CHAPTER 1

MOBILE-BASED SOCIAL DISTANCING AWARENESS SYSTEM INTEGRATED WITH GPS SENSOR: A CASE STUDY OF UMP STUDENTS

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ABSTRACT

Social distancing is becoming a norm in everyone's daily life due to the COVID-19 pandemic. As the pandemic has only started two years ago, there are not many social distancing awareness systems specifically made for higher education institutions (HEI) students. As many students are required to return to the campus to partake in physical lessons and assessment, social distancing practice is very important to reduce the risk of spreading of the viruses. Social Distancing Awareness System is a mobile application that helps students to increase their social distancing awareness. The objective of this research is to alert users to practise social distancing by developing a proposed system called mobile application for social distancing awareness. The proposed system applies the agile model of Software Development Life Cycle (SDLC) as the methodology for this work. The proposed system will detect nearby devices using GPS and save the location of detection coordinates. The system will generate reports for social

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distancing scores to show students' records of their social distancing practice. The risk of the detected device is categorised based on the distance between user coordinates. The closer the device to the students, the higher the risk and shall be able to get detection details sent by GPS sensors. The system will send notifications to the students' devices to warn them about their surroundings. Conclusively, the findings from this work are described as follows; the system is able to generate a social distancing report score based on the detection log to provide statistics to UMP students on their social distancing practices. Thus, the social distancing awareness has been increased. The proposed system was found to be a useful application for the social distancing detection in order to ensure that one of the SOPs during the COVID-19 pandemics is performed by students.

Keywords COVID-19, social distancing, mobile application, social distancing awareness, GPS sensor

INTRODUCTION

We are, currently facing COVID-19 pandemic; hence, social distancing is essential, especially with the Movement Control Order (MCO). Social distancing, or physical distancing, is important to keep a safe space between one individual and others. Social distancing within two-metres distance with the purpose of not allowing too many people in one place (NCRID, 2020). This is an effective way to reduce the interaction between people and the amount of crowd in the same place. Hence, spreading of the virus can be reduced significantly within the community. Universities such as UMP require the student to stay on campus to have normal and physical methods of teaching and learning sessions. The standard operating procedure (SOP) in UMP might not be sufficient if the students themselves are not fully conscious to practise social distancing or follow the SOP.

Most of the time, students might not be alert when there are other people near them. Often, they are preoccupied with their smartphone or not paying attention to their surroundings. In the scenario of a passer-by walking near them in a close proximity for a duration and the passer-by is also not keeping a distance, this will increase the risk of getting COVID-19, especially when the other person lingers near them closely for a long period. In the worst-case scenario that someone infected with COVID-19 might sneeze or cough near them, they might be infected even though they wore a mask through other means of contact (WHO, 2020). Places such as the café are even riskier as students are busy getting and eating food.

UMP students have been practising social distancing since the restriction for students to return to campus has been lifted. However, the main problem that UMP students face is having consistent social distancing awareness when being in public places. As students, they are always busy with classes and activities, or have forgotten to keep their distance out of habit. This problem occurs mainly because students' attention span and focus are always affected by smartphone usage. When students meet their friends or are in a group, they tend to forget the surrounding due to being busy interacting with their friends. While some students are always practising social distancing, unfortunately it is not applied by all the students as it requires everyone's cooperation to ensure the minimum risk of contracting COVID-19. This is because of forgetfulness or ignorance of students to follow the social distancing guidelines provided. Although there are existing systems to increase social distancing awareness, many UMP students do not use them because of lack of exposure and motivation. The existing system limitations lie on target user, lack of contact tracing and tangible factor that motivates social distancing. The existing system only uses Bluetooth and GPS to detect devices based on RSSI Signal that is not accurate to detect distancing.

Due to the problem mentioned above; therefore, this work is proposed with the main goal to provide a social distancing awareness system for UMP students to monitor their social distancing practice at anytime and anywhere. There are three objectives in this work; to study the effectiveness of social distancing awareness system in encouraging better social distancing, to develop and integrate the mobile application for social distancing awareness that alert user to practise social distancing using GPS location coordinates by calculating distance accurately, and to validate the functionality of the social distancing awareness application using functional testing.

RELATED WORK

The commonly known method for social distancing detection is giving a pass to people before entering a location or shop. Only a certain amount of pass is available and people would have to wait until a pass is available for them to take. This limits the amount of people inside a location.

