International Journal of Bio-Science and Bio-Technology
Vol.8, No.5 (2016), pp. 115-128
http://dx.doi.org/10.14257/ijbsbt.2016.8.5.11

Healthcare Platform and Big Data Analysis Based Personal Fitness Healthcare Service Model

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Abstract

Human beings are living longer these days thanks to developments in medical technology and health care services, and accordingly, the global population is rapidly aging. The increasing aging generation is causing unexpected social problems, one of the most critical of which is government health care costs. Personal gene analysis results and record-based personal health care ICT services should predict and prevent personal diseases while improving wellness. Technically, gene sequencing technology development not only reduces the time to decode genetic information but also decreases the cost. Various disease-related gene mutations have been found, and gene sequencing service is a new paradigm in personal health care. In socioeconomic terms, the proposed service model not only accurately diagnoses diseases to provide effective health care but also reduces government health care costs while promoting personal well-being. In this paper, we propose a PGAR (personal gene analysis record) and PHR (personal health care record)-based personal health care service. We implemented this big data analysis-based health care platform for more accurate disease prediction and prevention. When the personal smart health care ICT service is used, it significantly reduces personal health care costs in hospitals.

Keywords*: u-Health, big data, ICT, PGAR, PHR, cohort DB*

1. Introduction

According to a South Korea National Statistical Office survey report in 2015, health care costs for the over 13.1% of South Korea's population aged 65 and up make up 35.5% of total health insurance costs. The accelerated aging of society causes several serious problems such as economic deprivation, various diseases, emergency response issues, mental isolation, and so on. The South Korean government is seeking ICT (information and communication technology)-based practical solutions to resolve these social problems. Society must resolve the health care problems of the aging generation to help them stay healthy. Problems include the burden of health care costs and the technical challenges of disease prevention [1].

As the population ages and chronic disease rate grows along with rapid progression to a low fertility, aging society, the cost, access and quality of medical service become issues. Therefore, measures to satisfy the desires of consumers to save on medical spending and conveniently use medical services by expanding the public medical system while using information and communication technologies are emerging as agendas for major government policies. Convergence between the medical service and ICT technology started in forms that provide medical

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ISSN: 2233-7849 IJBSBT

information to patients and has been developed into u-Health that enables monitoring of patient conditions by using wireless communication. u-Health now provides medical services anywhere at any time [2]. u-Health care service is progressing in many countries as the most effective desirable alternative for medical cost saving, reduction of socioeconomic costs, economic and industrial impact including market expansion, and social and policy effects on public medical service and preventive health control.

It has been claimed that gene technology will induce revolutionary changes in health care. A generic framework was developed to distinguish between methodologically similar evaluations of health care technology. Methodological issues and the current state of economic evidence concerning human DNA technology were extracted from publications within these groups of evaluations.

Economic evaluations of “health care consisting of gene technology” were identified primarily for in vitro diagnostics for hereditary disease as well as for pharmacogenetics and molecular pathology. “Health care enabled by gene technology” is far more encompassing and includes, for example, biotechnology drugs for which various health economic evaluations can be found [3].

The rapid expansion of big data analytics has started to play a pivotal role in the evolution of health care practices and research. It has provided tools to accumulate, manage, analyze, and assimilate large volumes of disparate, structured, and unstructured data produced by current health care systems. Big data analytics has recently been applied to aid in the process of care delivery and disease exploration. However, adoption rate and research development in this space are still hindered by some fundamental problems inherent within the big data paradigm [4].

This paper aims to establish a PGAR DB for diagnosis and accurate drug administration for various congenital diseases and a PHR DB for daily health care services and to provide personalized health care services offering disease prevention services anywhere at any time.

In this paper, related research is presented in chapter 2. This chapter includes prior research on health care and ICT convergence and big data analysis platforms for health care. The personal fitness health care ICT service system is presented in chapter 3. This chapter describes the PGAR- and PHR-based platform and personal health care ICT mobile services. System implementation and evaluation are presented in chapter 4. Finally, the conclusion will be presented in chapter 5.

2. Related Research

Actual u-Health services offered by service providers are broadly classified into patient service, physician assistant service, personal health care service, and service for information sharing with external systems (interoperability). Patient service includes functions that continuously track and care for a patient (patient follow-up) and analyze the disease condition of a patient (patient status analysis). Physician assistant service includes functions that enable a physician to manage information about his/her patients (patient data management) and effectively provide treatment support information (medical diagnosis assistance). Personal health care service includes functions for managing schedules (health care schedule management) and analyzing and supporting decisions through health condition monitoring (analysis and decision support). Interoperability service includes functions to share data with external systems (data import/export) and to synchronize data between institutions (data synchronization) [5].

