Application technology to fight the COVID-19 pandemic: Lessons learned in Thailand

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ABSTRACT

Demands to address the COVID-19 pandemic rapidly surpassed global resources. Successful implementation of application technology resulting in people taking greater control of their own health and medical and public health personnel improving efficiency was requested by authorities in Thailand to reduce the demand on health resources to meet the health needs of the people. This paper examines the creation and implementation of three real-time application technologies using a bottom-up approach in an attempt to examine COVID-19 challenges and highlight control measures. These lessons learned represent participatory action research methods involving the people who were responsible for taking actions to improve their own and their communities' health. The objective was to build participation of users, academics and service organizations in a novel technology enhanced system leading to quality management of the COVID-19 pandemic. A new technology enhanced system for medical field personnel encouraged network participation resulting in co-creation of a health data center. Application technology assisted COVID-19 infected patients and high-risk people to identify their own symptoms and to provide a rapid tracking method that could be employed until public health surveillance was achieved. A patient and hospital management system employing new application technology was effective in monitoring COVID-19 patients utilizing an interconnected hospital network. Application technology was beneficial in promoting health, enhancing patient satisfaction, reducing readmission rates and extending health resources.

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1. Introduction

The COVID-19 pandemic is causing global disruption to societies and health-care systems [1]. The COVID-19 disease causes a wide range of respiratory symptoms from those similar to the common cold to more severe illness such as pneumonia, and its major channel of transmission is through droplet spread [2—4]. Organizations in the UK such as National Health Service (NHS) Digital, NHSX, and NHS Business Services Authority, have placed a focus on the need for mobile technology in managing and controlling the pandemic. This emphasis led to an increase in mobile phone applications developed to fight against COVID-19 [5—7]. Telemedicine developed to monitor health and care has shown an increasing role in the current COVID-19 pandemic in monitoring patients with diabetic and other chronic conditions and patients who have been 'self-isolating' at home and unable to attend clinic visits [8,9,11—13]. Internet of Medical Things (IoMT) incorporates a large number of interconnected devices to create a smart network for a comprehensive healthcare management system. IoMT tracks disease and alerts providers to improve follow-up and safety of the patient. It digitally captures the data and information about the patient without any human interaction. This data is also very helpful for appropriate decision-making by health care providers [10]. App Store (Apple, California, USA) and Google Play (Google, California, USA) platforms are also available using the search terms "coronavirus", "COVID-19", or "novel coronavirus". Approximately, 82 applications are identified from 35 different countries. Of these 82 applications, 32 are in the English language (April, 2020).

In order to reduce the risk of person-to-person transmission of the SARS-CoV-2 virus responsible for COVID-19 disease, governments around the world have introduced prevention strategies including lockdown' measures, social distancing', 'physical distancing', face masks, and healthy hygiene practices such as handwashing. Lockdown measures have essentially limited

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movement of citizens in communities while allowing essential services to continue in an attempt to contain and virtually stop the spread of the coronavirus pandemic. Consequently, COVID-19 has had a significant effect on daily life including an increased need for health care services, economic loss and social disruptions. Therefore, application technology is vital for managing and controlling the large amount of information needed to stop the COVID-19 pandemic [15].

2. The COVID-19 pandemic experience in Thailand

The COVID-19 disease was first reported in China in late 2019. Thailand was the first country outside China that reported a new case of COVID-19 in Bangkok on January 13, 2020. During the COVID-19 outbreak, the Thailand Department of Disease Control, Ministry of Public Health reported cumulative numbers of infectious cases for Thailand at 3310 with 41 cases from Chiang Mai province (June, 2020) [14].

Throughout the pandemic the Thai people were alerted and engaged in preparation for the prevention of the virus including the implementation of the national lockdown. Concerned agencies in Thailand developed platforms or applications to provide knowledge about and to monitor the spread of the virus. For instance, data from international tourists and Thais coming in from high-risk countries was collected from all domestic airports to facilitate tracking and quarantine. Another communication strategy, called "Thai Fighting Against COVID-19", was established to inform the general public about outbreaks and provide accurate information about the virus and prevention measures using Line, Twitter, Facebook, and TikTok. Web applications such as Line (https://lin.ee/dAEig3e) and Twitter (https://twitter.com/thaimoph), reported COVID-19 total number of cases, areas of high risk, and reports of new cases on a daily basis.