Other than that, there is more advanced existing system named COVIDSafe system (Currie et. al., 2020). COVIDSafe is a system that fastens the process of notifying people who were exposed to someone with COVID-19. It is used by Australian users to slow the spread of COVID-19 in Australia. Its special features allow detected device contact information to be shared. If anyone with the activated system is tested positive for COVID-19, other people can be contacted immediately with the user's consent to upload the information. Only the designated health authorities that are responsible for managing COVID-19 contact tracing can decode the encrypted information gathered and generated by the system. In terms of privacy, all stored information will be deleted from the device after 21 days. The system uses integrated Bluetooth sensor technology to detect smartphones that are installed with the same system, which are turned on within 1.5 metres for 15 minutes or longer. It is deployed in iOS and Android mobile applications.

Syook Social Distancing System (Syook, 2022) is a system that detects and tracks devices with Bluetooth within the surrounding range of 2 metres and alerts users with notification. It is used by people who want to practise social distancing easily. The feature of the system is generating the social distancing score based on how much social distancing you are following, to help you understand your daily interactions. In terms of privacy, no personal data or any other information are stored in the database other than the device detected history. The system uses the integrated Bluetooth and GPS sensor in smartphones, it detects and measures the proximity between devices. This system is deployed in an android mobile application. The third existing system is the 1point5 System (1point5, n.d) android mobile application. 1point5 is a system that measures a user's distance to other smart devices with Bluetooth turned on. It is used by normal users and workers in working space. Upon detecting any devices with Bluetooth turned on within the 1.5-metres distance, the system sends vibration notification to alert users. This system special feature is the Teams feature that allows users to join a team that are excluded from social distancing, such as family or colleagues, by adding them through QR code. The system mutes any notification from the Team's members and classifies them as safer in history. The data are anonymised for security and privacy, and it only show users date and time of detection alerts. This system also uses the integrated Bluetooth and GPS sensor in smartphones. This system is deployed in iOS and Android mobile applications.

Table 1: Features comparison on existing system

Feature/ System	**COVIDSafe System**	**Syook Social Distancing System**	**1point5 System**
Scope of User	Australian user	Normal user	Normal user and workers
Special Features	Share close contact information with user's consent to the health officials if user is tested positive for COVID-19	Generate a social distancing score to help users understand daily interaction	Create "Teams" of safe people and mute alerts from user
Privacy	Information is encrypted and stored in the	Does not collect and store any personal data	Anonymised for security and privacy. Shows users' date and

Feature/ System	**COVIDSafe System**	**Syook Social Distancing System**	**1point5 System**
	application on the phone for 21 days	or any other information	time of detection alerts
Method	All the existing systems use Bluetooth technology-based GPS sensor.		
Deployment	iOS and android mobile application	Android mobile application	iOS and android mobile application

In summary, in terms of user, both the Syook Social Distancing System and 1point5 system are more convenient as they can be used by all types of users, whereas COVIDSafe system can only be used by Australian users. If users travel abroad, COVIDSafe cannot function well as other foreign users do not use this system. Next, in terms of special features, the Syook social distancing score feature is suitable for the proposed social distancing system for UMP students as it motivates students to practise social distancing. Next, in terms of privacy, COVIDSafe privacy is better because it encrypts data and stores them in local phone storage only, then deleting them after 21 days. All the existing systems use Bluetooth technology-based GPS sensors. In terms of deployment, COVIDSafe and 1point5 are better as they are deployed in both major mobile systems, iOS and android.

As mentioned in the previous section, CovidSafe System is a system that detects devices and uploads contact information to people who were exposed to someone with COVID-19. The first advantage is that the data generated by the system are encrypted. These data can only be decoded by designated health authority and removed after 21 days regardless. The next advantage is the system stores the unique reference code of other nearby users with time, duration of contact and distance. The unique reference code is used to identify other user’s contact information to be contacted by health authorities.

Apart from that, this system also has some disadvantages. The first disadvantage is the detection rate between iOS iPhones is poor (Miller & Smith, 2020). This system cannot detect locked iPhone due to Apple default privacy settings. Next, this system does not provide notification if another user is close. The system only detects and logs the devices nearby, essentially just tracking other user's devices only.

