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Development of mobile application for hypertension surveillance and telemonitoring in older persons in rural community

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***Abstract*---**Hypertension is a cause of cardiovascular complications and premature death worldwide. Prevalence of hypertension is doubled older population. Close monitoring must be promptly equipped by healthcare team without delays to preserve intact cardiovascular system. In Thailand, village health volunteers (VHVs, OSOMO in Thai) are key healthcare personnel that co-ordinate health information between the older persons and health care professionals. The VHVs have been trained to measure blood pressure, record, and submit a report to health professionals in monthly basis. However, the blood pressure records in some health areas were still incomplete due to incontiguous data collection and difficult access to the older persons. This project was aimed to develop a geographical information system (GIS)-based mobile application for hypertension surveillance and monitoring in older persons in rural community by the VHVs using the analysis, design, development, implementation, and evaluation (ADDIE) model. Results showed that blood pressure data of 6,421 (76.92%) of the older persons were recorded. We employed the Google Map Application Programming Interface (API) to identify

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latitude and longitude of the older persons' living locations. Other health data were also recorded. The mobile application called "OSOMO prompt" for both iPhone (iOS) and Android systems containing health knowledge repository on hypertension will be distributed to 1,125 VHVs in 8 districts. In summary, this mobile application will be useful as a tool for surveillance and self-monitoring of hypertension in older persons in rural community.

***Keywords*---**hypertension, geographic information system, community health, mobile application, older persons.

Introduction

Hypertension is a global leading cause of cardiovascular disease and premature death (Mills et al., 2020). Prevalence of hypertension in high-income countries is decreasing, while low and middle-income countries are experiencing an increasing prevalence of hypertension (Mills et al., 2016). In Thailand, an upper-middle-income country with average incomes of US$3,976 to $12,275, the prevalence of hypertension ranges from approximately 11% to 48% (Deerochanawong et al., 2022). Interestingly, the prevalence of hypertension can be doubled in older persons (Sarki et al., 2015). Therefore, surveillance of hypertension in this group of population is crucial. Thailand is classified as an aged-society country in 2021 since its older population has reached > 18 percent of the whole population (Khamken, 2021). Continuous monitoring of blood pressure of older persons in rural areas of Thailand is performed at Subdistrict Health Promotion Hospitals (SHPHs), the key units of primary health care. In association with the SHPHs, village health volunteers (VHVs or community health workers) routinely collect health data including blood pressure of the villagers with pens and papers (Perry, 2020). Our previous study reporting general design of the mobile application for the VHVs showed a high level (46.26%) of the older persons with non-communicable diseases (NCDs – hypertension and diabetes mellitus) (Tudpor et al., 2022). However, the blood pressure records in rural areas were still incomplete due to incontiguous data collection and difficult access. Therefore, this present study was aimed to focus on development process of the GIS-based mobile application "OSOMO prompt" for hypertension and cardiovascular disease surveillance in older persons in rural community.

Materials and Method

Database creation

This sub-project was a part of the analysis, design, development, implementation, and evaluation (ADDIE) model in the project "Development of Mobile Application of Database of Older Persons Using Geographic Information System (GIS) to Detect and Analyze Risks of Chronic Diseases, Quality of Life, and Mental Illness by Village Health Volunteers in 7th Regional Health Office Territory" (Tudpor et al., 2022). Database of hypertensive individuals were drawn from 8,348 older persons in the analysis and design phases. Inclusion and exclusion criteria of the older persons were previously described (Tudpor et al., 2022). All research protocols

have been voted by 2 reviewers, approved by the Ethical Review Committee for Human Research, Maha Sarakham Provincial Public Health Office, and endorsed by the chairperson Mr.Pakee Sappipat (No.6/2564). Socio-demographic profiles of the older persons were previously presented (Tudpor et al., 2022).

Personal data of the participants were socio-demographic data (gender, age, marital status, living arrangement, educational level, occupational status, activities of daily living (ADL) level, present illness, drinking status, and smoking status). The participants' functional ability was assessed by the Barthel ADL index assessment tool developed by the Ministry of Public Health, Thailand as previously described (Jantapo & Kusoom, 2021; Tudpor et al., 2021). Patient database was securely encrypted, and only authorized staff had an access.

