Design of Philippine Public Health Services Information System to Improve the Department of Health's COVID-19 Initiatives

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Abstract

The study proposes a public health information system design that can support the Philippine community in general and the Department of Health in its battle against the COVID-19 pandemic. To ensure that the proposed system is timely in its features and effective in user adoption, the paper leveraged the requirements information from India's response to the Delta variant and then benchmarked the innovative COVID-19 technological solutions and well-adopted applications in recent years. The result points to a potentially faster, more convenient, easier to adopt, and better data solution that can be reused for upcoming pandemics and can also be extended for natural disasters.

Keywords
COVID-19, Public Health Services Information System, COVID-19 app, Philippines, Department of Health.

1. Introduction

The Department of Health, or DOH, is the Philippine government's executive department responsible for ensuring basic public health service access, quality health care provision, and regulation of healthcare providers (Department of Health n.d.). The department spearheads national health plan developments, health guidelines, and technical healthcare standards as part of its mandate. Aside from its primary functions, it also provides technical support and special tertiary health care services to healthcare providers and stakeholders (Department of Health n.d.).

Despite being the world's leading exporter of doctors & nurses, according to the Private Hospitals Association of the Philippines (Gotinga 2020), the poor working conditions and inadequate government support are just some of the reasons why almost half of the Filipino private hospital nurses resigned in 2020 (Ratcliffe 2021) and left the Philippines to work abroad even amid the pandemic (Gotinga 2020). While the Philippines is still reeling from the devastating effects of the Alpha variant, the Delta variant managed to set foot in the country. First identified in India, the Centers for Disease Control and Prevention (2020) described the Delta variant as much faster and more dangerous than its predecessors, with the ability to infect or spread through fully vaccinated individuals and has 1,260 times more viral load than those infected by the original COVID-19 strain (Reardon 2021). Before August 2021 ended, 13 hospitals in Metro Manila reported a 100% bed utilization rate, 11 were above 85% bed occupancy, and 24 were in the 70% and 85% bed occupancy (Vera 2021).

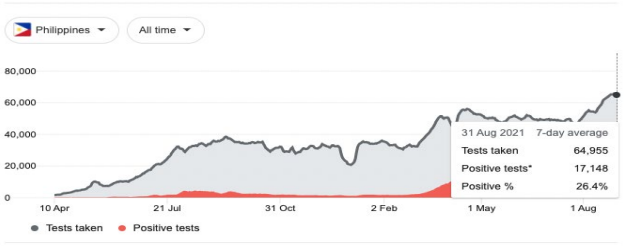

Figure 1. Tests taken and COVID-19 positive rate in the Philippines from 2020 to 2021

In the first week of September 2021, the Philippines logged over 20,000 new cases for at least 3 succeeding days, breached the 2 million-cases mark, and started a disturbing trend of at least 1 out of 4 Filipinos testing positive (Rappler 2021), with the latter reflected by Figure 1. Before the Philippine healthcare system and economy collapses, or before another highly infectious COVID-19 variant pummels what's left from the country, a reliable and automated computer-based automation system should be developed and deployed immediately to stem the increase of cases and even prevent the community transmission of future COVID-19 variants. While the Philippine government launched two systems, the StaySafe PH mobile app for contact tracing (Multisys n.d.) and the One Hospital Command Center (OHCC) for hospital referrals (DOH n.d). However, the StaySafe PH app quickly proved to be useless when it comes to contact tracing, as admitted by Health Secretary Duque III (Perez-Rubio 2021) and is merely being used as a digital logbook of major business establishments (Terrazola 2021). Echoing this sentiment, the StaySafe PH app suffered a 1.9 rating on the App Store and a 3.1 rating on the Google Play store from a total of 17,992 votes. This means that an upgraded and better version of this system is required, one that is convenient and automated.