The Syook Social Distancing System is a system that detects and tracks devices with Bluetooth within the surrounding range of 2 metres. One of the advantages of this system is that it can control received signal strength indication (RSSI). This allows users to choose to detect closer or further devices. The second advantage of this system is it can identify and display device name, mac address and last detection history. Knowing the device name and when it is last detected give users the knowledge on who is nearby them specifically.

Apart from that, this system also has some disadvantages. The first disadvantage is high battery consumption and requires disabling battery optimisation. The system consumes the smartphone's battery quickly, especially since it needs to be on the entire time. The second disadvantage of this system is it does not separate current detection and past detection when showing detected devices. This causes confusion on who is around the user now, as all the devices are listed in the same place.

The 1point5 system is a system that measures the user's distance to other smart devices with Bluetooth turned on. One of the advantages of this system is the system classifies active users with a proximity range from high-risk danger, warning, and caution. The range is categorised based on the distance between users, the closer the higher risk. Next, this system saves app users' detected log history. Upon detection, all the detected devices are stored and can be viewed in the system.

Apart from that, this system also has some disadvantages. The first disadvantage is it only detects active users that installed and opened the system. It is not effective for overall usage as it requires other users to install and use the system, making the detection rate low. Next, this system generates false positive results due to devices that turned on Bluetooth. False results will give wrong notification to users as the system is supposed to detect smartphone devices only (Gupta et. al., 2020).

Table 2: Advantage and disadvantage of existing system

System	Advantage	Disadvantage
CovidSafe System	Data generated by the system are encrypted.	Does not detect iOS iPhone accurately.
	Logs unique reference code of other nearby users with time, duration of contact and distance.	Does not provide notification if another user is close.
Syook Social Distancing System	Able to control received signal strength indication (RSSI).	High battery consumption and requires disabling battery optimisation.
	Identifies and displays device name, mac address and last detection history.	Does not separate current detection and past detection when showing detected devices.
1point5 System	Classifies active users with proximity range from high-risk danger, warning, and caution.	Only detects active users that installed and opened the application.
	Saves app users detected log history.	Generates false positive result due to devices that turned on Bluetooth.

METHODOLOGY

This work was proposed as a system named Social Distancing Awareness System (SDAS) and uses the user's smartphone to detect nearby devices using GPS sensors to tell the users how many devices are within the range of the user. If there is a device that is nearby, the system will send sound or vibration to let the user know that someone is nearby. Finally, having a summary of a user's social distancing history in the form of a score serves as a motivation to keep up with their social distancing. Having a tangible factor will increase a person's cognitive mind-set that motivates people to practise social distancing (Kaspar, 2020). At the same time, having a goal on the user's daily interaction helps increase social distancing awareness.

The proposed system consists of a mobile application integrated with a GPS sensor. The GPS sensor coordinates nearby devices with tracking turned on and sends to the system. This system informs the users or students that social distancing is required with sound vibration notification warning. The detection risk is categorised into high risk, medium risk, and low risk on user's proximity with another device. The risk is categorised based on the distance by Google Map SDK coordinates between devices.

In this project, the Agile model (Figure 1) is used as the Software Development Life Cycle (SDLC). Based on agile, a full development cycle is performed by a sprint and repeated until the system is at the best release state. It includes requirement analysis, design, development, testing and deployment.

In the first phase is requirement analysis; requirement, scope and system function are identified. The first objective of the project is a social distancing awareness system to encourage better social distancing practice. Existing systems are studied and compared to further consolidate the system's specification, design and development. Other than that, Software Requirement Specification (SRS) is prepared to describe how SDAS is developed, consisting of context diagram, data flow diagram, use case diagram and description.

In the second phase: Design, prototype interface is designed. Moreover, Software Design Documentation (SDD) is also prepared to define the system's architecture, detailed design, and data dictionary. The system architecture that will be used in this proposed system is Model-View-Controller (MVC), consisting of three components; model, view and controller.

In the third phase: Develop, Android Studio is used as the development environment platform. The second objective of the project is to develop and integrate the mobile application for social distancing awareness that alerts users to practise social distancing with GPS sensor. The disease.sh Public API will be integrated in the system to retrieve Malaysia's COVID-19 statistics and MPAndroidChart API for chart library used in social distancing reports.

