The Prevent-U Application: Developing Mobile Phone Application for Elderly with Risk of Hypertension in Thailand (Study Protocol)

Jumneansuk, A.,[1]* Plalungrit, S.,[1] Dangkrajang, S.,[1] Tongyoo, A.,[1] Dechboon, P.,[2] Pathomrotsakul, J.,[2] Arsa, R.[2] and Prasert, V.[3]

[1]Department of Community Medicine and Family Medicine, Thammasat University, Pathum Thani, Thailand
  E-mail: Apichetkub@hotmail.com,* srimuang@tu.ac.th, suphi2515@gmail.com, assaneetongyoogmail.com
[2]Faculty of Public Health, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani,
  Thailand, E-mail: Phitchasuda@gmail.com, Pfuse@hotmail.com, Arsa.dragon27@gmail.com
[3]Faculty of Public Health and Allied Health Sciences, Praboromrajchanok Institute, Nonthaburi, Thailand
  E-mail: vanida@scphc.ac.th
Corresponding Author

Abstract

Currently, hypertension is one of five major non-communicable diseases (NCDs) in Thailand that places a large burden on the public health system and in terms of health care costs. Hypertension affects a patient's essential bodily functions, can damage and deteriorate arteries, and may lead to serious health problems. While much previous research has focused on hypertension patients, there is a lack of studies about the prevention of hypertension among elderly people at risk for developing hypertension. So, we conducted an action research study to develop a mobile phone application, called Prevent-U, for the elderly at risk of developing hypertension. Lasting a total of 9 months, this study consisted of 4 phases (PDCA). After participants completed the application, we evaluated the user satisfaction with the application among 45 participants. Data were analyzed by descriptive statistics. Factors related to high blood pressure were lack of physical activity, poor food consumption behavior, having a moderate level of stress, and not consistently measuring their blood pressure. We integrated these factors into creating application. The Prevent-U application consisted of 5 systems: personal mode, data mode, collecting mode, report mode and consult mode. Based on the data from 45 participants, the mean score of overall user satisfaction was 2.53. A mobile phone application for preventing hypertension is an intervention that may capture the interest of patient and lead to positive outcomes. We selected this format to encourage participants to take care of their blood pressure and ultimately to change poor behavior that can lead to developing hypertension. Our preliminary results show that our application may help engage patients in managing and controlling their blood pressure. However, we are still waiting for the results of a study on the process of implementation of this application.

1. Introduction

Non-communicable diseases (NCD), also known as chronic disease are is a long duration and generally slow progression. Nowadays, there are five major NCDs: Hypertension, Heart disease, Cancers, and Diabetes which, are public health burdens in Thailand whether the public health system or the burden of health care costs. From Epidemiological study shed other of an important and steady increase in NCDs was Hypertension (World Health organization, 2013). A summary report of Bureau of Policy and Strategy, Office of the Permanent Secretary presented the morbidity of Hypertension have increased last five years (2013-2017) were 12,342.14 per 100,000 population to 14,926.47 population (Policy and Strategy Bureau, Office of the Permanent Secretary, 2016). This summary report was in accordance with the incidence of Hypertension per 100,000 populations last three years (2015-2017) increased from 916.8 per 100,000 populations to 1,353.01 per 100,000 populations (Center of Information and Communication Technology, 2017). Hypertension can be caused by unhealthy behavior and personal risk factors such as high sodium consumption in food, smoking, lack of physical activity, being overweight or obesity, high stress, and high alcohol consumption (Tremongkontip et al., 2012 and Cherfan et al., 2020).

