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# Life style improvement mobile service for high risk chronic disease based on PHR platform

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**Abstract** As IT convergence technique develops, medical technology and apparatus are being modernized opening the era that we can obtain variable information easily anywhere, anytime thanks to wireless communication developed, further. These social changes enabled us to obtain information related to health more efficiently. Modern society is rapidly aging and more people experience chronic diseases because of their wrong eating habit, obesity and insufficient exercise. Thus a demand for health improvement and management at a certain term is increasing rather than complete therapy. Previously, major medical institutions managed personal medical history regarding patients mainly in health management but it is not changing its method to self-utilization and management by individual patient as of now along with medical institutions as fusion technology develops, and individual health record information can easily be checked anywhere, anytime through personal health record (PHR) platform. Unlike developing speed of related technology, however, there is a limitation in expansion, development of individual health record service, personal information security currently. In this paper, we propose mobile service regarding life style improvement targeting high risk chronic diseases based on PHR platform. PHR platform determines high blood pressure, diabetes, hyperlipidemia diseases which are three main chronic diseases using users' data and can monitor chronic diseases in portable mobile device. Also, the service provides by organically, mutually connected form through feedback towards input from health states of users in mobile device. By proposing contents about service based on efficient individual health record through mobile device that maximized transportability based on PHR platform, proposed method will contribute to industry development and activation of application service development of individual health record. Increase in consistency and reliability through standardization of afterwards health management service is expected to contribute to reduction in social cost and improvement of national health being the basis to realize communication activation of health record between medical institutions, efficient management and education of patients, reduction in dual examinations.

**Keywords** Chronic diseases · Elderly · PHR platform · U-Healthcare · Mobile application · IT convergence

## 1 Introduction

Paradigm of health management is changing because of multiple causes such as increase in medical costs, development in medical apparatus, increase in occurrence of chronic diseases, aging population, development in information communication. Recently, disease pattern has changed to chronic diseases focus from acute diseases focus regarding health of elders and to prevention and management of diseases from treatment after disease occurrence. Thus, smart health service that can manage health for disease management and prevention in daily life of elders is needed. A study on health management system is developed into a monitoring system with professionals in the hospital first-dimensionally. Recent

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disease management is changing to health management using smart device that is easy to access anytime, anywhere due to increase in the number of patients with chronic diseases. Availability of smart phone shows a high level exceeding 66.3 % of members thanks to development in information communication technology. In 2010, availability of smart phone in age of 45–74 was 30 % but in 2015, the age group with smart phone is rapidly increasing to 55 %. Among this, elderly group at age of 65–74 is more using it with wide range [1–4]. Health management based on smart device is medical service and health management considering convenience of users anywhere, anytime utilizing wired and wireless network, M2M, IoT, Peer to Peer by combination of IT and BT. It can provide remote medical service regarding chronic illness through re-feedback after analysis of data sent to medical institutions by wireless network measuring health information and body signal. Medical service which has been limited to temporary management and treatment in primary medical institutions is now changing to health management paradigm that can be used without spatial, time limit in daily routine through smart device from now on [5,6]. Recently, health management system using IT device has come out in the market as various products and its clinical effect is being verified continuously. Besides, many companies are investing and studying development of service solution associated with various devices development. We need social management since rapid increase in medical costs is expected along with increasing expectation regarding medical service, increase in chronic diseases, rapidly aging population. We need solution for social problem that steady life of elders fall as expenses on disease treatment and individual health management increase. When population older than 65 years old reaches 20 % due to rapid aging society, prevention and management of chronic diseases are one of matters that should be solved as important social issues. For patients with high risk target to perform disease management effectively, fusion technology based on smart health is needed more than anything. Recently, studies on health monitoring system, nonrestraint house type measuring sensor, remote medical service, M2M, wireless sensor that can be wearable for a long time are actively done. Also, service that measured heartbeat, respiration in mobile phone or MP3 player is launching. But most service is focused on general health management service based on remote monitoring and only provide display service that shows body signal information measured on the screen. This does not consider convenience of users and information is managed, created by medical service providers. To add, much health information searched on the internet currently can easily be used thanks to its features but it is hard to be continuously managed since health monitoring sites providing this only shows prescription depending on results and temporary measuring results to measurers only with figures of 1-day measuring result [7–11]. Likewise, it was hard to manage patients continuously since health information and many contents provided were not customized to users and monitoring service of health management now only provides prescription by measuring results without understanding measuring situation of users. To complement these matters, this paper proposes mobile service that can improve life style with high risk target of chronic diseases based on personal health record (PHR) platform [34,35]. Data can be received from PHR platform through mobile device, and users can input the data through it, enabling efficient health management. Also, the personalized service can be provided so that life style improvement service can be received for chronic disease management and monitoring anywhere, anytime through portable mobile phone as well as in hospitals regarding one's own health state.

The rest of this paper is organized as follows. Section 2 describes research related to the chronic disease management service for elderly and clinical decision supporting disease management. Section 3 describes the chronic diseases with high risk based on PHR platform. Section 4 describes the system and implement of the life style improvement mobile service. Conclusions are given in Sect. 5.

