GapanTrax: A QR Code-based Digital Contact Tracing System for COVID-19 in the City of Gapan, Nueva Ecija

Elijah Nicholas C. Isungga and Concepcion L. Khan

***Abstract*— The COVID-19 pandemic has introduced the importance of digital contact tracing. In digital contact tracing, the use of Quick Response (QR) codes is widely used due to its privacy. This study has developed a digital contact tracing system for residents of the City of Gapan, Nueva Ecija. The system utilizes QR codes to log users that enter the premises of an establishment. The system also supports an admin-reporting feature where administrators are responsible for classifying individuals as positive or as close contacts.**

***Index Terms*— COVID-19, contact tracing, QR code technology, Flutter**

I. Introduction

A. Background of the Study

The World Health Organization (WHO) defines coronavirus disease (COVID-19) as an infectious disease brought about by the SARS-CoV-2 virus [1]. Its serious symptoms include difficulty breathing, chest pain, and loss of speech, which when not given early medical attention can lead to death. The WHO (2020) [2] reported the first case of COVID-19 back in December 2019 in Wuhan City, China, and with its highly contagious property, the world soon plunged into a pandemic.

The Philippines' first case was documented on January 30, 2020, as announced by the Department of Health (DOH) [3]. With the infectious virus present in the country, the government's response and resilience to the pandemic was lacking as it was last place among 53 countries in a study conducted by Bloomberg that measured a country's economy to the pandemic [4]. The Philippines went through various stages of quarantine and classifications of alert levels, hoping to contain the spread of COVID-19.

The health sector has been one of the first to respond to the onslaught of the pandemic. To assist in the efforts to mitigate and control the spread of the disease, manual contact tracing has been implemented by the DOH and the Department of the Interior and Local Government (DILG). The latter urging all local government units (LGUs) to participate fully in this approach [5]. Contact tracing is the process of identifying and notifying people who had been in contact with an infected individual within the last 14 days [6]. This procedure also involves instructing the close contacts on what steps they should take given their health and vaccination status.

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With technological advancements, digital contact tracing applications have been developed to ease the process brought about by manual contact tracing. In April 2020, the National Task Force on COVID-19 signed with Multisys Technologies Corporation stating that the StaySafe.PH application is the official contact tracing application of the country [7]. However, not all cities and LGUs use this application. Baguio City Mayor Benjamin Magalong stated that StaySafe.PH is not categorically "highly reliable," commenting on the system's lack of documentation [8]. Health Secretary Francisco Duque III also said that StaySafe.PH has had "almost no impact" in contact tracing, with Sen. Pia Cayetano further adding that the application is merely a digital logbook of who goes in and out of establishments [9]. Other LGUs on the other hand have taken this problem to themselves by developing their own local contact tracing application. The Province of Cebu has endorsed a contact tracing application named WeTrace that aims to accurately trace and monitor those with symptoms of COVID-19 [10], and Valenzuela City, Metro Manila launched ValTrace as their application for contact tracing that utilizes Quick Response (QR) codes for a contactless approach [11], among others.

B. Statement of the Problem

With the emergence of COVID-19 in the Philippines, there is a need for contact tracing to help mitigate the spread of the disease. However, some LGUs who do not have their own contact tracing application also do not utilize StaySafe.PH. This can be correlated to Duque's statement that StaySafe.PH has had "almost no impact." In Gapan City, Nueva Ecija, most establishments and public spaces do not record the information of the people who enter their premises which may be due to the lack of authority from the local government. This information is vital for faster and a more streamlined contact tracing process. The study conducted seeks to answer the following research questions:

1) What is the design and approach of the contact tracing application that can assist in quickening the efforts of manual contact tracing?
2) What technologies will be used in developing the application? and
3) How can the effectiveness of this application be ensured?

C. Significance of the Study

Digital contact tracing has been assessed as an approach to mitigate the spread of COVID-19 that has high benefits and low costs [12].

There have been some contact tracing applications developed in the Philippines, with StaySafe.PH as the one launched by the Philippine government. Some LGUs develop their own applications using different technologies such as QR codes, Bluetooth, and Global Positioning System (GPS) technology. In Gapan City, Nueva Ecija, there has not been an implementation of a digital contact tracing system. With the ongoing pandemic, the development of this application aims to mitigate the spread of the virus by notifying contacts of an infected individual to undergo isolation.