Hypertension can also be caused by biological factors, including becoming older and having a family history of hypertension (Budreviciute et al., 2020). It is essential that we prevent and reduce hypertension because it can damage and deteriorate arteries (Tremongkontip et al., 2012). These effects can then contribute to developing atherosclerosis or hemorrhagic stroke. In addition, hypertension may lead to serious health problems such as disability, heart failure, Alzheimer's disease, or renal dysfunction arteries (Kokobo and Iwashima, 2015, Messerli et al., 2017 and Ungvari et al., 2021). Consequently, the Department of Disease Control in Thailand recommends that the public limits salt when cooking, and sodium intake in other prepared and processed foods. To maintain healthy blood pressure, the World Health Organization (WHO) recommends people should limit sodium intake to a maximum of 2 grams per day Hypertension (World Health organization, 2012), avoid smoking and alcohol drinking, monitor, maintain body mass index (BMI) of 18.5-22.9 kg/m^2, increase exercise and physical activity, and check blood pressure at least once a year.

There has been ample research about the prevention of hypertension by focusing on changing unhealthy behavior among hypertension patients on blood pressure control. In these studies, patients participated in programs designed to change their behavior took part in self-care programs for blood pressure. After participating in the programs, systolic and diastolic blood pressure significantly decreased compared pre-intervention. There were also differences in blood pressure in patients between the program (Phangsupat and Namjuntra, 2016 and Phetcharat et al., 2018). However, not only hypertension patients, but also individuals who are in the general public who have blood pressure at risky levels also need intervention. Hypertension prevention activity is needed for those who have borderline blood pressure levels that are not officially considered hypertensive yet. People who are at risk for hypertension, especially elderly people, may have difficulty managing their blood pressure and staying healthy. Based on our literature review, we found that a study about prevention of hypertension among elderly people at risk of hypertension is still lacking. Thus, we sought to take on the challenge of creating an intervention for hypertension prevention among elderly patients at risk of developing full-fledged hypertension. An application, also known as an "App" is a type of mobile phone technology that is designed for specific purpose, specific protocols, and functions.

Today people use applications in a variety of daily activities including communication, entertainment, traveling, working, finance, in addition to health care, health services, and prevention of diseases. Many researchers are interested in applications that can address hypertension because they are convenient, approachable and user friendly. Previously, researchers have created applications for the management of self-care, controlling blood pressure, and helping users improve their level of blood pressure self-management (Hallberg et al., 2016, Whitehead and Seaton, 2016 and Bozorgi et al., 2021). In addition, studies by Bengtsson et al., (2015), Gong et al., (2020) and Persell et al., (2020) have shown that blood pressure applications can contribute to users having better blood pressure self-management. These studies also showed that using the applications led to significant reductions in blood pressure levels in the intervention group (p<0.05).

In Thailand, many health educators and researchers that have designed applications that are related to health care and self-management of health. Such applications encourage people to take care of themselves, provide and educate user about diseases, provide health check-ups, and even have functions to prevent diseases. Some health applications are related to the prevention of chronic diseases. For example, the applications called C-Diabetes and Guideline DMThai are specific for diabetes. However, there are relatively few applications for prevention of hypertension, especially a dearth of applications that are suitable for elderly people at risk of hypertension. Hence in this study, researchers aimed to develop an application called Prevent-U, which consisted of a system and functions designed to change user behavior in order to better manage their blood pressure as well as to delay or prevent the development of high blood pressure.

2. Materials and Methods
2.1 Study Design and Participants
This an action research aimed to develop Prevent-U application for hypertension prevention among elderly people at risk of hypertension. We conducted this study from November 2020 to August 2021. Participants in this study consisted of 3 groups of health workers and hypertension patients including: 1) director of a health-promoting hospital, 2) health workers from health-promoting hospital and health volunteers, and 3) group of hypertension patients and elderly at risk of hypertension.

2.2 Study Procedures

The following study procedures followed the Deming cycle (PDCA):

Phase 1 Plan (P): We gathered data about epidemiology of hypertension, the current situation among elderly at risk of hypertension, as well as factors related to high blood pressure level among our target population. We used all of this data for creating our health application. Here is more information on the three steps of reviewing, finding data, and creating group meeting.