## 2 Related research

### 2.1 Chronic disease management service for elderly

Chronic diseases increase due to lifespan lengthening, improvement in quality of life, changes in life style, with aging population becoming social issue in medical industry. Unlike past, need for continuous management and improvement rather than approach in treatment dimension of diseases is continuously being proposed. Birth rate of our society rapidly decreases, entering so-called super aging society where elder population rapidly increases. In case of our country as of now, elders older than 65 years old take up 12.2 % of total population in 2013, increasing every year and the prospect says it will enter super aging society with 24.3 % in 2030. Especially 4 of 5 elder population have more than 1 chronic diseases. Most of elders suffer from diseases and consideration regarding needed cost for health management and later life medical costs is needed accordingly since disease management is a major factor in later life. Thus, elders need primary preparation through regular check-up or exercise and secondary preparation for prevention and treatment of diseases. There is Q-care [12] service made by collaboration of qualcome,[1] Ministry of Health and Diseases, Kyunggido, KT as the previous study to solve problems of increase in medical costs of aging society using fusion technology based on information communication. Q-

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[1] Qualcomm, https://www.qualcomm.com/.
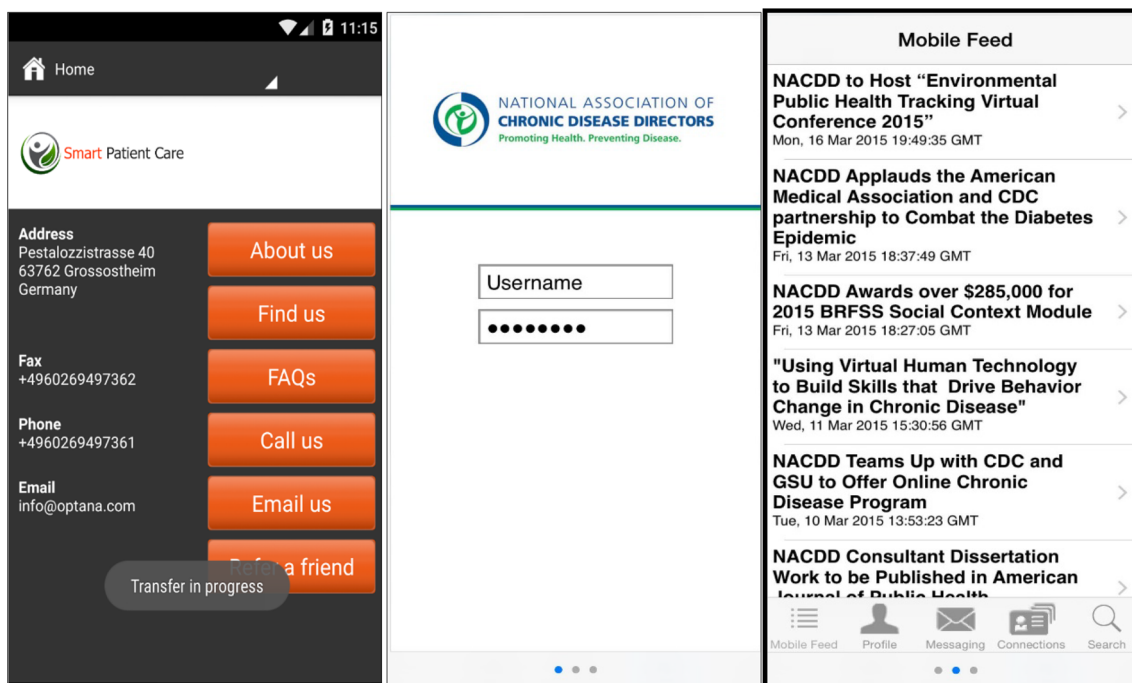
**Fig. 1** Previous health management service of chronic diseases for elders

care service enables patients with chronic diseases such as high blood pressure, diabetes, blood pressure management to receive health management of users anywhere, anytime through smart phone and Internet. Service enables patients with chronic diseases such as blood pressure management, diabetes and high blood pressure to receive health management by users anywhere, anytime through smart phone or Internet. Smart patient care system (SPaCS) [13] is a smart application that can manage, prevent diseases such as diabetes, high blood pressure, asthma. Mobile wireless health solution [14] of IBM is a mobile health care service that can measure, transmit information related to health such as blood pressure, weight, electric cardiogram, heartbeat in usual times regarding mobile health care. Figure 1 shows the previous health management service of chronic diseases for elders.
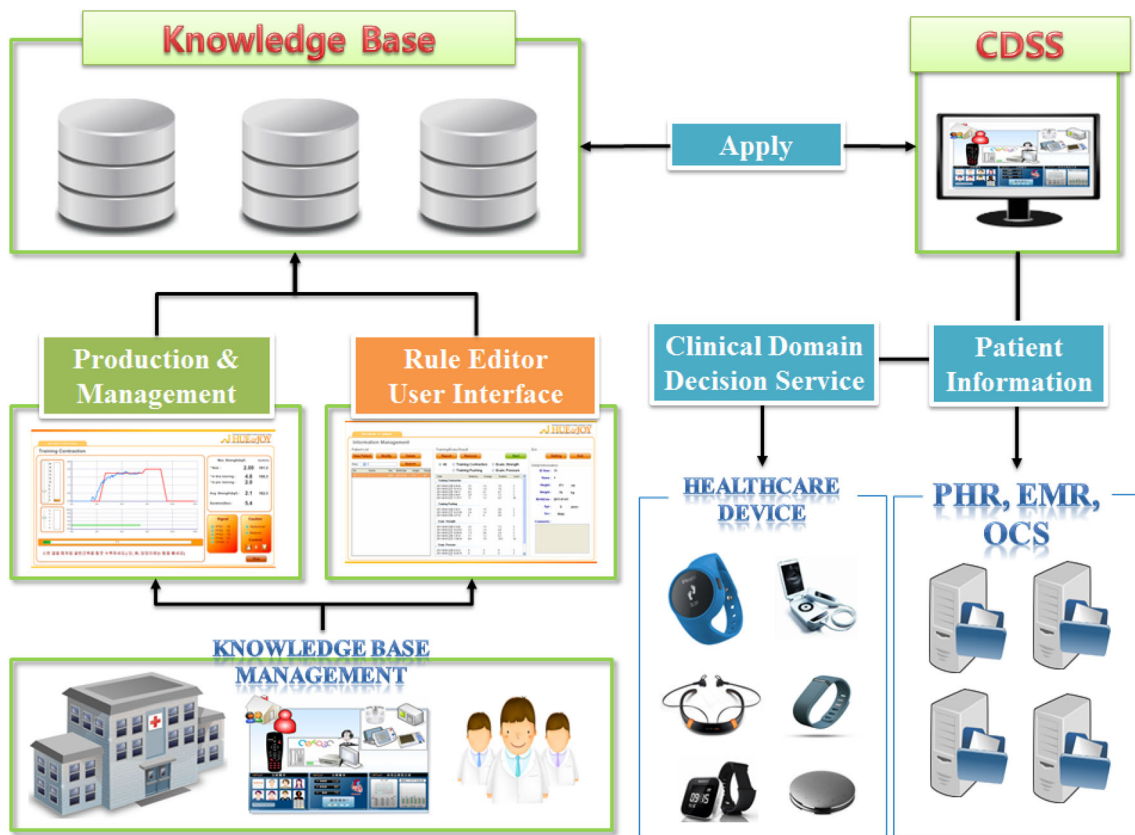
### 2.2 Clinical decision supporting disease management