The application focuses on offline usage, where users do not have to go online every time they enter an establishment or a public space. The use of QR codes is implemented in this study. With the utilization of QR code technology, data privacy and data minimization, or the collection of the least amount of data, can be highlighted in the application. Data privacy is a common vulnerability or weakness of contact tracing applications. QR code-based contact tracing applications conform with ethical and political standards [13].

Administrators of the system can check the recent contacts of a newly infected individual and can send a notification or text message stating that they may have been in contact with an infected person. With this, the message can tell them to home-quarantine if asymptomatic or go to the nearest hospital if they are experiencing symptoms of the virus. Furthermore, the application can serve as an information system for COVID-19 related news and facts for users to be up to date on recent events related to the pandemic.

D. Objectives of the Study

The general objective of this study is to develop a contact tracing application for Gapan City, Nueva Ecija. Specifically, the application aims:

1) To develop a user- and establishment-side application for contact tracing that focuses on offline usage and data privacy;
2) To develop an administrator-side application for contact tracing that enables administrators to query and trace recent contacts of an infected individual; and
3) To evaluate the usability of the user-side contact tracing application.

E. Scope and Limitations of the Study

The focal point of the study is the development of a contact tracing application exclusively for Gapan City, Nueva Ecija. The implementation of this contact tracing application focuses on scanning personal QR codes before entering establishments and public spaces to log the whereabouts of each user. Administrators are able to classify and notify individuals who are COVID-19 positive along with individuals who are possible contacts.

F. Date and Place of the Study

The study was conducted during the 2nd semester of the academic year 2021-2022 at the Institute of Computer Science, University of the Philippines Los Baños.

II. Review of Related Literature

Several studies on COVID-19 contact tracing have been conducted due to its importance, relevance, and timeliness. Additionally, the research and development of contact tracing applications have been increasing because of the same aforementioned reasons. However, there have been limited literature on contact tracing applications that follows the principle of data minimization.

With the emergence of the COVID-19 pandemic, manual and digital contact tracing are being implemented to mitigate and control the spread of the virus. Barrat et al. (2021) [12] conducted a study on the effects of contact tracing and found that non-pharmaceutical interventions, such as contact tracing, play a significant role in the fight against COVID-19. Manual contact tracing has been argued that it is labor-intensive, and that digital contact tracing can be seen as an effective complement.. Furthermore, the study stated that the development of contact tracing applications yielded high benefits with low costs if implemented alongside manual contact tracing. The efficiency of digital contact tracing depends on the level of adoption by the community, noting that any improvement in public support yields to a positive impact.

Contact tracing applications have been developed as an implementation of digital contact tracing. There have been several approaches in the development of contact tracing applications, with the technologies being used varying from one application to another. In 2021, Min-Allah et al. [14] conducted a survey that highlighted the different approaches of several contact tracing applications. The pros and cons of each approach are listed as follows:

- Bluetooth-based solutions are precise but may return high false-positive and false-negative rates.
- Wi-Fi-based solutions are faster than Bluetooth-based solutions because of the higher data rate. This approach is impractical for areas where Wi-Fi is not readily available especially in public spaces.
- Location-based solutions yield low costs due to smartphones already having this technology. Possible issues include privacy, security, range, and power consumption.
- Geofencing can cover an area bigger than any other technology. Its disadvantages include having a high mobile power consumption and lack of privacy especially when data is accessed by an attacker.
- QR code-based solutions reduce errors because of the automatic scanning of information. This approach does not have privacy issues since it does not retrieve the location of the user. A possible disadvantage is that users do not trust QR codes leading to a small number of people who download the application.

Another approach is through the use of Bluetooth Low Energy (BLE) for proximity detection, where a smartphone can identify other smartphones that are near its radius. Maccari

and Cagno (2021) [15] found that a smartphone can only detect two devices that are in its proximity. Also, the level of efficiency of using BLE depends on where the owners of the smartphones are and possible objects that can interfere. This method was observed to be invasive of the privacy of an individual, hence the need for a recalibration of the approach. Developing a contact tracing application with low levels of risk in terms of data leakage has been concluded as difficult to implement.