On the other hand, the One Hospital Command Center is faring better through its Pure Force Citizen app with its App Store rating of 4.6 and Google Play Store rating of 4.7 for a total of 1041 votes. However, this solution ultimately bared its major weakness in the face of the Delta variant: It's still a system run by humans. Since humans can get tired, overwhelmed, and contract COVID-19, an automated information system should be deployed as soon as possible to handle the inevitable rise of cases in the wake of the Delta variant. In fact, the OHCC noted that it could only handle around 700 calls after the average number of calls they received more than doubled from an average of 300 (Gonzales 2021). To top it off, OHCC's operation manager tested positive for the COVID-19 virus while the calls they received doubled (Ramos 2021), which underscores the dire need to have an automated system.

The Public Health Services Team was selected for this study for it's the DOH team that primarily focuses on disease identification, prevention, and control, as well as health protection and promotion against health emergencies and disasters. All line agencies under the Public Health Services Team can be bolstered by an automated system. To decrease chances of transmission and curb the steady rise of COVID-19 cases, the problems that need to be resolved and the solutions that need to be delivered through automation are the following: Contact tracing, Testing status, testing request, and testing information,Vaccination status, Hospital availability & referral, Mobile diagnostics. Virtual consultations. Covid-19 care market. Vaccine availability & referral and RFID card or QR card.

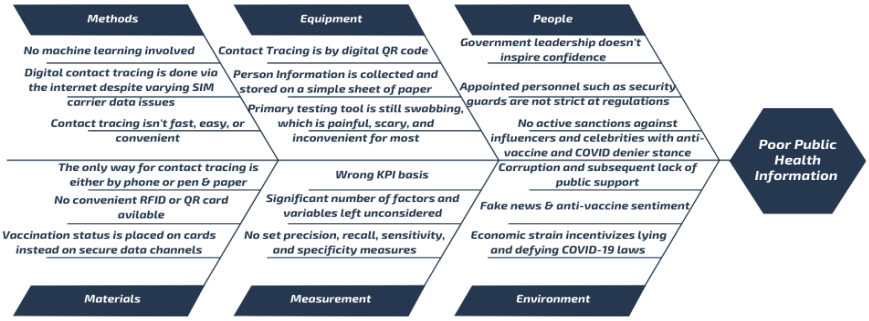

Figure 2. Ishikawa Diagram on the cause of poor public health information

Figure 2 shows the root cause of poor contact tracing efforts, lackluster testing initiatives, and slow vaccination rollout as the healthcare system is about to collapse from high bed utilization rates, long lines, complex triages. On

top of all of these, the Philippine economy is still not recovering. The country's healthcare workers are getting sick or dying from COVID-19, protesting, resigning from work, or leaving the country. Despite the introduction of the StaySafe PH contact tracing app and One Hospital Command Center hospital referral system, it is still not enough.

1.1 Objectives

As long as the Philippines do not have solid control and access to public health information, the Filipinos will still be in the dark while suffering from the effects of COVID-19 physically, financially, and psychologically. Thus, the study's objectives are as follows:

1. Design an automated public health services information system that is easy to access and navigate for Filipino citizens, including government personnel, provision, and collection of contact tracing, testing, and vaccination information
2. Design an automated public health services information system with ancillary features such as vaccine, hospital, oxygen, COVID-19 virtual consultation availability & referral to decrease unnecessary exposure and deaths.
3. Design an automated public health services information system that leverages all available technology and tools to ensure 24/7 accessibility and support despite disasters and unprecedented traffic load.

2. Review of Related Systems

Properly integrated into healthcare systems, contact tracing is useful in preventing COVID-19 infections (Lewis 2021). In this case, Singapore's TraceTogether mobile app is a cut above in terms of its features and deployment compared to its Southeast Asian counterparts. It's available on Apple's App Store, Google's Google Play, and even on Huawei's AppGallery. Even better, it addresses the problem of people who do not want to use or do not know how to use a smartphone with a trace together token (TraceTogether n.d.). The token is a wearable device that does the contact tracing information provision for the individual. This is levels above the Philippines' alternative contact tracing system, which meant writing your information on a piece of paper using the publicly used pen and dropping it off into a ballot box. Considering how data privacy concerns are the primary reason why most people won't use a contact tracing app, Singapore's TraceTogether also addresses this issue effectively by communicating its data privacy policy at every chance possible (Akinbi et al. 2021).