Clinical decision support system (CDSS) supports decision making applying communication and information technology related to medical studies and treatments about diseases of patients. To improve patients' treatment, it provides patients and doctors information and clinical knowledge by intellectual decision making rule at right point to patients and doctors [32–34]. Generally, objectives of CDSS means drawing clinical task or process. Components of CDSS are decision making model that analyzes. Organizes data and knowledge for data calculation, information model used

in deduction, knowledge basis function, result of decision making model, host application and application setting that transmits, collects data having interaction with application [15–20]. Major function of CDSS performs decision making support function, cost control function, management function over clinical complexity and detailed level, management and administration function. There is decision making support system in clinics with management on high blood pressure, ubiquitous high blood pressure management system applying CDSS by Catholic U-health care business group, half-automated blood sugar management system applying CDSS, internet based glucose monitoring system [21], life style improvement system customized to targets with high risk of chronic diseases, customized information provision system targeting members of health insurance that Seoul medical university of national health insurance participated in case studies utilizing domestic CDSS [27]. Figure 2 shows the process of clinical decision support system.

## 3 Chronic diseases with high risk based on PHR platform

Medical guideline and high risk disease management model of chronic diseases are needed to provide mobile service of life style improvement of chronic diseases. This paper describes disease management model of high risk regarding high blood pressure, diabetes, hyperlipidemia with high disease distribution among chronic diseases. Mobile ser-

**Fig. 2** Process of clinical decision support system

vice for life style improvement targeting high risk group of chronic diseases based on proposed PHR platform needs data distinction regarding diseases for efficient chronic disease management of users. National health examination result [22, 34] utilizes blood pressure and pulse measurement, urine and blood, body fat examination, exercise. Smoking, body weight index as examination factors that can be utilized according to diseases of chronic diseases to create management model for high risk of chronic diseases. This utilized decision making model based on rules of chronic diseases by CDSS [15–20, 23, 28, 34] in PHR platform of prior studies. When decision standard of high blood pressure, diabetes, hyperlipidemia, chronic diseases, is analyzed in decision making model based on rules of CDSS, there is a high possibility that another chronic diseases can occur at the same time when one has only one disease among chronic diseases such as high blood pressure, diabetes, hyperlipidemia and we can see that diagnosis standard for each chronic disease is not very different [22]. Thus, monitoring mobile service of chronic diseases model to enable service to users by dividing these complex chronic diseases into disease management of high risk group in high blood pressure and hyperlipidemia/diabetes for efficient management is needed.

### 3.1 High blood pressure high risk management model

High blood pressure, one of chronic diseases, is known as an important risk factor of cerebrovascular and cardiovascular disease which are 2nd, 3rd place of death cause in our country. High-fat diet and obesity due to lack of exercise, smoking, too much salt ingestion and low potassium and magnesium ingestion, too much alcohol ingestion, stress are said to be representative life environment factors that cause high blood pressure. Chronic diseases such as cholesterol, diabetes, kidney disorders as well increase the risk of high blood pressure. Improvement effect, complication occurrence, symptoms are observed, recorded, reported to medical faculty for accurate diagnosis and treatment to prevent and cure high blood pressure. Besides, active self-control management such as life style correction or ingestion of one's own drug is needed [24].

