandemic. Early detection, public notifications, sharing of case data, rapid screening, contact tracing, patient monitoring, information exchange, education, and treatment management were all done using mobile health technologies in response to the outbreak ^[12, 13]. Applications can help control COVID-19 pandemic in various ways, from remote monitoring by healthcare workers to tracking the number of infections ^[14]. mHealth is presently being used to track people who have COVID-19 symptoms. It can be utilized to detect virus exacerbations and, if necessary, clinical interventions. Users' real-time, longitudinal, and dynamic viral experiences are also tracked using mHealth. Fear of infection in the clinic has resulted in fewer on-site referrals and more use of mobile health services ^[9].

Despite the growing use of mHealth applications by both health professionals and the general public, quality of content, such as significant knowledge gaps about their utility and efficacy, software functioning, as well as data privacy and security, are all areas of concern in mHealth applications ^[7, 15]. The success of an app is determined by the context in which it is used and the design's suitability ^[14]. Different countries used different strategies to stop COVID-19 from spreading, with some being more effective than others ^[10]. Although the use of mobile applications is growing, research flows remain irregular and fragmented ^[16]. It is vital to study COVID-19 mobile applications to aid users in choosing a suitable app based on their needs and assist developers in refining the designs of their current or future mobile applications to improve quality. Therefore, this study aimed to evaluate the contents and features of COVID-19 mobile applications available in Apple's AppStore. After analyzing the functions of each application, recommendations for future health applications could be synthesised to improve the applications' practicality.

2. Materials and Methods

A content analysis, comparison, and functionality assessment of selected mobile applications for COVID-19 were performed. A search for COVID-19 mobile applications was conducted via the AppStore on the Apple iPad 2017. The search was conducted from 1st February 2022 until 31st March 2022 using iOS-based AppStore to obtain mHealth applications that were related to COVID-19 that had no language restrictions. The exclusion criteria included applications that supplied quarantined users with shopping or pharmacy items to contain the virus, paid applications, and game applications. The keywords “COVID-19,” “Coronavirus,” and “Covid” were used to search for COVID-19 mobile applications in the AppStore. An online search on Google using the key terms “mobile app,” “mHealth,” “Covid19,” “Coronavirus,” “Corona,” and “COVID-19” was also conducted to ensure that all relevant mobile applications were included. Boolean operator OR was used to ensuring full expansion of the search. The relevance of COVID-19 was then used to screen all mobile applications, which were further filtered using the inclusion and exclusion criteria. Only applications with an English language interface were evaluated and rated, as the author is mainly proficient in English. Figure 1 depicts the summary of the steps involved in picking appropriate mobile applications from the App Store.

