

## Perspective

# A tale of two applications: lessons learned from national LMIC COVID applications

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## ABSTRACT

Mobile health (mHealth) technologies in low- and middle-income countries (LMICs) have received increased attention for the significant potential benefits they can bring to underserved populations. As smartphones are becoming increasingly accessible, many stakeholders in the mHealth space have begun exploring smartphone applications as a means to impact individuals living within LMICs. With the COVID-19 pandemic straining healthcare systems around the world, many governments in LMICs turned to use smartphone applications to help support and manage their pandemic responses. By analyzing national COVID-19 applications created and launched by the Indian and Vietnamese governments, we highlight effective application functions and strategies, summarizing best practices for future LMIC application development.

**Key words:** mHealth, COVID-19 applications, LMICs, India, Vietnam, comparative analysis, technology, mobile health

## INTRODUCTION

The COVID-19 pandemic has created unprecedented strains on medical systems around the world. Early in the pandemic, governments were particularly challenged with reconciling massive amounts of original research<sup>1</sup> with public health policy to make timely and effective data-informed decisions while simultaneously tending to clinical care crises. The digital era of the COVID-19 pandemic is equally unprecedented: the world has never been more technologically connected.

In an increasingly digital world, mobile health (mHealth) technologies have gained significant attention for potential to overcome physical and temporal constraints of medicine.<sup>2,3</sup> While mHealth interventions' effectiveness has been predominantly studied in high-income countries (HICs),<sup>4,5</sup> mHealth's value in low- and middle-income countries (LMICs) is gaining interest.<sup>6–8</sup> In LMICs, mHealth offers opportunities to reach underserved populations, enhancing accessibility, patient-driven autonomy, and sustainability. Early mHealth LMIC studies have explored efficacy in areas of reproduc-

tive health,<sup>9</sup> medication adherence,<sup>10</sup> and management of noncommunicable diseases<sup>11</sup> with promising results.

While a digital divide still exists globally regarding internet accessibility—an estimated 37% of the world's population did not have reliable internet access as of 2021—significant progress has been made in the past decade to bridge this gap.<sup>12</sup> The COVID-19 pandemic has seen an unprecedented boom in global internet access; internet users globally grew by more than 10% in the first year of the pandemic which was the largest annual increase in over a decade by a significant margin.<sup>12</sup> Moreover, this growth was largely driven by developing countries. In United Nations designated developing countries, internet access increased by roughly 13% during the first year of the pandemic.<sup>12</sup> This observation was magnified in United Nations designated least developed countries, with average increases in internet access exceeding 20%.<sup>12</sup>

Of note, while major trends show great progress, the distribution of accessibility in developing countries stratified by population density (urban versus rural), sex, and age reveal disparities.<sup>12</sup> Urban

populations in developing countries have increased internet access as compared to rural populations at a ratio of about 2:1.<sup>12</sup> Fifty-seven percentage of males in developing countries have access to the internet as compared to 50% of females.<sup>12</sup> Lastly, 67% of individuals aged 15–24 have access to the internet in developing countries as compared to 51% of individuals outside this age range.<sup>12</sup> Many organizations are continuing to explore these demographic trends and have dedicated themselves to achieving parity.

In LMICs, the internet is most commonly accessed via smartphones.<sup>13</sup> Recent 2020 assessments estimate approximately 63% of phones worldwide are smartphones.<sup>14</sup> As smartphones have become globally more accessible, mHealth stakeholders have increased investment into smartphone applications (“mHealth applications”) that promote interactive user experiences. In the past decade, thousands of mHealth applications have launched<sup>15</sup> targeting conditions including smoking cessation, diabetes management, and geriatric care among many others.<sup>16</sup> Many mHealth applications serve HIC populations, augmenting already robust medical infrastructures. However, mHealth applications specifically designed for LMICs with goals of combating inequity, bridging disparities,<sup>17</sup> and/or promoting the democratization of healthcare are emerging.<sup>6</sup>

Given mHealth applications’ growth in LMICs during the pandemic, we explored government-launched applications from two countries—India and Vietnam—highlighting functions and strategies in mitigating COVID-19. While countries pursued different approaches in execution of COVID-19 strategies, many LMIC COVID-19 applications shared core features of contract tracing, quarantine tracking, testing coordination, screening, clinical management recommendations, and information dissemination.<sup>18</sup>

