

# Development of a Community-based Geographic Health Information System via Mobile Phone in Saraphi District



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**Abstract.** The public health information is essential material for public health care planning and operating system. The updating data can help health care workforce to create health care scheme or public health policy that suit with community and people health context and then improve citizen' quality of life. The geographic information system (GIS) is the technology which can be apply for support the healthcare workforce to collect and update data of health determinant and it is also have an ability to synchronize and analyze the real time data. The main propose of this study was to develop a mobile phone-based geographical information system for be like the real time health determinants data reporting system. The study was conduct under the developmental research design. There were divided into three phase; Preparation, Implementation, and evaluation phase by using focus group. The study result demonstrated that the developed system was compose of the part of data collection and the part of health determinant data report that can be display in various types of tables, charts and Google 360 degrees. Furthermore, this system was transform to be an application so everyone can reach it from App store or Google play store. The stakeholders found that the system was friendly for user because the system format is appropriate, very interesting, and easy for using. Moreover, the ability to analyze a real-time data is very useful for the health workforce; especially to detect the communicated disease like the Dengue fever for example. On the other hand, the barriers of using GIS was found. The users reflected that the coverage of internet network and internet access were the main obstacle. In conclusion, the developed system gave a lot of benefit for healthcare workforce but need to adjust or improve some function to make the system suit with other community context and need to prepare the internet network quality before using the system.

**Keywords:** community health determinants, data collecting system, developmental research, geographic information system, health data, mobile health, primary health care

## 1 Introduction

The public health information is an important key which can use to present health situation and health trend among people in each area or country [1-2]. The health planners and workforce require spatially referenced data about people demographic data, health status, health determinants, epidemiology information, disease surveillance, and also the environment which people live with [3-4]. According to the geographical framework for analysis, the data; especially health data, should be collected systematically and easy for management, and the geographic information system (GIS) can help health workforce to collect and evaluate the different aspects of health data and their relationships [5]. In addition, GIS can work as the data storage, the statistical manipulation which can synchronize and merge

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the geographic information with the health data, then transform these data into the various types of table, chart, histogram, graph or pictures [6-8].

Because of the GIS usefulness, it was applied by the healthcare workforce or the health related organization worldwide [8]. The previous study showed that the GIS has been applied for several epidemiologic studies, their result was used to support the health care planning and public health strategies [6]. According to the US Centers for Disease Control and Prevention (CDC), they established guidelines for using GIS to access and direct lead poisoning prevention in children [9]. In Thailand, Jaraeprapal and Aekwarangkoon applied the GIS as the Nakhon-Si Thammarat province health promotion system and found that GIS can provides an important data which beneficial for health promotion planning such as information related to local health facilities and the using herbal medicine statistic in each families [10]. According to Nakhapakorn and Jirakajohnkool, they studied the relationship between the reported incidence of dengue fever and spatial patterns in nine districts in Northern Thailand during 1999-2003 [11]. They found that the results from GIS showed the relationship between the infectious area and the incidence and prevalence of the Dengue fever patients. As a result of the previous studies, we can conclude that the GIS is play an important role to manage and integrate the health data by analyzing health care needs, and their beneficial is utilize for health care system and may worth for investment and widely apply [12].

Saraphi is a district in Chiang Mai, Thailand. It is semi-urban rural area with approximately 75,000 people [13] and the community need to develop the social capital and the primary health care system in their area. From district data report, district health data; such as the incidence, the prevalence and also the mortality rate of infectious and non-communicable disease, was routinely collected. However, some pieces of community health resource data such as the identities and jurisdictions of community leaders, availability and amount of local natural resources usage, demographics data of disability person and other health related data from each household are unclear or some is missing and not available [14]. For overcome this situation, The Health Promotion Hospitals and Saraphi Hospital tried to gather their health data and published the annual health report by using data collected by paper-based questionnaires. The annual health report was had a limitation for data analysis because it cannot integrate data temporally and spatially, cannot evaluate the health determinants with the diseases incidence, and data collection via paper questionnaires cannot processed and synchronize the result in time to time. Furthermore, this health data cannot be a cross-referenced with other data about issues affecting the health of individuals and the community, such as the social and economic environment, the physical environment, and the person's individual characteristics and health care behaviors [15]. Thus, GIS can work and be used effectively on these task.