In the fourth phase: Testing, each unit system is tested and then the overall flow of the system will be tested. If bugs or faults are detected, it will be fixed before deployment. The third objective of the project is to validate the functionality of the social distancing awareness application using functional testing. In the final phase: Deployment, if the system is not ready to be deployed, the development cycle will be repeated until satisfaction is achieved. After that, the SDAS is ready to be deployed in a real environment.

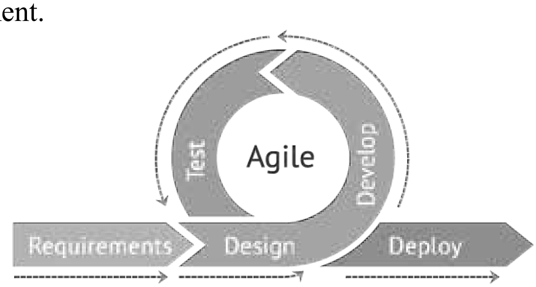

Figure 1: SDLC - Agile Model.

Proposed SDAS

- Using only Android systems with a minimum API of 25+. The data collected on the latest user's coordinates are limited to when tracking is enabled in the system for privacy purposes and does not show location of other users.

- The social distancing report score is used as references to showcase user’s detection histories in order to have good social distancing awareness with less and low risk histories.
- Distance is calculated based on the user's coordinates using Google Maps SDK API.

SDAS System Flow

Figure 2 shows the flowchart of proposed system of Social Distancing Awareness System (SDAS). First, the system will retrieve a GPS connection. The GPS will send location details to the system. Then, the system will crosscheck if the distance calculated from the coordinates between devices is within 1.5metres. If there are devices within 1.5 metres when tracking is turned on, the system sends notification to the user. The system displays a list of detected device. Users can choose to change tabs, detect log tabs and report tabs through the side menu. If the user changes to the detection log tab, the detection log is displayed and the user can download the log. If the user changes to the report tab, the system displays a social distancing report. If the user changes to COVID statistics tab, the system displays Malaysia COVID statistics. If the user did not choose another tab, the flowchart ends.

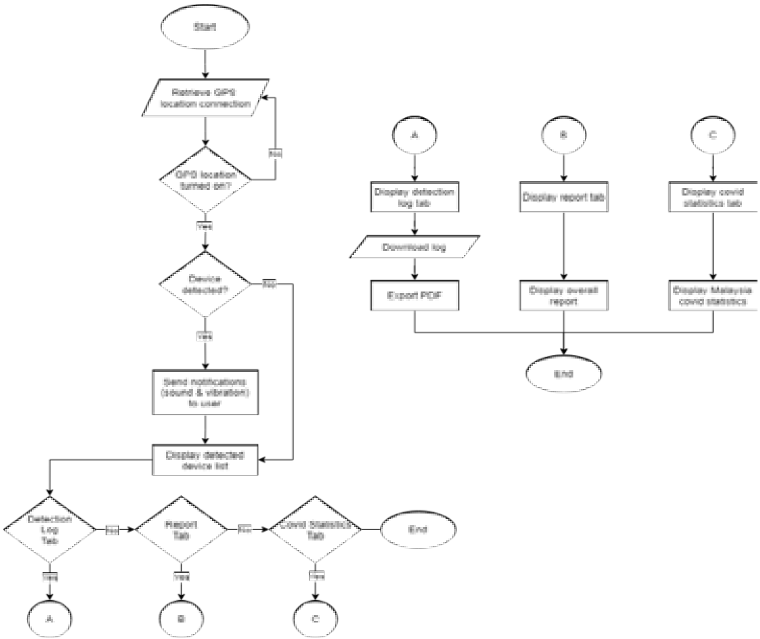

Figure 2: SDAS System Flow

User needs to turn on tracking to activate detection. Every 5 seconds, the current location of the user is updated into firebase. The system will calculate distance between coordinate devices based on longitude and latitude that are also tracked at the same time. After that, the system will send notification and display new detected history. The risk classification is based on (NNS, 2021):

- Low Risk = 1.5 metres > 1.0 metre
- Medium Risk = 1.0 metre > 0.5 metres
- High Risk = 0.5 metres > 0 metre
- Omitted = more than 1.5 metres

All the detailed design and interface are explained in Appendix A, which is Software Requirement Specification document and in Appendix B, which is Software Design Description document.