In the Netherlands, a QR code-based contact tracing application named Zwaai was developed as an alternative to the Bluetooth approach. QR code-based contact tracing applications conform with ethical and political seams, unlike Bluetooth technologies that bypass them [13]. This approach focuses more on user participation as compared to seamless approaches provided by other technologies. For the application to function properly, the user must go online which poses a problem if Wi-Fi is not readily available.

In the Philippines, the government officially adopted StaySafe.PH as the official contact tracing application of the country. The application also uses QR codes, worth noting that it once used Bluetooth and GPS features but it has been removed due to privacy concerns [16]. It was also found that StaySafe.PH failed to follow the ethical guidelines that the WHO has published and that it requires dangerous permissions to fully function [17]. Google [18] defines dangerous permissions as "runtime permissions that access private user data, a special type of restricted data that includes potentially sensitive information." The guidelines of WHO state that applications must adhere to the principle of data minimization. A solution that applies data minimization is found to increase effectiveness and efficiency [19]. Moreover, the use of sensitive location data, such as GPS, has been deemed neither necessary nor useful and that the trust of the users should be considered in order to find support from the population.

The preceding review shows the importance of contact tracing applications in the fight against the COVID-19 pandemic, also highlighting the different approaches and technologies used. With StaySafe.PH as the official contact tracing application of the country, adoption of this application by local government units, specifically in Gapan City, Nueva Ecija, still poses a problem. Health Secretary Francisco Duque III also stated that StaySafe.PH has had "almost no impact" on the efforts to aid in contact tracing [9]. This study aims to address this problem by developing a contact tracing application catered to Gapan City, Nueva Ecija. The application uses QR code technology, dealing with privacy and ethical concerns, also highlighting offline usage.

III. Methodology

A. Development Tools

A laptop with the following specifications was used in developing the contact tracing application:

- Operating System: Windows 10 64-bit
- Processor: Intel® Core™ i5-8250U 1.6GHz
- Memory: 8 GB DDR3 L

The following software development tools and technologies was used in developing the contact tracing application:

- ***Visual Studio Code***
  A source-code editor that served as the environment for developing the application.
- ***Cloud Firestore***
  A flexible, scalable NoSQL cloud database that served as the database.
- ***Flutter***
  A UI software development kit that was used to develop the mobile application.
- ***Firebase***
  A backend-as-a-service platform that served as the system's backend.

B. Features

This section is divided into three parts for each type of user: administrator, normal user, and establishment.

1) Administrator
   - *Log in*
     Administrators are required to log in to the application using the provided account.
   - *View Cases*
     Administrators can view the current number of positive cases and close contacts.
   - *Classify as COVID-19 Positive*
     Administrators can set if an individual is infected with COVID-19.
   - *Classify as Close Contacts*
     The system automatically classifies users who are close contacts of an infected individual.
   - *Approve Establishment*
     Administrators can approve or reject establishments that have registered into the system.
2) Normal User
   - *Register*
     Users are required to register themselves in order to use the application. Necessary information is needed as input.
   - *Generate QR Code*
     Upon registration, users are given a personal QR Code that is used to enter an establishment's premises. The QR Code can be downloaded as an image.
   - *View Status*
     Users can view their current COVID-19 status (positive, negative, close contact).
   - *View Account Information*
     Users can view their account information.
   - *Update Vaccination Status*
     Users can update their vaccination status.
   - *COVID-19 Symptoms*
     Users can view the common symptoms of COVID-19.
   - *COVID-19 Cases*
     Users can view the current number of COVID-19 cases in the country.

- *Essential Links and Hotlines*
  Users can view the important links and hotlines related to COVID-19, such as the Department of Health website or the hotline of the local hospital.

3) Establishment
   - *Register*
     Establishments are required to register themselves in order to use the application. Necessary information is be needed as input.
   - *Scan QR Code*
     Establishments are able to scan QR Codes of users that enter their premises. The data is stored in the database.
   - *View Account Information*
     Establishments can view their account information.
   - *COVID-19 Symptoms*
     Establishments can view the common symptoms of COVID-19.
   - *COVID-19 Cases*
     Establishments can view the current number of COVID-19 cases in the country.
   - *Essential Links and Hotlines*
     Establishments can view the important links and hotlines related to COVID-19, such as the Department of Health website or the hotline of the local hospital.