The u-Health service is currently converting to digital health. Figure 1 shows the major changes:

Division	U-health
Service	Tele-healthcare, management of chronic patient
User	Healthcare provider, patient
Provider	Medical institute, ICT industry
Product	Biometric measurement device

Digital-health
U-health and exercise, nutrition and healthy life management
Healthcare provider, patient, the general public
Medical institute, ICT industry, Insurance company, sports industry etc.
Smart device and wearable mobile device

Figure 1. Health care and ICT Convergence Trends and Features

The current health care paradigm is lifetime health and the periods are as shown in Table 1.

Table 1. Health Care Paradigm Periods

Division	Health Care 1.0 Public Health Care	Health Care 2.0 Disease Health Care	Health Care 3.0 Wellness Health Care
Period	18th-19th centuries	20th century	Since the 21st century
Representative innovation	Iron vaccination	Penicillin discovery	The human genome project
Purpose	Prevention of infectious diseases and their spread	Health care and cure of diseases	Disease management and prevention-based well-being
Key indicators	Epidemic mortality	Life expectancy, mortality from serious illness	Wellness for life, hospital fee saving
Provider	Country	Pharmaceutical and medical device companies, hospitals	Existing suppliers and IT/electronic, construction, automobile companies, *etc*.
Consumer	Citizen	Patient	Everyone
Major changes in health care industry	Vaccination, water and sewage distribution Invention of the stethoscope and x-ray establish a positive framework	Pharmaceuticals, medical devices, hospital industrialization Developing new drugs and therapies	Early diagnosis of personalized genomes and health care U-health care provision
Achievement and limitations	Epidemic mortality Lack of individual diseases	Overcome serious illness from the development of new drugs and therapies Increased health care costs	

Healthcare 3.0 has the following features:

(1) As the aging generation grows, medical consumers in the 21st century do not simply seek to live long and healthy lives, but also want reduced medical costs.

(2) The concept of health care as daily routine management is changing for the above reasons, and personalized treatment will spread so that early diagnosis and minimally invasive surgery for diseases will become commonplace. Patient convenience and effectiveness will increase throughout the whole process from diagnosis to aftercare.

(3) The paradigm shift is triggering trends such as health care and IT convergence with day-to-day management of patient-centered health care, diagnosis, and more refined treatment.

(4) As health care for such consumers includes a variety of demands, it must converge with various technologies such as electronics, construction, automotive, tourism, *etc*.

(5) It is expected that health care business opportunities in the IT industry will expand, with efficient analysis of extensive medical data such as personal genetic information and digital imaging data.

2.1. Health care and ICT Convergence

As health care and ICT converge into an m-Health system, a patient measures his/her own bio signals with a mobile application or a proprietary PC application and sends the signals to the hospital's bio signal storage system. The patient's health care service provider then diagnoses the patient's condition through the hospital's bio signal storage system. The health care service provider also uses the mobile m-Health system application or a proprietary PC application to observe a patient and send the observation results as feedback to the patient [6].

Establishment of a personal health care platform based on the convergence of health care and ICT implements a 1:n service structure and provides more accurate and varied personalized services. Figure 2 shows differences between the existing general PHR service and the PHR service extended through the platform.