(1) Reviewing: Researchers reviewed articles, journals, and textbooks about hypertension and the following topics:

- Epidemiology of hypertension (Bryan et al., 2018 and Thai Hypertension Society, 2019)
- Research related to interventions for the control or reduction, as well as management of blood pressure in people at risk for hypertension
- Overview of the mobile application development and programming
- Theory about engagement and changing behavior of patients and people at risk for hypertension (Becker and Maiman, 1974)

(2) Finding Data: Researchers went to the health-promoting hospital in the Phrae province, Thailand and met with the director of health-promoting hospital. The researchers received permission from director of health-promoting hospital to access secondary data about the ratio of elderly people, and prevalence of elderly at risk of hypertension in the Phrae province.

(3) Group Meeting: Researchers had a group meeting with stakeholder that consisted of the director of health-promoting hospital, 2 health workers from health-promoting hospital, 2 health volunteers, 2 hypertension patients, and 3 elderly people at risk of hypertension. At the meeting, we discussed identifying factors related to high blood pressure, previous interventions for control and management of blood pressure, results of interventions, and possible reasons why patients develop uncontrolled high blood pressure.

Phase 2 Do (D): We created the actual Prevent-U application. This application aimed to help users realize how dangerous hypertension is, and lead users to self-manage and control their blood pressure. The design of the Prevent-U application was based on user-interface (UI) design principles that consider visibility, development, and acceptance. We also applied the Health Belief Model and utilized the data we gathered from "Phase: 1 Plan" to create all of systems and functions. The procedure of creating Prevent-U application was as follows:

(1) After the meeting, the researchers analyzed the secondary data from the health-promoting hospital and the primary data we collected during the group meeting.
(2) The researchers consulted with the application creator to design the application system and functions.
(3) The application creator generated the design of application. The size of text, font, and every visual was intended to be user-friendly and suitable for presenting health information to users.
(4) We tested a close beta version or "mock-up" of the application with application creator team. After that the test, the application creator fixed any problems we identified on application.

Phase 3 Check (C): The researchers and application creator completed testing of the beta version. Next, the researcher tested the application with 45 elderly participants at risk of hypertension. All of participants evaluated their satisfaction with the Prevent-U application in structured interviews.

Phase 4 Act (A): The last step consisted of the researchers using results from the user satisfaction interviews to edit and fix all mistakes and problems on the application. Also, the application creator re-tested in all systems and functions one last time before uploading the application onto the Google Play store.

2.3 Measurement and Data Analysis

2.3.1 Measurements

1) Unstructured Interview of problem and requirement of stakeholder:
The first measurement was used for collected data of stakeholder. Because process of collecting data in this phase we implemented group meeting, so researcher decided to use unstructured interview. The unstructured interview consisted of 2 items, including a problem or barrier that stakeholder faced on implement or participated about exiting intervention and requirement for the new program.

2) Structured interview of user satisfaction with the Prevent-U application:
After the development of the application was complete (Phase 2: Do), we selected 45 elderly participants at risk of hypertension to evaluate their user satisfaction on the Prevent-U application.

The researcher developed a structured interview to assess user satisfaction with the Prevent-U application. The interview assessed user satisfaction in terms of the efficiency and effectiveness of application. The interview consisted of 10 items, including a series of items about design (items 1 to 5) and efficiency of application (items 6 to 10). Each question had a response score from 1-3 points (1=low to 3=high). (Details of each questionnaire displayed on Table 6).

2.3.2 Data analysis
We analyzed scores for satisfaction with the Prevent-U application using ddescriptive statistics including frequency, percentage, mean and standard deviation.

2.4 Ethical Consideration
This study had already been approved by the Human Research Ethics Committee of Thammasat University (Medicine). Project number: MTU-EC-CF-0-251/63. Number of COA: 028/2021. Date of approval: February 8, 2021.