C. Types of Users

The use case diagram is shown on Fig. 1. The following are the different types of users that uses the application:

1) *Administrator*
   - The administrator is in charge of approving establishments that register via the application.
   - The administrator is capable of tracing the persons who had close contact with an individual infected with COVID-19.
   - The administrator notifies the close contacts of an infected individual.
   - Only the administrator can view the contents of the database.
2) *Establishment*
   - An establishment logs and scans each customer's QR Code whenever they enter their premises.
3) *Normal User*
   - A user inputs the following data to login into the application:
     - Name
     - Address
     - Mobile number
     - Vaccination status
   - A user is given a personal QR code to show when entering establishments.
   - A user is able to update their vaccination status.

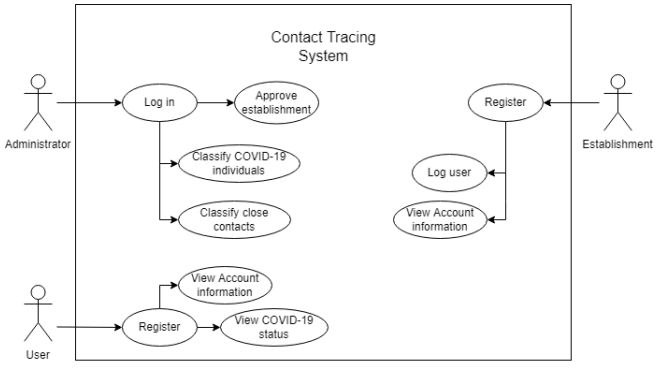

Fig. 1. *Use Case Diagram for the Contact Tracing Application*

D. Database Design

The database design consists of three entities: administrator, user, and establishment. Each entity has a unique ID. The number of attributes of the user aims to adhere to the data minimization principle which is the collection of the least amount of data. The entity-relationship diagram is shown on Fig. 2.

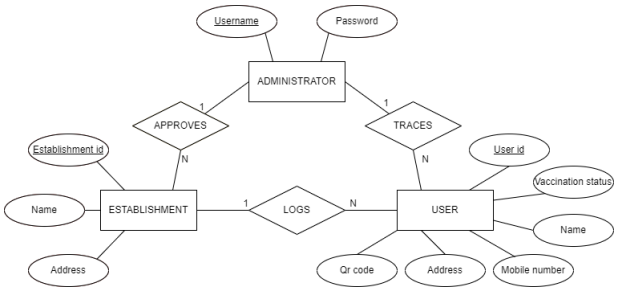

Fig. 2. *Entity-Relationship Diagram for the Contact Tracing Application*

E. Flowchart

The flowchart of the contact tracing process is shown on Fig. 3.

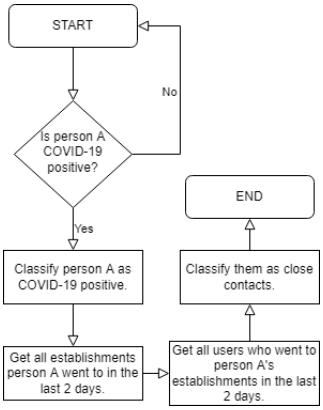

Fig. 3. *Flowchart of the Contact Tracing Process*

IV. Results and Discussion

The resulting digital contact tracing system consisted of a user-, an establishment-, and an administrator-side application.

A. Development Stage

Certain limitations were met with Firebase. The free Spark plan of Firebase was used, and this has limitations compared to the paid Blaze plan. Using Cloud Firestore for free can only do 50,000 reads and 20,000 writes per day. Cloud Firestore security rules were also updated to ensure that a user of the application can only read and write with what is intended for them. Each rule was tested using the Rules Playground of Firebase. Furthermore, Cloud Firestore does not allow the user to do a full-text search. This limits the ability to search names in the administrator-side of the system. Firebase recommends the user use a third-party search service such as Algolia.

