JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Coronavirus Pandemic

A content review of COVID-19-related apps used in Vietnam

Linh Tran[1 #], Federica Cucé[2 #], Nguyen Thanh An[3,4], Kadek Agus Surya Dila[5], Nguyen Hai Nam[6], Doan Le Nguyet Cat[7], Lee Wei Jun[8], Farrukh Ansar[9], Fatima Abdallh[10], Au Vo[11], Nguyen Tien Huy[12*]

[1] *University of Health Sciences, Vietnam National University Ho Chi Minh City, Ho Chi Minh City, 700000, Vietnam*
[2] *Surgery, Dentistry, Maternity and Infant Department, University of Verona, Verona, 37124, Italy*
[3] *Faculty of Medicine, College of Medicine and Pharmacy, Duy Tan University, Da Nang City, 550000, Vietnam*
[4] *Institute for Research and Training in Medicine, Biology and Pharmacy, Duy Tan University, Da Nang, 550000, Vietnam*
[5] *Giri Emas Hospital, Singaraja City, Buleleng, Bali 81171, Indonesia*
[6] *Department of Liver Tumor, Cancer Center, Cho Ray Hospital, Ho Chi Minh City, 700000, Vietnam*
[7] *University of British Columbia Faculty of Science, 2329 West Mall, Vancouver, BC, V6T 1Z4, Canada*
[8] *School of Medicine, International Medical University, Kuala Lumpur, 57000, Malaysia*
[9] *Department of Medicine, Alkhidmat Raazi Hospital, Rawalpindi, 46000, Pakistan*
[10] *Faculty of Medicine, Hashemite University, Zarqa City, 11623, Jordan*
[11] *University of California, Los Angeles, 90095, USA*
[12] *School of Tropical Medicine and Global Health, Nagasaki University, 1–12–4 Sakamoto, Nagasaki 852-8523, Japan*

# Authors contributed equally to this work.

Abstract

Introduction: Various digital applications (apps) have been developed as an aid to address the novel issues caused by the Coronavirus disease 2019 (COVID-19) pandemic. Vietnam has experienced a proliferation of apps for this purpose.

This review aims to evaluate all Vietnamese COVID-19 apps, analyzing their features, functionality, advantages, disadvantages, and ethical issues to inform developers, communities, and governments on the most desirable features of COVID-19 apps and the user's opinions.

Methodology: A systematic search was conducted on October 1, 2022, on PubMed, Scopus, Google, and the British Broadcasting Corporation (BBC) News's official website to identify COVID-19 apps available in Vietnam. The apps were evaluated through user reviews and content analysis of their specific features and drawbacks.

Results: Thirty Vietnam-based COVID-19 mobile apps were identified on the Apple and Google Play Store. Their functions were recorded and analyzed using a dedicated tool for appraising mobile applications.

Although useful, many specific COVID-19 features were dispersed and duplicated between the apps. The most comprehensive apps still lack important functionalities, such as vaccination information. The most serious user concerns were privacy breaches during data recording and storage, technical issues, and non-user-friendly interfaces.

Conclusions: The panorama of current COVID-19 apps in Vietnam is complex and includes many apps. Their overlap in features and functions could create a dispersion of mobile users that could undermine the apps' usefulness and effectiveness in combating the pandemic in Vietnam. An app that integrates the most useful features and addresses the main issues could facilitate user experience and usage uptake.

Key words: COVID-19; mobile app; contact tracing.

J Infect Dev Ctries 2025; 19(2):208-220. doi:10.3855/jidc.19329

(Received 12 October 2023 – Accepted 23 October 2024)

Introduction

The World Health Organization (WHO) announced Coronavirus disease 2019 (COVID-19) as a global pandemic on March 11, 2020 [1]. Since then, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread rapidly, and the number of cases has increased significantly. The health, social, and economic impacts of the virus have been immense, and many countries have declared an emergency status to slow the circulation of COVID-19. As the infection became more widespread, public health efforts to tackle it became more difficult, and extraordinary measures were employed. It became fundamental to provide updated information from reputable sources on the status of the pandemic, prevention measures, and healthcare provision, especially as limitations on movement and activities were imposed on the population to achieve social distancing, isolation of cases, and contact tracing.

The Vietnamese government's COVID-19 response has been one of the fastest and most effective in Asia, achieving extremely low overall mortality while maintaining a robust economy. It centered on prompt public health mandates that enforced widespread mask

use, lockdowns, and a strong communication campaign of institutions aimed at the general public. As smartphones represent the main Internet access for most of the Vietnamese population, one of the main communication tools chosen by experts and policymakers to effectively reach the wider public was mobile applications (apps).

The beneficial effects and great potential of medical health practice supported by mobile devices ("mHealth"), through the use of digital health apps have already been widely reported, although its use in a pandemic of this scale posed new challenges [2,3]. The use of mHealth in the management of chronic illnesses and infection prevention has been shown to improve treatment adherence and symptom control [4-6]. Users indicated as the most appreciated features of health-centered apps the possibility to receive tailored content, reminders via notifications, and personal support supported by a user-friendly and stable design.

Germany, Spain, and the United Kingdom (UK) adopted symptom monitoring apps, some even connected to smartwatches or health bands to record vital signs, along with travel and contact history. The information collected through these apps was further elaborated by a back-end algorithm to calculate for every user the chance of having contracted COVID-19 and the need for further diagnostics [7]. Apps in the United States of America (USA), Singapore, Indonesia, Malaysia, and Australia have been released to record close contacts via Bluetooth signals from mobile phones [8,9] to aid in contact tracing of cases, as manual tracing is time and resource consuming and prone to shortcomings. These data were also stored and analyzed to assess the evolution of the pandemic and for further planning [10].

Similarly, the Vietnamese government and many other independent developers built a diverse range of digital apps for COVID-19 with different functionalities, features, and purposes. Their focus was varied, some reported the number of COVID-19 infections and their distribution in the regions along with advice for the population on preventive measures, others reported on the availability of human and material healthcare resources, while some aided public health efforts providing a digital contact tracing [10-12]. In Vietnam, the exceptionally large number of mobile apps available for COVID-19 prevention and care has raised questions among communities and experts. The dispersion of users and the duplication of functions could diminish their overall usefulness and effectiveness, while concerns about potential risks were being posed, such as possible misuse of private data by app owners or hackers, technical errors in the system restricting the movement of healthy citizens, or biased self-reported data [13-15]. Therefore, this study aims to identify, review, and evaluate apps focused on COVID-19 publicly available for users in Vietnam, highlighting the advantages and disadvantages, to inform recommendations for mHealth developers.

Methodology

The methodology described by Zhang *et al.* was adopted to identify all COVID-19 mobile apps publicly available to users [16]. A systematic search was performed on October 1, 2022, 33 months after SARS-CoV-2 began to spread in Vietnam. An update of the search conducted on October 1, 2023, did not add any relevant content.

The initial research was conducted independently by two authors through a formulated search in PubMed, Scopus, Google Scholar, and Google Search (which included Apple App Store and Google Play Store) with search words related to COVID-19 apps in Vietnam. Subsequently, a manual search was performed on the British Broadcasting Corporation (BBC) News for Vietnam's official website [17] to find additional apps that might have been missed in the initial search. The keywords used and the search results are listed in Supplementary Table 1.

Inclusion criteria

All apps focused on COVID-19, developed by any organization, and available for use in Vietnam, were included. The inclusion criteria were as follows: (i) availability in one of the app stores (for the Android or iPhone Operating System (iOS)) for public use, (ii) availability in the Vietnamese or English language, and (iii) relative to COVID-19. Apps that were not free to use or that were specifically designed for an event such as a conference, for a clinical trial or a study were excluded. Two independent reviewers screened the results for relevant apps and compared the results to reach a consensus. Any disagreements between reviewers were resolved by consulting a senior reviewer.

App Characteristics

Information and descriptions available in the app stores were collected, such as app name; developer and affiliation (Government department or third party); compatibility; number of downloads; rating (in both stores if available); number of ratings; age restrictions; release date; date of last update; languages available; presence of informed consent or disclaimers regarding

Table 1. Characteristics of COVID-19 apps in Vietnam.