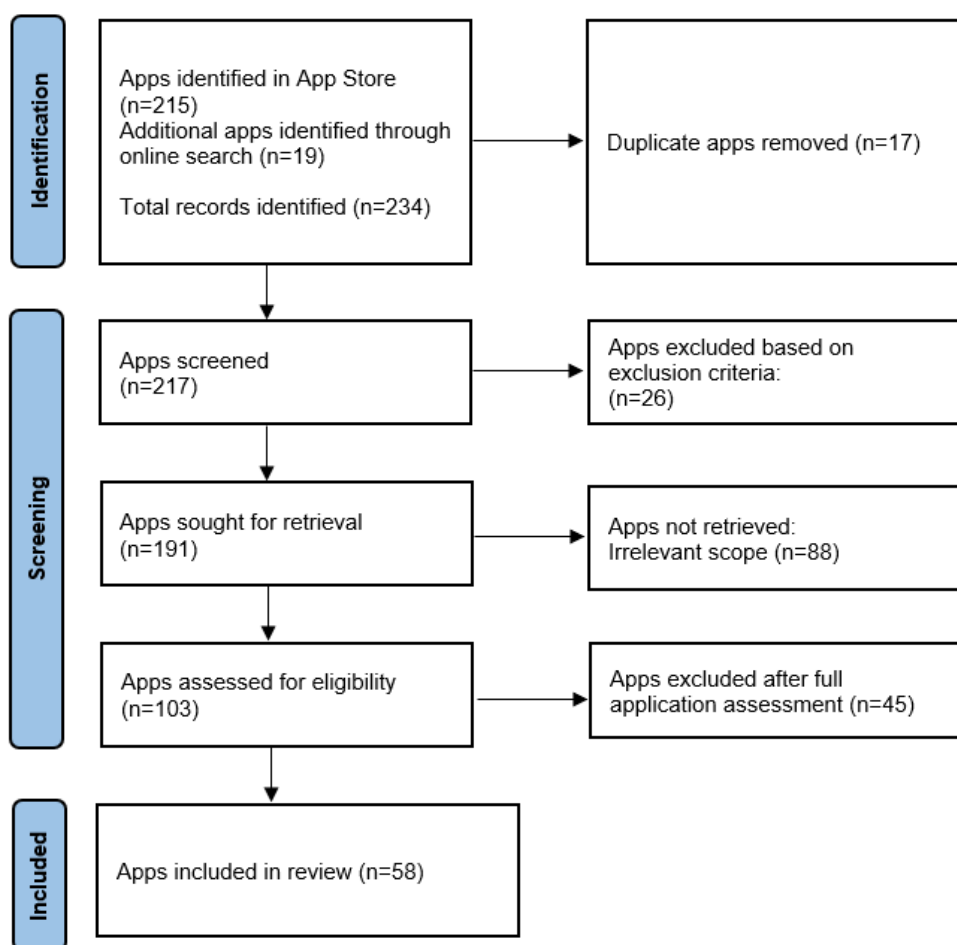


Figure 1. Selection process of mobile health applications.

2.1 Data collection

In the study, the basic features and functionalities of the included mobile applications were carefully assessed by three researchers. We modified the classification of mobile health applications assessment requirement reported by Nouri et al ^[17] and in the previous studies ^[11,16,21] to streamline the seven basic features. The seven basic features were (1) no internet requirement, (2) size of the app less than 50 MB, (3) no subscription needed (ie, free), (4) educational content (COVID-19 teaching), (5) export data (sharing of user's data with other platforms), (6) automated data entry (automatic update of data without user interference), and (7) advisory function. Inter-rater agreements were achieved through the consensus of the three participating researchers.

After completing the basic feature evaluation, the applications were categorized into distinct groups based on their purpose and functionality from reading the application's developer overview and explanation provided ^[5]. The categorized five functionalities of mobile applications were (1) knowledge (information on COVID-19), (2) tracing or mapping of COVID-19 cases, (3) home monitoring surveillance, (4) online consultation with a health authority, and (5) official mobile applications run by a health authority ^[17, 18]. We repeated our study conducted in 2020 ^[18] during the early pandemic phase to examine the latest mHealth applications on COVID-19 and incorporate updated features that can help in diagnosis, symptom reporting, and contact tracing of the disease.

Upon scrutiny of the content of the mobile applications of the researchers involved, two separate senior researchers provided advisory roles to finalize the functional classification of all selected mobile applications. We gave either one or zero points for the features that were fully or not/partially fulfilled by the said mobile application. A maximum score of 7 and 5 points could be given for the basic features and functionalities, respectively. Statistically wise, descriptive statistics (frequencies) were utilised to represent the characteristics of the mobile applications.

3. Results

After using the keywords to explore COVID-19 related mobile applications in Apple AppStore, 234 applications were discovered and identified. Applications were ranked based on the inclusion and exclusion criteria, with a final number of 58 applications. As shown in **Supplementary Appendix S1**, the accessible mobile applications were divided into three categories i.e., universal COVID-19, country-specific, and non-English applications.

Only 58 out of the total 234 (24.8%) mobile applications relevant to COVID-19 were evaluated; others were omitted because they failed the inclusion criteria. The selected mobile applications were evaluated based on their main features (**Table 1 & 2**) and functionality (**Table 3 & 4**). The assessment's conclusions were based on a scoring methodology in which the app was granted a score of one for each condition it met.

The main features were assessed by the prerequisite of internet connectivity to use the app, storage capacity, subscription requirement, educational content, ability to export data, automated data entry support, and an advisory feature. As per the findings of an evaluation of major aspects of mobile applications, as shown in **Figure 2**, majority of the applications (52/58, 89.7%) requires an internet connection, have the size of less than 50 MB (41/58, 70.7%), requires no funding (56/58, 96.6%), included educational content (34/58, 58.6%), does not export data (35/58, 60.3%), allow automated data entry (31/58, 53.4%) and offers advice (35/58, 60.3%).