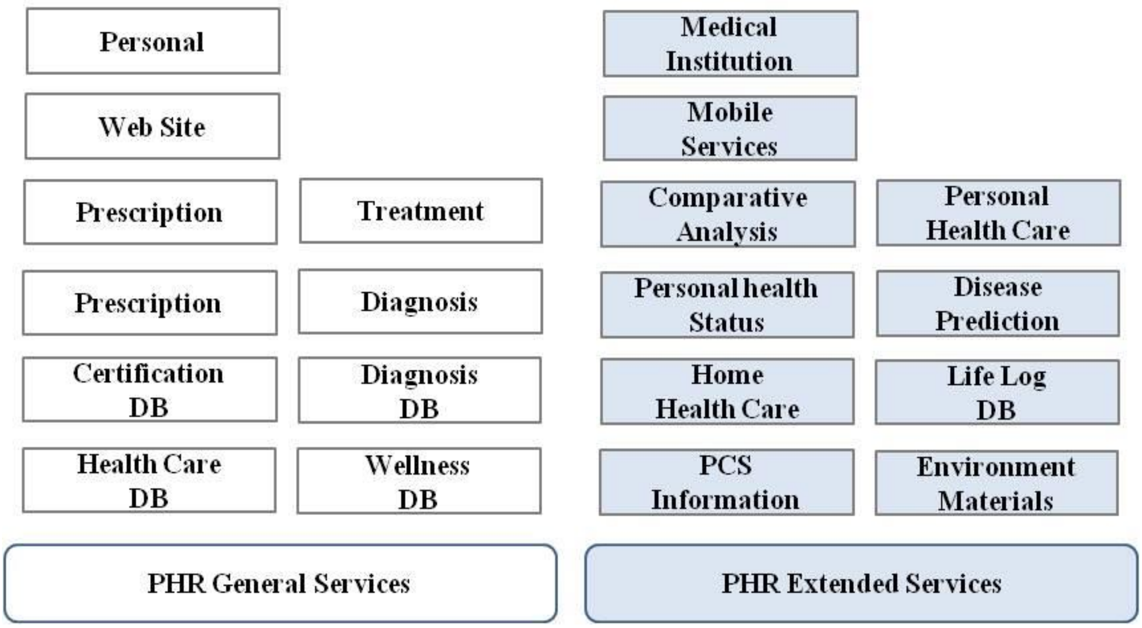

Figure 2. Structure of Ontology-Based Cohort DB

In the area of bio (medical) sciences and ICT convergence health care, there is an increasing need to integrate, normalize, analyze, store, and protect genomics data. Large datasets and scientific knowledge are rationally combined into valuable clinical information that ultimately will benefit human health care and lead to clinical practice. Data from biomarker discovery and NGS (next-generation sequencing) are very valuable and will be combined in comprehensive analyses to stratify medicine and guide therapy planning to ultimately benefit patients.

NGS personalized medicine generally promises to result in both higher quality of treatment for individual patients and in lower costs in health care since patients will be offered only those therapies that are more effective for them and treatments that will not be safe or effective will be avoided. Recent advancements in biomedical and genomic sciences have paved the way to translate such research into clinical practice and health policies. However, the move towards greater personalization of medicine also comes with challenges in the development of novel diagnostic and therapeutic tools in a complex framework that assumes that the use of genomic information is part of a translational continuum spanning basic and clinical research, preclinical and clinical trials, policy research, and the analysis of health and economic outcomes. The use of next-generation genomic technologies to improve the quality of life and efficiency of health care delivered to patients has become a continuous key theme in the field as benefits derived from such approaches include reducing a patient's need to go through ineffective therapies, lowering side- and off-target effects of drugs, prescribing prophylactic therapies before acute exacerbation, and reducing expenditures [7].

2.2. Big data Analysis Platform for Health Care

The main characteristic of big data is its massive size and complexity. Big data concerns not only the sheer scale and breadth of new data sets, but also their increasing complexity. A common way to describe the complexity of big data is the three "Vs": volume, variety, and velocity. Big data is a term used to describe information assemblages that make conventional data or database processing problematic due to any combination of their size (volume), update frequency (velocity), or diversity (variety). Veracity is a fourth "V" sometimes added to describe big data challenges [8]. To improve the quality of health care, we need to provide patient-centric services, detect spreading diseases earlier, monitor hospital service quality, and improve treatment methods. All these services need big data analytics for personal health care. The following are the 7 phases of ontology development methodology and the resolution measure for each phase [9]:

1) Determine the domain and purpose of ontology. The system domain is to set to the entire cohort DB while the purpose of an ontology-based cohort DB is to measure the connections between diseases and health information.

2) To reuse existing ontology, use an OWL API appropriate to the large cohort DB based on the ontology.

3) Establish the relations between diseases and health information of this system based on priorities to select critical objects for the ontology.

4) Define the DB table in Figure 3 as the main classes to define the classes and layers within the ontology. Define each layer by using the DB table and its sub-properties because the relations between the DB table and its properties are similar to the relations between the classes and objects in the ontology structure.

5) To define the characteristics of each class, first, consider the meaningful relations between the critical objects selected in 3). Then, define characteristics of each class according to the objects.

6) Limit the range and type of value to verify the effectiveness of each object forming the ontology based cohort DB. This is essential to delete invalid data due to the characteristics of this system forming a large DB.

7) Create each instant by entering diseases and health information for the cohort DB as the instant and characteristics of the corresponding class.