Phone authentication was used as the sign in feature of the application. Phone verification instances has a 10,000 limit per day in the Philippines. Also, the daily quota for the sending of one-time password (OTP) messages are limited to 50 per day in the free plan. It should also be noted that there are times that Firebase fails to send OTP messages. Firebase states that not all networks reliably deliver their verification messages. Furthermore, using phone authentication in general can compromise the security of the application especially when a user has access to text messages of another person. They can easily disguise themselves as a different person. Anonymous authentication was considered but was rejected due to the fact that users stay anonymous. If users sign out of the system, their data will be lost.

Initially, the administrator-side of the application was supposed to be developed using React. Since Flutter is a multi-platform framework that supports applications developed on the web, it was also used to develop the administrator-side of the system.

B. User-side Application

The first thing a user should do is to register their phone number and to input the sent OTP. This is the sign-in method of the user-side application. Firebase Phone Authentication was used for this feature. If the user is not yet registered, they will be asked to fill up their information. After successful registration, the user is directed to the main page of the application. The application consists of five pages: Symptoms Page, COVID-19 Cases Page, QR Code Page, Notifications Page, and Profile Page. The user-side application provides the user access to COVID-19 relevant information such as the common symptoms of COVID-19, the current cases in Central Luzon and the country, and essential links and hotlines to hospitals and information sites. The user is also given a unique QR code to show whenever they will enter an establishment. The user also has the ability to update their vaccination status. If a user is classified as positive or a close contact, the status bar is updated in realtime. The notifications page is also updated in realtime, along with a message on what to do next. Screenshots of the user-side application are shown on Fig. 9 to 16.

C. Establishment-side Application

The establishment-side of the application prompts the establishment to sign in using their phone number. After successful registration of the establishment, they are prompted to the main page. Establishments are able to scan QR codes of users that enter their establishments once they are approved by the administrators. This is to ensure that only legitimate establishments can scan QR codes and upload them to the database. The establishment-side application also has access to relevant COVID-19 information. Screenshots of the establishment-side application are shown on Fig. 17 to 19.

D. Administrator-side Application

The administrators are prompted to sign in using email and password. Only one email is used. Admins have the capability to view the current COVID-19 cases and close contacts. They can also search and classify users as COVID-19 positive, then the system automatically classifies their close contacts. Furthermore, admins can approve establishments that register into the system. Screenshots of the administrator-side application are shown on Fig. 5 to 8.

E. Testing

The user-side application was tested by 10 respondents using a System Usability Scale (SUS). This was used to test the usability of the application. It consisted of 10 statements with a five-point scale that ranged from ”Strongly Disagree” to ”Strongly Agree.” The average SUS score is 82. The statements were the following:

1) I think that I would like to use this system frequently.
2) I found the system unnecessarily complex.
3) I thought the system was easy to use.
4) I think that I would need the support of a technical person to be able to use this system.
5) I found the various functions in this system were well integrated.
6) I thought there was too much inconsistency in this system.
7) I would imagine that most people would learn to use this system very quickly.
8) I found the system very awkward to use.
9) I felt very confident using the system.
10) I needed to learn a lot of things before I could get going with this system.

The individual scores were computed after answering the survey. After, the mean score was evaluated. The individual scores are shown on Fig. 4. Based on the average score of 82, the system can be classified as above average.

Suggestions were also optionally asked to the respondents. Suggestions made were on improvements on the user interface and changes on the colors used in the application.

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Individual Score
1	5	2	5	2	5	2	5	2	5	3	85
2	4	1	5	1	5	1	5	1	5	1	97.5
3	4	1	4	1	4	1	3	1	4	1	85
4	5	2	5	2	3	4	5	4	5	1	75
5	4	1	4	1	4	1	5	1	5	1	92.5
6	5	1	5	1	5	1	5	1	5	1	100
7	5	2	1	4	5	2	5	2	4	4	65
8	5	5	5	1	5	2	5	1	5	1	87.5
9	5	2	5	2	5	2	4	1	5	4	82.5
10	3	3	3	3	3	3	3	3	3	3	50
Mean Score	82.00										

Fig. 4. *Individual Scores Table*

V. Conclusion and Future Work

The study was able to develop a digital contact tracing system for the City of Gapan, Nueva Ecija. The user-side application can register users using their phone numbers and can generate a unique QR code for each one. Users can also be notified immediately of their COVID-19 status and has the ability to update their vaccination statuses. The establishment-side of the application also registers establishments using their phone numbers. Administrators must verify and approve an establishment before they are able to scan QR codes and upload them to the database. The administrator-side of the application can classify users as COVID-19 positive and automatically classifies their close contacts. The administrator-reporting feature addressed the self-reporting problem of StaySafe.PH. With authorized personnel to classify individuals, contact tracing is more efficient.