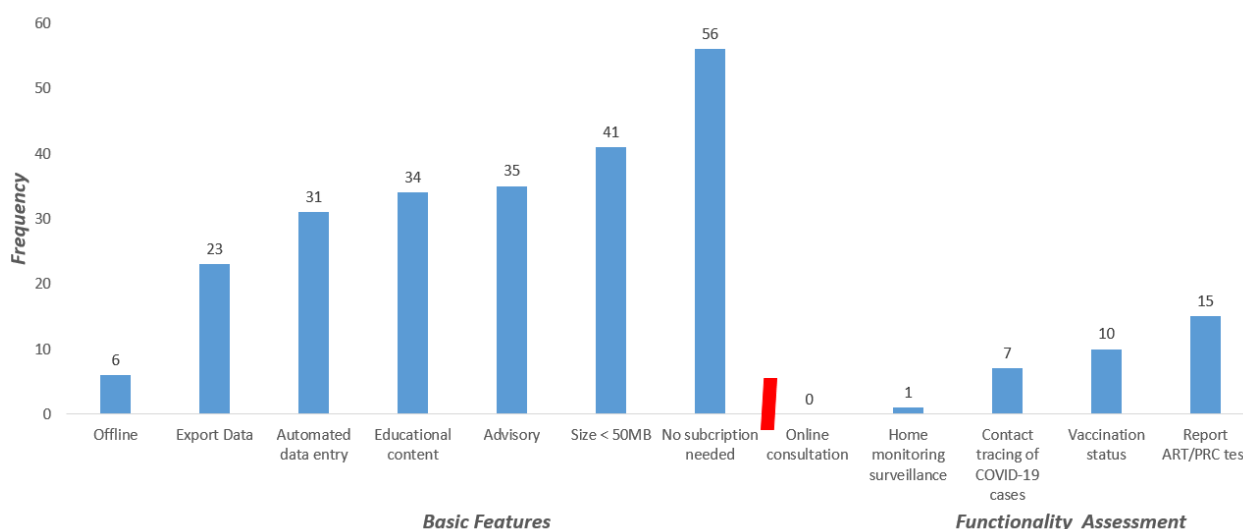


Figure 2. Assessment of iOS-based mobile applications (A: Basic features; B: Functionality assessment). COVID-19: coronavirus disease.