3. Results
3.1 The Situation of Elderly Population in Phrae Province by District
Phrae province is a northern province of Thailand, the record from the Department of Health showed the total of elderly population in 2019 was 87,735 people (the total population of Phare was 325,653 people). In addition, the highest elderly population is Muang Phrae district. So, this study focused and aimed to develop Preavent-U application for pre-testing on Muang Phrae district (Department of Health, 2019). The detail showed in Tables 1 and 2, Figures 1and 2.

3.2 Trend of Hypertension Case Fatality Rate in Phrae Province, Thailand
A Hypertension case fatality rate in Phrae province from 2015 to 2018 revealed that Hypertension is one of the important disease and the top 10 causes of death in Phrae population (HDC, 2018). The detail showed in Table 3.

The situation of Elderly population in Phrae province, Thailand (2019)
- 0.24 - 0.252
- 0.252 - 0.264
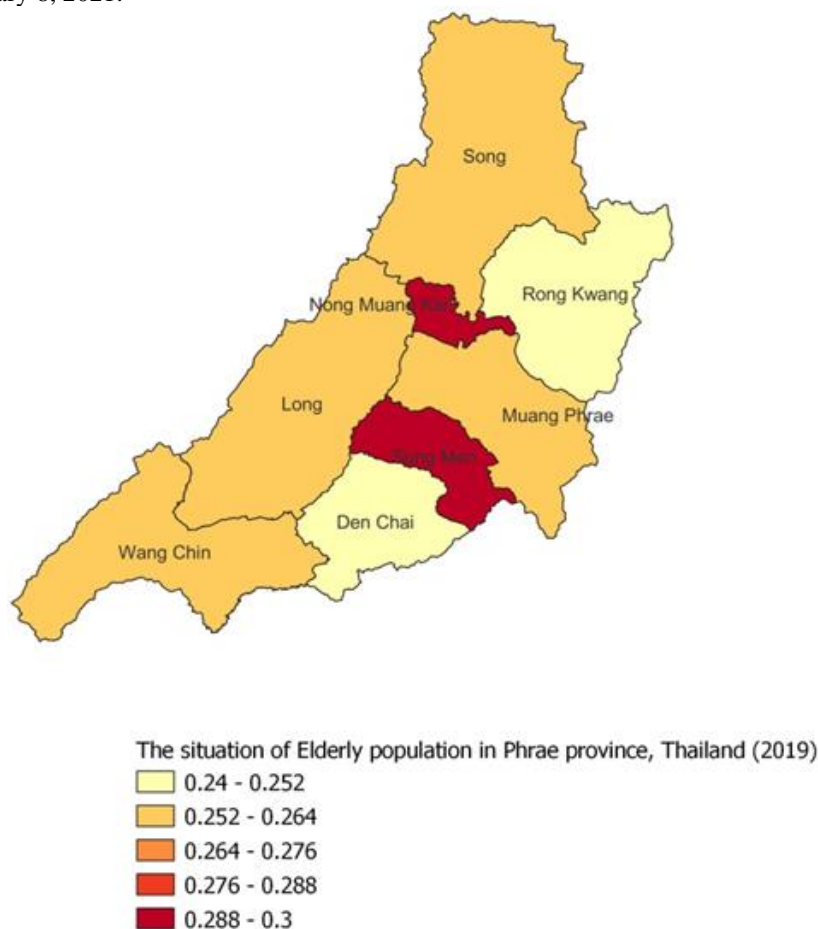- 0.264 - 0.276
- 0.276 - 0.288
- 0.288 - 0.3

Figure 1: The Geographic information of the ratio of elderly population with total population in Phrae province, Thailand (2019)

Table 1: The situation of Elderly population in Phrae province, Thailand (2019)