## India

India’s government—through its National Informatics Centre under the Ministry of Electronics and Information Technology—created a national COVID-19 application called Aarogya Setu, or “bridge to health” in Sanskrit.<sup>19</sup> The application released on April 2, 2020, in 11 different Indian languages and was quickly adopted, amassing 50 million downloads within two weeks.<sup>20,21</sup> The application initially had four major functions: COVID-19 risk-assessment; symptom-based likelihood of COVID-19 diagnosis; exposure tracking and notification; and information dissemination.<sup>19</sup> Multiple functions were later added through updates, including telemedicine and electronic passes for quarantine exemptions.<sup>19</sup>

Beyond Aarogya Setu, local governments, healthcare institutions, and private entities created unique COVID-19 applications in India, with at least 50 COVID-19 applications available in India by April 2020.<sup>19</sup> These applications’ most prevalent shared functions were information dissemination, quarantine monitoring, telemedicine via instant messaging, and COVID-19 symptom-based risk assessment.<sup>19</sup>

## Vietnam

Vietnam’s government—in coordination with its Ministry of Health, Ministry of Information and Communications, and multiple state-owned telecommunication groups—created multiple COVID-19 applications serving different functions, including the Vietnam Health Declaration application, “NCOVI,” and “Bluezone.”<sup>22</sup> The Vietnam Health Declaration application was a single-dimensional tracking and tracing application mandatory for all travelers, while NCOVI was multifunctional, entailing voluntary symptom logging, mobile healthcare provider access, and official public health recom-

mendations. Both applications were released in March 2020. In April 2020, Bluezone debuted, offering automated contact tracing and exposure notifications via low-energy Bluetooth technology.<sup>23</sup> To consolidate functionality and improve accessibility, a single conglomerate application (“PC-Covid”) launched in September 2021<sup>24</sup> replacing all previous nationally sponsored applications and adding functions like electronic vaccination certificates.

## COMPARATIVE ANALYSIS

In assessing India’s and Vietnam’s nationally sponsored COVID-19 applications, several commonalities emerge. Contact tracing, telemedicine, quarantine monitoring, and information dissemination were generally conserved; additionally, similarities exist between how each government launched and advertised their applications (Table 1).

When evaluating each application’s execution of functions more granularly, however, differences become apparent. For instance, while both incorporated automated contact tracing, Bluezone used exclusively low-energy Bluetooth technology<sup>21</sup> whereas Aarogya Setu used both Bluetooth and global positioning system (GPS)<sup>17</sup> technologies. Such differences have implications for each application’s capabilities and will be explored to highlight best practices for future applications.

### Roll-out and adoption

Both India and Vietnam released national COVID-19 applications early in the pandemic. Aarogya Setu launched on April 2, 2020, when India had 2543 cumulative cases of COVID-19.<sup>25</sup> Vietnam Health Declaration application and NCOVI, Vietnam’s first applications, launched on March 9, 2020, when Vietnam had 100 cumulative cases.<sup>20</sup> While the timeliness of launching these applications was rapid, getting users to download and use them thereafter was equally important. India’s government employed multiple marketing strategies, including social media advertising,<sup>26</sup> having public officials support the application via speeches,<sup>27</sup> and prioritizing inclusivity.<sup>18</sup> Additionally, India’s government required the application for anyone living in containment zones and all government and private-sector employees—a topic of legal debate.<sup>28</sup> While acknowledging legal concerns, India had major success in Aarogya Setu’s adoption; by May 2020, Aarogya Setu became the most downloaded healthcare application globally, with over 100 million downloads<sup>24</sup> among India’s estimated 500 million smartphone users.<sup>25</sup>

Vietnam approached its launches similarly, promoting public campaigns to download the applications as patriotic acts protecting all Vietnamese.<sup>21</sup> State-owned telecommunication companies and social media were also used to promote the applications. The Vietnamese government leveraged an existing communication platform—Zalo, Vietnam’s most popular messaging application—to send daily alerts promoting the applications.<sup>21</sup> In contrast to India, Vietnam’s government had fewer application downloading mandates. When Vietnam launched its first three applications, only the Vietnam Health Declaration application was mandatory for travelers entering the country. During large outbreaks in cities, local governments could enforce temporary mandates of specific applications, and later in the pandemic, entry to restaurants required the applications be downloaded (with business owner enforcement discretion).<sup>21</sup> By July 2020, NCOVI achieved 7.2 million downloads and Bluezone 200 000<sup>21</sup> among Vietnam’s estimated 76.8 million smartphone users.<sup>21</sup>

