Online Mapping and GIS Mobile Healthcare Systems for Intensifying Low-and-Middle-Income Community Accessibility

A H Zain Rashid¹, A R Abdul Rasam¹²*, A N Idris¹, N A Adnan¹ and F Othman¹
¹ Centre of Studies of Surveying Science and Geomatics, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Selangor,
²Environmental and Social Health Research Group,
³Faculty of Architecture Planning and Surveying, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia

Email : raf@uitm.edu.my

Abstract. Systematic healthcare facilities and accessibility system in developing countries are mostly located in urban areas instead of rural areas, causing inconvenience to low-and-middle-income residents to reach healthcare centres. Therefore, an innovative mapping and geomobile application or app is developed for the modernization of healthcare systems in Pulau Indah, Klang, Malaysia. This study aimed to provide relevant geoinformation of the healthcare centres and the optimum route to the nearby healthcare facilities. Data collection comprised of road access, lists of healthcare facilities, the type of healthcare facilities, travelling time, cost, as well as base map from Google Earth. The framework of geospatial functions and System Development Life Cycle (SDLC) were implemented to create the proposed system. Survey on 45 respondents revealed that 80% of them are displeased with the existing system performances. Thus, the proposed healthcare accessibility system has created eminent geospatial modules and cartographic elements to intensify the existing system. This personal app system also offers several spatial network analyses to assist the local community in finding the optimum accessibility to reach ideal healthcare centres. Inclusively, seven selected local communities agreed with the functions proposed in this system but there are several parts can be further improved.

1. Introduction
Mobile applications or Mobile apps are software programs developed for mobile devices such as smartphones, mobile books and tablets. They turned mobile devices into miniature powerhouses of function and fun [13]. [13] also added that the purposes of these apps run the gamut, with purposes not limited to utility, productivity, and navigation but also to entertainment, sports, fitness, and just about any other imaginable daily activities [13]. The common mobile apps are usually available to be downloaded via mobile operating platforms, either Apple App Store, Google Play, Windows Phone Store or Blackberry App World which can be free downloaded or in-apps purchases. They also generally offer productivity and information retrieval, such as email, calendar, contacts, a stock market and weather information.

However, the rising demand by the public and the development of the tools by the developers has become the main factors in the apps into other categories such as mobile games, factory automation, GPS and location-based services, banking, order tracking, ticket purchase, accessibility and medical
services. The services offered by the mobile apps has attracted many users from time to time to use mobile applications in their daily life to make their lives easier.

Health and well-being are the most important element in human life for longevity. The combination of a healthy diet and a well-practiced exercise in daily routine are not limited to maintaining a good health, but also to prevent any complex diseases infection and to reduce high medical cost. Although healthcare facility has rapidly grown from time to time, the handling capacity is still insufficient for people around the area. Therefore, the solution for finding healthcare services must be taken seriously from different perspectives.

This study focuses on the development of a mobile application with a function to provide users with information on healthcare facilities. Today, smartphones and mobile electronic devices such as tablets and ipads have transformed our daily communication lifestyles [10]. It is recorded that three-quarters of world population expected the mobile apps to be free, and their willingness to pay for apps are varied by several categories including technology, finance, travel, social, entertainment, and retail [10]. Hence, the development of a mobile application will be able to provide information on direction, location, and cost-estimation of the chosen healthcare facility thus making it easily accessible to the public.

Pulau Indah, Klang, Malaysia was selected to be the study area on several factors. This area is located remotely from Klang City and has a limited number of clinics. Most of the healthcare centres are located at Port Klang where local clinics are insufficient to accommodate many patients at a one time. Thus, a good information system of healthcare accessibility is proposed in this study area. There are three objectives of this study which are to carry out the study of user requirement on the proposed mobile applications system, to design and develop the proposed geomobile application according to user requirement, and lastly to evaluate the performance of the system functionality and application.