District	Number of total population	Number of elderly population	The ratio of elderly population
Muang Phrae	89,733	24,038	0.26788
Sung Men	55,992	16,771	0.29952
Long	39,861	10,586	0.26557
Song	35,145	9,470	0.26945
Rong Kwang	34,933	8,596	0.24607
Wang Chin	32,230	8,381	0.26003
Den Chai	25,439	6,106	0.24002
Nong Muang Khai	12,320	3,787	0.30738
Total	325,653	87,735	

Table 2: The ratio of elderly population with total population in Muang Phrae district by sub-district (2019)

Sub-district	Number of Population in sub-district	Number of elderly population	The ratio	Sub-district	Number of Population in sub-district	Number of elderly population	The ratio
Nai Weing	15,437	3,882	0.25147	Ban Thin	6518	1,515	0.23243
Na Chak	7,126	1,500	0.21049	Suan Khuean	5251	1,177	0.22414
Nam Cham	1,397	425	0.30422	Wang Hong	3172	806	0.25409
Pa Dang	2,666	1,142	0.42835	Mae Khum Mi	7256	1,897	0.26143
Thung Hong	6,112	1,289	0.21089	Thung Kwao	5834	1,248	0.21391
Mueang Mo	9,123	2,271	0.24893	Tha Kham	2391	466	0.19489
Wang Thong	2,509	647	0.25787	Mae Yom	1906	347	0.18205
Mae Lhai	4,469	956	0.21391	Cho Hae	8979	1,814	0.20202
Huai Ma	6,465	431	0.6666	Rong Fong	5367	687	0.12800
Pa Maet	12,140	2,860	0.23558	Kan Chana	1,003	4474	0.22418
Total	67,444	15,403		Total	47,677	14,431	

Table 3: Trend of hypertension case fatality rate in Phrae province, Thailand (2015-2018)

A.D.	Case fatality rate (per 100 population)	National ranking (Thailand)
2015	16.13	1
2016	4.43	8
2017	3.32	18
2018	4.00	2
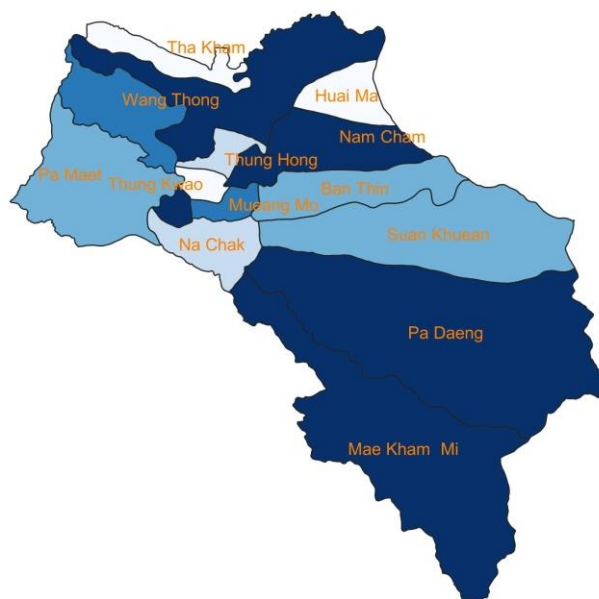
The ratio of Elderly population in Muang Phrae district by sub-district (2019)
- ☐ 0.02 - 0.198
- ☐ 0.198 - 0.218
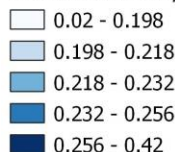- ☐ 0.218 - 0.232
- ☐ 0.232 - 0.256
- ☐ 0.256 - 0.42

Figure 2: The Geographic information of the ratio of the elderly population with total population in Muang Phrae district, Phrae province, Thailand (2019)

3.3 Results of Study Procedures Followed the Deming Cycle

3.3.1 Results of study procedures: Plan (P)

From group meeting found we founded with high blood pressure were lack of physical activities, poor food consumption behavior such as eating salty and greasy food, having stress on moderate level or above, and not regularly measuring their blood pressure. Besides risk factors, researchers founded another interesting point from stakeholder showed in Table 4. Target group of this study was elderly people at risk of hypertension. So, researchers considered on problems and requirements of them for analyzed and used for developing an application. Also, researchers considered and took problems and requirements of another as supporting on created an application as well.