It should be noted that the administrators can only detect and check records of COVID-19 positive individuals. Establishments do not have access to user data which maintains data privacy.

For future work, it is recommended that the scope of the application to be expanded to neighboring cities and municipalities. This can enable a more inclusive contact tracing process. Subscribing to the Blaze plan of Firebase can widen the capabilities of the features of Firebase such as Cloud Firestore and Firebase Authentication. This means more reads and writes can be done to the database and more text messages can be sent daily.

Moreover, enabling full-text search for easier and more diverse searching of names can be done through the use of a dedicated third-party search service.

Future researchers may also provide additional features such as the depiction of COVID-19 related data via charts and graphs, verification of users via government identification cards, and improvements on the user interface.

With some edits and appropriate fixes, this system can be adopted by other cities and municipalities aiming to have their own digital contact tracing system that uses QR code technology.

Appendix I
Screenshots of the Application

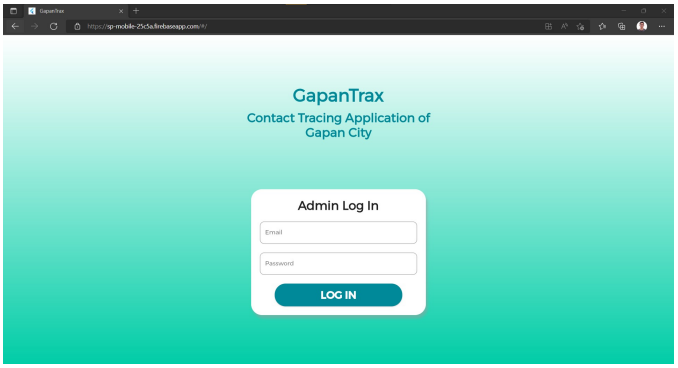

Fig. 5. *Admin Log In Page*

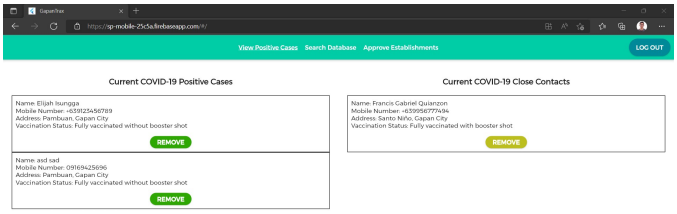

Fig. 6. *Admin Dashboard Page*

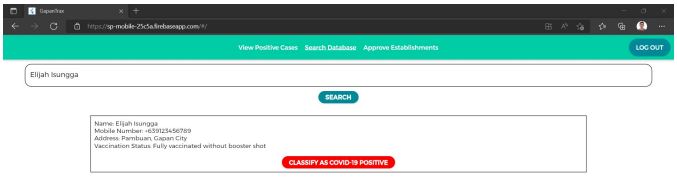

Fig. 7. *Admin Search Page*