Dietary control focused on low salt ingestion is very crucial for high blood pressure. Food with high salt content is excluded in diet recommendation and instant food should not be ingested to reduce ingestion of potassium. the major cause of rise in blood pressure. Also, extreme exercise should be avoided since it can negatively affect high blood pressure and right kind and amount of exercise should be set through consultation with doctors when there are complications such

**Table 1** Diagnosis standard for high blood pressure by blood pressure

| Classification | High, blood pressure (mmHg) | Low, blood pressure (mmHg) |
|---|---|---|
| Normal | <120 | <80 |
| Pre-high blood pressure | 120–139 | 80–89 |
| Blood pressure, stage1 | 140–159 | 90–99 |
| Blood pressure, stage2 | ≥160 | ≥100 |
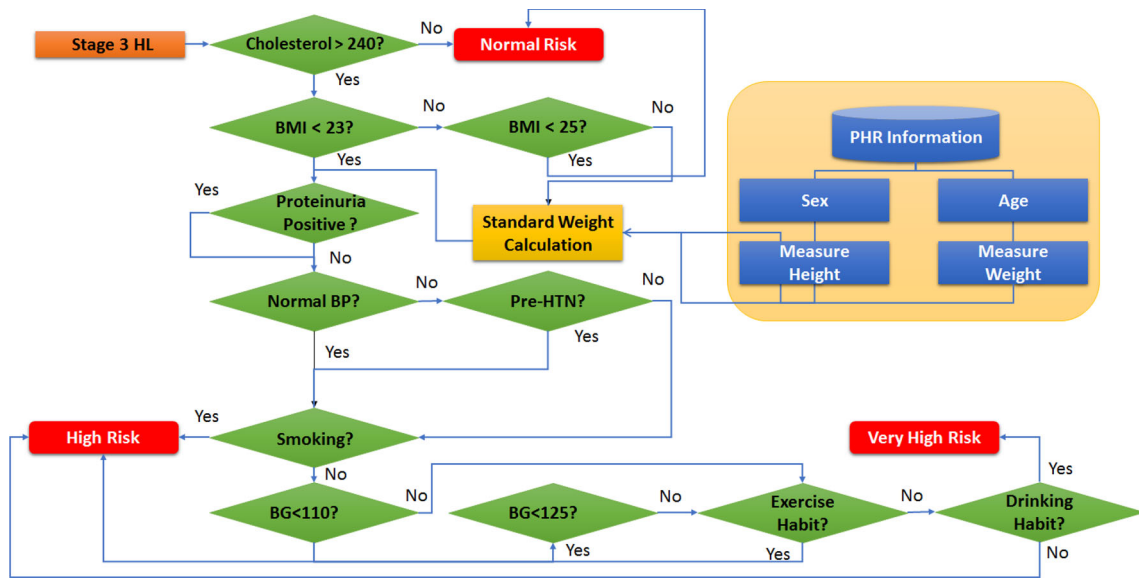


**Fig. 3** High blood pressure disease basis process in PHR platform

as heart disease or kidney disorder and one must not exceed it. Table 1 shows diagnosis standard for high blood pressure by blood pressure [25].

Diagnosis of high blood pressure disease identifies meaningful data regarding risk factors related to high blood pressure and personal medical history in PHR platform then creates decision making model based on rules through identified data. Rule basis process is proceeded based on medical history data that users put and data in PHR platform. High blood pressure management process is created using examination investigation data and basic information of users. Here, blood pressure, pulse, blood, urine, body fat test, exercise, smoking, body weight index, family history are data for examination investigation. Figure 3 shows the rule basis process of high blood pressure disease in PHR platform.

### 3.2 Diabetes/hyperlipidemia high risk management model

Diabetes is a metabolic disease caused when energy needed by body cells cannot be converted from glucose ingested in food form. Diabetes is classified into primary and secondary type and primary diabetes take up less than 10 % of total diabetes patients while secondary patients take more than 90 % of total diabetes patients. Insulin cannot be produced at all in primary diabetes. Secondary diabetes is common among metabolic diseases it is affected by life factors such as genetic factors, diet, lack of exercise, stress. Primary diabetes cannot be prevented and is shown naturally in young adult or children. Too much glucose remains in blood to destroy every damaged organ and body if not treated. Complication of diabetes can be fatal, causing heart disease, blindness, kidney failure, limb damage. Secondary diabetes usually occurs because of acquired factors being affected by life style factors. Those who are extremely obese or overweight are exposed to risk for diabetes because of lack of exercise. Eighty percentage of secondary diabetes can be prevented by simple changes in life style and medical attempt to accompany weight loss with right exercise, drug treatment for diabetes is on progress [26–28, 30–33]. Thus, systematic management such as diet, exercise, drug prescription is necessary for prevention and treatment of diabetes disease. This paper develops a process focused on model for secondary diabetes management. Diagnosis standard for diabetes is shown in Table 2. Figure 4 shows the diabetes rule basis process in PHR platform.

Hyperlipidemia is a state that cholesterol or neutral fat in the blood increased exceeding a certain amount. It is a cardiovascular disease that causes inflammation since serum lipid is melted abnormally too much with fat material accumulated