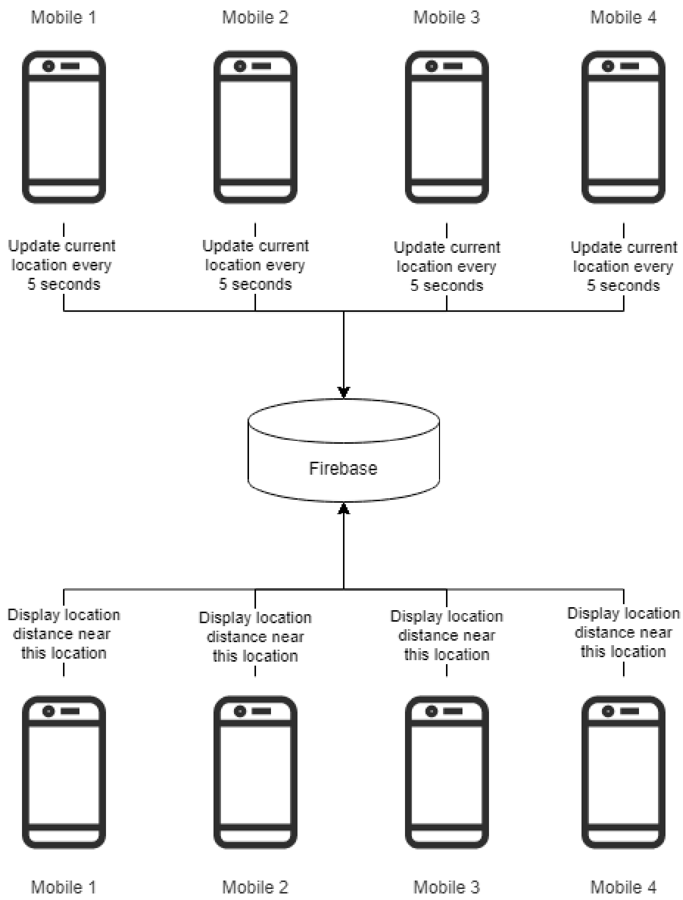

Figure 3: Proposed SDAS Model

SRS and SDD

The software requirements and designs of Social Distancing Awareness System are explained in Appendix A: Software Requirement Specification (SRS) and Appendix B: Software Design Document (SDD).

System Specification

The proposed SDAS has been developed using these software and hardware specifications, as depicted in Table 3 below.

Table 3: System specification of SDAS

Software/ Hardware	Description
Android Studio	Free integrated development environment for android system.
disease.sh Public API (Narang, Kaushal & Gambhir, 2021)	An asynchronous API that provides dynamic statistical data for getting COVID-19 statistics.
Visual Studio Code	Software for code editing released by Microsoft.
MPAndroidChart API	Chart library for Android.
Computer	To build and test the social distancing awareness system.
Smartphones	To run the social distancing awareness system to detect multiple devices within range.

RESULTS AND DISCUSSION

In this section, the modules of the Social Distancing Awareness System are described, consisting of Login, Detection List (Homepage), Detection Log, COVID-19 Statistics and Social Distancing Report (refer to Figure 4).

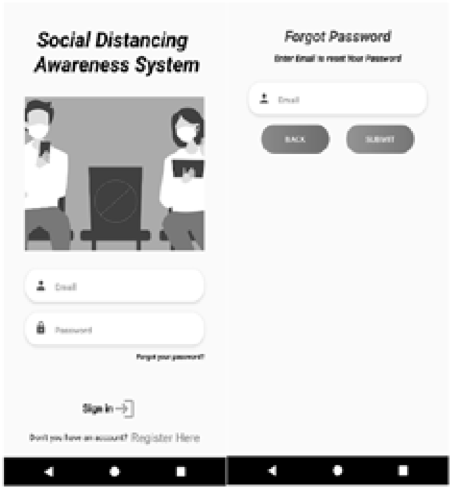

Figure 4: SDAS interface

Users must login into the SDAS to use the system using email and password. If a user forgot their password, they can request a forgotten password link to be sent to their email. If the user's email is not verified, the system will pop up a dialogue box if it wants to resend verification email link (Figure 5).