When vaccines are finally done and vaccination drives are on the rise, it paved the way for vaccination certification apps particularly to be used as a passport. This is primarily used to increase vaccination participation, ensure safe travel, and as an indirect means to stimulate the global economy. Almost every country launched its own version of vaccination certification apps, that the only question is which app to use in particular (McMahon 2021). In terms of vaccination initiatives, India leads the pack as the country even offers to integrate their vaccination app with 100 private companies via their application programming interface (API), which may nudge a lot of its citizens to take the vaccine (Sharma 2021). Furthering the initiative against COVID-19, a team of Yale professors even created an app that serves like a "Waze" for the coronaviruses, providing users with intel on which places to avoid (Belli 2020). In fact, Waze itself even ramped up its app to show pins on crucial information such as healthcare and food distribution centers, as well as triggering in-app notifications on local restrictions. Even better, they also offer city and country-wide data as a form of 'pulse checks'.

In terms of Hospital bed availability, an Australia-based Filipino data scientist built the Cobeds19 app, a robust web app that shows available spaces in hospitals within your area but can be toggled to view a wider range. It's easy to check with its green and red color-coding system for available and full status, respectively (Mendoza 2021). Its only downside is that it's the only thing the web app does. The same thing is done within the US, which is based on crowdsourced data (Chu 2020), while India's version includes the availability of ventilators (Hindu Business Online 2020). A year later, India also included information on the availability of oxygen (The Times of India 2021).

Overall, the development of apps as an initiative against COVID-19 is mostly created to solve a single problem. Treating each app as a silo that's disjointed from other relevant apps makes it hard for governments to improve data gathering and data analysis efficiency, which slows down recovery from COVID-19 as a country. It also lowers the chance of adoption rate as people will be mentally burdened handling multiple apps, not to mention the battery consumption of each app. It should be noted that India, which suffered from the devastating effects of the Delta variant, is quick to update and include new features into their systems, housing multiple features under one umbrella app and

offering integration with multiple companies, which goes to show that bundling different features into one app in a bid to combat COVID-19 is a must.

2. Methodology

The Philippines' estimated population is 108.1 million in 2019 (Data Commons 2020). With a 72.1% mobile internet penetration rate (Statista 2021), it can be inferred that there are 77,940,100 Filipinos who have access to smartphones (Figure 3), or almost 3 out of 4 Filipinos owning a smartphone. These significant numbers make it overwhelmingly obvious that the easiest, fastest, and most intuitive way to get Filipinos to adopt a unified COVID-19 solution is through a mobile app or, at the very least, through an app that can be easily accessed via mobile internet.

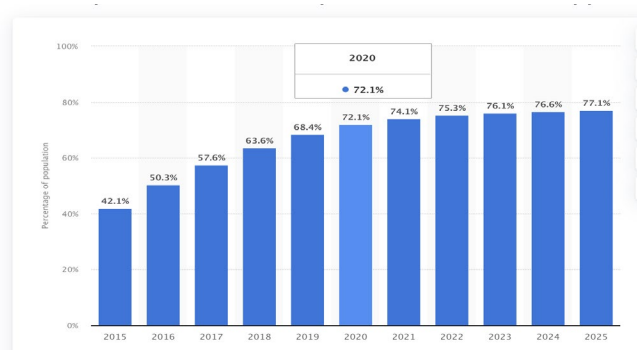

Figure 3. Mobile internet penetration rate in the Philippines *Source:* Statista

However, the benefit of using a mobile app or mobile internet-friendly app for COVID-19 solutions is based on convenience. A COVID-19 app that relies heavily on manpower will only defeat its purpose as humans can make mistakes, have energy limitations, and can get sick—weaknesses the Philippines cannot afford in its battle against COVID-19, especially against the extremely contagious Delta variant. This is the reason why the use of Artificial Intelligence is proposed to drastically cut the time, effort and ramp up availability to almost all Filipinos 24/7. Artificial Intelligence, in its most basic form, is all about replicating how humans approach decision-making and solve problems (IBM n.d.). The beauty of Artificial Intelligence, or AI, is that its automation power dramatically ramps up the capacity of an organization. In the context of COVID-19, that means Filipinos do not have to wait to get an answer.