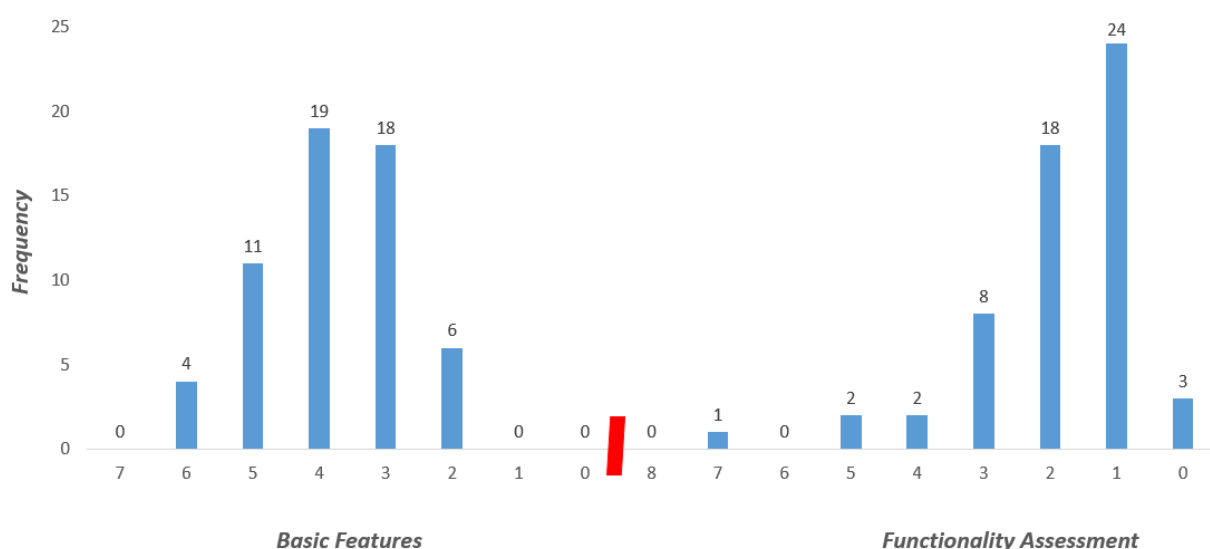


Figure 3. Total assessment score of iOS and android-based mobile applications (A: Basic features; B: Functionality assessment).

As shown in **Figure 3**, none of the applications scored a total of 0, 1, and 7. Out of the 58 applications, 6 applications (10.3%) scored two, 18 applications (31.0%) scored three, 19 applications (32.7%) scored four, 11 applications (18.9%) scored five, and 4 applications (6.9%) scored six. Apart from the basic features, the applications are also assessed based on the functionality assessment, as shown in **Figure 2**. The criteria evaluated under functionality included information regarding COVID-19 (46/58, 79.3%), COVID-19 contact tracing (7/58, 12.1%), home monitoring surveillance (1/58, 1.7%), vaccination status (10/58, 17.2%), online consultation with a health authority (0/58), the application is maintained by a health authority (29/58, 50%), COVID-19 statistics (18/58, 31.0%) and being able to report ART/PCR test (15/58, 25.8%). From **Figure 3**, none of the applications scored 6 and 8. Out of the 58 applications, 3 applications (5.2%) scored zero, 24 applications (41.4%) scored one, 18 applications (31.0%) scored two, 8 applications (13.8%) scored three, 2 applications (3.4%) scored four and five and 1 application (1.7%) scored seven.

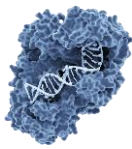


Table 1. Assessment of basic features of medical applications in AppStore for general use.

No.	Name	No internet requirement	Size of Application <50 MB	No subscription requirement (i.e., Free)	Educational Content	Export Data	Automated data entry	Advisory	Total Score
1	COVID-19!	X	X	1	1	X	1	1	4
2	Coronavirus – Covid19	X	1	1	1	X	1	1	5
3	WHO Academy: Covid-19 Learning	X	X	1	1	X	X	1	3
4	COVID-19 iChart	1	X	1	1	X	X	X	3
5	HEALTHLYNKED COVID-19 Tracker	X	1	1	X	X	1	X	4
6	Covid-19 Advisor	X	X	1	X	X	1	1	3
7	Relief Central COVID-19	X	1	1	1	X	1	1	5
8	Disinfection Checklist COVID-19	X	1	1	1	X	X	1	4
9	COVID-19: Response	X	1	1	1	X	X	1	4
10	COVID-19 Resources for Midwives	X	1	1	1	X	X	1	4
11	COVID19 Sounds	X	1	1	X	1	X	1	4
12	COVID-19 severity calculator	1	1	1	X	X	X	X	2
13	RA & COVID-19	X	1	1	1	X	X	1	4
14	COVID Symptom	X	1	1	X	1	X	X	3
15	HowWeFeel	X	1	1	X	1	X	X	3
16	COVID Coach	1	X	1	1	X	X	1	4
17	Managing your stress & anxiety	1	1	1	1	X	X	1	5
18	CoronaSurveys	X	1	1	X	X	1	X	3
19	Corona Expert	X	1	1	1	X	X	1	4
20	VirusAssist	X	1	1	1	X	1	1	5
21	Coronavirus Support App (UK)	X	1	1	1	X	X	1	4
22	Corona Check Screening	X	1	1	1	X	1	1	5
23	CoronaReport	X	1	1	1	X	1	X	4
24	Best in Covid: stats & updates	X	1	1	X	X	1	X	3
25	Responsum for Long COVID	X	X	1	1	X	1	1	4
26	CovidWatcher	X	1	1	X	1	X	X	2
27	COVID Protocols	1	1	1	1	X	1	1	6
28	Be+ against COVID	X	1	1	1	X	X	1	4

Table 2. Assessment of basic features of medical applications in AppStore with country-specific functionality.