Data collection and GIS mapping

Secondary health data were retrieved from the SHPHs. The mobile application was created with the Apache Cordova® platform for both Android and iOS devices. The Google Map Application Programming Interface (API) was employed for sharing latitude and longitude. The authorized web administrator exclusively had access to the encrypted server. Data were able to be exported only under permission. The global positioning system (GPS) were used for localization of the participants. The geographic coordinate system employed in this study was the World Geodetic System 1984, Universal Transverse Mercator coordinate system (EPSG:32648 WGS 84/UTM Zone 48N). All data collection process was performed from April to August 2021.

Results

Database of hypertensive older persons

The VHVs used papers or mobile phones to collect data in 3 steps: 1) general health assessment, 2) non-communicable disease data collection (diabetes mellitus, hypertension, and cardiovascular diseases), and 3) home visits. These data were administered by the older persons with assistance from the VHVs and managed by the web administrators. Non-hypertensive and hypertensive older persons were monitored by the SPPH staff. Health conditions were periodically reassessed by the staff with assistance from the VHVs (Figure 1).

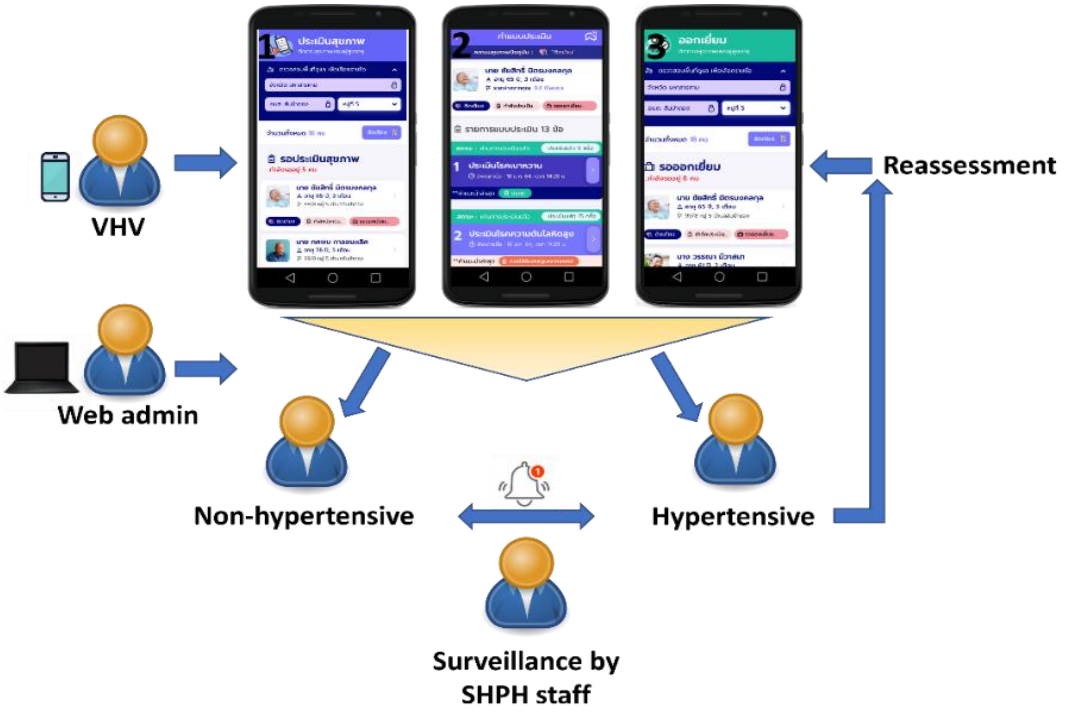

Figure 1 Creation of database of non-hypertensive and hypertensive older persons

Outcome measures and data collection tools

Secondary blood pressure data of total 8,348 older persons were retrieved from the SHPHs. Results showed that 6,421 blood pressure data were recorded (76.92%). Approximately 1/3 of them had elevated blood pressure and hypertension (Table 1). From 8,348 patients, the data of 1,927 patients were not yet collected. These data will be further collected by the end of this year. Classification of the collected data was based on the the American Heart Association/American College of Cardiology (AHA/ACC) guideline recommendations by blood pressure category.

