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The Development and Evaluation of the Citizen Telehealth Care Service System: Case Study in Taipei

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Abstract—**Because of the rapid aging population in Taiwan and the trend of fewer children, people are looking into technical solutions for continuous/intermittent monitoring of vital signs in the home setting environment and the interactions between family members. In this study we developed a smart medical services system for managing chronic disease, called Citizen Telemedical Care service System (CTCS). The system integrates biosignal measurement, hypertension risk estimation expert system, clinic appointment service, video communication service, medical assistance referral, health frequency program record, and health/hygiene education. The demo version CTCS is exhibited in the center of INSIGHT opened for visit and trial use. In order to verify the demand and acceptability of the system and services, we have interviewed 251 volunteers with a questionnaire survey with the help from Taipei City Government. The results showed that people have positive expectation about the service program for health care and the capability of home devices. They also expressed high motivation on learning to use the system and to participate in the program. According to the evaluation results, the system is processing a small user test led by Taipei City Government, in order to further verify the acceptability and satisfaction of the system.**

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I. Introduction

Being the fastest aging nation in the world, Taiwan is now facing challenges of changing society structure, house hold style, and national expanses on health care. According to the definition of population structure of the United Nations, the Aging Population Society is that over 7% of total population is exceeding 65 years old. The Extra-aging Population Society is that over 20% of total population is exceeding 65 years old. In terms of the population statistic in Taiwan in 2008, the population over 65 years old is 2.34 million, which stands for 10.21% of total population. This exceeds the threshold of the Aging Population Society [1]. It is inevitable to develop Smart Medical Home to decrease the expenditure of medical service cost.

Those living in the cities and urban areas can normally access health care facilities quite efficiently. It would thus require more emphasis on the quality of long term health care, especially for the home care sector. In view of the possible causes of deteriorating life quality can be as simple as age related or as complicated as disease related, the development of "Smart Medical Home" will have to cover the issues of both humanity and medical needs [2,3].

Smart medical home is a concept which could be defined as integrating several type techniques for providing telemedical services. The techniques commonly utilized in smart medical home include physical signal measurement, signal transmission, data mining and storage, communication and privacy. The telemedical services would include individual health care, social welfare, virtual vision, health assistance, and other services [4].

A number of smart medical home have been developed in different counties [5,6]. Both of them emphasized the technologies, services of health management and assistants. Several different evaluation methods have been provided in order to verify the effect of smart medical home [7,8]. The results showed that smart medical home provides a humanistic way for learning monitoring personal health condition. In financially issue, the implementation of smart medical could reduce the costs, which were verified in several countries [9,10]. Although smart medical home is useful and helpful for aiding health management, it is still a complex and discussible issue. It is equally important to include user evaluation in order to deal with the demand difference caused by different social structure [4].

In this study, we developed a smart medical services system for managing chronic disease, called Citizen Telemedical Care service System (CTCS). The system

integrated biosignal measurement, hypertension risk estimation expert system, clinic appointment service, video communication service, medical assistance referral, health frequency program record, and health/hygiene education. This system has been evaluated by interviews, questionnaire surveys and pre-testing in the Center of Innovation and Synergy for Intelligent Home and Living Technology (INSIGHT). The evaluation focused on the health services demand and acceptability of the system in different population group. The results could further help local social organizations to promote the smart medical home system.

II. Citizen Telemedical Care service System

A. The architecture of CTCS

This study focuses on the design and planning of an information-based smart medical services system, CTCS, which provide convenient home health care services. The assignment of CTCS is aiding user managing the personal physiological condition, actively providing health information and hygiene education, and integrating public medicine and social welfare resource. The architecture of CTCS shown in Figure 1was separated into two main parts, which were client and information provider. The home gateway was the medium of client and information provider, which provided the functions of biosignal measure, signal analysis, data transmission and information browsing. All of the operation procedure can be performed through a friendly user interface which was developed by Flash. In this study, we utilized touch panel as the hardware interface.

The core of the home gateway included medical expert system and information management system. Medical expert system would provide an objective suggestion for user after analyzing their biosignal records. Information management system is an intermediary between home gateway and public information providers, which has the mission of health information mining and collecting. The database system is developed by MySQL. Personal daily biosignal records, health check records and activity participant record were be stored in database.

B. Biological signal measurement

The biosignal measurement items involved in this home gateway system are shown in Table I, which includes blood pressure, blood glucose, heart rate, peripheral oxygen saturation (SpO_2) and peak flow. The photographs of the devices were shown in the upper left corner of Figure 1. In this study, we provided devices with wireless transmission function for measuring biosignal. The wireless technology utilized in this study is Bluetooth. Blood pressure and blood glucose could be measured by a 2-in-1 device which was produced by Tibac Technology Inc. The measured results could be sent and recorded in the database automatically. Heart rate and SpO_2 are also measured by a 2-in-1 device which was designed and built in this study. Heart rate, pulse and SpO_2 values and analysis results were immediately displayed on user interface. Peak flow meter was designed for asthma patients controlling and monitoring their asthma condition. The principal measure theory of peak flow meter is heat loss on the sensor surface. The peak flow curve and calibrated value were transmitted to home gateway by Bluetooth after per measurement automatically.