2. A review on geospatial mobile apps for healthcare community services

2.1. Healthcare network accessibility using a GIS approach

Healthcare accessibility is recognized as an important component of the overall health system due to its capability to promote socio-economic growth and development for the nation and reduce the burden of diseases by improving the quality mental and physical of all well-being (Surage et al., 2017). The study on the accessibility of healthcare is aimed to investigate the level of satisfaction from the public on whether they have an easy, simple and user-friendly access to healthcare services or otherwise. There has been a number of existing healthcare services that does not offer people the guarantee to have a good healthy life especially for people who live in a rural area as there is limited access for them. According to [7][15][16] which conducted a study on accessibility for healthcare centres the best way to find optimum access to reach ideal healthcare centres especially in peak time by focusing on the element of global accessibility. By focusing globally, the availability and suitability of the healthcare centre can be identified and determined.

As the fundamental principle for the health geography is even distribution of the healthcare services across space and time and easy access by the populace [11]. Often, hospital and other healthcare facilities are built in the area that has good access to public transportation. Most people in the urban area prefer to commute using cars as there are more stable financially but it is a different situation for people in rural areas. Most of them commute using motorcycles which is within their income, but it is very unsafe and impractical for long distance journey especially if they travel for the purpose of seeking health treatment. Besides that, the distribution of healthcare facilities also impacts people's health. This is because the location of healthcare facilities can affect people's ability to acquire and use the services. A great example would be for people who live in an area that has no healthcare facility and the one nearby is quite distant from their home hence there are high possibilities they will face problem in order to get help during an emergency.

The measurement of physical accessibility is well established and has been applied in many areas with the use of Geographical Information System (GIS). This includes transport analysis, retail site analysis, emergency service and healthcare planning. GIS is well suited to measuring spatial accessibility to
healthcare as they contain the core components needed for such analysis namely data capture storage, management and manipulation tools for both spatial and attribute (textual) data with the following capabilities:

- Programming environments to customize and extend existing algorithms and create new analysis tools.
- Core analysis algorithms such as buffering, overlay, proximity analysis, shortest path and raster cost-distance analysis.
- Mapping and visualization tools to communicate the results of the analysis title.

2.2. Online mapping and GIS mobile applications for healthcare information system

System navigation has been used widely nowadays and gradually it has evolved to a simpler and better method and it has become a part of people's everyday life. System navigation is a tool that helps people move or navigate from one location to another. This system is a combination between the modern mobile technology, satellite navigation system and cartography capability which makes this function a vital application in this era. There are many applications that have been developed to provide the same function which comprises navigation. Google maps are one of the best navigation applications available for free. Other than showing directions, it also shows real-time traffic information whether it is congested or not and provide alternative routes to avoid the issue. Consequently, users will be able to identify which roads can be chosen to avoid traffic congestion. This is beneficial for users in making their travel plans and selecting the best routes to reach their destinations.

Another mapping technology in cartography is GIS mobile apps that can be developed in various platforms and brands such as Lenovo, Smart Phone mobile operating system (Table 1). A mobile operating system is a software system designed to control computer hardware while the operating system that operates on mobile devices is called a mobile operating system [9]. This operating system operates on a smartphone, PDA, cellular phone, tablet or another digital mobile device. The system has the combined features of a personal computer operating system with including the features of the touch screen, cellular, Bluetooth, Wi-Fi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, Near field communication and Infrared Blaster [8].

Today, there are many accessibility apps that are available to the public, such as Google Maps, Waze, Navigation – GPS Maps Traffic, Life Navigation and many other apps related to the navigation concept. However, for the healthcare facility accessibility apps, they are not as popular compared to other healthcare apps. This is probably due to the existing apps that are related to navigation which also provide accessibility assistance to the users for monitoring patient, personal advice to aware the patient, education or training to the nurses or doctor regarding new available resources, treatment and decision support for health professional applications in health care accessing with the apps [2][3][5][6][12][14].

3. Data and materials

The methodology utilized in the study consisted of several stages to achieve the main objectives as presented in Figure 1. These stages used the framework of System Development Life Cycle or (SDLC), including user requirement, system design and development, system testing and implementation. SDLC assisted the developer in establishing a proper step in system development with an organized procedure at the beginning of the process.