Table 1 Blood pressure data collection and AHA/ACC guideline recommendations by blood pressure category (Jones et al., 2021)

Blood pressure category	Blood pressure range	Recommendation	n (%)
Normal blood pressure	<120/<80 mmHg	Promote healthy lifestyle	4,015 (48.10)
Elevated blood pressure	120-129/<80 mmHg	Non-pharmacologic therapy	1,630 (19.53)
Stage 1 hypertension	130-139/80-89 mmHg	Non-pharmacologic and/or pharmacologic therapy	664 (7.95)

Stage 2 hypertension	≥140/≥90 mmHg	Both non-pharmacologic and pharmacologic therapy	112 (1.34)
No data			1,927 (23.08)
Total			8,348 (100)

Discussion

User interface and utilities of GIS-based mobile applications for blood pressure data collection in older persons

The World Health Organization defined mobile health (mHealth) as "medical and public health practices supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDA), and other wireless devices" (Organization, 2011). Nowadays, mHealth is increasingly used for various purposes, particularly health promotion and disease prevention (Organization, 2011). More than 30 mobile applications were developed for monitoring blood pressure (Khoong et al., 2021). Our application was the first GIS-based mobile application for hypertension surveillance and telemonitoring in older persons by the VHVs in Thailand. In comparison to the old method of paper-based data collection, the data collected from mobile phones would be continually recorded into the database server and allow real-time monitoring by the health professionals.

Blood pressure data incompleteness

Our mobile application has several useful features to complete the data, which have been previously employed by others, including individual location identification with GIS (Nhavoto & Gronlund, 2014), logbook of blood pressure measurements (Jamaladin et al., 2018), emergency alarm as well as basic information about the disease for the patients, and treatment history (Plaza Roncero et al., 2020). However, there was a limitation of the project during COVID-19 pandemic, resulting in a communication gap between the development team, the VHVs, and the older persons.

Roles of community health workers in assisting older persons monitoring blood pressure

Community health workers (CHWs) are non- health professional persons working in a frontline for community health promotion and primary health care with more than 100 job titles including community health representatives (CHRs), public health aids (PHAs), lay health advisor (LHAs), community health advisors (CHAs), and VHVs in Thailand (Love et al., 1997; Perry, 2020; Sabo et al., 2017). Recently, Zha and colleagues showed that a community health worker-facilitated mHealth intervention had a potential to promote hypertension management in subjects living in underserved urban communities of New Jersey, USA (Zha et al., 2020). In low/middle-income countries (LMICs), Piette and colleagues demonstrated that automated telephone care management with home blood pressure monitoring improved outcomes of hypertension in patients aged between 18-80 years old in

Honduras and Mexico (Piette et al., 2012). E-mail alerts were automatically sent to CHWs when the patients reported a systemic blood pressure > 140 mmHg (Piette et al., 2012). In our study, the VHVs regularly recorded blood pressure of the older persons and could press an alarm button in emergency. Then, the health professionals would assume responsibility.

Risk factors of using mobile devices

Overuse of mobile has been reported as a risk factor for user's health problems. Volkow and colleagues reported that a prolonged use (≥50 min) of mobile phone increased level of glucose metabolism in brain tissues (Volkow et al., 2011). Keeping the mobile phone close to the chest increased heart rate variability; however, this effect was not significant compared to control (Ahamed et al., 2008). Nevertheless, length of time and frequency of the mobile phone use should be limited as mild health problems like headache and dizziness were also reported (Meena et al., 2016).

In conclusion, the GIS-based mobile application for hypertension surveillance and telemonitoring among the older persons in rural community of Thailand has been developed. The application will be further implemented and evaluated based on feedback from the VHVs and the older persons.

Conflict of Interest: The authors have no conflicts of interest to declare.

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