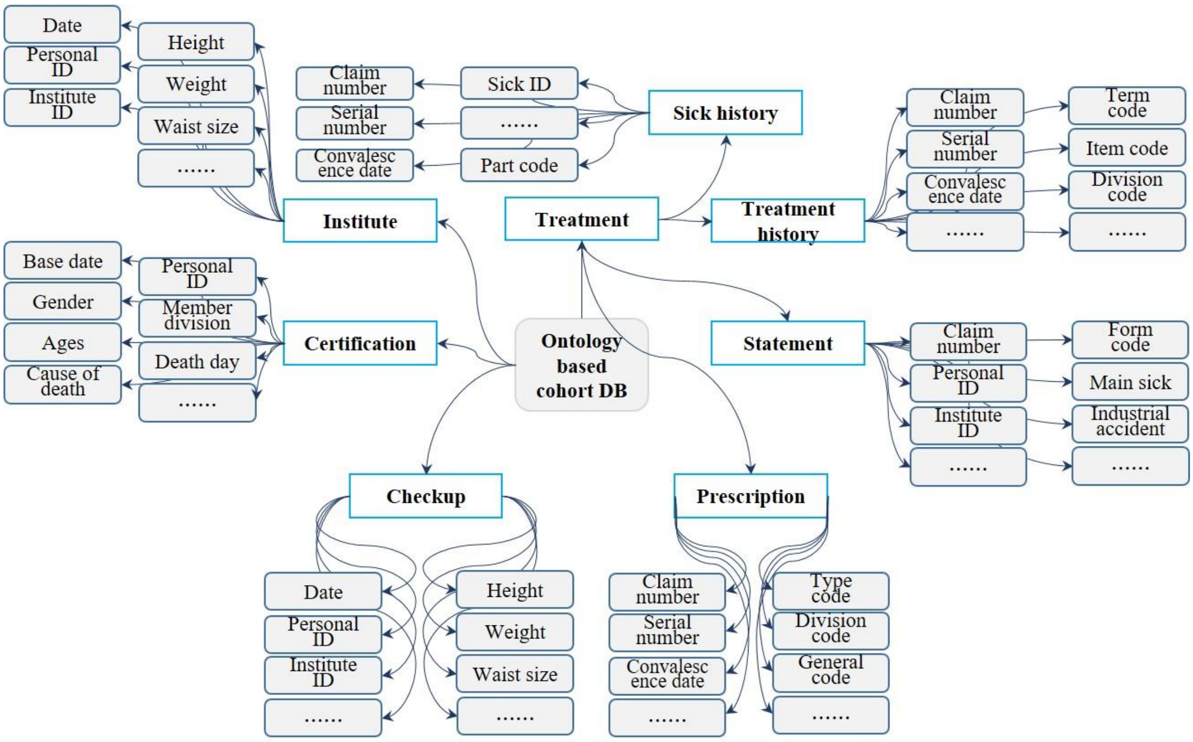

Figure 3. Structure of Ontology-Based Cohort DB

In the health care sector, government organizations and health insurance agencies such as the Korea Food and Drug Administration, National Health Care Insurance Corporation, Health Insurance Review and Assessment Service, and National Cancer Center have begun to apply big data analysis toward evaluating services.

In order to provide health care services tailored to a person's life cycle, it is imperative to formulate a model for future predictions and policy decisions by utilizing big data from various health care data sources. Integrated data management and analysis of big data are necessary to achieve proactive public health management and health care services. Moreover, it is necessary to establish an organization to analyze health risk and services, establish policies, and evaluate on the individual, community, and country levels. We named this hypothetical organization the "Health Risk Analysis Center" (Figure 4). The health risk analysis center is expected to enable early response to diseases at the national level. It will predict the distribution and trends of major diseases through monitoring health behaviors and home environments, use of medical services, and other health-related data and population statistics [10].