No	App name	Age rating	Developed by	Access date	Release date	Rating (out of 5) - App Store	Rating (out of 5) – Play store	Languages available	No. of downloads (percentage of Vietnamese population)	Compatibility
1	Bluezone (PC-Covid Vietnam)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Apr 18, 2020	4.2 (29K ratings)	4.3 (258K ratings)	English, Vietnamese	10,000,000 + (10%)	6.0 and up (on Android) requires iOS 10.3 or later
2	Sổ sức khỏe điện tử (Electronic Medical Book)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Jan 7, 2021	2.4 (18K ratings)	2.4 (38K ratings)	English, Vietnamese	100.000 + (0.1%)	iPhone and iPod touch (> IOS 11.0), Mac (macOS11.0 or Mac with Apple M1) iPad (iPadOS > 9.0),
3	NCOVI	4 +	Vietnam's Ministry of Health Ministry of Information and Communications	Oct 1, 2022	Mar 9, 2020	4.2 (6.3K ratings)	4.2 (54K ratings)	English, Vietnamese	7.920.570 + (8%)	iPhone (IOS > 9.0), iPod touch (IOS > 9.0), Mac (macOS > 11.0 or Mac with Apple M1), Mac (macOS > 11.0 or Mac with Apple M1)
4	Vietnam Health Declaration	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Sep 5, 2020	2.9 (480 ratings)	3.8 (2K ratings)	Vietnamese	1.000.000 + (1%)	iPad (iPadOS > 12), iPhone (IOS > 12), iPod touch (IOS > 12.0),
5	VssID (Social and Health Insurance Number)	4 +	Vietnam Social Insurance	Oct 1, 2022	Apr 12, 2020	2.2 (7K ratings)	4.1 (57K ratings)	English, Vietnamese	5.000.000 + (5%)	iPhone (iOS 11.0 >), iPad (iPadOS 11.0 >), iPod touch (iOS 11.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
6	COVID-19	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Mar 11, 2020	3.9 (475 ratings)	3.6 (1K ratings)	Vietnamese	Not available	iPhone (iOS 11.0 >), iPad (iPadOS 11.0 >), iPod touch (iOS 11.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
7	Hotline Bộ Y Tế (Ministry of Health Hotline)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Feb 21, 2019	3.3 (13 ratings)	4.1 (73 ratings)	Vietnamese	10.000 + (0.01%)	iPhone (iOS 9.0 >), iPad (iPadOS 9.0 >), iPod touch (iOS 9.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
8	Đường dây nóng Bộ Y Tế (Ministry of Health report)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	May 15, 2021	Not available	3.4 (14 ratings)	Vietnamese	1000 + (0.001%)	iPhone, iPad (iOS 10.0 >), Mac (11.0 >)
9	Cảnh báo tiếp xúc – CoviTrack (Exposure warning)	12 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Apr 28, 2020	2.0 (7 ratings)	3.3 (110 ratings)	Vietnamese	10.000 + (0.01%)	iPhone (iOS 9.0 >), iPad (iPadOS 9.0 >), iPod touch (iOS 9.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
10	Kiểm Dịch Y Tế (Medical Quarantine)	4 +	Vietnam's Ministry of Health	Oct 1, 2022	Feb 28, 2020	2.6 (23 ratings)	4.0 (120 ratings)	Vietnamese	50.000 + (0.05%)	iPhone (iOS 8.0 >), iPad (iPadOS 8.0 >), iPod touch (iOS 8.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
11	Y Tế Trực Tuyến (Telemedicine)	4 +	Department of Health of Ho Chi Minh City	Oct 1, 2022	Mar 10, 2020	4.1 (13 ratings)	4.3 (39 ratings)	Vietnamese	10.000 + (0.01%)	iPhone (iOS 10.0 >), iPad (iPadOS 10.0 >), iPod touch (iOS 10.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
12	Y Tế Việt Nam (Vietnamese Health)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Dec 17, 2020	4.6 (5 ratings)	4.5 (11 ratings)	Vietnamese	10.000 + (0.01%)	iPhone (iOS 9.0 >), iPad (iPadOS 9.0 >), iPod touch (iOS 9.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
13	An Toàn COVID-19 (COVID-19 safety)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Jan 6, 2020	1.8 (239 ratings)	2.6 (100K ratings)	Vietnamese	100.000 + (0.1%)	iPhone (iOS 10.0 >), iPad (iPadOS 10.0 >), iPod touch (iOS 10.0 >), Mac (macOS 11.0 > or Mac with Apple M1)
14	Quản lý cách ly (Quarantine Management)	4 +	VNPT Media Corporation	Oct 1, 2022	Sep 15, 2020	5.0 (1 rating)	3.4 (139 ratings)	Vietnamese	10.000 + (0.01%)	iPhone, iPod (iOS 11.0 >)

Table 1 (continued). Characteristics of COVID-19 apps in Vietnam.

No	App name	Age rating	Developed by	Access date	Release date	Rating (out of 5) - App Store	Rating (out of 5) – Play store	Languages available	No. of downloads (percentage of Vietnamese population)	Compatibility
15	Sức khỏe Việt Nam (Vietnamese Health)	4 +	Viettel Information and Communications Technology	Oct 1, 2022	Sep 15, 2020	3.8 (596 ratings)	4.4 (3.829 ratings)	Vietnamese	500.000 + (0.5%)	iPhone, iPad, iPod (iOS 9.0 >),Mac (> 11.0 or with the M1 chip)
16	Y Tế TPHCM (Ho Chi Minh City Health)	17 +	Department of Health of Ho Chi Minh City	Oct 1, 2022	June 15, 2021	2.3 (472 ratings)	2.3 (1.799 ratings)	Vietnamese	100.000 + (0.1%)	iPhone, iPod (iOS 11.0 >),Mac (> 11.0 or with the M1 chip)
17	SYT TPHCM (Ho Chi Minh City Health Department)	17 +	Department of Health of Ho Chi Minh City	Oct 1, 2022	June 13, 2019	3.5 (15 ratings)	4.2 (67 ratings)	Vietnamese	10.000 + (0.01%)	iPhone, iPad, iPod (iOS 8.0 >),Mac (> 11.0 or with the M1 chip) , Android 4.0 >
18	Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)	12 +	Vietnam Posts and Telecommunications Group	Oct 1, 2022	Sep 13, 2019	3.0 (2 ratings)	4.3 (45 ratings)	Vietnamese	10.000 + (0.01%)	iPhone (iOS > 9.0), iPod touch (iOS > 9.0), Mac (macOS > 11.0 or with the M1 chip) , Android > 4.1
19	Civid - hỗ trợ khai báo y tế (Medical Declaration Support)	3 +	XoSoLive	Oct 1, 2022	June 9, 2021	Not available	4.5 (8 ratings)	Vietnamese	5.000 + (0.005%)	Android > 4.1
20	Lấy mẫu xét nghiệm COVID-19 (COVID-19 testing)	4 +	Vietnam's Ministry of Health Office	Oct 1, 2022	Not available	4.2 (6 ratings)	3.6 (1.999 ratings)	Vietnamese	500.000 + (0.5%)	iPhone (iOS > 11.0), iPod touch (iOS > 11.0), Mac (macOS > 11.0 or with the M1 chip)
21	Hỗ trợ truy vết (Contact Tracing Support)	17 +	Vietnam Ministry of Health Office	Oct 1, 2022	Jan 1, 2021	4.0 (1 rating)	Not available	Vietnamese	100 + (0.0001%)	iPhone (iOS > 12.0), iPod touch (iOS > 12.0), iPad (iOS >12.0), Mac (macOS > 12.0 or with the M1 chip)
22	ISOFHCARE- bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)	17 + (for iOS), 12 + (for Android)	ISOFH Technology Joint Stock Company	Oct 1, 2022	Sep 17, 2019	4.4 (55 ratings)	4.7 (124 ratings)	English, Vietnamese	10.000 + (for Android) (0.01%)	iPadOS (iOS > 9.0), macOS > 11.0, Mac (M1 chip)
23	Khai báo y tế VTV9 (VTV9 Health Declaration)	3 + (for Android)	Phathienhung	Oct 1, 2022	May 17, 2021	Not available	4.4 (19 ratings)	Vietnamese	10.000 + (for Android) (0.01%)	Android > 4.4
24	Khai báo và kiểm soát vào ra (Declaration and Access Control)	4 + (iOS), Everyone (Android)	Quang Nam	Oct 1, 2022	July 20, 2021	3.0 (1 rating)	4.9 (7 ratings)	English, Vietnamese	1.000 + (for Android) (0.01%)	iPhone, iPod touch (iOS > 10.0), macOS11.0, Mac (M1), Android > 5.0
25	Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)	4 + (iOS) 3 + (Android)	National population data center – Ministry of Public Security Health and Fitness	Oct 1, 2022	August 16, 2021	3.4 (903 ratings)	3.8 (44 ratings)	English, Vietnamese	10.000 + (for Android) (0.01%)	Android > 5.0
26	Tiêm chủng (Vaccination)	12 + (for iOS)	VNPT Media Media Corporation	Oct 1, 2022	NA	2.0 (4 ratings)	Not available	Vietnamese	NA	iPadOS (iOS > 7.0), macOS > 11.0, Mac (M1 chip)
27	Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)	4 + (iOS), 3 + (Android)	Vietnam Ministry of Health Office	Oct 1, 2022	Feb 26, 2021	2.2 (97 ratings)	2.7 (109 rating)	Vietnamese	10.000 + (for Android) (0.01%)	iOS > 12.1, macOS > 11.0, Mac (M1 chip)
28	Sổ Tay Y Tế (Medical Handbook)	4 + (iOS), 3 + (Android)	KhaiThieuQuang	Oct 1, 2022	Apr 27, 2021	4.3 (6 ratings)	Not available	Vietnamese	500 + (for Android) (0.0005%)	iOS, iPadOS > 12.0, macOS > 11.0, Mac (M1 chip)
29	Family COVID-19	4 +	Family Healthcare Joint Stock Company	Oct 1, 2022	Not available	4.7 (3 ratings)	Not available	Vietnamese	100 + (0.0001%)	iOS 10.0 or later
30	ChungNhanTiem (Certificate of vaccination)	4 +	Viet Nam Ministry of Health Office	Oct 1, 2022	Not available	2.5 (13 ratings)	Not available	Vietnamese	Not available	Not available