C. Expert system

According to the statistics report announced by Bureau of Health Promotion in Taiwan, the hypertension population exceeded 43.1% of total population [11]. At risk evaluation,

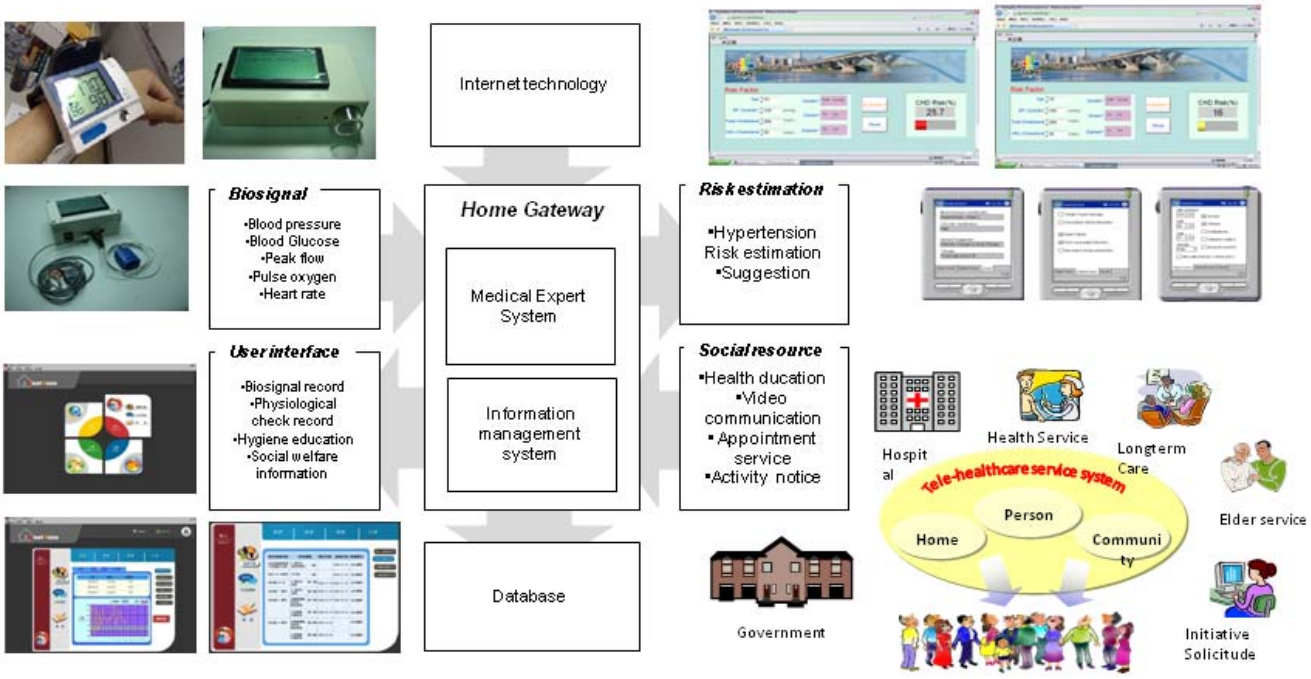

Fig. 1. The Architecture of Citizen Telemedical Care Service System

we followed the guidance of JNC7 for Chinese [12] to build a hypertension risk estimation expert system. The cardiovascular disease factors utilized to evaluate hypertension include age, gender, blood pressure, smoking, diabetes, total cholesterol (TC) and high-density cholesterol lipoprotein (HDL-C). There are four risk tiers, which are normal, minimal, moderate and severe. In the minimal tier, the expert system will suggest user to improve lifestyle. In the moderate and severe tier, the expert will further help user to contact physicians. This expert system not only integrates in home gateways but also in PDAs, as shown in the upper right corner of Figure 1.

D. Health information

The service items are designed and modified through several discussions with personnel who work in the hospital, social welfare organization and government. The health information built in CTCS including clinic appointment, video communication, medical assistance referral, health frequency program record, and health/hygiene education. The cooperative hospital of CTCS is Taipei City Hospital, which has top priority for receiving clinic appointment and medical referral case. The video communication service would combine with 1999 Citizen Hotline launched by Taipei City Government in 2004, which provides direct customer service for user. In order to encourage citizens managing their health condition, Taipei City Government announced the health frequency program in 2008. CTCS integrated the consultation function of health frequency program for user to encourage them to join neighborhood health activities. The demo version CTCS is pre-testing in the center of INSIGHT, where an open laboratory is allowed general public visit and test the system.