3.3.2 Results of study procedures: Do (D)

After researchers considered and analyzed data from Phase 1: Plan, the researchers and application creator used all data from the literature review in conjunction with Health Belief Model (HBM) to create the Prevent-U application. The details, components, and function of the application were the following: The Prevent-U application had 2D graphics and displayed all text in the Thai language.

It was based on key concepts of the HBM. In addition, this application could be downloaded from Google Play store only. There were neither costs nor fees to use the application. The Prevent-U application consists of 5 systems: personal mode, data mode, collecting mode, report consulting consult mode. The mechanics and example of the Prevent-U application showed in Figures 3 and 4. In addition, the details of each system on the Prevent-U application showed in Table 5.

3.3.3 Results of study procedures: Check (C)

Next, the researchers analyzed user satisfaction from 45 volunteers. The table below shows the user satisfaction with the Prevent-U application among elderly participants at risk of hypertension (Table 6). Even totally they were pleased with the Prevent-U application; we got comments from volunteers about systems used. Firstly, collecting data should make it less complex and uncomplicated to fill out data. In addition, sometimes downloading data from the data system took a long time, it was a barrier and made them less attractive on reading data. So, after we got their comment, the researchers and application creator worked together to edit some of design elements for visuals and text to make them more suitable for elderly people.

Table 4: Details of problem and requirement of stakeholder by group meeting

Stakeholder	Exiting Intervention	Problem	Requirement
Director of health-promoting hospital	Implementation standard care for Hypertension patients and people at risk of hypertension	- Sometimes, patients forgot an appointment or cannot go to health-promoting hospital for received service. - patients unawareness of their risk behavior	Intervention or innovation his elder that friendly, accessible, and useful for self-management from everywhere.
Health workers			
Health volunteers			
Hypertension patients	Received standard care from health-promoting hospital - interview and history taking - blood pressure levels service - dispensation service - health care consulting service P.S. service follow an appointment on Wednesday	- forgot an appointment or cannot went to health-promoting hospital for received service. - forgot health care consulting	- easier understand, accessible and reliable data for preventing hypertension
Elderly people at risk of hypertension	Received stand and care from health-promoting hospital - interview and history taking - blood pressure levels service - health care consulting service	- forgot health care consulting - some of them unawareness of their health status, so they did not attention on their risk behavior and did not follow the health care consulting	- Need to know their health status and can check it by themselves - tool for help on self-management - easier understand, accessible and reliable data for preventing hypertension

Table 5: Details of each system on the Prevent-U application

System	Description
Personal mode	Personal mode which related to showing characteristics data of users. The following are characteristics data that users have to record; ID number received from researcher, gender, age, height, weight, BMI and Health insurance. Almost of characteristics data users just record those data only once at first log in, except weight. Users have to re-record about weight every week.
Data mode	Automatic system for giving information to users. Users can read info about Hypertension every week, 12 weeks. Each week has difference topic. All topic present with info graphic and displayed in Thai language. Topic in data mode separated to 12 topics such as basically knowledge of Hypertension, Food for changing blood pressure, flavoring, work out for elderly with Risk of Hypertension, Thai herbs and sake of herbs for reduce blood pressure, how to measure blood pressure at home and complications of Hypertension.
Collecting mode	A system related to recording data about blood pressure level, consumption behavior and exercise of users. Users have to record all data by themselves every week (1 day per week). After they recorded data, the system will evaluate users data and feed data back to users to show trends of change each week in number, color level and line graph