app use and data collection; and focus areas (awareness or news; vaccination information; contact tracing; contact with health professionals; health advice; helplines; vaccine or negative test certification, with or without QR codes).

App Quality Ratings

Content analysis and quality evaluation were performed by two independent reviewers (all Vietnamese COVID-19 app users) using a modified version of the Mobile Application Rating Scale (MARS) that integrates specific requirements and concerns that arose in the exceptional pandemic situation. Collected data were aggregated in a narrative review, composed of a general technical analysis and a specific COVID-19-related evaluation [4-6,18].

The technical aspects section (corresponding to the functionality and aesthetics items of MARS) assessed

the ease of use, responsiveness, layout and design, organization, and readability of information and news, the interference of advertisement (ads) banners, bugs, and errors, and defective signing-up or signing-in features.

The analysis of specific COVID-19 directed functions and information (corresponding to the engagement and the information items of MARS) and the ethical aspect included the spectrum and efficacy of COVID-19 functions, accuracy of COVID-19 information, privacy protection, type of collected data and their use, and presence of informed consent banners [18].

Results

General characteristics of COVID-19 apps in Vietnam

A total of 30 COVID-19 mobile apps were found in the Apple App Store (n = 27) and Google Play Store (n = 29); their characteristics are summarized in Table 1.

Fifteen apps were developed and run by third-party creators, and the remaining apps were financed and approved by government agencies in their development (as reported in Supplementary Table 2).

Independent creators included the Department of Health of Ho Chi Minh City, Vietnam Post and Telecommunications Group (VNPT) Media corporation, Viettel Information, and Communications Technology, "XoSoLive," Innovative Solution for Health Care Technology Joint Stock Company, Phathienhung, QuangNam, National data center - Ministry of Public Security Health and Fitness, KhaiThieuQuang and Family Healthcare Joint Stock Company.

All apps were available in Vietnamese language and 7 were also available in English: 'Bluezone (PC-Covid Vietnam)', 'Sổ sức khỏe điện tử (Electronic Medical Book)', 'NCOVI', 'VssID (Social and Health Insurance Number)', 'ISOFHCARE – bác sĩ ơi (Innovative Solution for HealthcareCARE - Doctor)', 'Khai báo và kiểm soát vào ra (Declaration and Access Control)', 'Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)'. The age restriction ratings of the apps depended on the content available, ranging from 3 to 17 years +, with the majority of the apps presenting an age rating of 4+.

Characteristics of most used apps in Vietnam

Developed by Vietnam's Ministry of Health and compatible with both Android and iOS, the 'Bluezone (PC-Covid Vietnam)' app was the most used in Vietnam. Since its release in April 2020, it has been downloaded more than ten million times and rated by at least 287 thousand users with an average of 4.25 out of 5 points. The number of users corresponds to approximately 10% of the total Vietnamese population of 99 million people, although only approximately 60-70 million people have access to smartphones in the country, according to official statistics from the National Technology Center for COVID-19 Prevention and Control. In Hanoi, 3.7 million out of 6.68 (55%) million smartphones in use had the PC-Covid app installed [19,20].

The 'NCOVI' app was developed by Vietnam's Ministry of Health and the Ministry of Information and Communications in March 2020, it was the second most downloaded resource, reaching eight million users and an average rating of 4.2 over 5, in more than 70 thousand reviews.

The third most downloaded app was 'VssID (Social and Health Insurance Number)', which totaled over 5 million users. It was introduced in April 2020 and grew popular among Android users with an average rating of 4.1 over 5; however, this app was unable to gain credit among iPhone users and earned a below-average rating (2.2 out of 5).

Purposes and features of COVID-19 apps in Vietnam

Among the 30 unique apps currently available to the Vietnamese population, each offers different features and purposes; an overview can be found in Table 2. The most popular apps ('Bluezone (PC-Covid Vietnam), 'NCOVI', and 'VssID (Social and Health Insurance Number)') share the possibility of having various built-in utilities that can be accessed on the same platform, such as news about COVID-19, recording of symptoms, contact tracing and warning, and data on the number of nearby cases. This reflects why some of the apps were not only listed under the health and medicine categories, but also under news, business, travel, and lifestyle tags.

The most common features of the apps (present in 14 out of 29 of them, 48%) were to provide awareness and news about SARS-CoV-2 and to maintain a symptoms and treatment diary available to the authorities; other frequent features were contact tracing and warning (present in 11/29, 38%), including five apps designed for this sole purpose: 'Khai báo y tế VTV9 (VTV9 Health Declaration)', 'Khai báo và kiểm soát vào ra (Declaration and Access Control)', and 'Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)', and contact with health professionals and medical centers (11/29, 38%).

Helplines, maps of nearby cases, and health management features were less common, vaccine or

negative test QR code generation, and vaccination information functions were present in a few apps ('Sổ sức khỏe điện tử (Electronic Medical Book)', 'Tiêm chủng (Vaccination)", 'ChungNhanTiem (Certificate of vaccination)', 'Family COVID-19').

Technical strengths of COVID-19 apps in Vietnam

COVID-19 apps in Vietnam had good overall quality, their specific strengths are noted in Table 3. Some of the positive features were: ease to use, especially valid for 'Sổ sức khỏe điện tử (Electronic Medical Book)' and 'Khai báo y tế VTV9 (VTV9 Health Declaration)', 'Y Tế TPHCM (Ho Chi Minh City Health)' and 'Family COVID-19', responsiveness, in particular for 'Sổ sức khỏe điện tử (Electronic Medical Book)', curated layout and design in 'ISOFHCARE-bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)', organized and easy to read information and news in 'COVID-19' in 'SYT TPHCM (Ho Chi Minh City Health Department)', and 'Tiêm chủng (Vaccination)'. Two apps intended for healthcare professionals: 'SYT TPHCM (Ho Chi Minh City Health Department)' and 'Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)' contained useful information and protocols to help with the management of COVID-19 cases.