3. Development of application technologies addressing the COVID-19 outbreak in Thailand

At the beginning of the COVID-19 outbreak in Thailand knowledge about the coronavirus and the pandemic was very limited and caused a lot of panic among the people in the country including both Thai citizens and foreign visitors. Information on how SARS-CoV-2 virus could spread, signs and symptoms of disease, and effective prevention measures was not readily available. Between February 2020 and May 2020, the Faculty of Public Health, Chiang Mai University developed a number of application technologies to support prevention and control activities in Chiang Mai and Thailand including Self-Screening for COVID-19, Self-Health Check for COVID-19 and Chiang Mai COVID-19 (CMC-19) hospital information system (see Fig. 1).

3.1. Self-Screening Application (SSA) for COVID-19

On January 13, 2020, the first case of COVID-19 in Thailand was reported in one Chinese visitor followed on January 15, 2020 with the first case of COVID-19 reported in one Thai citizen. Access to viral screening and diagnosis inside the country was limited at that time to select hospitals and concerned agencies under the Ministry of Public Health. Over the next weeks the virus spread to several provinces in Thailand, especially provinces deemed tourist attractions. Chiang Mai province located in the north of Thailand, was designated a high-risk area due to receiving a lot of visitors from China. The increasing number of COVID-19 patients and suspected cases spreading through many provinces in Thailand caused a lot of panic and concern among the people. Public health officers in Chiang Mai received a great number of telephone calls from people

speaking Thai as well as foreign languages asking about the disease and wanting to know where they could go to get a test for COVID-19. These circumstances motivated Chiang Mai University Faculty of Public Health to develop a self-screening for COVID-19 using a mobile application provided in three languages: Thai, English and Chinese. The Self-Screening Application served as a preliminary screening for the general public who wanted to learn more about the disease and for those who might feel nervous or suspect they had contracted the coronavirus. The main purpose of this application was to help people make a self assessment inputting any signs and symptoms they had (eg; fever, dry cough, tiredness, sore throat, difficulty breathing or shortness of breath) and their risk exposures related to COVID-19 (eg; countries they had visited in the last 14 days, their occupation if it had a high chance of contact with foreigner visitors). Then the application tabulated the data resulting in an indication of their overall condition. This was presented as one of three levels of evaluation and advise: Red = suspected Covid-19, "Medical evaluation is immediately needed"; Yellow = probable exposure, "If you have any symptoms please see a doctor"; and Green = healthy, "No indication for novel Coronavirus 2019 infection" . The application's report page also provided a number of educational materials in Thai, English and Chinese about COVID-19 that led the participants to websites to increase their health literacy and learn more about how to prevent themselves from getting the disease. Reports indicating suspected COVID-19 infection, also listed the telephone number of the Department of Disease Control under the Ministry of Public Health in Thailand so they could call in to ask for further assistance.