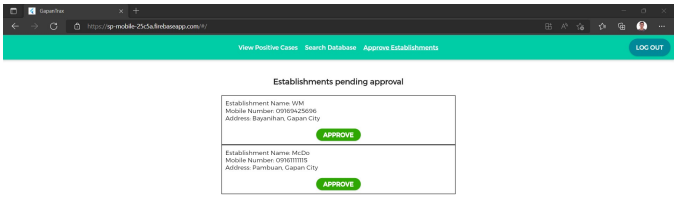

Fig. 8. *Admin Approve Establishments Page*

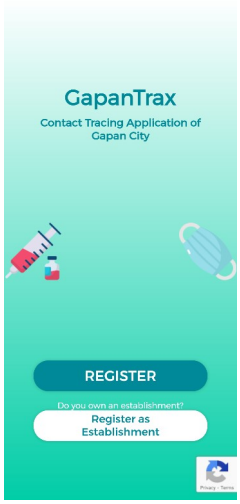

Fig. 9. *Registration Page*

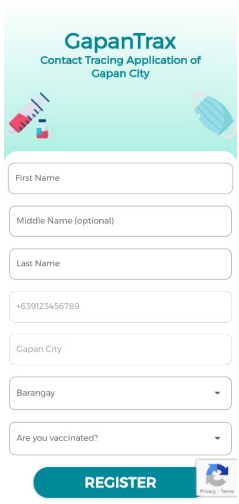

Fig. 10. *User Sign Up Page*

Fig. 11. *QR Code Page*

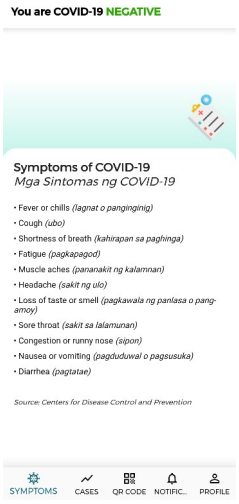

Fig. 12. *Symptoms Page*

Fig. 13. *Cases Page*

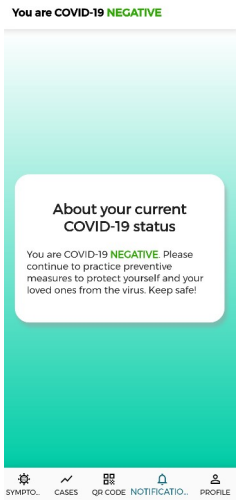

Fig. 14. *Notifications Page*

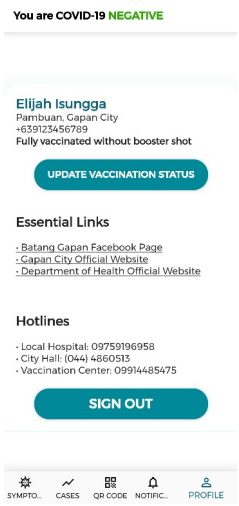

Fig. 15. *User Profile Page*

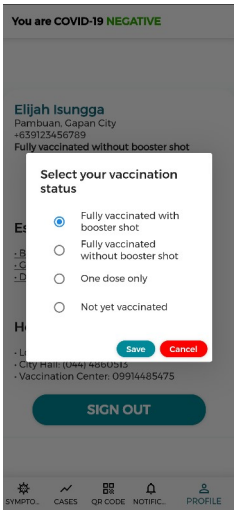

Fig. 16. *Update Vaccination Status Modal*

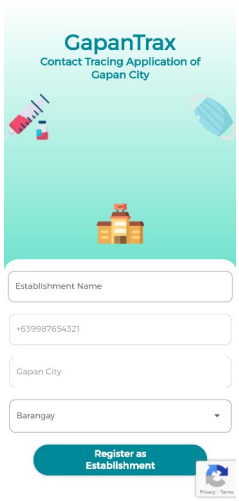

Fig. 17. *Establishment Sign Up Page*

Fig. 18. *QR Code Scanner Page*

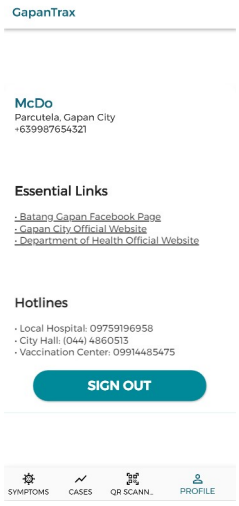

Fig. 19. *Establishment Profile Page*

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REFERENCES

[1] World Health Organization, "Coronavirus disease (covid-19)," last accessed 12 November 2021. [Online]. Available: https://www.who.int/health-topics/coronavirus#tab=tab_1

[2] ——, "Coronavirus disease 2019 (covid-19) situation report – 94," April 2020. [Online]. Available: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200423-sitrep-94-covid-19.pdf

[3] Department of Health, "Doh confirms first 2019-ncov case in the country; assures public of intensified containment measures," January 2020, last accessed 12 November 2021. [Online]. Available: https://doh.gov.ph/doh-press-release/doh-confirms-first-2019-nCoV-case-in-the-country