Technical limitations of COVID-19 apps in Vietnam

Notwithstanding the meaningful positive features, a total of 25 apps, including NCOVI, 'VssID (Social and Health Insurance Number)', and Vietnam Health

Table 2. Purposes and overview features of COVID-19 apps in Vietnam.

	Bluezone (PC-Covikd Vietnam)	Sổ sức khỏe điện tử (Electronic Medical Book)	NCOVI	Vietnam Health Declaration	VssID (Social and Health Insurance Number)	COVID-19	Hotline Bộ Y Tế (Ministry of Health Hotline)	Đường dây nóng Bộ Y Tế (Ministry of Health report)	Cảnh báo tiếp xúc – CoviTrack (Exposure warning)	Kiểm Dịch Y Tế (Medical Quarantine)	Y Tế Trực Tuyến (Telemedicine)	Y Tế Việt Nam (Vietnamese Health)	An Toàn COVID-19 (COVID-19 safety)	Quản lý cách ly (Quarantine Management)	Sức khỏe Việt Nam (Vietnamese Health)	Y Tế TPHCM (Ho Chi Minh City Health)	SYT TPHCM (Ho Chi Minh City Health Department)	Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)	Civid - hỗ trợ khai báo y tế (Medical Declaration Support)	Lấy mẫu xét nghiệm COVID-19 (COVID-19 testing)	Hỗ trợ truy vết (Contact Tracing Support)	ISOFHCARE- bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)	Khai báo y tế VTV9 (VTV9 Health Declaration)	Khai báo và kiểm soát vào ra (Declaration and Access Control)	Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)	Tiêm chủng (Vaccination)	Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)	Sổ Tay Y Tế (Medical Handbook)	Family COVID-19	ChungNhanTiem (Certificate of vaccination)
Awareness/News	X	X	X	X	X	X			X		X	X	X	X	X		X	X											X	
Contact tracing and contact warning	X		X						X	X			X		X					X	X		X	X	X					
Warning of nearby cases (on a map)	X		X						X				X		X						X									
Contact with health professionals; booking, info and complaints for medical centers		X	X	X		X	X		X			X			X		X				X	X								
Health declaration, personal information, recording symptoms / treatment	X	X	X	X	X	X	X			X			X		X	X				X		X							X	
Health management		X														X			X								X			
Health management (for physicians/health facilities)								X										X										X		
Helplines			X		X	X	X							X			X													
QR for vaccine / test certifications		X																											X	X
Vaccine information																											X			X

Declaration, were deemed as 'non-user-friendly', meaning slow, difficult to use, unresponsive to user input, presenting bugs, error messages, or malfunctioning account signing in or signing up features, as well as excessive advertising causing interference; these are listed in Table 3.

Moreover, 9 apps were found to be either slow to provide updates on the latest COVID-19-related information or without any updates from the app release. 'Y Tế Trực Tuyến (Telemedicine)', 'Y Tế TPHCM (Ho Chi Minh City Health)' and 'Sổ Tay Y Tế (Medical Handbook)' contained false or inaccurate information. 'COVID-19' and 'Khai báo y tế VTV9 (VTV9 Health Declaration)' apps were hard to use for foreigners due to limited English commands posing a language barrier. The 'Civid - hỗ trợ khai báo y tế (Medical Declaration Support)' app was only available for Android devices, the 'Family COVID-19' and 'Tiêm chủng (Vaccination)' apps were not available for Android devices while the 'Khai báo y tế VTV9 (VTV9 Health Declaration)' was accessible at first and is currently unavailable to users. Most mobile apps require an iOS version of 9 or higher to operate on an iPhone. The 'Sức khỏe Việt Nam (Vietnamese Health)' app cannot be supported by iPhone X. While 'Khai báo và kiểm soát vào ra (Declaration and Access Control)', app's functionality was limited to a specific geographical location, specifically the Quang Nam Province.

Strengths of specific COVID-19 apps' features

Evaluating specific COVID-19 app functionality: 'Bluezone (PC-Covid Vietnam)', 'Cảnh báo tiếp xúc – CoviTrack (Exposure warning)', and 'Hỗ trợ truy vết (Contact Tracing Support)' could alert the user of a close encounter with individuals who were confirmed as COVID-19 cases through device interaction and 'Cảnh báo tiếp xúc – CoviTrack (Exposure warning)', 'Civid - hỗ trợ khai báo y tế (Medical Declaration Support)', 'Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)' could let users list their travel history and recently visited places and whether they had tested positive for COVID-19, to alert possibly infected people. While 'An Toàn COVID-19 (COVID-19 safety)' provided broader information on the risk of

Table 3. Evaluations of COVID-19 Mobile application (apps) in Vietnam

Apps name	Advantages	Disadvantages
Bluezone (PC-Covid Vietnam)	Alerts users of a close contact with a COVID-19 confirmed case	Often users get kicked out from the application COVID-19 confirmed cases have to be registered in the app to allow others to be alerted of a close contact
Sổ sức khỏe điện tử (Electronic Medical Book)	Easy to use Helps register and control personal health information of users Fast and responsive New functions added: QR code for vaccination or past COVID-19 infection certification, health declaration for traveling	Outdated information Cannot scan the QR code of the National Health Insurance card Some users encounter a system error and unable to register
NCOVI	Allows users to fill in a medical declaration (presence of COVID-19 symptoms) Updating news about COVID-19 quickly	Errors while filling in health declarations Slow at loading new information Often users get kicked out from the application Cannot scan QR code certifying vaccination, COVID-19 recovery, or health declaration for traveling The number of cases in the area is not correctly displayed even though GPS is enabled
Vietnam Health Declaration	Allows users to fill in a medical declaration (presence of COVID-19 symptoms) Updating news about COVID-19 quickly	Hard-to-use app Slow at loading new information Presents a lot of errors and bugs Forces users to declare unnecessary information Confusing sign-up process
VssID (Social and Health Insurance Number)	Can use VSSID in place of insurance number (số BHXH) All information and news from BHXH Vietnam are available within the app	Limited features Slow at loading data and information Technical errors (can't choose ID pic, doesn't allow to change passwords, etc.) Confusion layout that renders hard to find information
COVID-19	Information and news organized in easy-to-read formats Emergency phone numbers are easily accessible	No English available Technical Errors Long loading time Outdated news, information, and data
Hotline Bộ Y Tế (Ministry of Health Hotline)	Directly provide information to the agencies that belong to the Ministry of Health	Technical errors (cannot sign-up or sign in)
Đường dây nóng Bộ Y Tế (Ministry of Health report)	Helps health facilities control and monitor reports	Cannot create an account
Cảnh báo tiếp xúc – CoviTrack (Exposure warning)	Users can record their travel history Alerts users of a close contact with a COVID-19 confirmed case	In the registration process the OTP code needed is not correctly sent by the system
Kiểm Dịch Y Tế (Medical Quarantine)	NA (cannot register or sign in)	Technical errors (cannot sign-up or sign in) Lack of information
Y Tế Trực Tuyến (Telemedicine)	The main functions is to allow users to report to the Vietnamese government health care workers alleged errors and violations while practicing (i.e. hygiene practice)	Confusing sign-up process with users often kicked out from the application Easy target for fraudulent users to send false information about health facilities and physicians/doctors Some of the reports are not correclty processed

Table 3 (continued). Evaluations of COVID-19 Mobile application (apps) in Vietnam.

