Home health care network in the elderly

Toshiyo Tamura and Isao Mizukura

Abstract— **We propose a new home health care network for the acquisition and transmission of data from ordinary home health care appliances such as blood pressure monitors and weight balances. In this study, we develop a standard protocol for data collection and a simple interface to accommodate different monitoring systems that make use of different data protocols. The system provides for one-way data transmission, thus saving power and conforming to Japanese pharmaceutical law. Our standardized protocol was verified during a 1-year field test involving 20 households in Japan. Data transmission errors between home health care devices and the home gateway were 4.21 per a day with our newly developed standard protocol. Over a 1 year period, we collected and analyzed data from 241,000 separate sources associated with both healthy, home-based patients and chronically ill, clinic-based patients, the latter through physician intervention. We evaluate some of the possible applications for collecting daily health care data and introduce some of our findings relating primarily to body weight and blood pressure monitoring for elderly subjects in their own homes..**

I. Introduction

Metabolic syndrome encompasses a wide range of medical disorders often associated with increased weight and obesity, which increase the risk of cardiovascular disease, stroke, and diabetes. The term "metabolic" refers to the biochemical processes, sometimes easily monitored, that are involved in the body's normal functioning. Metabolic and behavioral risk factors are conditions that increase the probability of disease, and these risk factors are generally very high in the elderly. Therefore, we propose a new home health care system to monitor such risk factors, maintain good health, and prevent disease in the elderly.

Today, home health care and home-based primary care have been commercialized due to cost considerations and convenience. Patients with chronic conditions are heavy users of the health care system, and ideally, benefits of considerable cost savings and improvements in health care are achieved if patients can be maintained in their homes. Home telecare and telemonitoring systems have been demonstrated but are not completely satisfactory. Insufficient health monitoring has been associated with adverse outcomes including increased emergency department visits and hospitalizations, and deceased caregiver well-being.

Manuscript received April 30., 2008. The Ministry of Economy, trade and Industry (METI) also implemented this study. The New Energy and Industrial Technology Development Organization (NEDO) has given its continuous proactive support for developing the medical devices.

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Previous systems for data acquisition and transmission have been used to prevent disease and some automated systems have also been developed, but high costs have been a bottleneck to their general implementation. Established automated systems include ECG monitoring during sleep and bathing, although monitoring for routine health care is largely an underdeveloped area.

In this report, we propose a new health care system to monitor data from ordinary home health care appliances such as blood pressure monitors and body weight scales. We also discuss some of the potential applications of this new system for home-based elderly patients.

II. Method

A. System configuration

The system consists of three parts. The first part is the data acquisition system connecting the health care monitoring devices for health care data measurements and the interface for data collection. The second part is the data transmission system connecting the interface and the center server via the Internet. The third part is the Web-based system connecting the Internet server to the subjects' personal computers and the terminals of health care professionals including doctors, administrative dieticians, and physical trainers if such intervention is permitted and authorized by the home subjects.

B. Data acquisition system

For the field test, the timing of data acquisition was carefully considered with regard to the behavioral patterns and daily routines of each subject. For blood pressure and body weight data, the measurements and data acquisitions were most conveniently carried out once in the morning and once at night. Urine sugar was measured and transmitted after each requisition. The step counter data were acquired and transmitted at the end of each day.

The blood pressure manometer, the scale for body weight, and the urine sugar pan each have an identifier button for the subjects to identify themselves prior to taking their individual measurements. Each device can accommodate up to four personal IDs for assignment to family or household members. The IDs were registered to the monitoring device or the interface with the appropriate attributes for each subject. Each device with the exception of the scale for body weight, transmits the data automatically after the measurements are completed. Body weight is transmitted only after patient approval with the push of a button. The system allows for the continuous or intermittent transmission of small or large data sets at specific times or intervals as may be convenient or required.

C. Data transmission protocol

The standard protocol for interfacing the monitoring device and the interface is one of the most important aspects of this project. In general, each commercial home HCD has a unique communication system and users must purchase different communication adaptors accordingly. In addition, combining or analyzing the data from different instruments is difficult as each instrument has it own data format. For example, problems arise when trying to plot the data for body weight and blood pressure at the same time in the display. Combining and analyzing data from different appliances is also problematic since each instrument has its own data format and time stamp method. We modified the application, presentation, and session layers in the OSI model. We did not modify the layers assigned to controlling the wireless technology that is still advancing and remains part of the present protocol.