|	
Report mode	Reporting mode is a function that sends warning the users when score or data that users recorded higher than standard score. So, this mode linked and collaborate working with collecting mode. 　Users will notice from report mode when data or score which they recorded in application is higher than standard score more than 2 times.
Consult mode	A one-way communication service for searching frequency asked questions about Hypertension. Users who get warn or notice from for report mode can search more information about Hypertension in this function.
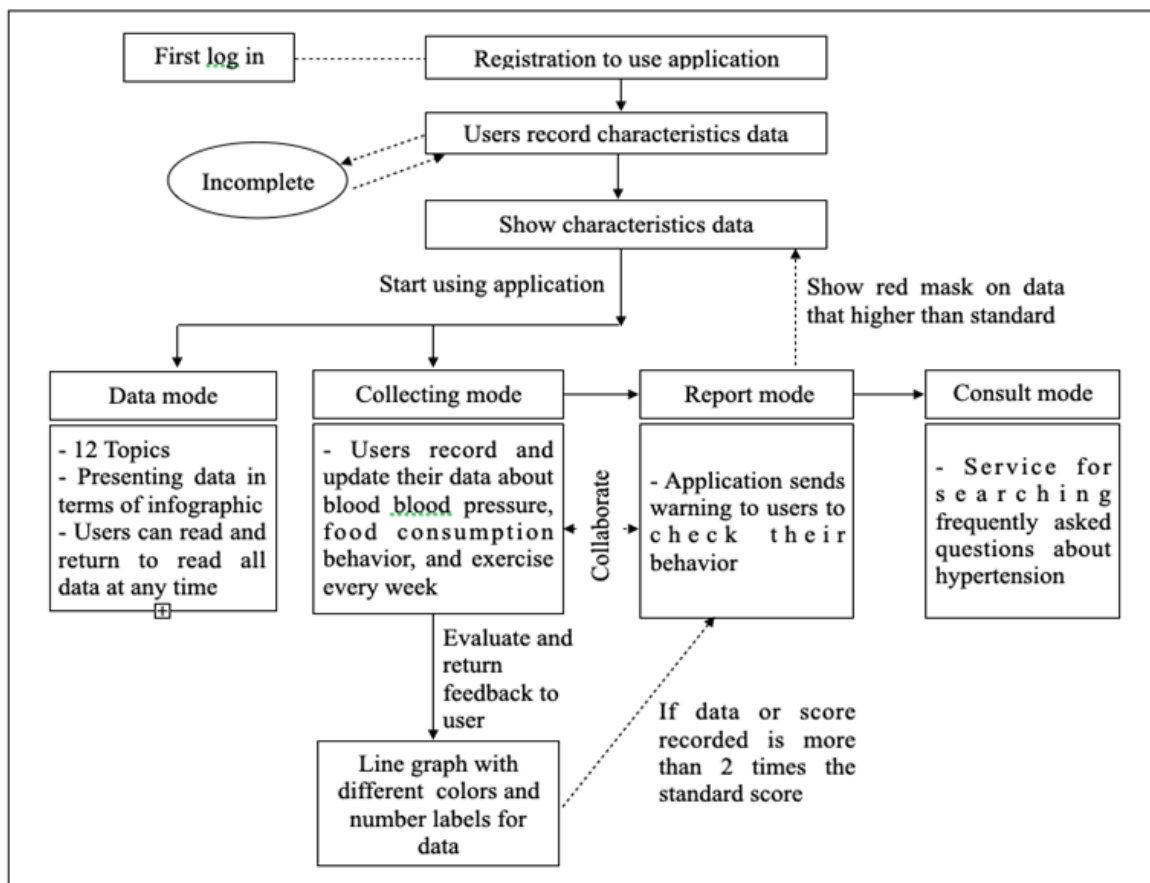
Figure 3: Flow chart showing the mechanics of the Prevent-U application (Authors 'design)