App name	Advantages	Disadvantages
Y Tế Việt Nam (Vietnamese Health)	Act as a "social media" platform for healthcare workers (users can chat, write articles/posts, comment etc.) Create a checklist on COVID-19 preventive measures	Reserved for only some of healthcare facilities workers
An Toàn COVID-19 (COVID-19 safety)	Color-based system that indicates infection risk of different regions based on number of cases Users can monitor the trend of new and total number of infections	Cannot sign-up or sign-in Slow at loading new information
Quản lý cách ly (Quarantine Management)	Provide information about the pandemic Provide hotlines for medical facilities	Cannot sign-up
Sức khỏe Việt Nam (Vietnamese Health)	Provides updated relevant information Users can fill in symptom surveys as well as prevention checklists	Does not support iPhone X Slow at loading data and new information Presents a lot of errors and bugs The interface is quite slow Technical errors (cannot sign-up or sign in) Software errors (required to repeatedly remove and reinstall the app for it to work)
Y Tế TPHCM (Ho Chi Minh City Health)	Friendly and responsive interface	Slow at loading new information Inaccurate news/information Cannot look up or search for specific information Unclear interface
SYT TPHCM (Ho Chi Minh City Health Department)	Presents constantly updated medical information and news about COVID in Vietnam (5-6 updates/month) Information pages on COVID-19 prevention and control cite reputable sources Provides invitation to users to join upcoming seminars, conferences, etc. on the treatment of COVID-19 patients Can provide working hours of healthcare workers and their information (name and phone number) News and information in the app is divided into clear categories for ease of use (invitations, work schedules, etc.) Allows users to schedule an appointment via the app Can provide information (users can input clinical and demographic data before a medical consultation to reduce wait times)	Presents a lot of features that might be confusing for users Missing some health facilities information Technical errors when trying to changing password, some users are unable to sign-up or sign in Each health facility, department, hospital, etc. have their own format of the app, that might create confusion or technical errors
Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)	Can track the number of patients in outpatient and inpatient departments at each health facility to inform users and workers of healthcare burden Can provide medical history and reports of previous appointments Users can save information about healthcare facilities they have visited	The "Create new account" button is hard to find Technical errors (cannot sign-up or sign in)
Civid - hỗ trợ khai báo y tế (Medical Declaration Support)	Users can save information about places visited and if they have a positive COVID-19 test	Only available on Android Doesn't provide the number of confirmed COVID-19 cases contacts or number of cases in the area Outdated information Software is too heavy for some devices
Lấy mẫu xét nghiệm COVID-19 (COVID-19 testing)	Share information about COVID-19 test between testing facilities and healthcare professionals	Cannot sing-up
Hỗ trợ truy vết (Contact Tracing Support)	For healthcare authorities and the wider population participating in the prevention of COVID-19 Tracking COVID-19 patients, contacts, and contact of contacts	Cannot sing-up
ISOFHCARE- bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)	Lets users connect with doctors to have online consults, ask questions and get answers immediately Easy-to-use interface Curated layout and design The app and the consultations are free of charge	Slow loading new information and news Sometimes presents technical errors Often users get kicked out from the application
Khai báo y tế VTV9 (VTV9 Health Declaration)	Presents a convenient feature of quick symptom surveys Easy-to-use interface	Limited English functions Currently unavailable on App Store or Google Play Store
Khai báo và kiểm soát vào ra (Declaration and Access Control)	Used for the Quang Nam province Offers efficient digital contact tracing	Only available in the Quang Nam Province Lacks fundamental information (hotline numbers, healthcare facility numbers)
Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)	Clear and easy-to-use interface App interface offers an English option	Lacks possibility to register health declaration of negative tests necessary to enter quarantined zones Not tourist-friendly: only national citizen ID and local ID options are available for registration Presents a lot of errors and bugs (also when signing up)
Tiêm chủng (Vaccination)	Responsive and easy-to-use interface Well-organized interface by topics	Technical errors (cannot sign-up or sign in)
Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)	Allows users to fill in a medical declaration (presence of COVID-19 symptoms) Users can keep track of vaccination schedule and information	Cannot sing-up Doesn't update information that users added Is not updated according to users' feedback
Sổ Tay Y Tế (Medical Handbook)	Includes COVID-19 symptom registration and includes also functionalities directed to other infectious diseases	The great number of ads interferes with user experience Slow interface Information provided might be partially incorrect
Family COVID-19	Responsive and easy-to-use interface	Only for patients at the Gia Dinh Hospital in the Da Nang province Not available for Android users Users can't update personal information Often users get kicked out from the application
ChungNhanTiem (Certificate of vaccination)	Provides a certificate of vaccination	Not available for Android users Presents a lot of errors and bugs, and some sections are still unfinished

infection in the regions of the country based on the current number of cases. The Vietnam Health Declaration' provided rapid updates on news related to COVID-19.

Other useful functions to improve access to medical assistance regarding COVID-19 were a list of emergency contact numbers provided by the 'COVID-19' app; the contacts of nearby medical facilities present in the 'Quản lý cách ly (Quarantine Management)' app; telemedicine available through the 'ISOFHCARE - bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)' app; and the possibility to indicate known COVID-19 active infections of family members or acquaintances in 'Hỗ trợ truy vết (Contact Tracing Support)' app. Other features were a checklist for effective disease prevention provided by 'Sức khỏe Việt Nam (Vietnamese Health)', and 'An Toàn COVID-19 (COVID-19 safety)' apps; a symptoms survey present in 'Sức khỏe Việt Nam (Vietnamese Health)', 'Khai báo y tế VTV9 (VTV9 Health Declaration)' apps; vaccination information, schedule and certificate of vaccination status in 'Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)' and 'ChungNhanTiem (Certificate of vaccination)' apps.

Limitations of specific COVID-19 apps' features in Vietnam

The newly introduced COVID-19 specific functions were not exempt from shortcomings. The app 'Bluezone (PC-Covid Vietnam)' can alert users of sick contacts, but it requires the sick patient and their contacts to be all registered in the app. The 'Civid - hỗ trợ khai báo y tế (Medical Declaration Support)' app alerts users of elevated infection risk but does not disclose the number of positive cases in the area or the number of infected contacts. Moreover, instruments, technology, and algorithms used by contact tracing apps 'Bluezone (PC-Covid Vietnam)', 'NCOVI', 'Cảnh báo tiếp xúc – CoviTrack (Exposure warning)', 'Kiểm Dịch Y Tế (Medical Quarantine)', 'An Toàn COVID-19 (COVID-19 safety)' , 'Lấy mẫu xét nghiệm COVID-19 (COVID-19 testing)', 'Hỗ trợ truy vết (Contact Tracing Support)', 'Khai báo y tế VTV9 (VTV9 Health Declaration)', and 'Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)', especially in the beginning, lacked publicly-available data on effectiveness and false positive rates in real-world applications. Additionally technical faults in both 'Sổ sức khỏe điện tử (Electronic Medical Book)' and 'NCOVI' apps cause errors in QR code generation for health certifications, affecting the ability of users to declare their health status (last negative test or infection) or vaccination status.

Ethical aspects of COVID-19 apps in Vietnam

An aspect to consider when working with personal medical information, contacts, and location tracking is the necessity to obtain informed and qualified consent from users and guarantee the right and ethical use of personal and collective data. Among the government-approved apps, 6 apps asked for consent for data use, and the remaining 9 apps had a privacy disclaimer explaining how the app utilized user data and how it would be protected. Among the third-party run apps, 8 apps had informed consent disclaimers, while the remaining 7 apps did not include any form of consent or disclaimer regarding data use. The 'Vietnam Health Declaration' app was additionally scrutinized for accusations of excessive personal data collection, possibly infringing user privacy and risking grievous data leaks.

Discussion

To our knowledge, this is the first study to systematically identify and evaluate the currently available Vietnamese smartphone apps designed to slow the spread of COVID-19.

The features, interface, attention to ethical aspects, and rapidity in providing updates and thus, the overall quality was widely heterogeneous in the included apps. As Salehinejad *et al.* [18] pointed out in an early evaluation of mobile apps dedicated to the pandemic, their quality cannot be fairly evaluated using standardized scales created for all-purpose apps because these rapidly developed apps usually do not focus on graphics, layout, or user experience. The users' need-centered approach and the high quality of the content (especially when reporting news, evidence-based medical advice, or local health policy) are the aims of these apps. Thus, a modified app evaluation model was built from the widely established mobile application rating scale (MARS), based on technical aspects (corresponding to functionality and aesthetics items of MARS), specific COVID-19 directed functions and information (corresponding to engagement and information items of MARS), and the ethical aspect, which has been a focus of public concerns regarding COVID-19 apps [4-6,18].