3.1. Preliminary study and user need assessment

From the comparative review of the existing android apps for healthcare facility services, this study has decided to use MIT Apps Inventor to develop the Androids Apps. MIT Inventor is an open source web application originally provided by Google and today it is operated by the Massachusetts Institute of Technology. It uses a graphical interface, and quite like Scratch and the StarLogo TNG user interface. This MIT Inventor allows a user to drag and drop the visual objects with the aim to create an application
that can run on Android devices. In creating this mobile app, Google drew upon significant prior research in educational computing, and the work is done within Google on online development environments. For the user requirement, the online questionnaire via Facebook and WhatsApp were distributed to the community in Pulau Indah, Klang in getting the user feedbacks on the proposed apps. From the findings, there are several components used in the analysis for the mobile apps, from the operating systems of the mobile phones to the agreement from the users to use the function for the development of research mobile apps. The questions are also focused on the functions of healthcare facility, information of healthcare, information of health, comment for users review, and costing information i.e. travel cost to healthcare facilities. The questionnaires received feedback from 45 respondents from the community.

**Figure 1. Methodology of GIS mobile healthcare apps system**

### 3.2 Data collection
There are several data that were combined in the mobile application to produce the application that will meet the need of the community of Pulau Indah. The data were integrated into the application as maps, health information, healthcare information and transportation. The data can help the community to obtain information, navigation then provides users with the ability to solve their problems on the healthcare facility. The maps and the information on healthcare data can be obtained from open sources such as Google maps while the data for the transportation were collected through the survey of the transportation services provided by the people of Pulau Indah.

### 3.3 System design, development and testing
There are five interfaces in the application which are the home page, healthcare page, health info page, driver contact page and complaint page. For example, healthcare page provides information about health care facilities services listed in the app and the navigation assistance to the desired healthcare. There are two buttons provided in this page; a button for navigation and a back button. Maps are provided in this page together with a list of the clinics or hospital that is shown in the page on the chosen health care facility's distance. Additional function is added in the app, which is useful for cost travel calculation and vehicle information services when using Grab car and My Car. For system development, the tasks were app coding system and app data attachment. Meanwhile, in the last stage, it was all about system testing which conducted among 11 selected communities in Pulau Indah, Klang.
4. Results and Discussion

4.1. User requirement for the proposed mobile apps

There are three sections of a questionnaire that have been answered by residents in Pulau Indah, Klang. The first section focuses on demographic, while the second section emphasizes on the level of technology savvy of the residents and the last section is on the introduction of the apps and the ways to improve it. In terms of demography, seven residential communities involved in this questionnaire are Kampung Sungai Kembung, Kampung Perigi Nenas, Pulau Indah's Customs Resident, Kampong Teluk Nipah, Bandar Armada Putra, Kampong Sungai Pinang, and Kampung Orang Asli Pulau Indah. 75.5% of the respondents have been living in the areas of more than 5 years with a majority range of household incomes are between RM 1000 to RM 2000 (low-and-middle-income). Therefore, it is not surprising if most of the respondents in these communities are using motorcycles (45.5%) and personal cars (54.5) only as main transportation, with difficulties using or having access to public transports (0%). Majority of the respondents (80%) seem not to be satisfied with existing mobile applications as shown in Figure 2. One of the reasons is that 61.4% of the respondents do not have any experience using the specific type of mobile apps while another 38.6% have experiences in using mobile apps that provide navigation to healthcare facilities.

![Figure 2. Respondent satisfaction on the existing mobile applications](image)

Therefore, Figure 3 reveals that most of the respondents agreed with the proposal to develop a new mobile application for healthcare services in Pulau Indah community. 55.6% from 45 respondents agreed with the proposal, while 28.9% were neutral with the proposal and another 15.6% disagreed with the idea to develop the proposed mobile application. The respondents also expressed strong agreement if the proposed apps do not only provide a directory map but also offers some important menu such as healthcare database, healthcare information, transportation cost estimation and transportation report. Some of the respondents disagree with the proposal due to having general knowledge on the local accessibility to healthcare centres and some of them have also own transportations.