**Table 2** Diagnosis standard for diabetes

| Grade | Before meal (mg/dL) | After meal (mg/dL) | 2 hours after meal (mg/dL) |
|---|---|---|---|
| Hypoglycemia | Below 70 | Below 100 | Below 70 |
| Normal | 80–110 | 110–200 | 80–140 |
| Hyperglycemia | Above 140 | Above 220 | Above 170 |
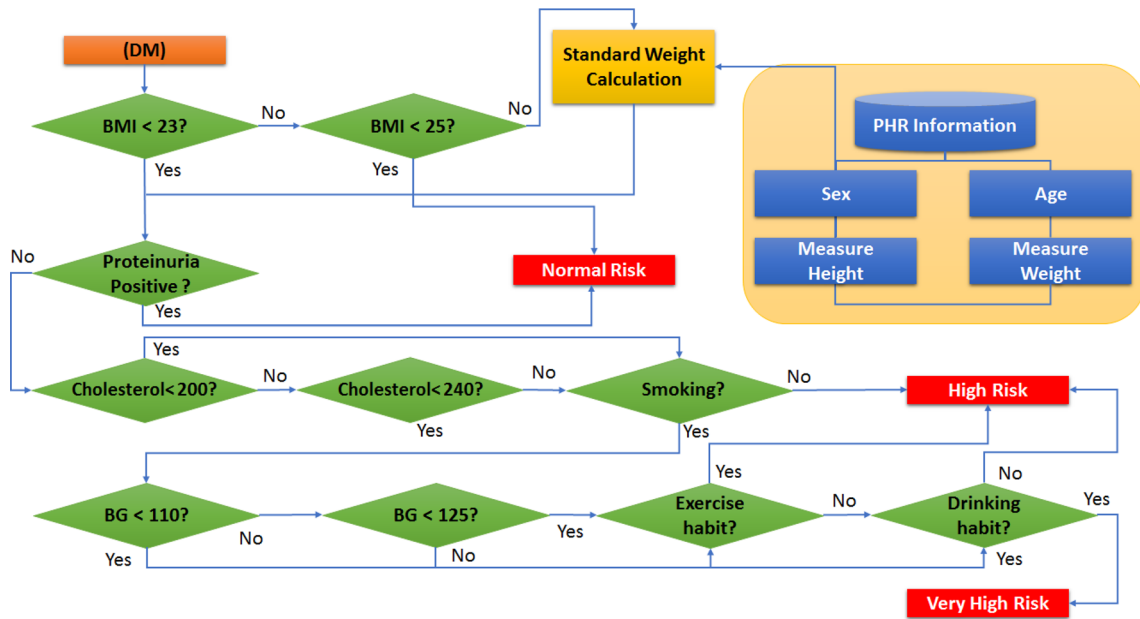


**Fig. 4** Process diabetes rule in PHR platform

**Table 3** Diagnostic standard for hyperlipidemia

| Classification | Range (mm/dL) | |
|---|---|---|
| Hyperlipidemia stage1 | Cholesterol < 200 | LDL 130–159 |
| Hyperlipidemia stage2 | 200 ≤ Cholesterol ≤ 239 | LDL 160–189 |
| Hyperlipidemia stage3 | Cholesterol ≥ 24 | LDL >190 |

in the blood more than needed. Abnormal state of serum lipid in the blood is also called dislipemia. Too much ingestion of animal fat, drinking, lack of exercise cause fat in the blood not to burn leading to blood contamination by fat accumulated in the body, causing hyperlipidemia. Hyperlipidemia is diagnosed by measuring figures of HDL-cholesterol, LDL-cholesterol, neutral fat, cholesterol in the blood through blood test after fasting generally. Table 3 shows diagnostic standard for hyperlipidemia. Figure 5 shows the hyperlipidemia rule basis process in PHR platform.

