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A Online Tele-Monitoring System for Delivering Healthcare in Rural Sarawak, Malaysia

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Abstract. The delivery of healthcare services in rural Sarawak is restricted by geographical distance and underequipped healthcare facilities. Rural residents are forced to travel long distance in order to obtain advanced health examination and professional advices. Besides, there are low levels of health knowledge and awareness among rural residents, causing poorer health outcomes and underutilization of healthcare services. To tackle these challenges, an online tele-monitoring system is proposed to facilitate the delivery of healthcare services in rural areas. The system consists of two parts: (1) an android-based mobile application for rural residents to report their health conditions and interact with healthcare service providers without having to travel inordinate distance; and (2) a web-based application for healthcare service providers to remotely monitor the health conditions of their patients and examine health trends in rural communities. The ultimate goals of the system are to improve the knowledge and understanding of health, disease and self-care among rural residents, and to facilitate the accessibility and provision of healthcare services to those living in rural areas.

Keywords; digital platform; healthcare; rural area; socio-economic; tele-monitoring

1. Introduction

Sarawak is the largest state in Malaysia, with a rural-to-urban ratio of 52:48 in 2016 [1]. The rural population is distributed in more than 6000 small villages over a vast geographical region with rugged terrains. Due to poor transportation facilities and lack of good road networks, rural residents have to travel a long distance to obtain advanced health examination and professional advices in urban areas [2], [3]. Previous studies reported that geographical distance affects the delivery of rural healthcare in many

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ways, which include limited healthcare facilities, lack of healthcare professionals, delay in transportation of drugs and underutilization of available health services [4], [5]. In addition, rural residents in Malaysia have been shown to have lower levels of health knowledge and awareness, when compared to those living in urban areas [6], [7]. A systematic review of literature showed that low health literacy is related to poorer health outcomes and poorer use of healthcare services [8]. The low levels of health knowledge and awareness and difficult access to quality healthcare could put rural residents in Sarawak at higher risk for poorer health outcomes and reduced quality of life.

The use of mobile applications has been shown to have the potential to improve the level of health literacy and self-management of symptoms among those living with chronic diseases such as diabetes mellitus, cardiovascular disease and chronic pulmonary disease [9], [10]. In Sarawak, there is a lack of standard reporting and monitoring system to improve self-management of symptoms for patients with chronic diseases and to facilitate the delivery of healthcare to those living in rural areas. An online tele-monitoring system is presented in this paper to solve the geographic factor and making healthcare services more accessible to the rural population. The objectives of the system are two-fold: (1) to provide a platform for rural residents to report their health status and interact with medical practitioners; and (2) to allow health service providers, particularly medical practitioners, to monitor the health status of their patients and examine health trends in rural communities. Section II of this paper presents the development process, process flow and key features of the tele-monitoring system, followed by the challenges and future directions of this study in Section III

2. System Design and Features

The system is developed following an evolutionary model of the software development lifecycle. Figure 1 shows the typical activity of development with evolutionary approach. At each evaluation, it is decided whether the prototype is ready to be made into the final version or to be refined. The evaluation stage may be performed on the test team, the product owner and the users to gain useful feedbacks on the usability, the logic and correctness and the interface of the prototype. At the prototype refinement stage, the flaws found from the evaluation are fixed or if no flaws are found, the team can move on to the next feature. When the prototype has no found flaws and all the features has been added, the prototype is deemed to have evolved to the final product. This approach however comes with a disadvantage where unless the requirements are clear, it may be troublesome to decide when to stop refining and determine it is ready for final version.

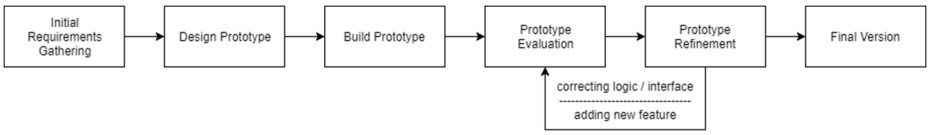


Fig. 1. Typical activity of development with evolutionary approach

The system process flow is separated into two parts, the android application used by rural residents to report their health status and the web application for health providers to monitor the reports from the communities. All the data are served from a web application via REST API and Pusher service for real-time interaction. Figure 2 shows the process flow of the system between the user and the service provider.