The basic requirements of the communication protocols between the monitoring devices and the data collection interfaces are as follows:

1. Data measured by several monitoring devices can be transmitted.
2. Both newly developed the monitoring devices and newly developed monitoring parameters can establish communication with the interfaces easily.
3. Both the monitoring device and the interface can inquire about the health care information with each other.
4. Lightweight communication software is needed considering poor CPU and poor battery power.
5. The protocol defines the upper five layers of communication in the OSI layer model.
6. Monitoring parameters can be multi-informational including, for example, English names, units, and scales.

Generally, health care data contain the parameter name, unit, and scale information in every data transaction. The protocol between the monitoring device and the interface is designed to minimize the total data transmission, accept new devices into the system, and exchange the monitoring device with respect to byte name, registration of communication data information, and the definitions for reserved words.

D. Web system

The collected data are transferred to the center server via the Internet using secure communication protocol SSL. The center server creates a database for each subject and plots the data on a graph for display using the Web server.

To monitor a subject's health conditions, a gateway that acquires the data from the monitoring device is installed in the homes of the subjects. The collected data have been transferred to the center server via the internet using secure communication protocol. The center server creates the database and the web pages for each subject.

E. Experimental procedure in the field test

The subjects selected for the field test were patients in the Hospital of Kansai Medical University and the procedure was approved by the ethical committee of the university. We obtained written informed consent from all members of the 20 families including both normal-type and borderline-type patients for participation in this study. Subjects received no monetary compensation for this field test with the exception of the appropriate Internet Service Provider fee and electricity charges to assure its successful operation.

The conceptual design and operation of the 1st stage of unified communication protocols between the monitoring devices and the interfaces were executed from December 2004 to August/October 2005. We received no monetary compensation associated with the field test.

III. Results

Overall, we automatically acquired and analyzed 241 thousand individual data transmission packets for the monitored subject health care parameters during approximately 1 year of field testing. A typical example of the graphical data presentation method for 39 individual subjects from 20 families (1.95 individuals/family) demonstrates the overall trend in the body weight parameter over a 10-month period (Figure 1). The level of involvement for each subject was determined through physician intervention.

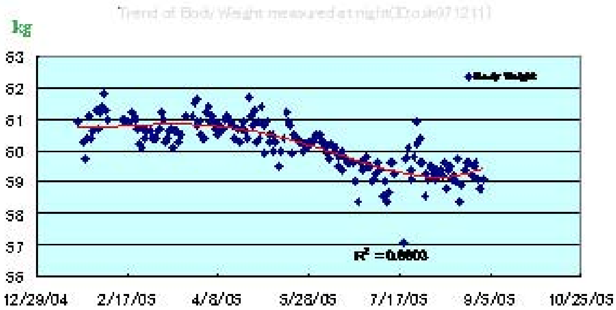

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Figure 1 A typical example of body weight change

A. Error rate

Transmission errors are due to collisions of radio waves, electromagnetic interference, and the power of the radio wave communication driver. To verify the performance of the protocol, we used the same radio wave driver and the same allocation of the repeater for radio waves in-house. The outcome of the error rate between the monitoring device and the interface is 4.21 times/day.

B. Feasibility of the system

Through our extensive patient parameter monitoring in the field test, we observed several data trends that provide some interesting medical insights:

1. Circadian change in body weight

All subjects measured their body weight twice daily, prior to sleeping at night and after rising in the morning. Over half of the subjects who measured their body weight more than 100 times through the field test exhibited a circadian pattern associated with their body weight (Figure 2).

2. Seasonal control for body weight

The subjects could observe their own changes in body weight and effectively monitor themselves with respect to causal factors such as festive overeating, holiday binges, and responses to job stress. Our intervention staff changed the intervention cycle from biweekly to weekly in the event of overeating.

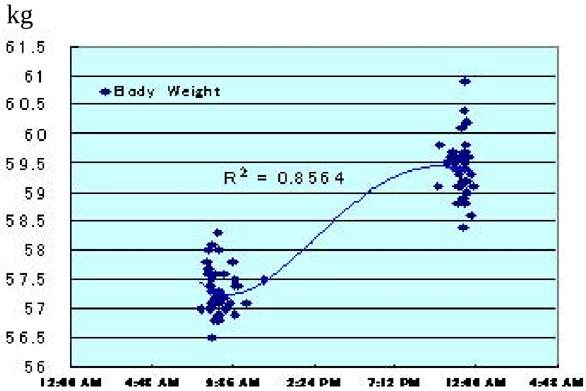

Figure 2 Body weight changes in the morning and evening

3. Predictive information for the appearance of disease

One subject took note of his body weight data by checking his Web pages. His body weight decreased extremely without physical exercise or dietary change. He went to the hospital immediately for physical examinations and found an effusion of blood in his upper digestive tract. He had an emergency transfusion of 2.2 liters. The subject's perceptiveness made him go to the hospital. He understood the correlative relationships between his exercise and diet, and body weight. The routine checking of time-oriented body weight has the possibility of finding some physical disorder.