3.2. Self-health check (SHC) application for COVID-19

When China reported the outbreak, many countries such as Thailand initiated travel limitations from China, and also within country and from other high risk countries as well. However, airline travel continued though on a more limited scale globally. The idea of an application was initiated to address this challenge targeting Thai and foreign visitors who travelled into Thailand from a number of listed countries experiencing COVID-19 outbreaks between Feb and May, 2020. People who entered into Thailand were asked to cooperate at the airports to download this application on their mobile phones and were asked to be socially responsible by reporting their health condition, related to symptoms of COVID-19, daily for 14 consecutive days. The application was used for all travelers at Chiang Mai International Airport. Airlines also collaborated by asking travelers coming to Chiang Mai to download this application. During the 14 day follow-up after travel if a person developed any symptoms and reported them through the mobile application, they would be informed by a public health officer how to proceed through a short message system (SMS) immediately sent to their mobile phone (see Fig. 2). The application also informed Thai relevant agencies, (e.g., Department of Disease Control or provincial public health offices) via emails about suspected cases. The system was able to provide real-time information about how many people had arrived in the country and how many had any symptoms related to COVID-19, how many were at risk for the disease, and what were their names, address and contact phone numbers in Thailand. This information enabled local public health officers to contact suspected cases instantaneously. The travelers could also send questions with the application text box to the health authorities who would respond to the travelers later. This helped enhance better communication efficiency between the traveler and Thailand public health officers. After completion of the 14 day follow up, the system closed automatically. Use of this application helped local health authorities follow up with a great number of travelers and to be alerted immediately if any travelers
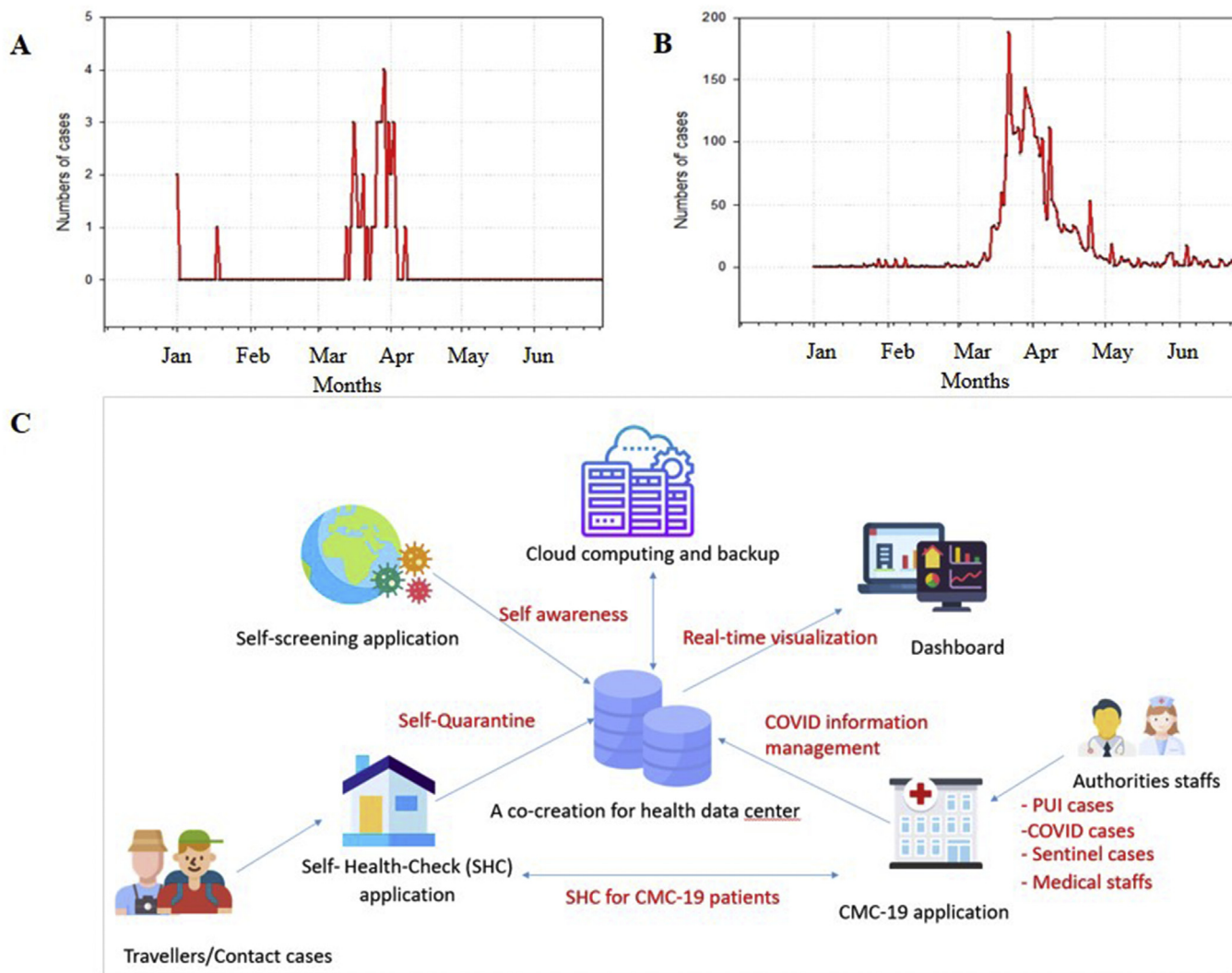
Fig. 1. (A) COVID-19 daily statistics in Chiang Mai Province, (B) COVID-19 daily statistics in Thailand, (C) overview of a public health platform to manage and control COVID-19 pandemic including three new application technologies, Chiang Mai Thailand, 2020.