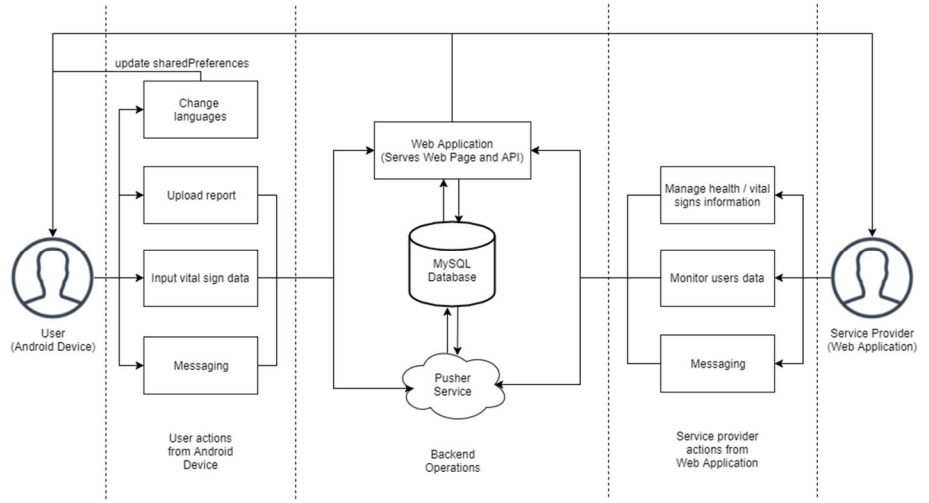


Fig. 2. System process flow between user and service provider

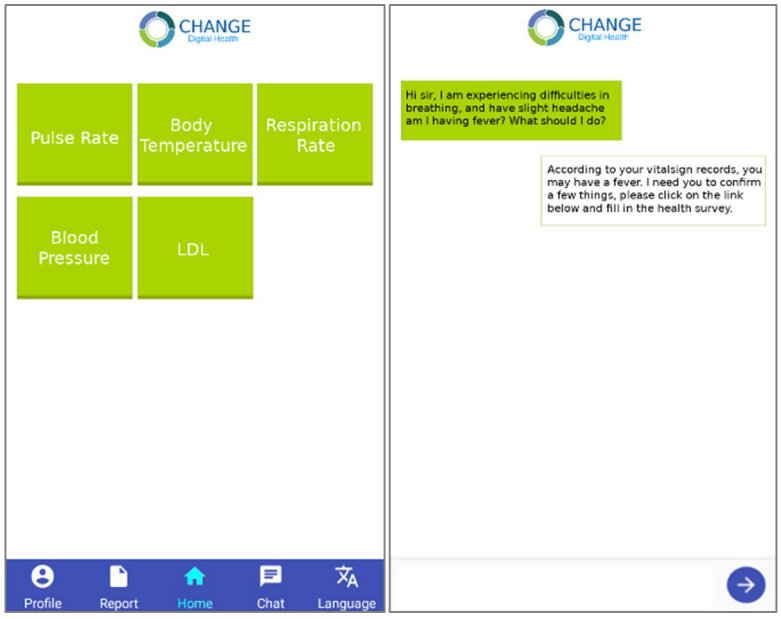
The key features of the system are presented in Figure 3. The main functionality of the platform is to let the user input their vital sign information such as body temperature and blood pressure. When the value of a specific vital sign goes above or below the limit, the color will change from green to red. This functionality allows the users to be aware of the state of their health and with the data accumulated over time, service providers will be able to see the trend of general health in the rural communities. The intention of this feature is to increase the health awareness and health literacy through the data they report through this feature. A person with heart disease for example can monitor their own blood pressure and cholesterol level and whether they are following the treatment well without having to be admitted into the hospital in the city.