No.	Name	No internet requirement	Size of Application <50 MB	No subscription requirement (i.e., Free)	Educational Content	Export Data	Automated data entry	Advisory	Total Score
1	Coronavirus Australia	X	1	1	1	X	1	1	5
2	BruHealth	X	1	1	1	1	1	1	6
3	myAUS COVID-19	X	1	1	1	X	1	1	5
4	COVID19 – DXB Smart App	X	X	1	1	1	1	1	4
5	Infected – COVID-19 NL	X	1	1	X	X	1	X	3
6	TracVirus - COVID19 Test eCert	X	1	1	X	X	1	X	3
7	Coronavírus - SUS	X	X	1	1	X	X	1	3
8	My COVID-19 Tracker	X	X	1	X	X	1	1	2
9	TousAntiCovid	X	X	1	X	1	1	X	2
10	Zanzibar COVID-19 Testing	X	1	1	X	1	1	X	3
11	COVID-19 EHS	X	X	1	1	1	1	1	5
12	BC COVID-19 Support	X	1	1	1	1	X	1	5
13	Grey Bruce COVID19 Vaccine App	X	1	1	1	X	X	1	4
14	AMAN - Aman.jo JORDAN COVID-19	X	1	1	X	1	1	X	4
15	COVID-19 Virginia Resources	1	1	1	1	X	X	1	5
16	JamCOVID19	X	1	1	1	1	1	1	6
17	NHSGGC Clinical Guidelines	X	X	1	1	X	X	1	3
18	Apollo COVID-19	X	1	1	X	X	X	1	3
19	UCLH COVID19	X	1	1	1	X	X	1	4
20	Путешествую без Covid-19 (Israel) Release without Covid-19	X	X	1	X	1	1	X	3
21	Hough Home Test Kit	X	X	1	X	1	1	X	3
22	Covid Result Verifier	X	X	1	1	1	1	1	5
23	Wlncs	X	1	X	X	1	X	X	2
24	המגן 2 האפליקציה למלחמה בקורונה	X	1	1	X	1	1	X	4
25	NZ COVID Tracer	X	1	1	1	1	1	1	6
26	Covid SafePass	X	X	X	1	1	1	X	3
27	Covid Secure	X	X	1	X	1	X	X	2
28	NYC COVID SAFE	X	1	1	X	1	X	X	3
29	CovidPassEu	X	1	1	X	1	1	X	4
30	UC COVID Check	X	1	1	X	1	X	X	3

26	CovidWatcher	X	X	X	X	X	X	X	X	0
27	COVID Protocols	1	X	X	X	X	1	X	X	1
28	Be+ against COVID	1	X	X	X	X	1	X	X	2

Table 4. Quality assessment of medical applications in AppStore with country-specific functionality.

No.	Name	Knowledge	COVID-19 Contact Tracing	Home Monitoring Surveillance	Vaccination Status	Online Consultation with Health Authority	Official mobile application maintained by Health Authority	COVID-19 Statistics	Report ART/PCR Result	Total Score
1	Coronavirus Australia	1	X	X	X	X	1	1	X	3
2	BruHealth	1	1	1	1	X	1	1	1	7
3	myAUS COVID-19	1	X	X	X	X	1	1	X	3
4	COVID19 – DXB Smart App	1	X	X	X	X	1	1	1	4
5	Infected – COVID-19 NL	X	X	X	X	X	X	1	X	1
6	TracVirus - COVID19 Test eCert	1	X	X	1	X	X	1	1	3
7	Coronavirus - SUS	1	X	X	X	X	1	X	X	2
8	My COVID-19 Tracker	X	X	X	X	X	X	1	X	1
9	TousAntiCovid	X	1	X	1	X	1	X	X	3
10	Zanzibar COVID-19 Testing	X	X	X	1	X	1	X	1	3
11	COVID-19 EHS	1	X	X	1	X	1	1	1	5
12	BC COVID-19 Support	1	X	X	X	X	1	1	X	3
13	Grey Bruce COVID19 Vaccine App	1	X	X	X	X	1	1	X	3
14	AMAN - Aman.jo JORDAN COVID-19	X	1	N/A	N/A	X	1	X	X	2
15	COVID-19 Virginia Resources	1	X	X	X	X	1	X	X	2
16	JamCOVID19	1	X	X	N/A	X	1	1	N/A	3
17	NHSGGC Clinical Guidelines	1	X	X	X	X	1	X	X	2
18	Apollo COVID-19	X	1	X	X	X	X	X	X	1
19	UCLH COVID19	1	X	X	X	X	1	X	X	2
20	Traveling without Covid-19 (Russian Путешествую без)	X	1	X	1	X	1	X	1	4