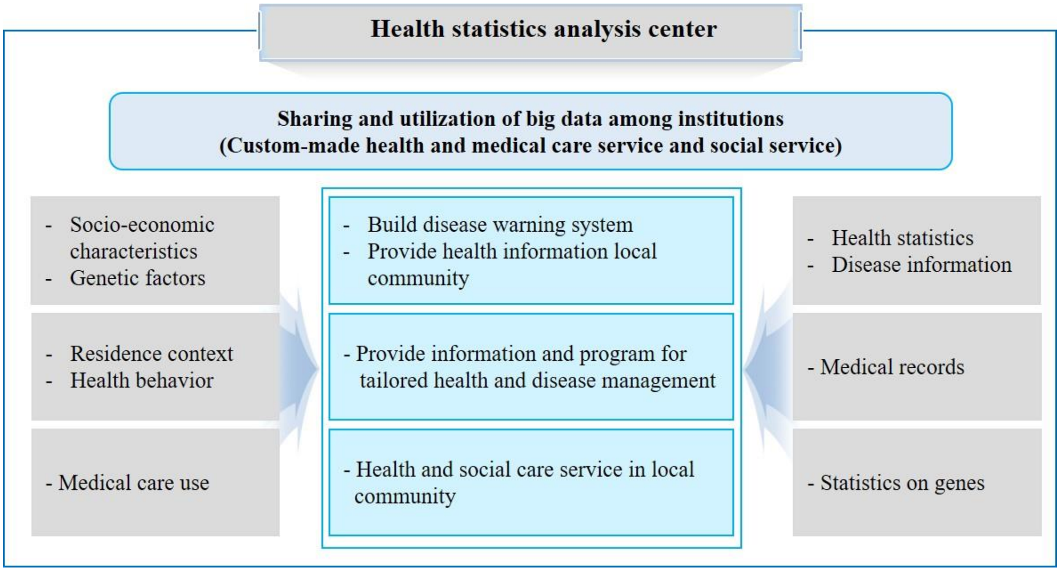

Figure 4. Big data-Based Health Statistics Analysis Center

3. Personal Fitness Health Care ICT Service System

3.1. PGAR- and PHR-Based Health Care ICT Platform

A safe and seamless service was provided by applying the equipment control and the certification solution to each interface as shown in Figure 5 based on international patient and medical information standards for strong support of the personalized health care service.

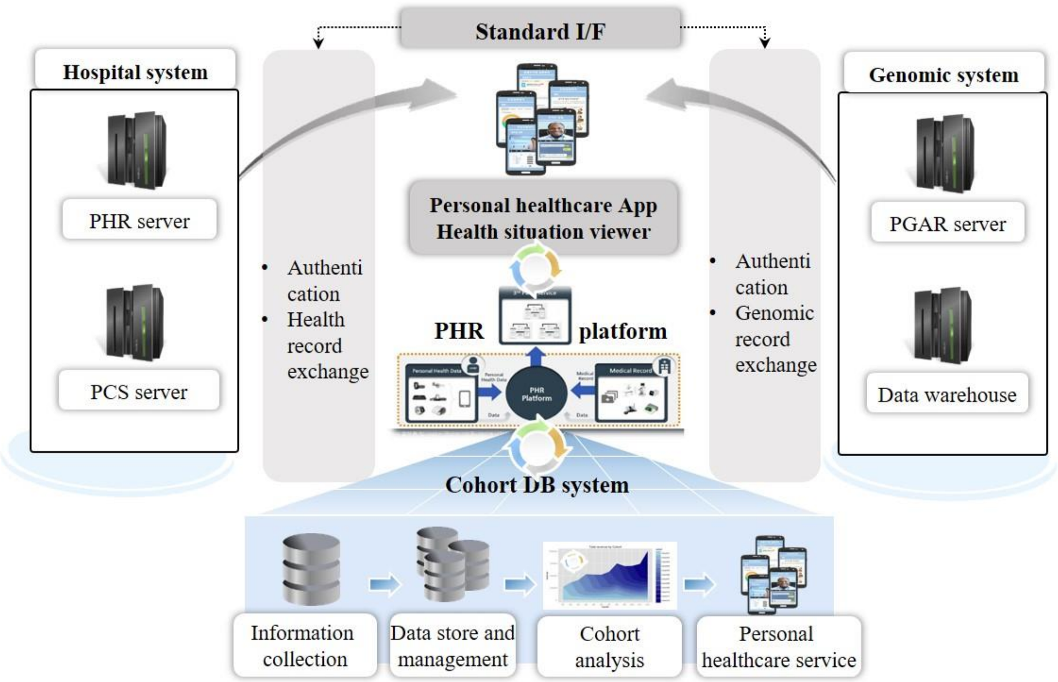

Figure 5. Health Care ICT Platform Configuration

International criteria of the transmission standards for the health care service such as DICOM, HL7, IEEE, ISO, CEN, IHE, WHO and SNOMED were followed for personal information security and documentation. Directives specialized for the medical information field were used with personal information security standards: ISO/IEC 27002 to handle information security of entire areas and ISO 27799 (health informatics-information security management in health using ISO/IEC 27002).