Either the user or the service provider can initiate a conversation. The conversation works the same as a call-center help line but in messaging mode. The intended use of this feature is so that the user does not have to travel a long distance for a common diagnosis. This feature is made possible through Pusher service to push real-time messaging data to both party. Similar to WhatsApp, a check mark indicates the message is sent, a double checkmark indicates the message has been delivered.

Cross mark indicates the message has not been sent, probably due to the lost internet connection. This solves the geographical issue where there is no need to travel to the city to seek medication advice or treatment follow up and to report daily situations like breathing difficulties.

Android comes with an out-of-the-box locales module to manage the language used by the phone. However, supported locale data are limited to the International Components for Unicode (ICU) shipped with android versions [11]. Thus, native languages such as *Bahasa Iban* and *Bahasa Bidayuh* are not supported. To cater for this, a dictionary module is maintained by the service provider. Language setting is saved into android's *sharedPreferences* to ensure the setting is correct. Other settings include *text size, language module version* and more. This helps the users to be more comfortable using the application. This is intended to aid with both their digital and health literacy as they navigate and use the application.

To allow the service providers to give a better diagnosis, additional health data may be required for certain cases. This data may be in the form of a graph or report and can be uploaded as a picture. This report may be in the form of an electrocardiogram (ECG) image, blood test results and more. Upon choosing or taking a picture of the report, it will go through a using OpenCV blur detection algorithm to ensure the image is clear enough for further processing. An example scenario would be: some clinics may be equipped with an ECG device but due to the unavailability of healthcare professional in rural areas, the results will be sent to the city hospital or specialist clinic for analysis; causing unnecessary lag to the treatment time. This feature is intended to aid the service provider with advising and decision making and solves the issue for lack of healthcare professionals in rural areas.



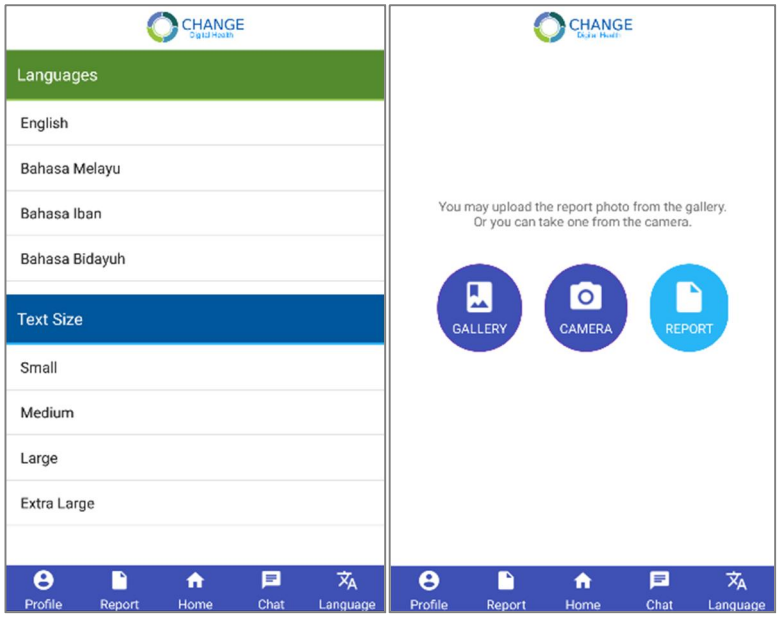


Fig 3. Screenshots of features: vital signs (top left), messaging (top right), changing language (bottom left) and uploading health report (bottom right)

Figure 4 and 5 shows the screenshots of the web application. The service provider would be able to see the list of users (patients), their status, condition and date of reported sick and cured and the id of the user. From this list, the service provider would be able to view the vital sign reports and messages for the users.