The most common features when considering all Vietnamese apps are news reports, health declarations, and contact tracing. In reviews conducted in April-September 2020 of early COVID apps available in North America, Mexico, Brazil Europe, India, Pakistan,

and other countries [3,16,21], the same features were the most represented, signaling how many countries utilized from the beginning of the pandemic easily accessible tools, such as mobile apps, to inform the population as widely as possible, when in-person activities were limited. In a comparative review of apps used to combat the COVID-19 pandemic in East and Southeast Asia by Lee *et al.,* health monitoring and information were the most common features present in more than 50% of platforms [12]. Consistent with our findings, Vietnam had the highest number of unique apps (although only 9 of the 30 apps included in the study were included in the mentioned review), covering many focus areas and functions.

A similar UK-based COVID-19 app content analysis by Pandit *et al.* underlined that mHealth tools have enormous potential to aid public health efforts, as they demonstrated effectiveness in pandemic surveillance, symptom registration, and contact tracing, along with population information [22]. Contact tracing features were less present in the apps described in the earlier reviews, compared to newer ones; and our review reflects this trend, most likely because apps with this functionality started being released in July 2020 and subsequent months, as more technical and ethical issues had to be address during development before their authorization. These apps often employ new technologies that have never been tested by public health experts, researchers, or app developers on such a great scale. Preliminary data showed a possible reduction in contagion, but no large-scale experimentation would have been feasible before their rollout because of the nature of the disease, the gravity and rapidity of the pandemic spread, and the innovative nature of the technology application.

Therefore, as Colizza *et al*. [9] underlined, COVID apps focusing on contact tracing must adhere to a high standard in both technology and backend software to be effective. They should interact with public health authorities to obtain rapid updates on confirmed cases, either through direct access to test results or through user reports. It is also fundamental to integrate local health policies on quarantines and the limitations of movement to provide clear communications to people infected with COVID-19 and their contacts. The information contained in these apps should be updated and reliable, with clear and accessible scientific references to combat misconceptions and effectively inform the population [23-25]. Because they should adapt to as many users and devices as possible, they should be highly responsive and easy to use.

COVID-19 apps in Vietnam mostly follow these guidelines, with 'PC-Covid Viet Nam' (formerly known as 'Bluezone'), 'NCOVI' and 'VssID (Social and Health Insurance Number)' being the most used apps for the purpose, developed respectively by Vietnam's government branches under the Ministry of Health, the Authority of Information and Technology, and the Social Insurance Institute. Direct supervision by official authorities can provide faster policy updates and professional supervision over the information provided, although the rapidity in reporting the newest regulations and the accessibility for the general public of referenced scientific sources has not been monitored. Adaptation of isolation measures based on contact tracing apps should also be evaluated according to updated infection spread rates. As in Barbarossa *et al.,* freedom of movement limitations perceived as unnecessary were one of the main reasons for the refusal of contact tracing app use in young adults [26, 27]. An improvement of current technologies and software employed in mHealth could integrate other data (length of contact, presence of symptoms and severity, vulnerability, etc.) to obtain a more accurate model and personalized recommendation to avoid uncontrolled contagion, without significantly limiting the movement of uninfected people, as Gupta *et al.* proposed [27].

Furthermore, the apps used for contact tracing should have a high uptake and usage, most likely around 70% of the population, as shown by Cencetti *et al.* and Kahnbach *et al.* [8-9], who report how a large number of users significantly increases the effectiveness of the apps. Achieving high percentages in all communities is a goal inherently limited by smartphone and Internet penetration in the population, which in Vietnam is around 60-70% along with mHealth illiteracy and users reluctance, which are have been already reported in other developing Asian countries [25,28]. The most downloaded Vietnamese app ('Bluezone (PC-Covid Vietnam)') reached only 10% of the population or 15% of smartphone users. When considering countries with a mobile device penetration much higher than Vietnam's, uptake remains variable, in the USA, a great number of contact tracing regional apps dispersed users and had less than satisfying results. The National UK COVID-19 app had an uptake of around 18% as UK authorities concentrated development and advertising efforts on a single platform and paid attention to quality and privacy concerns, as Wymant *et al.* indicate every user counts, as a "1% increase in the number of NHS COVID-19 app

downloads led to a 0.8–2.3% reduction in the number of COVID-19 infections" [29].

Reaching a high number of users for each individual app is much more difficult when a plethora of apps are in use in the country. The current large number of similar COVID-19 apps in Vietnam is due to the widespread effort to quickly respond to the pandemic at the early stages, during which each Vietnamese authority tried to develop a useful tool for the specific needs of the government branch. In addition, local provinces in Vietnam have also launched apps for citizens to inform them about the COVID-19 situation locally, regardless of other apps released by the government. The multitude of apps does not allow for universal information sharing across different platforms, causing data loss and multiple partial databases. Central coordination of these efforts could avoid resource wastage in duplicated projects and ensure better quality.

It could also be useful to increase users' uptake, to reassure the greater public of the app's safety (in addition to the informed consent disclaimers currently present), explaining its advantages and possible benefits for the community and how it can integrate with government regulations. As pointed out by Elkhodr *et al.* [15] and Almalki *et al.* [30], the fear of data misuse significantly limits user uptake. Vietnamese apps collect a high quantity of information and retain it anywhere from 14 days to 3 years, future updates should address the issue possibly reducing the quantity of data or the timeframe of storage and protecting it with encryption methods. Information campaigns directed at users' beliefs and the protection layers put in place by developers could aid in gaining public trust [31-34]. Many countries have utilized extensive national communication campaigns aimed at skeptical citizens delivered by television, social media, or any other widely used platform [9,31,34].

The most complete and popular apps, namely: 'PC-Covid Viet Nam' (formerly known as 'Bluezone'), 'NCOVI' and 'VssID (Social and Health Insurance Number)', presented various useful features such as a symptom tracker with infection and contact history, statistics on COVID-19 infections rates and the health care system burden, information on public health policies and restrictions, digital check-in into health facilities, and helplines numbers. These were extremely valuable in the first months of the pandemic but other features that became beneficial in second phase of the pandemic were never implemented. In particular, the unavailability of a vaccination-related section remains a critical shortcoming of these apps and should be addressed in future possible updates.

Building on a comprehensive understanding of the advantages and limitations of each currently available app, a more community-focused, clear, and effective COVID-19 app could be developed. It would be ideal to obtain an "optimal app," that contains all the required features and addresses the common drawbacks, eliminating duplicate functions and reducing system maintenance cost, focusing most users of one platform, if possible, integrating with medical e-records [35]. Moreover, a friendly user interface that can be used by people with disabilities and with multilanguage content should be developed to increase widespread usage. Privacy issues and public distrust need to be addressed publicly along with clear information on the official app store and in the app interface, as they pose an important limit to user uptake.

At present, the Ministry of Health in Vietnam has officially launched a new 'PC-COVID' app with the intent of replacing multiple redundant applications. However, this app still lacks vaccination-related functions present in 'Sổ sức khỏe điện tử (Electronic Medical Book)' and 'Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)'. Nonetheless, with timely updates and features implementation, 'PC-COVID' could be a useful tool to effectively control the pandemic addressing several reported shortcomings regarding COVID-19 apps.

The current analysis and similar systematic evaluations of COVID-19 apps can aid future developers and public health officials in planning and launching mHealth platforms focused on other infectious diseases or public health crises. Differently from previous apps developed for non-communicable diseases, "emergency" apps should respond to different users and stakeholders' priorities, such as rapid development and update, ease of use, attention to privacy concerns, and widespread uptake, aided by public campaigns. Epidemics or natural disasters in which authorities need to collect health information, health status, vaccination declarations, or contact tracing could benefit from the technology developed in these years to combat COVID-19, which in some cases is also freely available through open-source licenses [36]. These functions could also be adapted to seasonal flu or other easily transmissible human-human infections that have a great impact on the population, especially for fragile individuals and their caregivers, in addition to other public health interventions.

Study limitations

Our review was conducted mainly on Apple Store and Google Play, the most widely used mobile software stores in Vietnam. Nonetheless, other mobile apps not listed in the stores could be present. This choice was made because when discussing COVID-19 apps available to the public, the app stores that most mobile users refer to when searching for apps would be the most representative of the experience of average utilizers.