Table 6: User satisfaction on Prevent-U application among elderly participants at risk of hypertension (n=45)

| Design of application	Mean	Efficiency of application	Mean
Application uses readable font and text sizes for elderly	2.41	Using each menu buttons or toolbar gives quick and convenient	2.21
Design of application uses properly colors for elderly	2.65	Application is fast responsive and fast to load data	2.40
Icons and symbols easy to understand	2.33	infographic	2.25
Data content and infographic are beautiful and easily understand	2.44	All menu on application are user-friendly	2.69
Application design is visualization and interesting	2.58	Overall of satisfaction of Prevent-U application	2.53
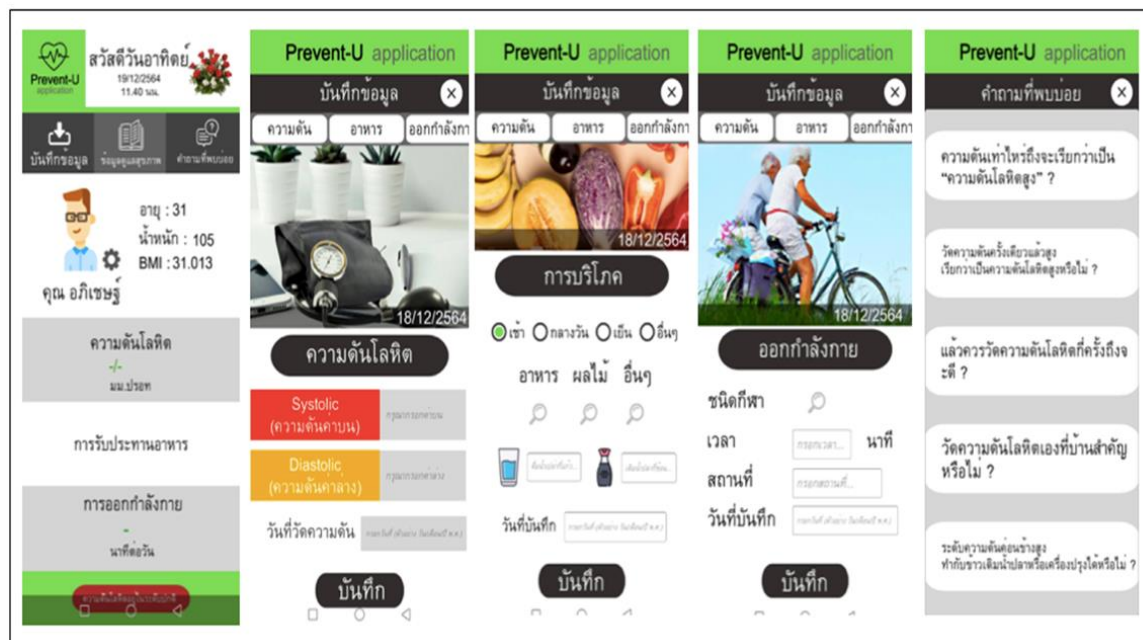
Figure 4: Example of Prevent-U application (Authors 'design)

We made sure the application was pleasant to look at on screen. We also fixed all defects, bugs and errors on the application. Moreover, the researchers adjusted some of more complex, intensive info graphics to make them more easily understood.

3.3.4 Results of study procedures: Act (A)
After this next round of modifications on the Prevent-U application was completed, the researchers and application creator re-tested application for last time before uploading it onto the Google Play store.

4. Conclusion
The Prevent-U mobile phone application to reduce blood pressure is an engaging intervention that perhaps may capture user's interest more effectively than other methods. The researchers selected this method to encourage participants to start taking care of their blood pressure more effectively and change poor behavior that may lead to developing full hypertension. The researchers expect that all other f systems and functions on this application will useful and will help users better manage and control their blood pressure.

5. Recommendation
This paper provides details on the study protocol. The current data in this paper only presents the process of developing and mockup of the Prevent-U mobile phone application. A future study is needed to examine how use of this application may be associated with better management and control of blood pressure levels among elderly patients at risk of hypertension.

Funding

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