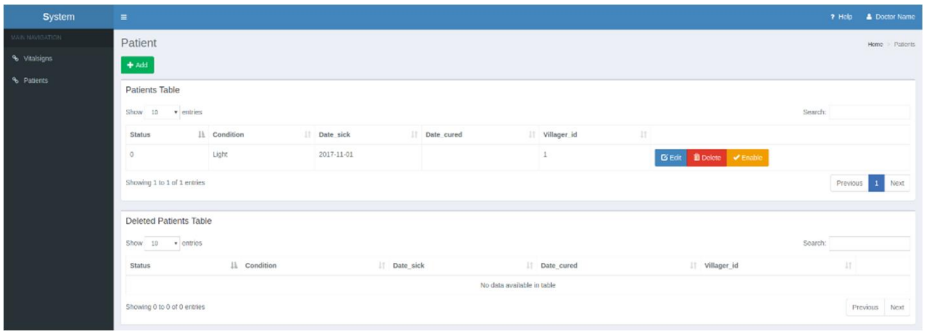


Fig. 4. Screenshot of patient list feature

The health data reported and the health reports uploaded by the users from the android application will be visible from the edit page which will be used to advise the treatment of the users. The service provider will be able to select and view the data in table or graph forms. Once the users are deemed healthy, the service provider will update the status and date cured of the patient. The patient will then receive an end-of-treatment notification.

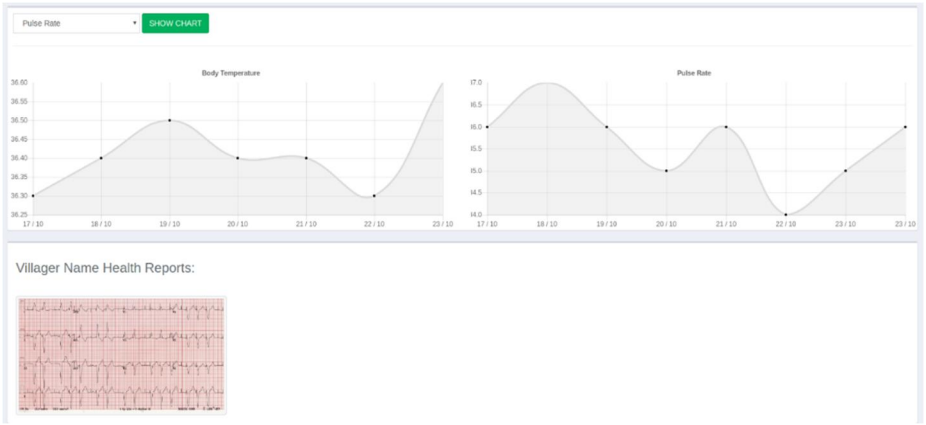


Fig. 5. Screenshot of vital sign records (graph) and health reports feature

3. Challenges and Future Directions

This study was limited by two key factors, which are discussed below, along with the possible solution for future research.

First, the use cases work well for city and nearby rural areas because of the available internet connectivity. For deeper rural areas without internet connectivity and phone line, the application would only be partially usable. In case of no internet connectivity, the user will still be able to enter the vital signs data and the data will be saved in the local database on android. Once the user entered an area with internet coverage, the system will update the online database using version check module. Future works on the low powered wide area network technology (LPWAN) may have a solution for this challenge.

Second, low health literacy may limit the use of the mobile application for self-management of symptoms and diseases. To improve the usability of the application, in future study, the vital signs feature interface will be replaced by a more interactive interface using multimedia tools like Unity. This improvisation is intended to make the vital signs more informative and interesting for all age groups. However, this feature is at a very early stage and highly dependent on the Unity and Android plugin compatibility [12].

4. Conclusion

The proposed system is intended to provide a digital platform for reporting and monitoring of health conditions of rural residents in Sarawak. Through the use of the system, rural residents (the users) are allowed to self-manage their health and make conversation with medical practitioners, whilst medical practitioners are able to

monitor the health status of their patients and examine the health trends in rural communities. The anticipated digital inclusion outcomes include: (1) increase in the take up and the use of mobile technologies for health monitoring and reporting in rural areas, (2) increase in the accessibility of health care services by improving the interaction between rural residents and service providers, (3) improve health awareness and dissemination of reliable and accurate health information to rural communities, and (4) the monitoring of health trends in rural areas, in order to raise awareness about the healthcare needs of rural communities and provide early warning of potential threats to public health.

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