The assessment for each mobile app was based on the reviewers' analysis and users' opinions present on Apple and Google Play stores in Vietnamese and English; this method, while reporting real-world experience with the technology, can be prone to bias because of different user experiences and preferences, depending on the device used. Moreover, since the study was conducted, several apps have been updated and new features could be present, as this represents a rapidly evolving field.

Conclusions

Current COVID-19 apps in Vietnam focus on education and awareness, health status declarations, contact tracing, and efficient communication with health professionals. Common shortcomings include lacking data protection, outdated information, and poor design and function. The results of this analysis represent a reliable reference for the Vietnamese government (or third parties) to develop an improved COVID-19 application to respond to the current needs of the population and healthcare officials to apply health policies. Lessons learned from the current analysis, namely the importance of focusing on ease of use and wide uptake for infectious disease-focused mHealth platforms and redundant app development caused by the emergency status of the pandemic, could be useful for developers of apps that aid the public health response to epidemics, pandemics, or natural disasters requiring exceptional public health responses.

Acknowledgements

The authors would like to thank Vo Cao Danh, Faculty of Medicine, University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam; Hoang Ngoc Lan Huong, VNU-HCM High School for the Gifted, Ho Chi Minh City, Vietnam; Nguyen Khoi Quan, John Hopkins Bloomberg School of Public Health, Baltimore, MD, United States for their initial contributions in the manuscript.

Authors' contributions

All authors contributed to collecting data, results, interpretation, and manuscript writing. All authors critically revised and approved the final manuscript.

Corresponding author

Nguyen Tien Huy, MD, PhD
School of Tropical Medicine and Global Health,
Nagasaki University, 1-12-4 Sakamoto,
Nagasaki 852-8523, Japan
Tel: +81-95-819-7558
Email: tienhuy@nagasaki-u.ac.jp

Conflict of interests

No conflict of interests is declared.

References

1. World Health Organization (2021) Timeline: WHO's COVID-19 response. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline. Accessed: 18.01.2024.
2. Becker S, Miron-Shatz T, Schumacher N, Krocza J, Diamantidis C, Albrecht U (2014) mHealth 2.0: experiences, possibilities, and perspectives. JMIR Mhealth Uhealth 2: e24. doi: 10.2196/mhealth.3301.
3. Budd J, Miller BS, Manning EM, Lampos V, Zhuang M, Edelstein M, Rees G, Emery VC, Stevens MM, Keegan N, Short MJ, Pillay D, Manley E, Cox IJ, Heymann D, Johnson AM, McKendry RA (2020) Digital technologies in the public-health response to COVID-19. Nat Med 26: 1183-1192. doi: 10.1038/s41591-020-1011-4.
4. Schnall R, Iribarren SJ (2015) Review and analysis of existing mobile phone applications for health care-associated infection prevention. Am J Infect Control 43: 572-576. doi: 10.1016/j.ajic.2015.01.019.
5. Iribarren SJ, Schnall R, Stone PW, Carballo-Diéguez A (2016) Smartphone applications to support tuberculosis prevention and treatment: review and evaluation. JMIR Mhealth Uhealth 4: e25. doi: 10.2196/mhealth.5022.
6. Jakob R, Harperink S, Rudolf AM, Fleisch E, Haug S, Mair JL, Salamanca-Sanabria A, Kowatsch T (2022) Factors influencing adherence to mHealth apps for prevention or management of noncommunicable diseases: systematic review. J Med Internet Res 24: e35371. doi: 10.2196/35371.
7. Whitelaw S, Mamas MA, Topol E, Van Spall HGC (2020) Applications of digital technology in COVID-19 pandemic planning and response. Lancet Digit Health 2: e435-e440. doi: 10.1016/S2589-7500(20)30142-4.
8. Cencetti G, Santin G, Longa A, Pigani E, Barrat A, Cattuto C, Lehmann S, Salathé M, Lepri B (2021) Digital proximity tracing on empirical contact networks for pandemic control. Nat Commun 12: 1655. doi: 10.1038/s41467-021-21703-2.
9. Colizza V, Grill E, Mikolajczyk R, Cattuto C, Kucharski A, Riley S, Kendall M, Lythgoe K, Bonsall D, Wymant C, Abeler-Dorner L, Ferretti L, Fraser C (2021) Time to evaluate COVID-19 contact-tracing apps. Nat Med 27: 361-362. doi: 10.1038/s41591-021-01236-6.
10. Min-Allah N, Alahmed BA, Albreek EM, Alghamdi LS, Alawad DA, Alharbi AS, Al-Akkas N, Musleh D, Alrashed S (2021) A survey of COVID-19 contact-tracing apps. Comput