reported symptoms on each day. Health officials could then contact the symptomatic travelers and ask them to come to the hospital for testing, and to be hospitalized while waiting for the testing results. This application was also offered to the general public during the mandatory lockdown in Thailand emphasizing the need for social responsibility.

3.3. Chiang Mai COVID-19 hospital information system

When Thailand declared a national lockdown the first week of April 2020 and closed all international airports prohibiting international visitors, there was already a growing number of COVID-19 patients and a great number of patients under investigation (PUI) for COVID-19. The challenges of administering patient care and monitoring suspect cases made it vital to know the number of daily cases, diagnosis results, and transfers of COVID-19 patients to hospitals for treatment. An application to manage all this data throughout the healthcare system was requested by Chiang Mai Provincial Health authorities. A real time information system on suspect cases (PUI) and COVID-19 patients could also assist in allocation of resources among the network hospitals informing individuals in each public health agency how to manage the

patients. Chiang Mai COVID-19 (CMC-19) hospital information system was initiated on March 21, 2020 (see Fig 3). The data on suspected cases and confirmed COVID-19 patients was inputted by staff in each of 51 public and private hospitals into one platform. The data included the name, address, registration with codes for laboratory results, and transfer information of suspected cases. If the laboratory results confirmed a positive result for COVID-19, patients were referred to one of the 13 network hospitals assigned for COVID-19 treatment in Chiang Mai. The advantage of the system was that all the hospitals were able to manage data within one platform, including severity of patients (mild, moderate, sever), laboratory results, drug prescription, blood test, hospital bed management or referral to another hospital. History of each patient was checked via this application platform. Administrators of each hospital or provincial health authorities were able to view the information from a dashboard about the number of COVID-19 patients, number of suspected cases who were waiting for laboratory results, their names, their symptoms, and trends of COVID-19 situations. Administrators at different levels of responsibility were allowed different rights to access in order to safeguard the data and privacy of the patients.
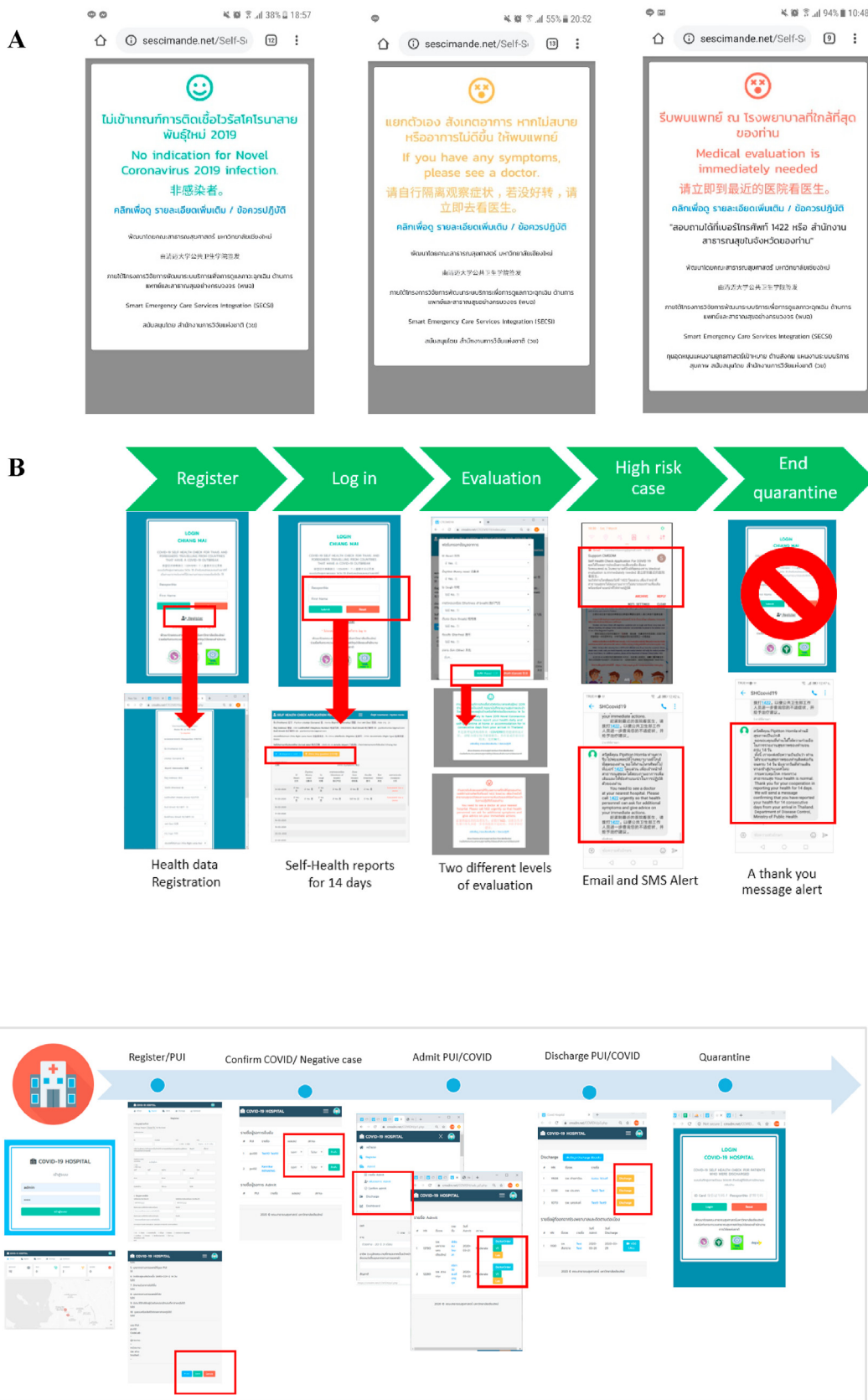