Natural Language Processing or NLP is a branch of AI that allows computers to receive, interpret, and communicate human language. NLP can eliminate the need for human workers to respond to multiple inquiries on a massive scale, which can lead to long waiting times for patients and inevitable mistakes or burnouts for the workers. Senti AI, a Philippine-based AI company that focuses on Natural Language Processing, built a call-center type bot that can easily respond to Filipino-based inquiries (Senti AI 2021). This means it's possible to handle a lot of inquiries without compromising the quality of support. For the optimization end, where people need to know the closest hospital with available rooms to rush into, location-based and map-based apps such as Waze (Waters 2017) and Google Maps (Lau 2020) also use AI to optimize routes and even provide additional data like information of nearby establishments. This eliminates the unnecessary waste of time looking for available hospitals or establishments with auxiliary equipment such as oxygen cylinder tanks.

AI can also be used to ease the transition to mobile apps for COVID-19 related solutions. Optical Character Recognition is an AI-based solution that automatically captures the information listed on a valid ID and uses the same information to fill up the required spaces to register for the app (Appen 2021). This means technologically-challenged individuals can still get access to the app. With a strong grasp of data, the government can create a sound action plan. Considering that the highest official 1-day record of COVID-19 cases in the Philippines is 22,820 (Magsambol 2021) and that the average Philippine household size is 4.1 (Philippine National Demographic and Health Survey 2017), the app's server should at least be able to handle 100,000 visitors per hour and at least 1 million interactions or requests per hour.

The Department of Health's 2021 budget is P134.45 billion (DOH 2021), and the estimated cost of building the proposed app is $84,700 or P 4,261,468.75 with all the features included, as shown in Figure 4. Multiplying the

estimated cost by 10 to cover for additional features such as Artificial intelligence leads to P40.2 million pesos, which is .03% of DOH's total budget, making the app entirely feasible to create and deploy.

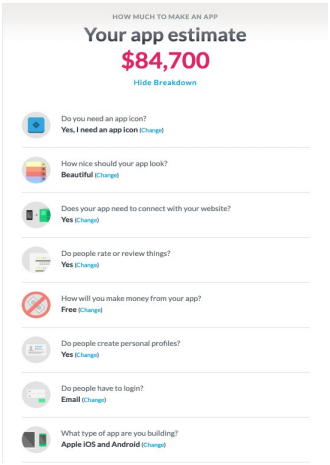

Figure 4. The estimated total cost of apps with all the features included *Source:* howmuchtomakeanapp.com

4. Results and Discussion

4.1 System Design

The resulting Public Health Information System will be temporarily labeled as 'Counter COVID' in order for the masses to easily convey the point of the application and secure a stronger impact to make it easy to remember. The Counter COVID system design is essentially a combination of all the benchmarked software applications that provide quick, convenient, and reliable information such as Cobeds19, Google Location History, Grab Food, NowServing, TraceTogether, and automated chatbots, among others. The system will leverage Cobeds19's convenient and easy-to-understand hospital bed availability design so that users can easily see from their phones all the relevant information they need for hospital selection when rushing a patient to the emergency room. The app will also borrow Senti AI's chatbot solution for Filipino-language interactions (Reyes 2021) so that it could alleviate the problems of those who are technologically challenged and task force call centers. For quick overall user status and information regarding COVID-19 exposure, testing, and vaccination, Singapore's TraceTogether app features will be utilized (Zoey 2021). The system design is also inspired by Grab Food and NowServing apps, which are food and doctor selection solutions, respectively, where both apps offer a complete selection solution that is convenient—key features needed by a user looking for healthcare service providers and other healthcare equipment. Lastly, for quick and reliable contact tracing information, Google's Location History feature will also be implemented into the app so that contact tracers can easily get a rough idea of the general movement of persons under monitoring (PUM) and persons under investigation (PUI).