Biol Med 137: 104787. doi: 10.1016/j.compbiomed.2021.104787.
11. Kahnbach L, Lehr D, Brandenburger J, Mallwitz T, Jent S, Hannibal S, Funk B, Janneck M (2021) Quality and adoption of COVID-19 tracing apps and recommendations for development: systematic interdisciplinary review of European apps. J Med Internet Res 23: e27989. doi: 10.2196/27989.
12. Lee B, Ibrahim SA, Zhang T (2021) Mobile apps leveraged in the COVID-19 pandemic in east and south-east Asia: review and content analysis. JMIR Mhealth Uhealth 9: e32093. doi: 10.2196/32093.
13. Goggin G (2020) COVID-19 apps in Singapore and Australia: reimagining healthy nations with digital technology. Media Int Aust 177: 61-75. doi: 10.1177/1329878X20949710.
14. Collado-Borrell R, Escudero-Vilaplana V, Villanueva-Bueno C, Herranz-Alonso A, Sanjurjo-Saez M (2020) Features and functionalities of smartphone apps related to COVID-19: systematic search in app stores and content analysis. J Med Internet Res 22: e20334. doi: 10.2196/20334.
15. Elkhodr M, Mubin O, Iftikhar Z, Masood M, Alsinglawi B, Shahid S, Alnajjar F (2021) Technology, privacy, and user opinions of COVID-19 mobile apps for contact tracing: systematic search and content analysis. J Med Internet Res 23: e23467. doi: 10.2196/23467.
16. Zhang MWB, Chow A, Ho RCM, Smith HE (2021) An overview of commercially available apps in the initial months of the COVID-19 pandemic. Front Psychiatry 12: 557299. doi: 10.3389/fpsyt.2021.557299.
17. BBC News (2021) Vietnam: 'Matrix' for applying anti-epidemic technology. Available: https://www.bbc.com/vietnamese/vietnam-58473295. Accessed: 14th Sep 2021.
18. Salehinejad S, Niakan Kalhori SR, Hajesmaeel Gohari S, Bahaadinbeigy K, Fatehi F (2021) A review and content analysis of national apps for COVID-19 management using mobile application rating scale (MARS). Inform Health Soc Care 46: 42-55. doi: 10.1080/17538157.2020.1869144.
19. Vietnam Ministry of Information and Communications (2023) At least 55% of Hanoi's smartphone users download national unified COVID-19 app. Available: https://english.mic.gov.vn/at-least-55-of-ha-nois-smartphone-users-download-national-unified-covid-19-app-197149646.htm. Accessed: 12 May 2024.
20. Vietnam Ministry of Information and Communications (2023) Vietnam among 10 countries with largest number of smartphone users. Available: https://english.mic.gov.vn/vietnam-among-10-countries-with-largest-number-of-smartphone-users-197153596.htm. Accessed: 12 May 2024.
21. Ming LC, Untong N, Aliudin NA, Osili N, Kifli N, Tan CS, Goh KW, Ng PW, Al-Worafi YM, Lee KS, Goh HP (2020) Mobile health apps on COVID-19 launched in the early days of the pandemic: content analysis and review. JMIR Mhealth Uhealth 8: e19796. doi: 10.2196/19796.
22. Pandit JA, Radin JM, Quer G, Topol EJ (2022) Smartphone apps in the COVID-19 pandemic. Nat Biotechnol 40: 1013-1022. doi: 10.1038/s41587-022-01338-8.
23. John Leon Singh H, Couch D, Yap K (2020) Mobile health apps that help with COVID-19 management: scoping review. JMIR Nurs 3: e20596. doi: 10.2196/20596.
24. Kondylakis H, Katehakis DG, Kouroubali A, Logothetidis F, Triantafyllidis A, Kalamaras I, Votis K, Tzovaras D (2020) COVID-19 mobile apps: a systematic review of the literature. J Med Internet Res 22: e23170. doi: 10.2196/23170.
25. Bali S (2019) Barriers to development of telemedicine in developing countries. IntechOpen. doi: 10.5772/intechopen.84769.
26. Barbarossa C, Patrizi M, Vernuccio M, Carmen Di Poce M, Pastore A (2023) The resistance toward COVID-19 contact tracing apps: a study of psychological reactance among young adults in Italy. Health Policy 136: 104881. doi: 10.1016/j.healthpol.2023.104881.
27. Gupta P, Maharaj T, Weiss M, Rahaman N, Alsdurf H, Minoyan N, Harnois-Leblanc S, Merckx J, Williams A, Schmidt V, St-Charles PL, Patel A, Zhang Y, Buckeridge DL, Pal C, Schölkopf B, Bengio Y (2023) Proactive contact tracing. PLoS Digit Health 2: e0000199. doi: 10.1371/journal.pdig.0000199.
28. Sujarwoto S, Augia T, Dahlan H, Sahputri RAM, Holipah H, Maharani A (2022) COVID-19 mobile health apps: an overview of mobile applications in Indonesia. Front Public Health 10: 752465. doi: 10.3389/fpubh.2022.752465.
29. Wymant C, Ferretti L, Tsallis D, Charalambides M, Bonsall D, Hinch R, Kendall M, Milsom L, Ayres M, Holmes C, Briers M, Fraser C (2021) The epidemiological impact of the NHS COVID-19 app. Nature 594: 408-412. doi: 10.1038/s41586-021-03606-z.
30. Almalki M, Giannicchi A (2021) Health apps for combating COVID-19: descriptive review and taxonomy. JMIR Mhealth Uhealth 9:e24322. doi:10.2196/24322
31. Splinter B, Saadah NH, Chavannes NH, Kiefte-de Jong JC, Aardoom JJ (2022) Optimizing the acceptability, adherence, and inclusiveness of the COVID Radar surveillance app: qualitative study using focus groups, thematic content analysis, and usability testing. JMIR Form Res 6: e36003. doi: 10.2196/36003.
32. Fan Y, Wang Z, Deng S, Lv H, Wang F (2022) The function and quality of individual epidemic prevention and control apps during the COVID-19 pandemic: a systematic review of Chinese apps. Int J Med Inform 160: 104694. doi: 10.1016/j.ijmedinf.2022.104694.
33. Matt C, Teebken M, Özcan B (2022) How the introduction of the COVID-19 tracing apps affects future tracking technology adoption. Digit Transform Soc 1: 95-114. doi: 10.1016/j.ditras.2022.100005.
34. Dowthwaite L, Fischer J, Perez Vallejos E, Portillo V, Nichele E, Goulden M, McAuley D (2021) Public adoption of and trust in the NHS COVID-19 contact tracing app in the United Kingdom: quantitative online survey study. J Med Internet Res 23: e29085. doi: 10.2196/29085.
35. Johnson C, Barker W (2023) Integrating third-party apps with electronic health records to support COVID-19 response. Am J Manag Care 29: e8-e12. doi: 10.37765/ajmc.2023.89456.
36. Muwonge A, Wee BA, Mugerwa I, Nabunya E, Mpyangu CM, Bronsvoort BMdeC, Ssebaggala ER, Kiayias A, Mwaka E, Joloba M (2023) An open-source digital contact tracing system tailored to haulage. Front Digit Health 5: 1199635. doi: 10.3389/fdgth.2023.1199635.

Annex – Supplementary Items

Supplementary Table 1. Search strategy and keywords.

Database	Keywords	Results
PubMed	(Apps OR app) Vietnam (SARS OR MERS OR coronavirus OR coronaviruses OR HCoV OR nCoV OR Cov OR Cov2 OR COVID OR COVID-19 OR corona OR coronaviridae)	Only 2 papers present, but no apps could be found
Scopus	(Apps OR app) Vietnam (SARS OR MERS OR coronavirus OR coronaviruses OR HCoV OR nCoV OR Cov OR Cov2 OR COVID OR COVID-19 OR corona OR coronaviridae)	No relevant papers
Google	1) ứng dụng công nghệ chống dịch 2) ứng dụng công nghệ COVID 3) App chống dịch 4) App chống COVID	30 apps

Supplementary Table 2. Ethics aspects of COVID-19 apps in Vietnam.

No.	Apps Name	Informed Consent	Reviewed/Approved by
1	Bluezone (PC-Covid Vietnam)	Yes	Vietnam's Ministry of Health Office
2	Sổ sức khỏe điện tử (Electronic Medical Book)	Yes	Vietnam's Ministry of Health Office
3	NCOVI	Yes	Vietnam's Ministry of Health, Ministry of Information and Communications
4	Vietnam Health Declaration	Yes	Vietnam's Ministry of Health Office
5	VssID (Social and Health Insurance Number)	Yes	Vietnam Social Insurance
6	COVID-19	Yes	Vietnam's Ministry of Health Office
7	Hotline Bộ Y Tế (Ministry of Health Hotline)	No	Vietnam's Ministry of Health Office
8	Đường dây nóng Bộ Y Tế (Ministry of Health report)	No	Vietnam's Ministry of Health Office
9	Cảnh báo tiếp xúc – CoviTrack (Exposure warning)	No	Vietnam's Ministry of Health Office
10	Kiểm Dịch Y Tế (Medical Quarantine)	No	Vietnam's Ministry of Health Office
11	Y Tế Trực Tuyến (Telemedicine)	Yes	Department of Health of Ho Chi Minh City
12	Y Tế Việt Nam (Vietnamese Health)	Yes	Vietnam's Ministry of Health Office
13	An Toàn COVID-19 (COVID-19 safety)	No	Vietnam's Ministry of Health Office
14	Quản lý cách ly (Quarantine Management)	No	VNPT Media Corporation
15	Sức khỏe Việt Nam (Vietnamese Health)	No	Viettel Information and Communications Technology
16	Y Tế TPHCM (Ho Chi Minh City Health)	Yes	Department of Health of Ho Chi Minh City
17	SYT TPHCM (Ho Chi Minh City Health Department)	Yes	Department of Health of Ho Chi Minh City
18	Y Tế Điện Tử - VNPT Care (Electronic Health - Vietnam Posts and Telecommunications Group Care)	No	Vietnam Posts and Telecommunications Group
19	Civid - hỗ trợ khai báo y tế (Medical Declaration Support)	No	XoSoLive
20	Lấy mẫu xét nghiệm COVID-19 (COVID-19 testing)	Yes	Vietnam's Ministry of Health Office
21	Hỗ trợ truy vết (Contact Tracing Support)	Yes	Vietnam Ministry of Health Office
22	ISOFHCARE- bác sĩ ơi (Innovative Solution For HealthcareCARE - Doctor)	Yes	ISOFH Technology Joint Stock Company
23	Khai báo y tế VTV9 (VTV9 Health Declaration)	No	Phathienhung
24	Khai báo và kiểm soát vào ra (Declaration and Access Control)	No	Quang Nam
25	Khai báo di chuyển nội địa (VNEID-Viet Nam Electronic Identification)	Yes	National population data center – Ministry of Public Security Health and Fitness
26	Tiêm chủng (Vaccination)	No	VNPT Media Corporation
27	Sổ sức khỏe điện tử Bác sĩ (Electronic Medical Book for Professionals)	Yes	Vietnam Ministry of Health Office
28	Sổ Tay Y Tế (Medical Handbook)	No	KhaiThieuQuang
29	Family COVID-19	Yes	Family Healthcare Joint Stock Company
30	ChungNhanTiem (Certificate of vaccination)	Yes	Vietnam Ministry of Health Office