21	Hough Home Test Kit	X	X	X	X	X	X	X	1	1
22	Covid Result Verifier	1	X	X	X	X	1	X	1	2
23	WInss	X	X	X	X	X	X	X	1	1
24	המגן 2 האפליקציה למלחמה בקורונה Defender 2 The Corona War Application (Israel)	X	1	X	X	X	1	X	X	2
25	NZ COVID Tracer	1	1	N/A	1	X	1	X	1	5
26	Covid SafePass	1	X	X	X	X	X	X	1	2
27	Covid Secure	X	X	X	1	X	1	X	1	2
28	NYC COVID SAFE	X	X	X	1	X	1	X	1	2
29	CovidPassEu	X	X	X	X	X	X	X	1	1
30	UC COVID Check	X	X	X	1	X	X	X	X	1

4. Discussion

This study assessed the fundamental characteristics and functionalities of COVID-19 applications. This study could contribute to developing a top-notch COVID-19 mobile application or aid in enhancing the current COVID-19 mobile applications. Only ‘BruHealth’ has the capability of home monitoring surveillance. In circumstances of insufficient inpatient conditions or medical resources, WHO emergency guidelines advocate adopting alternative quarantine techniques, such as homecare and isolation, for patients with COVID-19 who have mild symptoms. Identifying people with disease conditions that are likely to worsen or become serious may be challenging. Therefore, the patients who are quarantined at home may require ongoing medical observation, which could save their lives ^[19].

Only seven COVID-19 contact tracing applications are available as per our criteria. Controlling the spread of communicable diseases can be done by tracing and isolating those who have had contact with an unwell person. According to the classic definition of contact tracing, healthcare professionals will interview known disease carriers and then identify the type of close contact with the disease-positive person. Subsequently, the close contact would be identified and quarantined. This method is used for illnesses that are not known to spread quickly and where patients can be identified without difficulty ^[20]. The results show that only 15 applications have the function to report ART/PCR test. This feature helps with contact tracing of COVID-19 cases. According to recent research, COVID-19 cases might be contained using quick and accurate digital contact tracing (DCT). Ferretti et al. ^[21], argued that DCT might dramatically minimize tracing delays, allowing the outbreak to be managed with a tracing probability much lower than 70%. As a result, it is critical that anyone even experiencing the mildest symptoms gain easy access to a COVID-19 investigation ^[20]. Four COVID-19 mobile applications from the AppStore scored the maximum score 6 in the calculation of key features, which are ‘BruHealth’, ‘JamCOVID19’, ‘NZ Covid Tracer’ and

'COVID Protocols'. Meanwhile, the lowest score 'two' was obtained by 6 applications: 'My COVID-19 Tracker', 'TousAntiCovid', 'COVID-19 severity calculator', 'Wlss', 'CovidWatcher' and 'Covid Secure'. When evaluating the functionality assessment, only 1 app obtained the highest score of 7, which is 'BruHealth'. Meanwhile, 3 applications received zero scores for the evaluation, namely 'COVID-19 severity calculator', 'HowWeFeel, and CovidWatcher'.

Overall, 'BruHealth' obtained the highest score (6 and 7) for both basic feature and functionality. It lacks the 'no requirement of internet and online consultation' with a healthcare person. The app was given a rating of 3.8 out of 5 (n=10) from the AppStore. Both 'COVID-19 severity calculator' and 'CovidWatcher' obtained the lowest score (2 and 0) for both basic features and functionality. 'COVID-19 severity calculator' calculates the severity of COVID-19 based on demographic, clinical, and laboratory values.