## 4 System and implement

### 4.1 Service environment

Users put medical history directly through mobile device in smart health and it is transmitted, analyzed to PHR server through the previous home gateway [30,35]. Analyzed information provides monitoring service of chronic diseases to users through mobile application UI and gives a feedback. The server module that protects medical information and conforms to safe guideline with Health Level 7 (HL7) standard [29], coding based on the standard are used upon data sync in PHR platform. Server module analyzes current health state information, HL7 based medical information, and synchronizing EMR of hospital and medical institutions in PHR platform. Data transfer between server and mobile with Android basis uses interconnecting technology with HTTP basis developed recently [28]. Analyzed information provides life style improvement guide, exercise therapy, dietary nutrients, life health index, and health information to users through mobile service [30,31]. This is provided by users for management of chronic disease with high risk based on PHR with the feedback. Figure 6 shows the service environment in PHR platform. This service environment is provided the
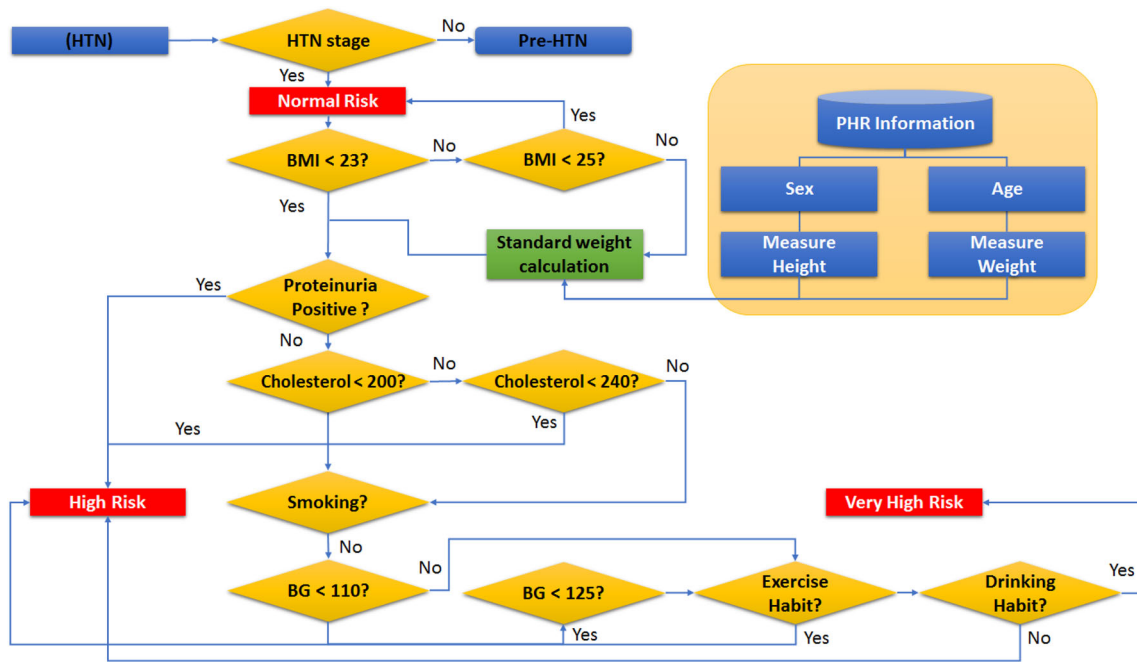
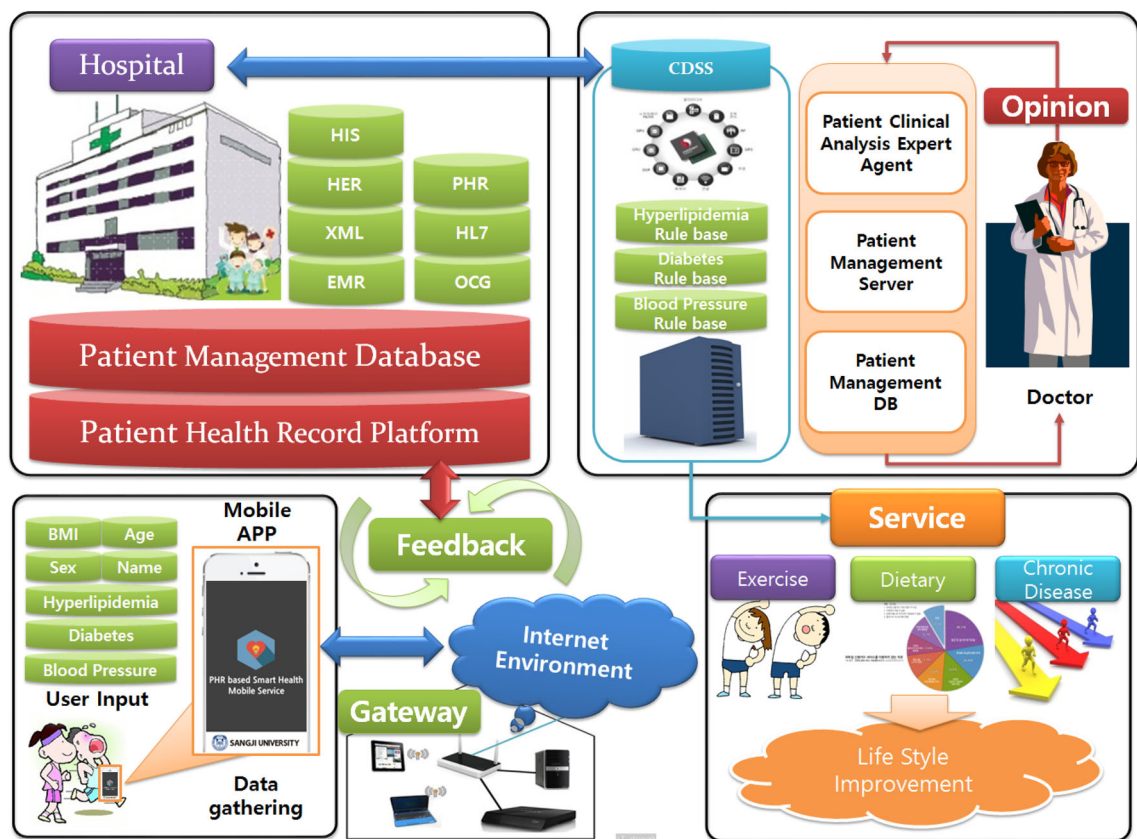**Fig. 5** Hyperlipidemia rule basis process in PHR platform



**Fig. 6** Service environment in PHR platform

mobile service on life style improvement of chronic diseases with high risk based on PHR platform.

## 4.2 Life style improvement mobile service of chronic diseases with high risk

Mobile service on life style improvement of chronic diseases with high risk was developed utilizing Android Studio 1.1.0 in environment of Windows 10 Pro. KN 64 bit, in specifications of Intel(R) Xeon(R) CPU E5-1620 v2, 3.7 GHz, 12.00 GB RAM in PHR platform [30,31,35]. Life style improvement service of chronic diseases is comprised of obesity state, disease management, disease prevention. Obesity state provides obesity measurement, body weight index measurement, obesity of abdomen measurement, obesity risk index measurement, diet recommendation while disease management provides high blood pressure, hyperlipidemia, diabetes management and health calories, diet addiction therapy. Disease prevention provides management over exercise amount, setting exercise goal, blood pressure, blood sugar, cholesterol, blood sugar/cholesterol to prevent chronic diseases. As a service for diet of chronic patients, self-diagnosis provides diet recommendation by dietary habit, stress, depression.

It provides daily changes in blood pressure service by putting data, time, figure of low blood pressure/high blood pressure to users to prevent and manage high blood pressure diseases. Blood pressure in relaxation period, in contraction period, on average time, pulse put through UI are shown in graph form for easy understanding to users through period searching of first data and last data. Normal range of blood pressure is below 80 mmHG in relaxation period and 120 mmHg in contraction period. Patients with high blood pressure or high risk group can set goal figure of blood pressure by users diagnosed by doctors. PHR button can be pressed to receive data through interconnection of electronic medical record (EMR) diagnosed by hospitals for users through PHR platform. Besides, time to be measured can be stored by receiving figures of high blood pressure/low blood pressure of users and disease management of high blood pressure with high risk is possible through graph of blood pressure change. Figure 7 shows interface of blood pressure input for disease management of high blood pressure.