**Table 1.** Summary of national COVID-19 mHealth applications released by India and Vietnam

Country	Application name	Release date	Adoption	Functions
India	Aarogya Setu	April 2, 2020	50 million downloads within first 2 weeks of launch 100 million downloads 1 month after launch	Risk assessment of contracting COVID-19 Likelihood of having COVID-19 based on self-reported symptoms Exposure tracking and notification Information dissemination Electronic passes for movement through checkpoints <sup>a</sup> Telemedicine (virtual doctor visits, home laboratory testing, and home medication delivery) <sup>a</sup> Electronic vaccination verification <sup>a</sup>
Vietnam	Vietnam Health Declaration application	March 9, 2020	>1 million downloads before being retired <sup>b</sup>	Medical declaration upon entry of country at airport or border Electronic passes corresponding to medical declaration
	NCOVI	March 9, 2020	7.2 million 4 months after launch	Voluntary symptom logging Telemedicine (triaging services provided by healthcare professionals) Information dissemination Mapping of suspected positive cases based on symptom logs Electronic passes for checkpoints <sup>a</sup>
	Bluezone	April 18, 2020	200 000 downloads 3 months after launch 20 million downloads 4 months after launch	Exposure tracking and notification Information dissemination
	PC-Covid	September 30, 2021	Over 3.6 million downloads in the first month after launch	Medical declaration upon entry of country at airport or border Voluntary symptom logging Exposure tracking and notification Telemedicine (scheduling tests and vaccinations) Information dissemination Electronic domestic travel passes and vaccination cards Mapping of suspected hot spots based on symptom logs and reported test results

<sup>a</sup>Functions added in updates after initial application release.

<sup>b</sup>Downloads by month after release not disclosed.

India's higher early adoption rates may result from download mandates amongst specific populations. Additionally, India's singular, centralized application approach versus Vietnam's multiple applications likely facilitated adoption. Vietnam's significant difference between NCOVI versus Bluezone downloads may derive from the latter's delayed release, or the government more heavily promoting the former; regardless, the differences illustrate potential drawbacks of the multiple application approach, including users having to consciously download multiple applications and requiring separate ongoing application updates. In LMICs, limited phone data plans could magnify this challenge. After 18 months, Vietnam ultimately transitioned to a centralized application, believing it superior for accessibility and convenience.<sup>22</sup>

Both India and Vietnam tailored their applications and rollouts to their individualized populations. India's launch in 11 different major Indian languages acknowledged its population's heterogeneity. Vietnam's government utilized Zalo to advertise, knowing it was well-established and heavily used. These measures targeting the

intended populations and utilizing existing infrastructure highlight best-practices to enhance mHealth applications' impact in LMICs.

### Contact tracing

Contact tracing—which can significantly blunt COVID-19 spread<sup>29</sup>—was a mainstay practice during the pandemic, and many countries (including India and Vietnam) leveraged mHealth applications to aid the resource-intensive process. Application-based contact tracing effectively decreases transmission when used in conjunction with social distancing.<sup>30</sup> India's Aarogya Setu and Vietnam's Bluezone both possess contact tracing, but differ in technologies used, the data collected from users, and data utilization by public health officials.

Aarogya Setu employs Bluetooth and GPS technologies while Bluezone uses exclusively Bluetooth. Using Bluetooth, phones transmit and receive radio waves from one another, recognizing other devices within short distances. Applications using Bluetooth can be

programmed to automatically list proximate devices within 2 meters (~6.5 ft), a common social distancing radius. By simultaneously tracking positive COVID-19 cases in the application, a users' history of exposure to positive cases can be compiled and automatic alerts can be sent informing users of exposures, as is done in Vietnam's Bluezone.<sup>21</sup> GPS technologies can work synergistically with Bluetooth to provide real-time geolocations of users and precise information on movement trends. Aarogya Setu simultaneously collects users' GPS data while enabling Bluetooth to record close contacts to cross reference with positive cases.<sup>17</sup>

From a disease control perspective, incorporating both technologies affords more detailed data collection versus Bluetooth alone. Clustering GPS data from positive COVID-19 cases can map "hotspots" and determine containment zones. Bluezone only allows for stored contacts to be cross-referenced with positive cases, notifying users of exposures. Aarogya Setu's GPS-enabled added capabilities, however, raise concerns regarding data collection and privacy,<sup>31</sup> especially when considering the application's download requirements. Future developers must be conscientious of privacy concerns, weighing mandates of such technologies and impacting established trust with users.