Fig. 2. Three application technologies: (A) Three levels for Self-Screening evaluation, (B) Real time Self-Health Check application data monitoring for travel follow-up, quarantine, and lockdown, Thailand, March 3, 2020, (C) Chiang Mai COVID-19 Hospital Information System implementation, Chiang Mai, Thailand, March 21, 2020.

Fig. 3. CMC-19 dashboard for Decision-making: (A) Patient Under Investigation patients in each hospital, which are represented by thee level; mild, moderate and severe, (B) Bed management for COVID-19 patients admitted within 51 hospitals, (C) Lab results monitoring.

4. Results and lessons learned

The integration of application technology in to pandemic COVID-19 policy could be rapidly deployed in term surveillance, testing, tracing, quarantine, and hospital management (see Table 1). The Self-Screening Application (SSA) for COVID -19 was implemented at the provincial and Thailand national levels. The application was a collaboration between the Faculty of Public Health, Chiang Mai University; the National Research Council of Thailand; and the Department of Disease Control, Ministry of Public Health as well as those individuals who chose to take action and complete the screening. A large number of people used this application because it was available in three languages: Thai, English and Chinese. The application could determine where the participant was located and choose from the telephone numbers of 1422 Thailand provincial public health offices and the national Department of Disease Control depending on their location. Consequently, it was also possible to know where the application was used in various parts of the world. The system indicated that over 200,000 people globally used the application by February–April, 2020 (see Fig. 4a). Of this number, 95% were domestic users and 5% international users. This

high use was in part because the application was easy to access by scanning a QR code or clicking the link provided on multiple forms of media. The application also provided knowledge about COVID-19, and provided resources to obtain additional information. This application raised health-related awareness of the public and enabled them to self-screen themselves for the disease at home in an attempt to lessen their worries and panic. It also helped to reduce the large number of telephone calls experienced by health officers from the general public asking about health conditions when screening results showed a normal or healthy status. People who had symptoms related to COVID-19 were given a telephone number to call for further communication before going to the hospitals.