Use of PHR in disease control and health care and for exchange and sharing was set as the purpose and trustworthy policies in medical practice compliant with medical institute diagnosis records were used. DRM (digital rights management) solutions were used for document security.

Currently, various NGS-based clinical diagnostic services are offered in the gene analysis field. Among such services, NIPS (non-invasive prenatal screening), cancer panel (BRCA 1/2, cancer hotspot, hereditary cancer and others), PCS (preconception carrier screening), NS (newborn screening), and MLPA (multiplex ligation-dependent probe amplification result) have already passed tests and are used in health care. The accuracy of analysis results of the gene information-based forecast for hereditary diseases is improved by linking gene analysis results from the genome research center to the health care platform.

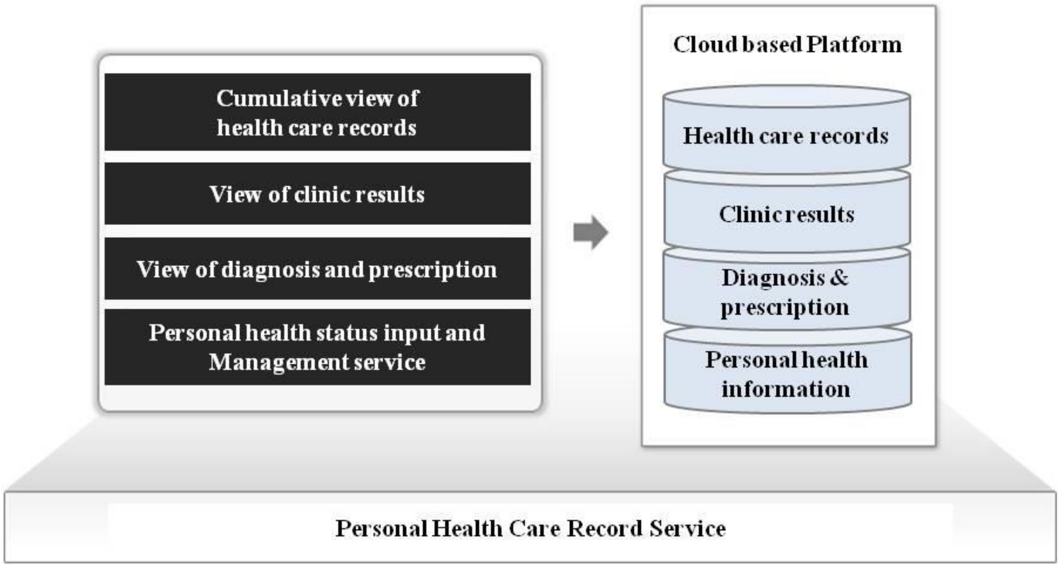

Figure 6. PHR Services

3.2. Cohort DB-based Personal Health Information Analysis

An organized data collection system using PGAR and PHR data as shown in Figure 7 was used to collect standard cohort data. A data collection system using domestic and international data and standard data (Korean Health Insurance Corporation) was established including a classification structure for data analysis and data purification [11].

The health screening DB, checkup history DB, certification DB, personal consulting DB and health care history DB were established based on personal lifestyle, family disease history, checkup results, demographic factors and health care history by applying the ontology development methodology as in previous research. PGAT-based disease prevention, PHR-based health care, and information on health, aging, metabolic syndrome and health risks and prescriptions were provided as mobile services.

Standard cohort data focused on individuals were extracted to provide personalized standard cohort data and the subjected layers were classified with various parameters including the gender, age, and income level of individuals. Chronic and other disease prevention services for the lifecycle based on the cohort data analysis were considered the most important advantage of the analysis. Furthermore, service typicality was acquired with consideration for medical costs varying by income level and an evaluation feature for health checkups was constructed. The standard cohort DB requires a great deal of initial investment due to its large scale and limitations of time and data ranges so that user convenience may decrease.