Application utilization also impacts overall effectiveness, as application-based contact tracing only works if large numbers of people actively use it consistently. Models can predict what percentage of populations must use an application for significant disease-modifying impacts<sup>28</sup>; in LMICs, smartphone prevalence must be considered. Prior to launching Bluezone, Vietnam's Ministry of Health determined 50 million users would ensure meaningful impact, which the government believed was plausible. If reaching an optimal user base is implausible based on demographics, resources may be better allocated toward other contact tracing methods.<sup>21</sup>

### Telemedicine

Telemedicine components were present in both India's and Vietnam's applications. In LMICs, where medical resources may not be as accessible, the benefits of telemedicine are considerable. India's Aarogya Setu added an update "Mitr" allowing users to virtually consult doctors, schedule home testing, and request medication delivery.<sup>32</sup> Vietnam's NCOVI allowed users to get advice from healthcare providers on self-quarantining or clinical management options.<sup>21</sup>

Multiple studies of telemedicine interventions in LMICs outside of applications have reported positive outcomes.<sup>33,34</sup> Particularly during the COVID-19 pandemic, many LMICs have expanded telemedicine through both legislation and healthcare provider training.<sup>35</sup> Aarogya Setu's and NCOVI's incorporation of telemedicine represent another medium to access remote care; application-based telemedicine's efficacy on overall COVID-19 burden requires further characterization.

In the later stages of the pandemic when vaccines became available for widespread use, both India and Vietnam added features via application updates of vaccination scheduling and electronic vaccination certificate validation. Both countries added these features by integrating their applications with existing national healthcare technology infrastructure in combination with electronic validation software that was created through a collaborative international open-source model.<sup>36</sup>

### Information dissemination

Both India's and Vietnam's applications incorporated information dissemination. Aarogya Setu's first version's "COVID-19 Updates"

section served as a direct government communication channel. NCOVI served as an official Vietnamese government channel to share best practices, new case numbers, neighborhood hotspots, and real-time health recommendations. Bluezone, though mainly launched for contact tracing, also provided real-time numbers of cases, deaths, recoveries, and public health recommendations.

One creative quality of Aarogya Setu's information dissemination was user communication flexibility. Aarogya Setu established multiple communication channels to disseminate information based on phone service capabilities. In addition to interacting directly with the application's Updates section, users with slower-speed data could opt for voice calling and/or text messaging. Using combinations of interactive voice response systems, voice recognition, and user inputs like pressing numbers on a keypad, the voice calling and text messaging options offered quasi-interactivity, allowing all users to access information irrespective of data constraints.<sup>37</sup>

Vietnam capitalized on the government's ownership of major telecommunication groups to disseminate information, providing free data to some users accessing NCOVI. Moreover, text messages and phone calls coordinated through the applications were subsidized.<sup>21</sup> These efforts could be emulated in other countries with privatized telecommunications, for example, by forming public-private partnerships to achieve similar outcomes.

## CONCLUSIONS

The COVID-19 pandemic has highlighted mHealth's utility in government-organized responses to a pandemic. Utilizing increased smartphone access and growing digital infrastructures, India and Vietnam created national COVID-19 mHealth applications to augment accessibility, communication, and public health practices. While the applications differed in how functions were organized and executed, overarching themes including telemedicine, automated contact and quarantine tracing, and formal information dissemination were shared. Best practices for application rollouts included utilizing existing infrastructure to advertise applications, emphasizing inclusivity in design, and using a centralized, one-application model. Incorporating both GPS and Bluetooth-based tracing offers numerous capabilities for contact tracing but raises questions of personal privacy. Both applications offer telemedicine services, but data on their impact is needed. Information dissemination through multiple modalities and free or subsidized data usage combated financial barriers and promoted greater flow of information.

mHealth applications in LMICs can bridge gaps of accessibility, provide greater patient autonomy, and augment governments' abilities to respond to rapidly evolving healthcare crises. New research to characterize application capabilities and technology modalities implemented will be pivotal for guiding future, data-driven application design. As future applications are designed and currently available applications are updated, creating open dialogue on best practices and failures will promote global health equity and respect the contexts of different society's cultures, norms, and local policies.<sup>38</sup> Lastly, while LMICs are experiencing digitalization at increased rates in recent years, the benefits that mHealth applications offer must always considered in the context of known technology accessibility disparities.<sup>12</sup>

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Both authors made substantial contributions to the conception or design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published. The authors agree to be accountable for all aspects of the work.

## CONFLICT OF INTEREST STATEMENT

None declared.

## DATA AVAILABILITY

All data underlying this article are available in the article and in the references cited below.

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