The Self-Health Check for COVID-19 (SHC) application was truly beneficial for preliminary screening of those people who travelled from outbreak locations. In addition to reducing the number of people visiting public health service centers, which might lead to a wider spread of the virus, the application reduced the workload of medical personnel in answering questions, so that their time could be more efficiently used. Self-Health Check enabled health authorities to know vital information about those traveling into

Table 1
Three application technologies to help fight against the COVID-19 pandemic, Thailand, 2020.

Applications	Descriptions
1. Self-Screening Application (SSA)	SSA is a preliminary screening tool for the general public who want to learn more about the disease and who might feel nervous or suspect they have contracted the coronavirus. After inputting their signs and symptoms and history of risk exposures, data is tabulated resulting in an evaluation of and response guidance to address their self-assessed condition.
2. Self-Health Check (SHC) Application	SHC represents a health data monitoring system initiated through mobile technology used during self-quarantine after travel or during lockdown. The system provides a means for communication between high risk people and staff using a data link and question and answer input. An individualized alert using SMS is initiated when the system detects a high risk case.
3. Chiang Mai COVID-19 (CMC-19) Hospital Information System	CMC-19 represents a single real time information system for 51 hospitals/centers in Chiang Mai province to analyse their patients' health data and to access testing data on suspect and confirmed cases of COVID-19. Administrators receive various levels of dashboard access to help with decision-making such as regarding bed capacity and transfer needs.

A

B

C
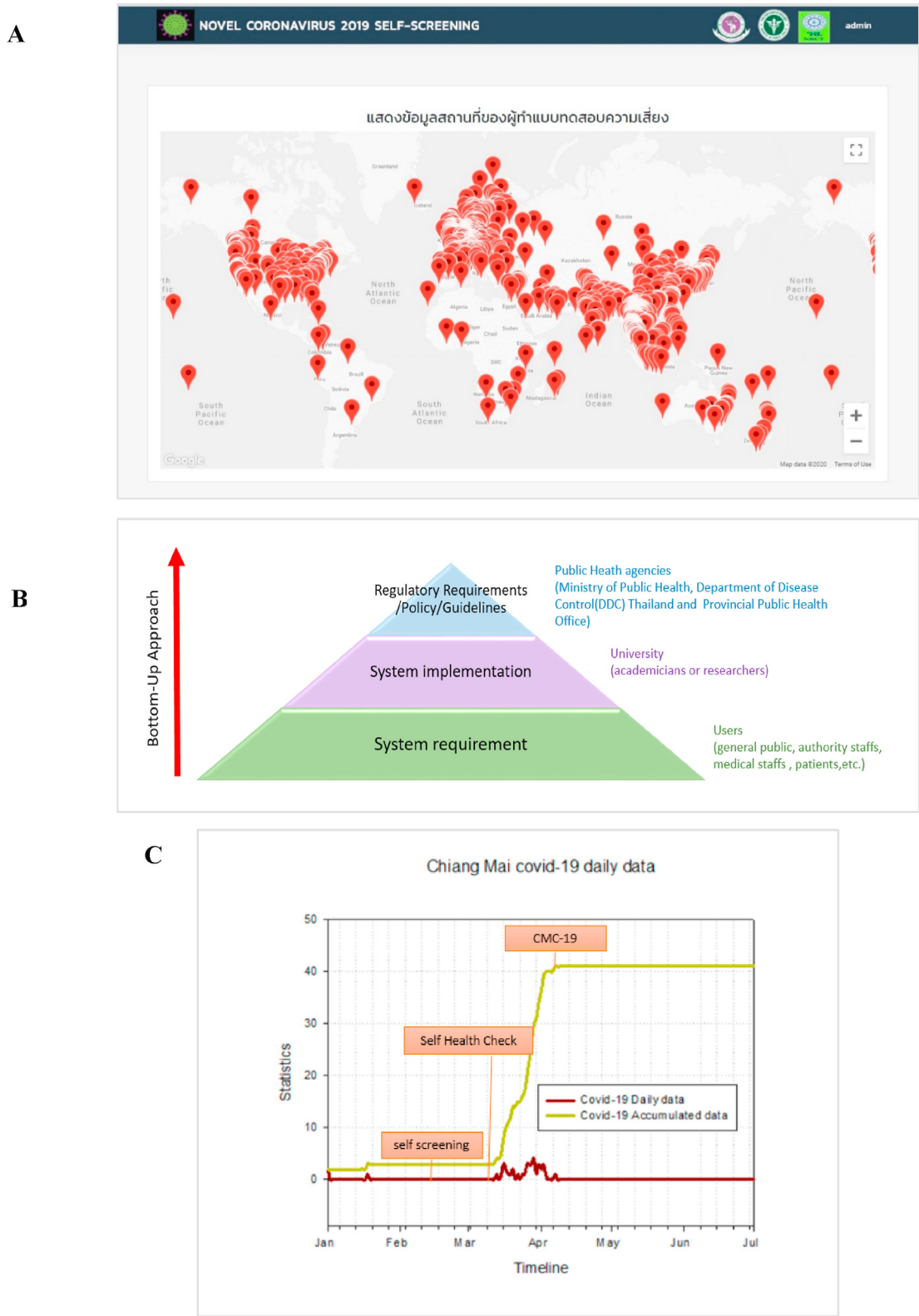
Fig. 4. (A) Global location of the use of a Self-Screening Application for Covid-19 as of August 31, 2020 (B) Bottom-up approach for fighting the COVID-19 pandemic, Thailand, 2020, (C) Three applications have been established during the COVID outbreak timeline in Chiang Mai province.