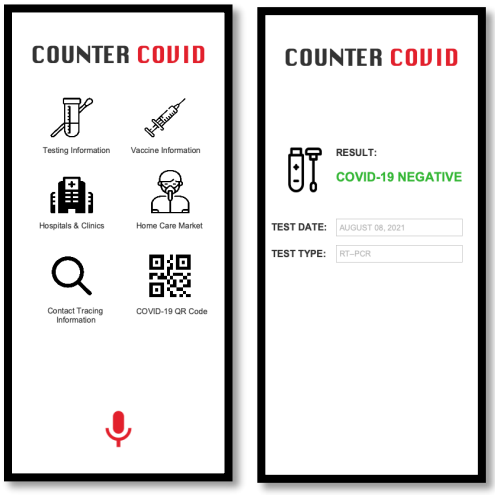

Figure 5. Process flow from the system's main modules to testing information's subsystem's functionality

Figure 5 shows the process flow from the system's main menu to the Testing Information Subsystem's main function after clicking the Testing Information icon, which shows all the pertinent details of the user's test status, which includes the test date, test type, and test results. This serves as a quick overview for other personnel in charge of checking a person's eligibility for establishment access or when making a judgment call. The same functionality is shared by the Vaccine Information Subsystem, albeit it includes a lot number for easy verification.

The Hospitals & Clinics Subsystems' first functionality is providing information on all the hospitals and clinics with available beds in real-time while simultaneously providing the distance, route, and estimated time of arrival so that users can make decisions when it comes to rushing a patient to the emergency room. This functionality is a combination of the Cobeds19 web app and Google Maps. The next functionality is designed to help users find the right doctor, book a virtual consultation, and secure a prescription, just like the NowServing app. The Home Care Market Subsystem's main function is to serve as a marketplace for COVID-19 home care solutions and devices such as medical oxygen tanks, medical oxygen concentrators, and accessories such as a nasal cannula, simple face mask, and regulator. The market also includes service providers such as home service diagnostics like RT-PCR tests, x-ray, and ECG tests. This subsystem will mirror the way Grab Food functions.

The Contact Tracing Information Subsystem's first function is to provide location history data, from GPS coordinates to time, and day in order to provide an accurate contact tracing idea. Another function that is similar in operation but slightly different in feature is the QR code/Bluetooth logs, which will show the time and day of QR capturing for Inbound Information. For Outbound Information, this is when other personnel will scan the user's QR code to generate all the pertinent COVID-19 information from the user with a single scan. It also counts as a contact tracing log. Hand to hand with the Contact Tracing Information Subsystem is the COVID-19 QR Code, which shows the unique generated QR code for the user as well as a QR Code Scanner for quick and convenient contact tracing.The Notification Subsystem's main function is to notify and remind time-bound information such as lower antibodies, which generally happens after 6 months, and vaccine side effect notifications. Finally, the Chatbot Subsystem's main function is to receive, interpret, and converse in English and Filipino and provide the relevant subsystem that the user needs.