Figure 5: Detection List Module in SDAS

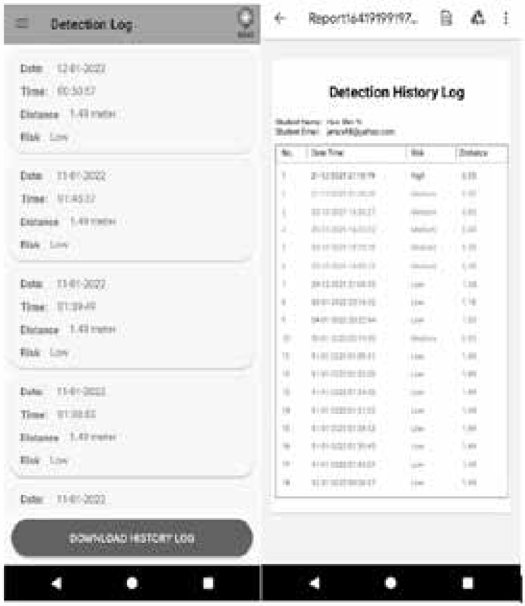

Figure 6: Detection Log in SDAS

The functional testing is used as the testing strategy for this project. The purpose of the functional testing is to verify that the system is fixed for release. Each function is tested to ensure all the functionalities are working as intended. This ensures the requirements are met. The testing result is shown in Appendix C – STD. The criterion for the unit testing is based on six interface function modules from register, login, detection list, detection log, COVID statics and social distancing report. The tester carried out all the functions based on the listed criteria. Each testing will be tested for normal or erroneous type of testing with its expected results as pass or fail. The summary of the testing results is as follows: -

Figure 7: COVID Statistics and other functions in SDAS application

- The registration function is tested to pass as requirement indicated.
- The login function is tested to pass as requirement indicated.
- The detection list function is tested to pass as requirement indicated.
- The detection log function is tested to pass as requirement indicated.
- The COVID statics function is tested to pass as requirement indicated.
- The social distancing report function is tested to pass as requirement indicated.
- The unit components are properly integrated as a system for users to easily learn and use the SDAS.

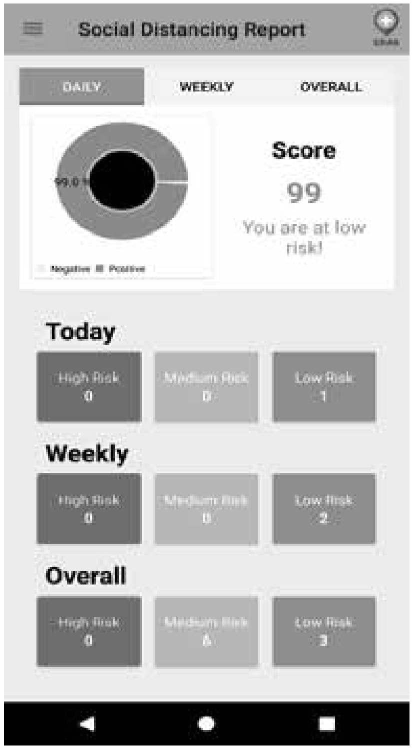

Figure 8: Social Distancing Report

CONCLUSION

The effectiveness of social distancing awareness system (SDAS) in encouraging better social distancing can be checked by using the social distancing report. The score can be used as the measurement to evaluate the effectiveness of social distancing awareness over time. SDAS has been developed and integrated with the mobile application for the awareness of social distancing that alerts users to practise social distancing with GPS sensors. Validation of the SDAS has been performed using functional testing and the system requirements were met, which is an improvement of the social distancing awareness (Bakar, Majid & Adam, 2019).

The limitation of this project is the SDAS has been developed in an android environment that is programmed in Android Studio using JAVA language. Thus, it is not supported in the iOS system. For higher accuracy and faster detection, the coordinates must be even more detailed to have more than 6 decimal places, which is the limitation of Google Map SDK that only records coordinate till 6 decimal places. There is a large number of users as the SDAS does not implement Google Map Marker Clustering that clusters users' location into respective areas that optimise the detection speed. Instead, SDAS pings each user's coordinates that have tracking turned on. Therefore, for future work, the SDAS can be expanded to integrate with the quarantine system as a mean of way to monitor UMP students during the period of quarantine, as well as contact tracing (Bakar, Majid & Ismail, 2017) with the experimental data to gain more insights. Other than that, more parameters with different levels could be added, such as the Geographical Information System (GIS) that can be integrated into this work for a more user-friendly setting in the future work (Bakar et al., 2018; Fernandez et al., 2021).

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