### 1.1 Goal and Purposes

Because of both the GIS advantages and the important of health related data in term of supporting the healthcare organization and workforce, the researchers developed the mobile GIS application in both iOS and Android operational system for purpose of collecting, analyzing and evaluating community and household health data. We expect that these system will help all health care stakeholder can access the real time health data and use the result from this system to support their mission, and we may transform this system to be like the public health data based innovation in the future.

## 2 Method

The developmental research design was used for conducting the study. The study was divided into three phases; preparation, implementation, and evaluation phase.

### 2.1 Participants

The participants in this study consisted of:

- (1) The developers including the community nurse peoples and the computer scientist peoples
- (2) The data collectors 150 peoples. The researchers recruited data collectors who work in the community, have their own smart phone or tablet, understood the data collection instrument, able to store the GPS of each household, and insert a picture into the application.

(3) The stakeholders in the community: including of 80 government officials, the 12 chairmen of the village health volunteers, the 30 village health volunteers, community leaders and approximately 14,000 households in Saraphi District (60% of 26,257 households). The study information were explained to the participant and the permission for collecting data was asked by the researcher before start the study process. The participants have right to deny or not allow the researcher for collecting their data or reject to join in the study process. The study process took place from November 2012 to May 2013.

## 2.2 Tools and Instruments

Tools and instruments of this study included

(1) Mobile GIS application which was developed from the GIS framework. The data which is recorded via the mobile GIS application including of latitude and longitude of each house, house photo, physicals and demographics data, household environment data, household members' health data, and social funds in Saraphi district. The application had both iOS and Android operational system version.

(2) The structural interview questions guideline for focus group discussion.

(3) The form for public hearing recoding.

**Quality of Instruments.** The content validity of the questionnaire in the mobile GIS application, the structural interview questions guideline for focus group discussion and the form for public hearing recoding were evaluated by the panel of nine expertise in area of the epidemiology, public health specialists and geographic information system. Then, the items in the questionnaire and the guideline was revised based on the experts' recommendations.

## 2.3 Ethical Considerations

This study follows ethical principles and was approved by the Research Ethics Committee of the Chiang Mai University Faculty of Nursing, Chiang Mai University (Approval Number 104/ 2555).

## 2.4 Data Collection Procedures

**Phase 1: Preparation phase.** The preparation steps of the research team and community are as follows:

(1) The developers met up to discuss and brainstorm about the how to develop the GIS for collecting data and what skills were require for data collection phase.

(2) The developers developed the health Information in Community Based on Geographical Information System (GIS) via Mobile Devices Computer Network and then, transform the system into the application for iOS and Android operational system

(3) The developers created the data collection manual. The content in the manual including of community data

(4) Community cooperate preparation by approaching community leaders, authorize people, and village health volunteers.

(5) The developers trained the data collectors to ensure the ability of data collection.

**Phase 2: Research implementation phase.** The data collection process was as following steps:

(1) The data collectors uploaded the mobile GIS application into their own device; mobile phone or tablet for example.

(2) The data collectors started to gather the household and community data according to the mobile GIS application. During the data collection step was ongoing, the developers visited and phoned the data collectors to check about the feasibility and the barriers while collecting data.

(3) The mobile GIS application were pilot in twenty households and stakeholders in the Saraphi distric area.

(4) Public hearings from community stakeholders event were held for discussion about the types of data that should be improved or adjusted.

(5) The mobile GIS application was improved and modified by the developers. Then, the update version of the mobile GIS application was uploaded.

(6) The data from mobile GIS system was upload real time on the internet site and data based. The data was monitoring by the developer.