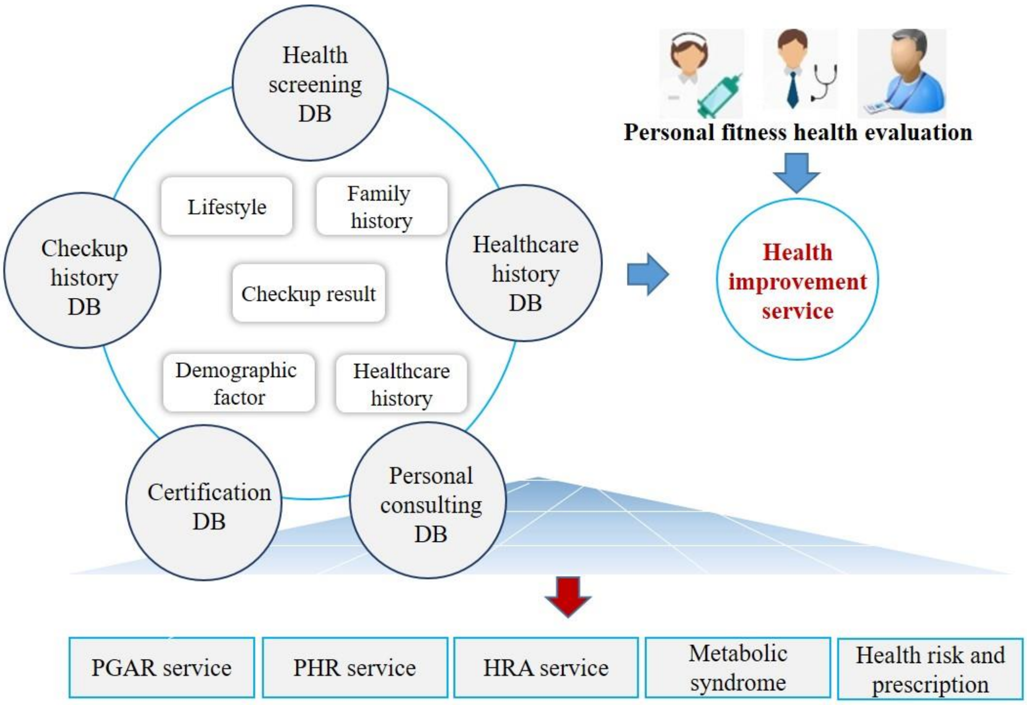

Figure 7. Personal Fitness Health Care Service Configuration

3.3. Personal Health Care Mobile Service

The web is developed according to the global standards to support multiplatform user environments. To comply with the web standards, new mark-up and API made by W3C to develop HTML5 apps are provided. CSS3 (cascading style sheets), the W3C standards, were used to define the layout and style. A Cordova multiple language support API is used for global language support. A user may receive personalized health care service and other services including physician assessment, online chatting and the health information monitoring.

Figure 8. Personal Health Care Mobile User Interface

4. Implementation and Evaluation

The following analysis parameters were applied to the platform data analysis feature for the personalized health care services. Major parameters are listed from Table 2 to Table 5.

Table 2. Demographic Factors

Gender	Male/female	**Insurance Type**	Company/local/medical benefits
Age	Treatment time	**Insurance Premium**	Insurance premium amount
Birth	Date of birth		Calculation of criteria parameters
Death	Date of death		20 insurance premium classes
Disability	15 disability types		Dependent number adjustable insurance premium
	1-6 disability ratings	**Business**	Type of work, type of business
	Date of disability registration		Size
Locations	Patient address		
	Medical institution address		
	Business address		

Table 3. Health Examination and Medical Institution Factors

Division	Medical institution	**Division**	Health examination institution
Human Resources	Personnel status	**Basic**	Basic status
	Physician status		Consigned items
	Specialist status		Health examination types
	Physical therapy manpower	**Manpower**	Manpower status
Facility Status	Establishment division		Manpower training
	Medical institution type		Dispatched health examination records
	Numbers of rooms and beds	**Equipment**	Equipment check
	Occupational health And safety insurance designated medical institution		
	General status of physical therapy institution		
Equipment	Detailed equipment record of medical institution		

Table 4. Health Conditions and LAB DATA

Division	Health conditions	Division	LAB
Smoking	Current smoking status	**Physical Measurements**	Height, body weight, BMI, waist measurement
	Smoking frequency, period		Vision, hearing
Drinking	Current drinking status	**Blood Pressure**	Systole, diastole
	Drinking frequency, period	**Blood Sugar**	Fasting blood sugar
Physical Activity	General, moderate, intensive	**Blood Lipids**	Total cholesterol, HDL, TG, LDL
Medical History	Examinations for hypertension, diabetes, hyperlipidemia, cardiopathy, cancer and/or others	**Liver and Kidney Functions**	Liver and kidney function tests, hepatitis B (lifetime)
	Examinations for hypertension, diabetes, hyperlipidemia, cardiopathy, cancer and/or others	**Bone Density**	Bone density test (lifetime)
Family History	Examinations for hypertension, diabetes, hyperlipidemia, cardiopathy, cancer and/or others	**Cancer Tests**	Endoscope, Bx
Cognitive Function	KDSQ		
Depression			
ADL			