Users can put time to measure the blood pressure in memo part, putting pulse numbers, average blood pressure, and blood pressure in contraction period, relaxation period in interface of blood pressure input. Users can determine the colors based on the standard of high blood pressure decision in primary, secondary high blood pressure, delivery period, average blood pressure in interface while putting blood pressure of them. Medical history of users put is represented after being recorded by data in the diary related to high blood
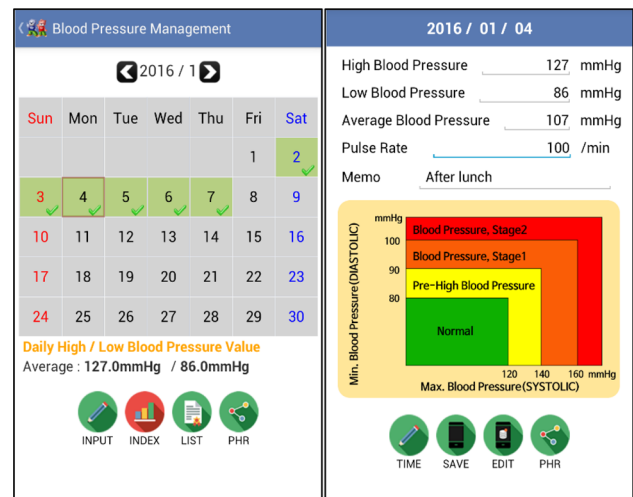


**Fig. 7** Interface of blood pressure input for disease management of high blood pressure
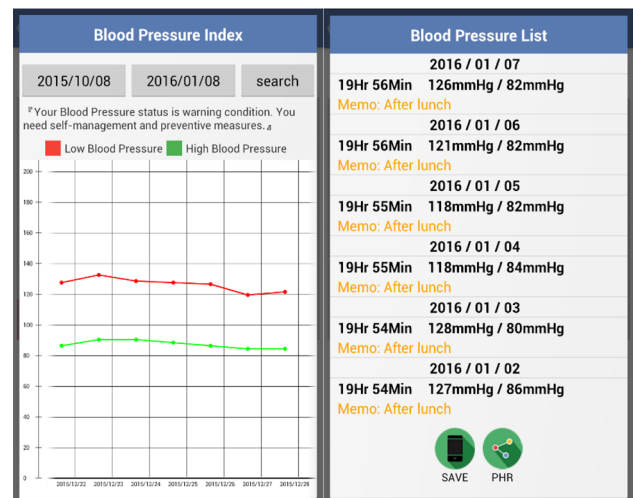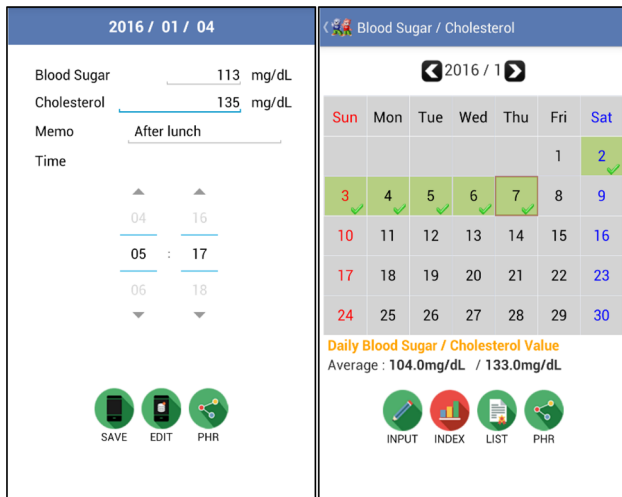


**Fig. 8** Graph and list of blood pressure change for high blood pressure management

pressure. Blood pressure in relaxation period, on average, contraction period was calculated, shown to users. Blood pressure information by hospital medical history or history data of users is synchronized in the real time with PHR platform through PHR sync button.

Figure 8 shows graph and list of blood pressure change for high blood pressure management. If you put starting date and period in the diary of high blood pressure management, you can see changes in blood pressure in the present and past. Change amount in bottom part shows figure of blood pressure in relaxation period, while change amount in upper part shows figures of blood pressure in contraction period in blood pressure change graph. Blood pressure information of users shown in blood pressure change graph is shown in daily unit and disease management of high blood pressure with
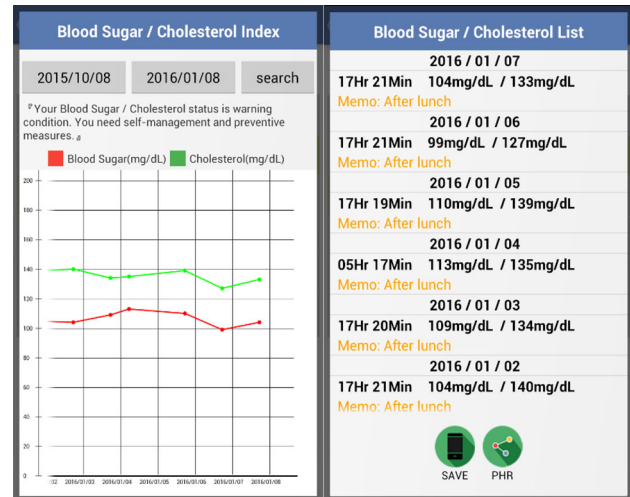
**Fig. 9** Input interface of cholesterol and blood sugar