(7) The data collectors uploaded the update version of GIS application and then collecting health data from all household in the Saraphi district area.

### Phase 3: Evaluation phase.

(1) Public hearings from community stakeholders event were held for discussion about the advantages, disadvantages and obstacle in process of using mobile GIS application that should be improved or adjusted.

(2) The Focus group interviews with the data collectors and data users was held for exploration about the obstacle which happen during data collecting and data using process.

(3) The developers sum up all feedback from public hearing and focus group.

### 2.5 Data Analysis

Health data were analyzed by using the correlation analysis techniques. The analyzed data were transformed to the tables, bar charts, pie chart and histogram, and then there were presented on the internet site. The data from public hearing and focus group interview was analyzed by using regression techniques and compared against health data.

## 3 Results

The results were presented into two parts and the detail in each part was described:

### 3.1 The Result From Data Collection

The results of data collection are divided into five categorized as follows:

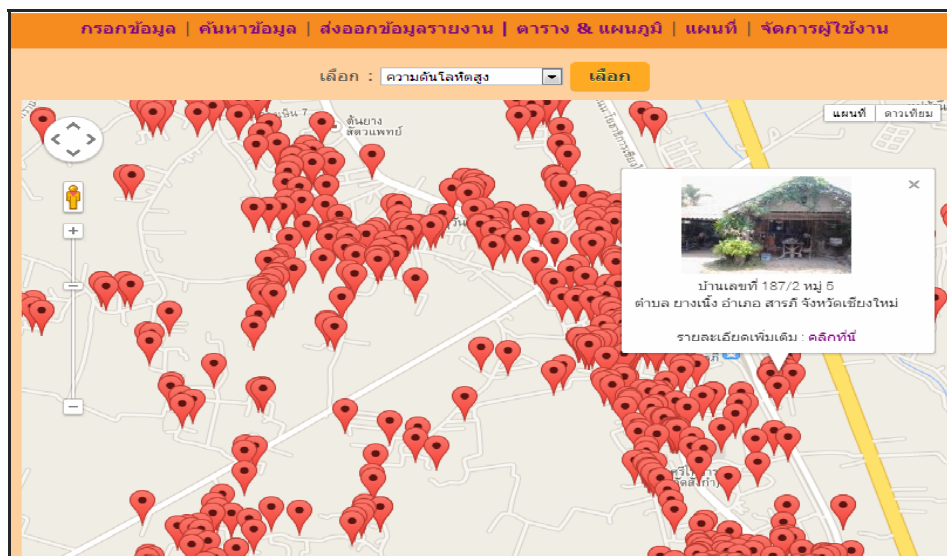
**Demographic data.** The Demographic data composed of the information of member in each household; such as age, gender, occupation, income, education, medical welfare, role and position in the community, folk wisdom or expertise, special care needs, nationality and self-employed worker data.

**Health conditions.** The health conditions consists of chronic disease, infectious disease, mental health and disability.

**Health behaviors.** The health behaviors are substance abuse, eating behaviors, medication and exercise. Environmental Management. The environmental management included garbage management, insect-borne diseases, waste water treatment, toilets, household safety, pets and disturbance of household.

**Health service system.** The health service systems included self-care, primary healthcare service, choosing a health service system, primary care service development needs, and primary care service satisfaction.

The report shows coordinates, a table, a chart and links house coordinates with Google 360 degrees (Fig. 1 to Fig. 3 shown the example).