Table 5. Disease Tests and Treatment Activities

Disease Name	KCD6; Main Sick and Sub Sick	Detailed Records	Activities, treatment materials, drugs
Medical Uses	Hospitalization, hospital visit and/or via emergency room		Dosage, daily dosages
	Number of hospitalization and/or visit days, number of prescription days		Total administration days, practice count
	Medical department code		
	Expense of Decision		

5. Conclusion

The authors established a health care platform providing personalized health care services based on personal gene analysis and health examination record for better quality of life and wellness. If this health care platform based on the big data technology is used, not only the prediction and prevention of hereditary diseases, but also personalized health care service for the life cycle and/or chronic diseases becomes available through cohort analysis based on the data accumulation. A multi-language supporting mobile app is also offered for more convenient services for smartphone users.

The development of personalized health care has been attempted as a global remote service based on cloud technology. However, more research is required since each country's protection policies for personal medical information are different.

Acknowledgements

This work was supported by the Catholic Kwandong University International ST. Mary's Hospital research fund of 2015 (FA607-15-1014).

References

[1] K. S. Eun., "Population Aging and Social Strategies for Aging Problems in Korea", The Journal of the Korea, Korean National Commission for Unesco, vol. 48, no. 4, **(2008)**, pp. 5-34.
[2] G. S. Kim, J. E. Lee and Y. H. Yoon, "Integrating u-health care service in the housing for low income seniors", The Journal of the AIOK, Architectural Institute OF Korea, vol. 31, no. 1, **(2011)**, pp. 89-90.
[3] W. Rogowski, "Current impact of gene technology on healthcare A map of economic assessments", The Journal of the Health Policy, ELSEVIER, vol. 80, no. 2, **(2011)**, pp. 340-357.
[4] B. Ashwin, T. Raqhuran, S. M. Reza Soroushmehr, N. Fatemeh, B. Daniel A and N. Kayvan, "Big Data Analytics in Healthcare", The Journal of the BMRI, Human Genome Organization, vol. 6, no.1, **(2012)**, pp. 01-09.
[5] W. S. Yang, S. H. Lee, K. M. Lee, W. J. Kim and S. J. Yun, "Design of Ubiquitous Healthcare Service Development Framework for Ubiquitous Hospital", The Journal of the KIIS, Korean Institute of Intelligent Systems, vol. 16, no. 2, **(2006)**, pp. 57-60.
[6] J. H. Seo and H. B. Park, "m-Health System for Processing of Clinical Bio signals based Android Platform", The Journal of the KSCI, Korea Society of Computer and Information, vol. 17, no. 7, **(2012)**, pp. 97-106.
[7] G. M. M. L. Marta and R. Michael, "Translational genomics in personalized medicine – scientific challenges en route to clinical practice", The Journal of the HUGO, BioMed Research International, vol. 2015, no. 5, **(2015)**, pp. 01-16.
[8] B. Emilie, D. Samuel, B. Regis and C. Emmanuel, "Toward a Literature-Driven Definition of Big Data in Healthcare", The Journal of the Hindawi Publishing Corporation, BioMed Research International, vol. 2015, no. 639021, **(2015)**, pp. 01-09.
[9] J. H Song, J. M. Hwang, J. S. Choi and S. G. Kang, "Ontology-based Cohort DB Search Simulation", The Journal of the Korea Society for Simulation, Korea Society For Simulation, vol. 25, no. 1, **(2016)**, pp. 29-34.
[10] T. M. Song and S. R. Ryu, "Big Data Analysis Framework for Healthcare and Social Sectors in Korea", The Journal of the Healthcare Information Research, The Korean Society of Medical Informatics, vol. 21, no. 1, **(2015)**, pp. 03-09.
[11] L. R. Wen, S. M. Yang and B. M. Lee, "Study on the Telemedicine Healthcare Consultation System", The Journal of Information Technology and Computer Science 2016, Advanced Science and Technology Letters, vol. 133, no. 29, **(2016)**, pp. 155-158.

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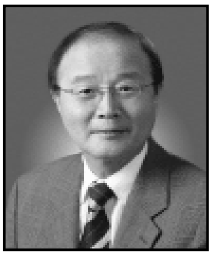

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