Chiang Mai so health could be monitored from the headquarters rather than face to face contact. SHC also proved beneficial for self and home quarantine as the follow-up consisted of daily reports over the required 14 days. This information was sent to the provincial public health officers and if a participant forgot to self-report their health condition for more than two days, they were

notified to update the information. Also if the officers were notified about high risk groups of people, the office could contact them and offer this self-check application.

Chiang Mai COVID-19 (CMC-19) hospital information system application was the most extensive platform in the response strategy. CMC-19 was derived from a strong collaboration between public health agencies and all hospital networks in Chiang Mai Province. Chiang Mai was the only province that managed patients' data within one platform using the CMC-19 application. CMC-19 development and training sessions conducted with all public health agencies within the province on how to use the application began in late March. Rapid response to the growing pandemic and the health care system's needs may well have contributed to the low incidence of Covid-19 cases and death experienced in Chiang Mai (41 cases and 1 death as of September 11, 2020). CMC-19 is now enforced by the Provincial Public Health Office and used by 2 public health agencies and 51 hospitals.

The COVID-19 pandemic provided an opportunity for further evolution of health informatics in Chiang Mai, Thailand, as new technologies supported public health approaches to prevention and control of disease using a statistical-based method and health providers realized a real-time dashboard visualisation for decision-making. The results showed an effective collaboration and a co-creation of a health data center.

The Faculty of Public Health Chiang Mai University was asked by authorities to test suspected patients and create a tracking system. Their use of digital technology and the incorporation of self-assessment and self-health checking proved most efficient, rapid and easily accessible. The CMC-19 hospital information system platform successfully met the needs of hospitals for monitoring because it was co-created by advocates for health cooperation within the hospital network participant groups. The applications also have assisted local health authorities responsible for contact tracing in support of hundreds of tracers.