Table I
The characters of medical devices

Item	Biosignal	Safe range	Transmission rate
Blood pressure monitor	Blood pressure	S: 85~95 mmHg D:120~140 mmHg	1dataset after measurement
Blood glucose monitor	Blood glucose	<140 mg/dl	1 dataset after measurement
Heart rate monitor	ECG or Pulse	50 ~ 110 beat/min	1024 data points/ sec
Pulse oximeter	Pulse	95 ~ 100 %	1024 data points/ sec
Peak flow meter	Respiratory flow	-	1 dataset after measurement

Table II
Market Survey Questions

Item	Question
Agreement	
1	After the introduction film, I completely understand the contents of these service
2	I think CTCS is meaningful
3	My family or I has the needs of some of these service.
4	My family or I am capable to use the appliances.
5	My family or I would like to learn to use the appliances shown in film.
6	If Government put these service into practice, I will be willing to participate.
Rank	
7	Importance rank of functional category. (6 options)
8	Need rank of specific service. (9 options)
Multiple Choice	
9	The maximum cost you would like to pay for appliance-renting per month.
10	Other services. (10 options)

III. EVALUATION

A. Evaluation method

In order to understand people's point of view on the CTCS system, this study carried out an acceptability survey with questionnaire. The questionnaire shown in Table I includes ten questions about CTCS and nine demographic variables. Questions one to six are quantitative questions about general perceptions and acceptability of CTCS. Questions seven and eight are about the priority of provided information and services. Questions nine and ten are multiple choice questions. The estimation method utilized in quantitative questions is a 5-point scale. The middle point is three, the score higher than three means agreement, and less than three means disagreement. In order to avoid the confusion of elders, the questions are simplified with no negative statements. All of the questions are listed in Table II.

251 volunteers over 40 years old were randomly collected from five Taipei City Hospitals with the help from Taipei city government. These five hospitals are chosen because they are located in different neighborhoods in order to provide stratified sampling. In the beginning of the interview procedure, volunteers were shown a short introduction film about CTCS, and then they were asked to complete a paper survey. The results were analyzed by statistic methods including descriptive statistics and Student's t-test. The analysis software used is SPSS and Microsoft Excel.

B. Evaluation results

According to the t-test result shown in Table III, the scores of quantitative questions show the highly significant positive attitude toward CTCS (p-value < 0.001). They understand and highly accepted the services included in CTCS (Q1 to Q3). Furthermore, they are willing to try those appliances (Q4, Q5). The low score of item 3 means not all volunteers have instant need. Then there is a positive feedback of volunteers with the results of item 6. According to the results of questions seven to ten, people paid more attention and had more expectations about health-related information and health risk estimation. The result of questions nine shown in Figure 2 presents the maximum acceptable payment for renting the CTCS equipment.

Besides the general analysis above, this study also concerns the differences caused by demographic variables. For psychometry (keeping appropriate sample size), three demographic variables were used to separate data: gender, level of education, and health status. Gender: male / female. Level of education: junior college and above / senior high and under. Health status: healthy / ill.

The result of gender analysis shows that only price factor for renting the equipment has impacts on people's attitude

Table III
Student's t-test Result

One sample t-test				Test Value = 3		
				t	df	Sig. (2-tailed)
Item	N	Mean	Std. Deviation	Lower	Upper	Lower
1	251	4.4661	0.79615	29.175	250	.000
2	251	4.5339	0.78093	31.118	250	.000
3	251	3.6096	1.32323	7.298	250	.000
4	251	4.0359	1.16735	14.058	250	.000
5	251	4.1315	1.04816	17.102	250	.000
6	251	3.9044	1.17933	12.149	250	.000

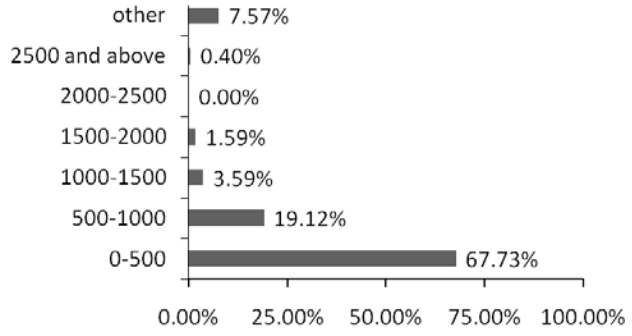

Fig. 2 Maximum acceptable payment for renting CTCS appliances.

toward CTCS. Female volunteers would pay less than male. It may be related to vocational structure that most female volunteers are housekeepers. With the analysis by level of education, it shows that higher education-level volunteers have more capability of learning the health management system. In addition, the higher education-level volunteers paid more attention to health-related information than daily physiological measurement. Moreover, there are three major diseases which are hypertension, hyperlipidemia and hyperglycemia with health status analysis. The result shows higher scores in ill volunteers group (with at least one disease) than healthy group in questions one to six, and they also would like to pay more than the healthy group.

IV. Conclusion

In this study we developed a smart medical services system for managing chronic disease which is called CTCS. CTCS already integrated several physiological measurement items for aiding user managing their health. Besides, CTCS already built in several public health information and services, which refer to the policy of Taipei city. The demo version of CTCS is exhibited in the center of INSIGHT, open to the public for visit and trial use. The evaluation results showed that people have positive expectations and accepting of CTCS. It also showed that CTCS is easy to use for middle age to elderly population in that they would accept utilizing this new technology to maintain their health. According to the evaluation results, the system is processing a small user test led by Taipei City Government, in order to further verify the acceptability and satisfaction of the system.

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