**Fig. 1.** The example of data presentation with coordinates which shows house position of patients that suffer from other chronic diseases such as cerebrovascular disease, nephropathy and cardiopathy



Fig. 2. The example of data presentation that link with Google map

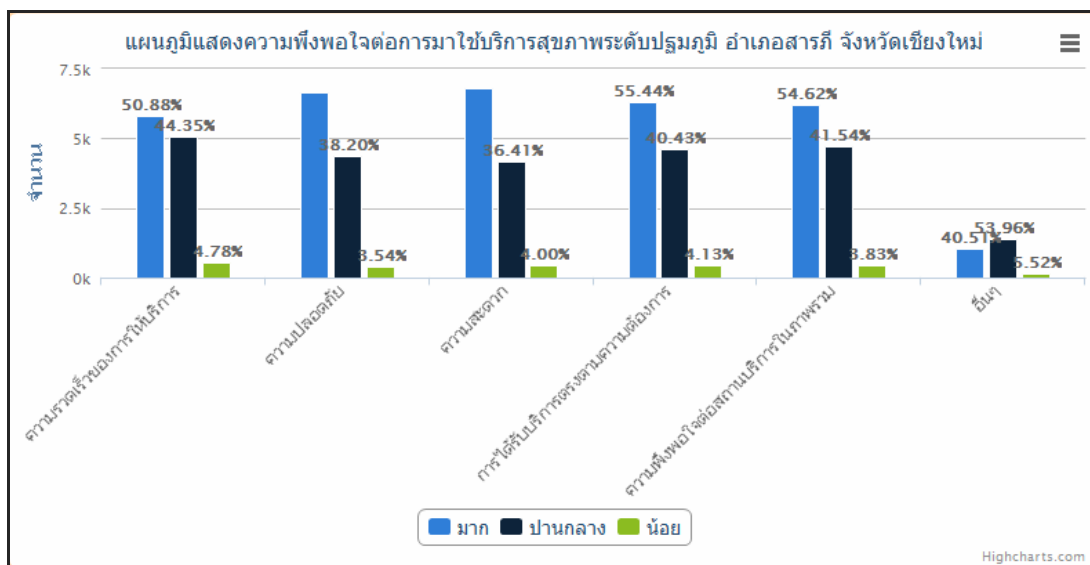


Fig. 3. The example of data presentation with a chart

### 3.2 Problems and Barriers Identified by Stakeholders

The problems and barriers of stakeholders are classified according to three research phases which are the preparation phase, data collection phase and evaluation report phase.

**Preparation phase.** In this phase, data collectors did not attend all sessions and did not complete their training. Moreover, some data collectors who attended did not pay attention, resulting in them not understanding some questions, the vocabulary and computer techniques. Furthermore, some data collectors did not have a smart phone or tablet that could work on the 4G mobile network. This made it impossible to collect the data.

**Data collection phase.** The problems and barriers of the data collection phase are classified into 3 parts which are problems and barriers of data collectors, problems and barriers of people who were asked and problems and barriers of the management system. The details are as follows:

*Problems and barriers of data collector.* The study found that some devices could not support SIM 4G 2100 MHz frequency and some devices could not search for GPS coordinates. The data collectors lacked

skills in using mobile devices. Moreover, some data collectors, particularly youth did not understand the context of the community. During the first period, the number of data collectors and tools were not enough to collect the data in the short collection period.

*Problems and barriers of informants.* Some people were not able to provide information about their household, so it took more than one interview to achieve complete data. Some sensitive topics were hard to collect data such as household debt, so some of them did not give true information. Moreover, households were reluctant to provide the information and some households were rented causing information lacking in those households.

*Problems and barriers of system management.* The study found that the internet or Wi-Fi signals in the area were weak causing unsuccessful data collection and leading to repeated data recording. At the call center, some representatives were skilled on iOS and while others were skilled on Android. The data collection was slow because some data collectors were youths they could only collect data when they were not in school. The public health staffs who were supposed to collect data themselves did not have time to collect the data. 4G and Google maps did not have full coverage in some areas.

*Modifications based on problems and suggestions.* The modifications for the data collectors, people the management system were made:

(1) Give an advice to the data collectors who do not have smart phones or tablets to borrow devices from the local government for data collection.

(2) Inexperienced data collectors were encouraged to call the call center to for advice on questionnaires and computer techniques.

(3) Data collectors did not understand the context of the community were paired with village health volunteers and healthcare providers who were familiar with the area.

(4) Data collection was extended for two months due to lack of time.