4.2. System interface and elements

The interface is designed based on the requirement that was proposed by the respondents. The interface was developed using the MIT Inventors. There are three main layouts of the interface designed for these apps as shown in Figure 4. The first layout is the Home page. It contains three buttons which are Healthcare button, Healthcare Information and User Manual button. Each of the button in this page is the door to get through to another interface. The second interface is the main page. This page gives the users the option to choose their healthcare treatment. The government and private buttons are for the user's option to choose different types of healthcare facilities listed in the app.
Besides this, this page also provides a button (Aduan button) for users to lodge a report or comment regarding their feelings toward the healthcare facilities. The third layout is the next page after users choose the option on the healthcare facility, either government or private healthcare facility. In this layout, the users will be provided with the information on the healthcare facility i.e. its address, operation hours and specialization. This page also provides users the option maps to get the best routes for their destination healthcare centre.

![Figure 3. Respondents’ responses on the proposed mobile applications](image)

### 4.3. System functions and capabilities

The proposed app has three main menus as displayed in the home page i.e. Healthcare Accessibility, Healthcare Information and Manual for user’s guideline as shown in Figure 5. The Main page is divided into two parts which are government healthcare facilities and private healthcare facilities. This page will list all the healthcare nearest to Pulau Indah and users will be guided by Google maps to get to the healthcare facility of their choice. In addition, the page also provides some information related to the chosen healthcare facility such as its address, operation hours and the capability of the healthcare to perform the treatment.

The Map page is also one the most important function in this app due to the navigation function it provides. It is generated from the government or private healthcare button in healthcare accessibility page. When users choose healthcare facility, a map is shown with the direction to the destination. This
map is linked to the Google maps application from the user’s smartphone. The app’s system also has the following functions: for querying, locating, sending a report (comment) of the local healthcare information. Its functions also include Sending Message of the public driver, travel cost estimation and health info.

![Diagram](image)

**Figure 5.** Main functions of the proposed mobile applications system

4.4. **System functions and capabilities**

According to the respondents’ satisfaction level on the mobile app organization as illustrated in Figure 6, 37.5% of the respondents feel that this app is well organized while another 62.5% feel that this app is moderate. Notably, no respondent thinks that this app is not well organized. An interesting fact is that more than 80% of the selected respondents were satisfied with the functions and performances developed in the system, including Maps Function, Healthcare Information Function, Health Information Function, Cost Estimation Function, and Complaints/Report Function.

In terms of the practicality and possibilities of the proposed apps to be applied in the community routine, a majority of the respondents agreed that the apps are easy to understand, and it could be adapted in the local daily activities. Figure 7 illustrates that 50% of the respondents agreed that the application is easy to understand while the remaining 50% disagreed. This may be due to the fact that some of them are not well versed with such mobile technology.

![Pie Chart](image)

**Figure 6.** Respondents’ satisfaction on the proposed mobile application structure.
With regards to respondents’ agreement for apps adaption into daily applications, Figure 7 shows that 75% of the respondents agreed to recommend the app to the public while 25% expressed their disagreement. This may be due to the fact that they are not well versed with the usage of such technology.

![Figure 7. Respondents’ understanding and recommendation on the proposed mobile app](image)

## 5. Conclusion
From the site visit conducted at Pulau Indah, the communities faced several problems to reach the healthcare facilities. For a community of senior citizens, in general, their knowledge of technology is relatively weak and most of them do not know how to use the existing apps on the market and some do not use smartphones. Besides this, services limitation at available local healthcare centre, transportation problem and cost constraint causing the communities to get the appropriate health services, thus they need a practical information system for healthcare accessibility and information services. A mobile healthcare app has been developed in this study with some benefits and special features. The app functions to help residents obtain information on the nearest healthcare services for treatment and supplementary information of health clinic. The app also assists users in the selection of healthcare centres that suit their needs. Users could also get information on operating hours, the level of treatment provided, estimated travel costs, health info information, address and navigation assistance via the mobile app. By using the information provided in this app, it will make it easier for users to decide on a clinic closest to them.

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