**Fig. 10** Graph and list of blood sugar/cholesterol change

high risk is possible. This applies medical guide that severe blood pressure change increases death risk in patients of high blood pressure with high risk. Those who have higher blood pressure change width than 14 was shown to have high death risk with increasing risk of stroke and heart disease. If there is a big difference in blood pressure measured at the same time daily, improvement over life style is needed since it is high blood pressure of high risk. Blood pressure change list shows measured data, notes, time that data was put regarding blood pressure of users in history data. This is stored in database after being synchronized in the real time in medical history of users of PHR platform.

Abnormal blood sugar and cholesterol become the basic cause of diabetes and hyperlipidemia which are chronic diseases of representative high risk group. Blood sugar/cholesterol figure, data, time of users are put for efficient management to prevent and manage chronic diseases of high risk group. Figures of blood sugar/cholesterol users put are shown in graph form for easy understanding through period searching of first date and last date. Normal range of blood sugar/cholesterol is below 120.0 mm/dL of blood sugar, cholesterol below 140.0 mm/dL. Chronic patients with high risk group can set goal figure of blood sugar/cholesterol of users diagnosed by doctors. Figures of blood sugar and cholesterol can be individually managed each. Fundamental figures of blood sugar/cholesterol should be shown in one graph for efficient monitoring since hyperlipidemia and diabetes are likely to appear as complication disease of arteriosclerosis such as high blood pressure, angina, myocardial infarction, and stroke. In addition, if one uses PHR synchronization button, users can easily receive data through link with EMR diagnosed in the hospital. Figure 9 shows input interface of cholesterol and blood sugar.

Users input blood sugar and cholesterol in input interface of it and time of measurement in memo part. Users can easily input time of measurement of blood sugar and cholesterol through scrolls and input information of users is stored by data in management diary of blood sugar and cholesterol, with average blood sugar and cholesterol being automatically calculated then shown. Life style improvement is needed such as diet improvement, aerobic exercise, right weight maintenance, smoking in case of hyperlipidemia with high risk higher than normal cholesterol figure. Medical history data and health examination result are provided through real-time synchronization in PHR platform since blood sugar and cholesterol can be known through blood test.

Figure 10 shows graph and list of blood sugar/cholesterol change. Examination data put in the diary of blood pressure/cholesterol is shown in graph form by date if first date and period are put. The graph in the bottom shows figure of blood sugar while the graph in the top part shows cholesterol figure. Blood sugar and cholesterol information of users shown in graph can be checked regarding its change state of blood sugar and cholesterol in the present and past by daily unit. State change graph of blood sugar and cholesterol of users can manage disease and improve life style. Change list of blood sugar and cholesterol presents data of blood sugar and cholesterol input and special note, time of measurement in history data. This is synchronized in the real-time in medical history by users of PHR platform and stored in database.

## 5 Conclusions

The era that we can obtain many kinds of information anywhere and anytime as medical service and apparatuses have been developed using fusion technology based on M2M, IoT, Smart health has come. Human became to obtain infor-

mation related to health more efficiently thanks to these social changes. Chronic diseases are increasing due to wrong dietary habit, obesity, lack of exercise in rapid aging society. Current health management includes regular national health examinations, manages personal medical history in primary medical institutions, and cures diseases. As convergence medical technology develops, there have been changes that patient himself control the self and utilizes along with medical institutions recently and they can easily obtain their own health record anywhere and anytime through PHR platform. Unlike developing speed of related technologies, however, there exists limit in expansion service of personal medical history, remote medical service, security of medical information, disagreement regarding privatization of medical service. This paper proposes mobile service of life style improvement targeting high risk group of chronic diseases in PHR platform. PHR platform manages diseases in mobile device as well as determining hyperlipidemia, diabetes, high blood pressure which are three main diseases of chronic diseases by utilizing health data of high risk group target and personal medical history. It receives health state of users in mobile device for high blood pressure, diabetes, hyperlipidemia disease management then stores them in PHR platform. It determines high risk group of chronic diseases of users by utilizing EMR data of medical institutions that determine high blood pressure, diabetes, hyperlipidemia which are three main diseases of chronic diseases in PHR platform then adjusts them to algorithm based on rules of CDSS. Also, it provides customized service by users through organic interconnection using feedback in disease management model of hyperlipidemia and diabetes, and high blood pressure targeting high risk group through mobile device. Service by user targeting high risk group provides diagnosis of high blood pressure, diabetes and hyperlipidemia disease together with medical guideline. Provided mobile service offers functions such as obesity management, obesity measurement, body weight index, abdomen obesity, diet recommendation, diet habit improvement of chronic patients. Elders with chronic diseases can also manage his own health more easily and conveniently by realizing UI/UX that considered convenience of users and receives convenient service such as communication and convenience in elderly group through mobile function. By suggesting element technology regarding life style improvement service and health management targeting high risk group through mobile device anywhere and anytime in PHR platform, it will contribute to the development of health industry and activation of application development in personal medical history. Increase in consistency and reliability through afterwards health management service standardization expects decrease in double examination, efficient patient training and management, activation in communication of medical history in silver town and nursing house. It is expected to contribute to decrease in medical costs that need social support and national health improvement.

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