(5) 4G mobile network and Google maps were not available in all areas. The researchers coordinated with True Corporation to extend the 4G signals to cover the whole all area and to use other appropriate 4G networks in the area. Coordination with Google allowed for Google maps to cover all areas of Saraphi district.

(6) The call centers are specialized on either iOS or Android system. The solution is making a contact with the technicians who have specialized on both systems.

**Evaluation report phase.** The evaluation of data from the first period identified problems because some parts of data were incorrect, the analyzed numerical is unstable and some percentage calculations were incorrect. Moreover, the subset data which can have more than one choice has new percentage calculation to the consistency of data.

Programmers modified the program by filtering the irrelevant information and junk data causing stability issues and conformed data in every table. However, the percentage calculation in some subset tables, and then the researchers have new percentage calculation for the accordance.

Information from interviews with random data users found that the reporting was more convenient, faster and easy to access. Moreover, the reporting was in real time and it is clear text on screen and the health data were entered into the data base. The overall graphic design was appropriate and beautiful. Furthermore, the program was able to record multiple file types such as JPG, PDF, and PNG. Tables and graphs could be easily copied from the program for use in health reports. Additionally, the program has tiered access for both administrators and operators, which is an appropriate for planning according to the context of area.

The results from the random interview of data collectors found that the use of database system is easy, and allowed them to store and edit data anywhere with an internet network. The mobile device is overall friendly to use and fast at updating information. Because the researchers developed software displays data in a variety of views [14]. The system was easy to use, access and record. Reporting is modern, appropriate in format and colors, complete and correct and incorporated map location information with street views from Google Maps [14]. However, there were some problems were described above.

The results from the random interview of the data users found that the database system via mobile device is appropriate as clear text on screen, accurate information and overall graphic design is modern. The accurate information is fundamental to decision-making of community development. Moreover, it is timely, easily to access and edit data at everywhere that have internet network. The mobile device is friendly to use, having appropriate presented graphic and usability. The health report can show in both table and graph types. The system has efficient processing, real time, modern, completeness and correctness.

## 4 Discussion

The geographical information system is both database system which has ability to manage spatial data in the form of numerical map, characteristic data and the operating system to analyze those data [7, 16]. In this study, the researchers developed the geographical information system via mobile devices computer network following the guideline with research and development. The data management used information of GIS by encoding a network area. The file is arranged in a systematic way and created based on location. Thus, this systematic way leads to fast and efficient in editing retrieving and sorting data in the file [17]. The results showed that all users were satisfied with the GIS in the capability and feasibility for working because it was easy to understand. They also revealed that the report of the system was easy and clear to understand. Then, it is effective tool for rural area surveillance [18-19].

According to accurate information of health data can be empowered healthcare providers and community residents to collect reliable and complete health infrastructure data [20]. Moreover, the report was accurate information can be used in community planning and decision-making for community development. These are consistent with the study of McLafferty [21] and Cromley and colleague [22] revealed that GIS has accurate information resulting in the capability to be used in decision-making to plan in community development.

The combination of the software with in the devices allows for managing, analyzing and report data related to spatial information [23-24]. The report was appropriate in format, color and having real time reporting were consistent with the study of Tuanrat and Boonchieng who developed a database system in the schools, which found that the reporting via computer is feasible and report findings related to spatial information [25-26].

Mobile device and tablets has become appropriate in working purposes. It has increased in sensitive information that need in security and privacy concerns [27]. In this study, the program showed the data with having the access control and the health data were entered into data base. According to access control, it is the privacy and has received attention from the researchers [28]. Access control have been developed base on legitimate action for effectively operation of the user about computer system [29-30]. Access control seeks the way to prevent some activities that could be violate the law or security [29]. In this study, because the health data was document into data base and it exchange on the internet, this should precise security requirements for preventing importance health data [31].

Additionally, the data collectors have opinions that it is more convenient, faster and easy to record the data. It has advantages over paper questionnaires. However, if the data collector is not in an internet area, there will also be problems to collect data.

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