[4] K. A. T. Atienza, "Philippines worst in covid-19 pandemic response," September 2021, last accessed 31 December 2021. [Online]. Available: https://www.bworldonline.com/philippines-worst-in-covid-19-pandemic-response/

[5] Department of the Interior and Local Government, "Dilg to lgus: Intensify covid-19 case finding, contact tracing under new alert level system; assign one contact tracer in every barangay," September 2021, last accessed 31 December 2021. [Online]. Available: https://dilg.gov.ph/news/DILG-to-LGUs-Intensify-COVID-19-case-finding-contact-tracing-under-new-alert-level-system-assign-one-contact-tracer-in-every-barangay/NC-2021-1183

[6] World Health Organization, "Tracking covid-19: Contact tracing in the digital age," September 2020, last accessed 16 November 2021. [Online]. Available: https://www.who.int/news-room/feature-stories/detail/tracking-covid-19-contact-tracing-in-the-digital-age

[7] Department of the Interior and Local Government, "Dilg to lgus, public: Use staysafe.ph app to boost contact tracing," March 2021, last accessed 14 November 2021. [Online]. Available: https://dilg.gov.ph/news/DILG-to-LGUs-public-Use-StaySafePH-app-to-boost-contact-tracing/NC-2021-1062

[8] K. Aguilar, "Magalong can't say staysafe.ph 'highly reliable'," May 2021, last accessed 31 December 2021. [Online]. Available: https://newsinfo.inquirer.net/1427011/magalong-cant-say-staysafe-ph-highly-reliable

[9] B. Perez-Rubio, "Duque: Staysafe app has 'almost no impact' on contact-tracing efforts," August 2021, last accessed 23 November 2021. [Online]. Available: https://www.philstar.com/headlines/2021/08/25/2122636/duque-staysafe-app-has-almost-no-impact-contact-tracing-efforts

[10] Manila Bulletin, "'wetrace' mobile app for contact tracing now available on android," April 2020, last accessed 14 November 2021. [Online]. Available: https://mb.com.ph/2020/04/05/wetrace-mobile-app-for-contact-tracing-now-available-on-android/

[11] B. Malaya, "Going to valenzuela city? register to valtrace qr code now!" April 2021, last accessed 14 November 2021. [Online]. Available: https://www.whatalife.ph/going-to-valenzuela-city-register-to-valtrace-qr-code-now/

[12] A. Barrat, C. Cattuto, M. Kivelä, S. Lehmann, and J. Saramäki, "Effect of manual and digital contact tracing on covid-19 outbreaks: A study on empirical contact data," *Journal of The Royal Society Interface*, vol. 18, no. 78, 2021.

[13] A. S. Hoffman, B. Jacobs, B. van Gastel, H. Schraffenberger, T. Sharon, and B. Pas, "Towards a seamful ethics of covid-19 contact tracing apps?" *Ethics and Information Technology*, vol. 23, no. S1, pp. 105–115, 2020.

[14] N. Min-Allah, B. A. Alahmed, E. M. Albreek, L. S. Alghamdi, D. A. Alawad, A. S. Alharbi, N. Al-Akkas, D. Musleh, and S. Alrashed, "A survey of covid-19 contact-tracing apps," *Computers in Biology and Medicine*, vol. 137, 2021.

[15] L. Maccari and V. Cagno, "Do we need a contact tracing app?" *Computer Communications*, vol. 66, pp. 9–18, 2021.

[16] A. L. Balinbin, "Multisys's staysafe.ph removes gps, bluetooth for data privacy," January 2021, last accessed 23 November 2021. [Online]. Available: https://www.bworldonline.com/multisyss-staysafe-ph-removes-gps-bluetooth-for-data-privacy/

[17] P. Lin, J. Knockel, I. Poetranto, S. Tran, J. Lau, and R. Deibert, "Unmasked ii: An analysis of indonesia and the philippines' government-launched covid-19 apps," Citizen Lab, Tech. Rep. 136, December 2020.

[18] Google, "Permissions on android," December 2021, last accessed 2 January 2022. [Online]. Available: https://developer.android.com/guide/topics/permissions/overview

[19] J. Abeler, M. Bäcker, U. Buermeyer, and H. Zillessen, "Covid-19 contact tracing and data protection can go together," *JMIR mHealth and uHealth*, 2020.

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