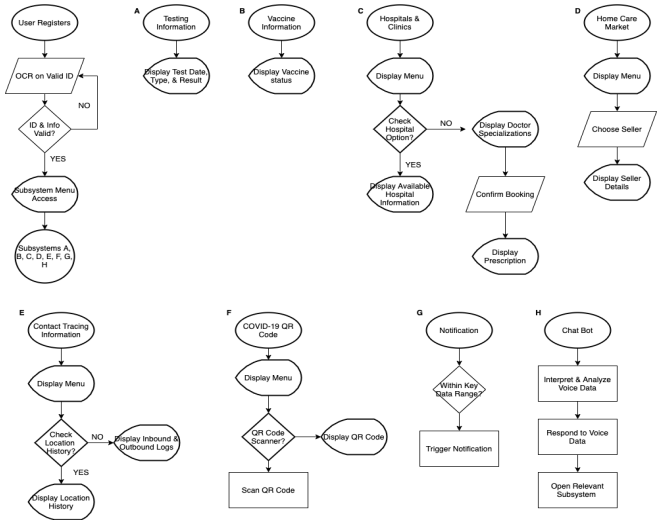

Figure 6. Public Health Information System Proposed System Flowchart

In Figure 6, the proposed public health information system flowchart can be easily mistaken for a complex system for its multiple flowchart branches. But a closer inspection will reveal that the system flow is typical of applications and all the subsystems covered are simple and straightforward, making it harder for typical human errors to pervade, especially if deployment is on a national scale. The user will start by registering on the app using a preferred account or creating their own and then verify the information by taking a photo of their valid ID. Once registration is confirmed, the user will then have complete access to all the subsystems included in the app, labeled as A to H in Figure 7. Subsystems A, B, E, and F have the simplest function as their main function is to display data for key personnel.

Subsystems C and D are more complex than the previously mentioned subsystems as it requires interaction with external data and users. However, the process of Subsystems C and D is the same as most applications that require selection and location information. Subsystem G is basically a calculation function that notifies the user when 6 months after the user's last dose has elapsed and a week of notification after vaccination to ensure safety from side effects. Lastly, Subsystem H is a button function that allows the user to converse with a chatbot in either Filipino or English, and the chatbot will respond by providing the subsystem that closely matches the user's requirements.

4.2.3. System/ & User Interface

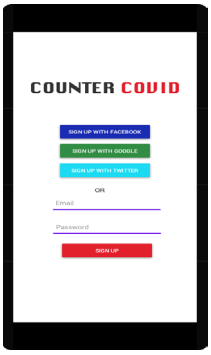

Figure 7. Public Health Information System Registration Sample

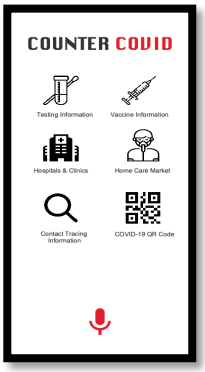

Figure 8. Public Health Information System Main Modules Sample

Figure 7 shows a registration sample that shows that a user can register on Facebook, Google, or Twitter: The 3 main online identity platforms used by Filipinos. Users can also opt to register using their email and password. Figure 8 shows the main modules or subsystems the user has access to. Each module is labeled accordingly, except for the red microphone icon. When the red microphone icon is tapped, it triggers that automated chatbot.

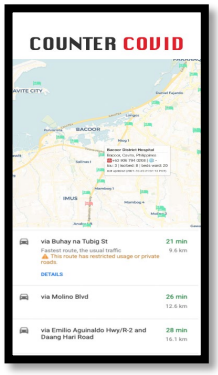

Figure 9. Public Health Information System Hospital Bed Availability Sample

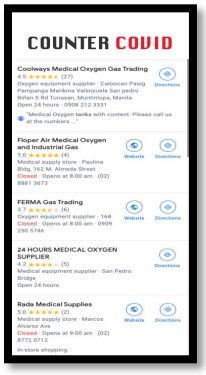

Figure 10. Public Health Information System Home Care Market Sample

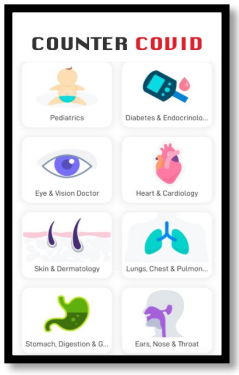

Figure 11. Public Health Information System Virtual Consultation Sample

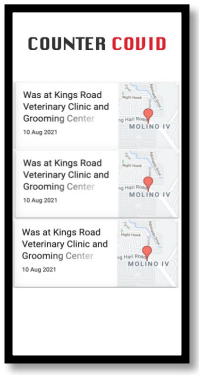

Figure 12. Public Health Information System Contact Tracing Information Sample

Figure 9 shows how the Hospitals & Clinics subsystem is supposed to work. The green beds mean there are available beds, and the pink ones are hospitals with limited beds available. Tapping on any of the bed icons should reveal contact information as well as distance, available routes, and estimated travel time. Figure 10 shows a sample of what a user may see if they tap on the Home Care Market selection for Medical Oxygen Tank supplier. It should show contact information, availability status, opening hours, as well as their ratings for convenience and reliability. Figure 11 shows what a user might see when they try to use the Virtual Consultation feature of the proposed system. The virtual consultation category selection should encompass all medical specializations to ensure that traveling and subsequent potential exposure are avoided. Figure 12 shows the date, the name of the establishment, and the exact coordinates