5. Conclusion

Control and mitigation of COVID-19 requires that many sectors including the general public get involved. Application technologies provide the means by which these varied sectors can innovate, communicate and take action rapidly. Successful creation and implementation of three new application technologies in Chiang Mai, Thailand resulted in the public taking greater control of their own health and medical and public health personnel improving efficiency to control the demand on health resources while responding to health needs. A bottom-up approach was used to assess, plan, create and implement each application in support of an integrated system. Participation of users, academics and service organizations enhanced success of these technologies to support learning about COVID-19, to encourage social responsibility of all and to integrate applications for real time monitoring of suspect and confirmed cases of disease. A bottom-up approach provided a strong backbone in support of a coordinated system. Adoption across borders was also evident with the use of the Self-Screening Application in several countries as a result of ease of use and application provided in multiple languages. The overall intention for these application technologies was to assist not only Chiang Mai province, the country of Thailand but also globally to contain, eradicate and become free from the virus in the quickest manner possible.

Declaration of competing interest

There is no conflict of Interest for this paper.

References

[1] M. McKee, D. Stuckler, If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future, Nat. Med. 26 (2020) 640–642.

[2] Centers for Disease Control and Prevention, Get the Facts about Coronavirus, 2020. https://www.cdc.gov/coronavirus/2019-nCoV/index.html.

[3] World Health Organization, Coronavirus Disease (COVID-19) Advice for the Public, 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

[4] A. Haleem, M. Javaid, R. Vaishya, Effects of COVID 19 pandemic in daily life [published online ahead of print, 2020 Apr 3], Curr. Med. Res. Pract. (2020), https://doi.org/10.1016/j.cmrp.2020.03.011.

[5] K. Wilson, Mobile cell phone technology puts the future of health care in our hands, Can. Med. Assoc. J. Apr. 190 (13) (2018) E378e9.

[6] National Health Service Digital, Coronavirus (COVID-19) increase in use of NHS Digital tech. https://digital.nhs.uk/coronavirus/nhs-digital-tech-analytics. (Accessed 26 April 2020).

[7] S. Findlay, S. Palma, R. Milne, Coronavirus contact tracing apps struggle to make an impact. https://www.ft.com/content/21e438a6-32f2-43b9-b843-61b819a427aa. (Accessed 26 April 2020).

[8] A. Ghosh, R. Gupta, A. Misra, Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: guidelines for physicians [published online ahead of print, 2020 Apr 4], Diabetes Metab. Syndr. 14 (4) (2020) 273–276. https://doi.org/10.1016/j.dsx.2020.04.001.

[9] S.Q. Zheng, L. Yang, P.X. Zhou, H.B. Li, F. Liu, R.S. Zhao, Recommendations and guidance for providing pharmaceutical care services during COVID-19 pandemic: a China perspective. Research in Social and Administrative Pharmacy, 2020 Mar 26.

[10] T. Yang, M. Gentile, C.F. Shen, C.M. Cheng, Combining point-of-care diagnostics and internet of medical things (IoMT) to combat the COVID-19 pandemic, Diagnostics (Basel) (2020), https://doi.org/10.3390/diagnostics10040224.

[11] R. Gupta, A. Misra, Contentious issues and evolving concepts in the clinical presentation and management of patients with COVID-19 infection with reference to use of therapeutic and other drugs used in Co-morbid diseases (hypertension, diabetes etc.). Diabetes & metabolic syndrome, Clin. Res. Rev. 14 (3) (2020) 251e4.

[12] R. Gupta, A. Ghosh, A.K. Singh, A. Misra, Clinical considerations for patients with diabetes in times of COVID-19 epidemic. Diabetes & Metabolic Syndrome, Clin. Res. Rev. 14 (3) (2020) 211–212.

[13] A. Ghosh, R. Gupta, A. Misra, Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: guidelines for physicians, Diab. Meatbol. Syndr.: Clin. Res. Rev. 14 (4) (2020) 273e6.

[14] Digital Government Development Agency, COVID-19 open data government. https://data.go.th/dataset/covid-19-daily. (Accessed 31 July 2020).

[15] S. Whitelaw, M.A. Mamas, E. Topol, H. VanSpall, Applications of digital technology in COVID-19 pandemic planning and response, Lancet 2 (August 2020) web document, https://www.the.lancet.com. accessed September 10, 2020.