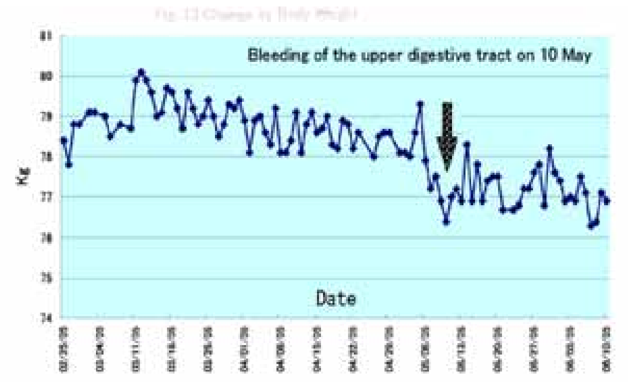

Figure 3 The risk finding with regard to body weight changes

4. Blood pressure changes in day and season

Figure 4 shows the time course of a systolic and diastolic blood pressure change. These data show that the systolic pressure gradually increased, while the diastolic pressures remained constant. The blood pressure in right half panel shows somehow the risk of diseases. Additionally, Figure 5 shows the risk finding from the daily blood pressure data. After increasing systolic pressure in the morning and in the evening, the attack of transient cerebral ischemia has been occurred.

IV. Discussion

Home health care network was conducted successfully and without any difficulty, although the physician and medical staffs including therapist and mortician intervened, The data wee transmitted from private house to data collection center smoothly. Whenever any kind of the health care appliances in the private home can connected data collection interface, we can obtain several kind of healthcare data simultaneously recorded..

The volume of stored data was huge and types of data are different, ie some were continuous functions and others were intermittent input values. Further, intervention staffs had to revise the measurement protocols several time. Nevertheless, the staffs were accurately aware the various type of data which allowed the more precise intervention to the user. The number and variety of interventions interfered with the subject life style, and thus the subjects sought to avoid the risk by development of own strategy methods in this regards.

Further studies need to solve the prevention of disease with our obtained long tern data.

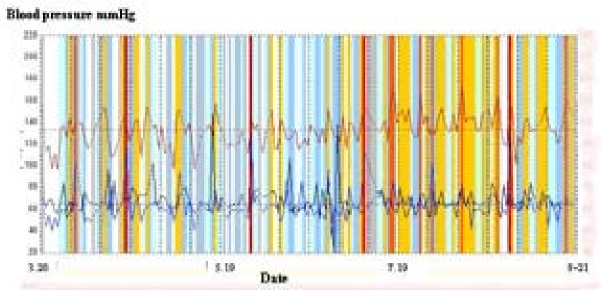

Figure 4 Time course of blood pressure changes

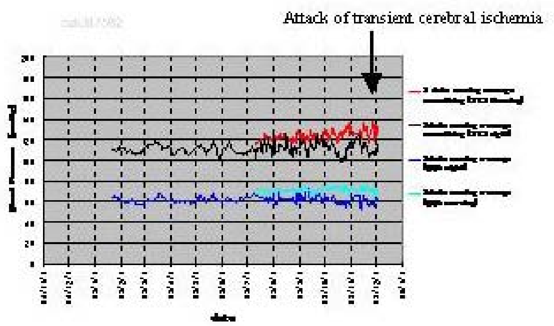

Figure 5 The risk finding with regard to blood pressure changes

V Conclusion

We have proposed a new home health care network system based on ordinary home health care appliances including blood pressure monitor and weight scale. The data were successfully obtained with new protocol with commercially available home healthcare devices. Further studies need to solve the prevention of diseases, especially cardiac diseases.

Acknowledgment

This research was conducted in close collaboration with the developers of the equipment used by the home healthcare model verification project. The authors thanks The Technology Association of Medical and Welfare

Apparatus (TRAMWA) to cooperate with a development committee composed members of academic and industry..

REFERENCES

[1] C. M. Horwitz1, M. Mueller1, D. Wiley1, A. Tentler1, M. Bocko1, 4, L. Chen1, 2, A. Leibovici1, 5, J. Quinn1, 6, A. Shar7, A. P. Pentland1, 3 Is Home Health Technology Adequate for Proactive Self-care? Methods Inf Med. 2008;47(1):58-62.