which user and key personnel can both use for contact tracing efforts. This will help relevant parties to trace and map out the movement and potential infection vectors of users listed as a person under investigation (PUI) or a person under monitoring (PUM).

4.3 System Evaluation

Table 1. Previous System to Proposed System Evaluation

Previous System	Proposed System
● No uniform data collection ● No central database ● No automated follow up for lowered antibodies after 6 months ● No automated vaccine side effect checks ins ● No safe and secure way to procure proof of vaccine and result of testing ● No automated system on procuring hospital availability information ● Contact tracing information is manual ● Poor adoption rate ● COVID-19 individual information updates are manual ● No list of trusted and vetted healthcare supplier	● Data is collected and updated automatically ● Data is stored under one central database in a secure server ● Automated notifications for lowered antibodies and vaccine side effect check in ● All pertinent COVID-19 information such as vaccine status and testing results can be reliably accessed via app or through QR code ● Automated and updated hospital availability and all relevant information ● Automated contact tracing information retrieval based on GPS, QR code, and Bluetooth ● Vetted and rated healthcare suppliers of products and services ● Features are benchmarked from most used and well-loved apps for easier adoption and transition ● Less prone to errors due to lesser human interventions and interactions

Table I presents how the Counter COVID Public Health Information System addresses all the gaps, issues, and unseen pitfalls of all the present systems relied on by the Philippine government and its Filipino citizens in its battle against COVID-19.

The usage of Optical Character Recognition technology on valid IDs automatically relieves the burden of technologically challenged users while decreasing the chance of enabling fraudulent schemes, like faking of COVID-19 related information to access establishments. This will greatly help adoption rates as well as ensure quality data is being received and analyzed by key personnel. Another advantage of the Counter COVID Public Health Information System over the current systems is that the transfer of pertinent COVID-19 information is faster, easier, and more convenient. All the user or key personnel must do is either scan the unique QR code or view the internal outputs, and everything they need to know is laid out before them. This eliminates unnecessary exposure and subsequent infection, as well as improves contact tracing efforts that may eliminate avoidable clusters.

Finally, Counter COVID app is convenient and more reliable access to healthcare providers, goods, and services means that sick people aren't forced to go out and expose other people, and otherwise, healthy people do not have to unnecessarily expose themselves. With this kind of solution, Filipino citizens do not have to set up a Google Sheets solution of their own where information might be wrong, incomplete, or outdated. The constant vetting of personnel and rating provided by users will keep the market in check. With this approach and solution, we can alleviate the burden on the already battered healthcare system of the Philippines and even improve the morale of Filipinos by reducing unnecessary deaths in its battle against COVID-19 and all its variants. With quality information as to its main weapon, the improved public health Information System will allow the Philippines a faster economic recovery with more businesses opening and more citizens gaining access and mobility.

5. Conclusion

The beauty of the Philippine Public Health Services Information System proposed in this paper lies in how this solution can be easily repurposed for upcoming pandemics and even be extended to handle other massive-scale problems such as natural disasters. Using the proposed system in this paper, even in principle, will help save a lot of lives or prevent unnecessary infection and deaths at the very least.

By benchmarking all the best features of the most used and well-loved applications and solutions of this decade, we can reliably come up with a system that will be easy for Filipinos to adopt while keeping the speed, effectiveness, convenience, reliability, and data quality intact. The best part of this is that we can reasonably create a high-quality application system that will cost less than 1% of typical funds allocated to the Department of Health's teams, ensuring that we are getting the best possible solution without spending on a level that will dent the Philippine healthcare agency's funding on its health-related initiatives and activities.

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