Meanwhile, 'CovidWatcher' by Columbia University is used as a research tool where the user needs to answer a survey regarding their symptoms and medical history. 'HEALTHLYNKED COVID-19 Tracker' was given a ranking of 4.3 (n=2.8k) from the AppStore, but after both basic feature and functionality assessment, the app received a score of 4 and 1, respectively. This is because the application does not have a reliable source of information regarding COVID-19. The consequences of false or misleading health information can be devastating. Misinformation can undermine healthcare professionals' credibility and lead to a lack of trust in medicines and vaccines [22]. The only functionality assessment score that it received is the information regarding statistics of COVID-19 cases globally. 'Wlss' and 'Covid SafePass' are the only two applications that did not meet the requirement for no subscription as both applications require the user to buy the company-specific ART kits. 'COVID-19 iChart' is an app for healthcare professionals to cross reference for COVID-19 drug interactions.

4.1. Recommendations for COVID-19 Mobile Applications

Based on the findings, mobile applications that would be recommended are the ones monitored by the health ministry of the respective nation. Resources regarding COVID-19 were updated, and protocols for each country would differ. Information regarding the disease should be from an eligible source to not mislead the public. App development companies' applications show that competent healthcare personnel were not involved in developing the applications [23]. Online consultation with healthcare professionals might help the public when the country is in lockdown, and they do not have access to the nearest hospital. Digital platforms could turn out to be patients' number one source of information, or at the very least, an alternative to in-person communication when unavailable. As a result, mobile applications may bridge the gap and provide healthcare professionals with a new way of disseminating public health messages [24].

Vaccination status is also an essential feature of the COVID-19 application. Securing COVID-19 vaccination digital certificates or also namely passports are required to overcome

the constraints of old-fashioned immunization cards. Old-style immunization cards or vaccination certificates are susceptible to falsification, manipulation, and modifications, and being hard to interpret by non-health professionals, easily forgotten, and susceptible to environmental conditions such as rain ^[25].

Furthermore, the availability and appointment booking of COVID-19 booster vaccines should be added to facilitate the update of immunization ^[26]. The booster dose info, along with the news update of the prevalence and spread of variants of concern and their main symptoms, is vital information update in such mobile applications ^[27,28,29]

4.2. Limitations

There are some limitations acknowledged in the current study. This study examined just one digital platform (Apple AppStore); therefore, we could not compare the results with another digital platform (Android). The scoring system placed equal weight on each of the included eight criteria. Additionally, several increasingly important aspects have been overlooked in this study i.e., privacy, security, and breach protection, including the use of information by third-party applications. These may imply a significant gap in the characteristics and functionality of the reviewed applications. Lastly, applications other than the English language interface were also not studied.

5. Conclusions

A significant portion of the global smartphone user population can facilitate and carry out mobile interventions to distribute information and support the COVID-19 pandemic response. The onslaught of the COVID-19 pandemic has created a profound positive impact of using these mobile applications in promoting better information collection and dissemination, which is vital in saving lives during a pandemic.

Digital platforms could become patients' favourite sources of information and substitute for face-to-face communication when unavailable. As a result, mobile applications may bridge the gap and provide healthcare professionals with a new way of disseminating public health messages.

This study discovered mobile applications that may be useful in checking the spread of COVID-19. The most popular applications provided knowledge and guidance, as well as information on contact tracing and hot spots, and half of the evaluated applications were maintained by respective country health authorities. Governments could use these mobile applications to disseminate information to the general public and collect full data for disease control. Given the current COVID-19 situation, continuous development and optimization of these applications are critical in curbing the spread of COVID-19. Further studies on the applications are encouraged to expand the research scope to applications that have not been evaluated.

Author Contributions: Conceptualization, LCM, AH; methodology, MJL, NAO, LCM, AH; formal analysis, MJL, NAO, JSD, YMW, KSL; data curation, MJL, KWG, NAO, LCM; writing—original draft preparation, MJL, KWG, NAO, LCM; writing—review and editing, JSD, AH, YMW, KSL.

Funding: No external funding was provided for this research.

Conflicts of Interest: The authors declare no conflict of interest.

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