

An Easy to Use and Affordable Home-Based Personal eHealth System for Chronic Disease Management Based on Free Open Source Software

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Abstract: This paper describes an easy to use home-based eHealth system for chronic disease management. We present the design and implementation of a prototype for home based education, exercises, treatment and following-up, with the TV and a remote control as user interface. We also briefly describe field trials of the system for patients with COPD and diabetes, and their experience with the technology.

Keywords: Telehealth, Systems Architecture, Patient Monitoring, Disease mgt., Telemedicine, User-computer interface, Open source, Computer-supported training, Online/distance education, eHealth.

Introduction

The number of people with chronic diseases such as Chronic obstructive pulmonary disease (COPD), diabetes, heart disease, stroke, obesity and cancer increases rapidly. Accounting for 59% of the 57 million deaths annually and 46% of the global burden of disease, chronic diseases are the major cause of death and disability worldwide. It is even projected a 17% increase in deaths due to chronic diseases from 2005 to 2015 [1,2]. In addition, as we live longer and the risk of chronic conditions increases with age, the number of people with one or more chronic condition also increases [3,4,5]. This leads to huge burdens on the healthcare system and require innovative approaches to provide out-of-hospital treatment. The home environment can be a potential arena for treatment and following-up; reducing in-hospital stays and costs. Home based eHealth systems can give life and health improvements such as stabilization of the chronic disease, prevention of exacerbations, less hospitalization, and lost work days,

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reduced risk for hospital infections, better treatment compliance, cognitive status, mastering of the disease and patient satisfaction, and improved quality of life [6,7].

A challenge for home based eHealth is that large user groups experience technological barriers today, especially in the elderly part of the population [8,9]. Since the number of chronic conditions *increases* with age, and the computer skills in the population *decreases* with age, there is a need for easy to use technologies. However, many advanced telemedicine systems for chronic patients use computers or smartphones, which are not necessarily a familiar interface for the elderly.

Our home-based eHealth system for chronic disease management is built on free open source software and we use the TV and remote control as interface. Several aspects of the system and services have been evaluated by using qualitative methods; in this paper we briefly address the usability results.

Having a patient centric view, our system aims at assisting the individuals in the management of their chronic disease, and including them in the healthcare process. It is not a traditional patient remote monitoring system [10,11] where the patient is under surveillance and information typically transferred to a central server to be viewed by healthcare personnel only. The rest of the paper describes our home based system for chronic disease management.

1. Materials and method

1.1. System Design

The patients use their ordinary TV and a remote control as an interface to the system. In addition they need a camera and a headset for audiovisual communication with healthcare personnel and peers suffering from the same disease. The healthcare personnel use their PC-based systems and stand alone videoconferencing systems.

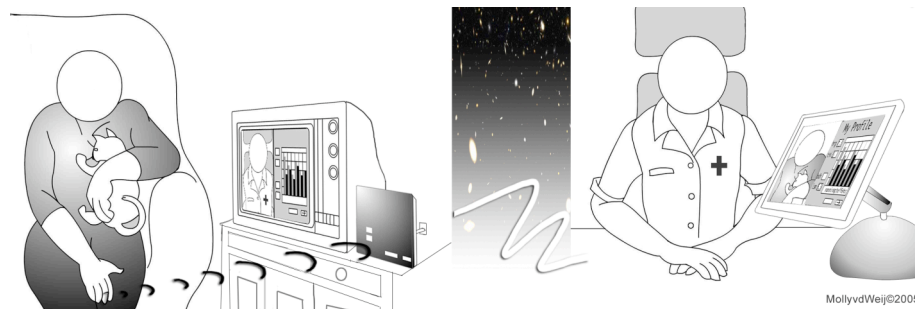


Figure 1: The Residential Patient Device connected to a TV

As part of our system, a *Residential Patient Device* (a dedicated computer) is connected to the users TV and a broadband connection. It provides a rich set of functions to implement personal eHealth-services, provides storage, and a secure and reliable communication channel between the home and the public health service.

Information is visualised on the TV in a useful format for the chronically ill, while the information needed by the healthcare personnel are visualised on their PC-based systems in an appropriate format. The following functionality is currently provided by the system:

- Presentation of health related educational material, both video and text-based
- Two-part and multipart videoconferencing
- A *Patient Health Diary* with:
 - o Disease related questions
 - o Vital signs measurements such as heart rate, oxygen saturation, and blood glucose values and other sensor data (wirelessly transmitted or manually registered)
- Visualization of information in the Patient Health Diary with possible different views for the patients and the care persons.
- User authentication and data encryption/decryption
- Message transmission

This functionality can be used to orchestrate home-based services for the chronically ill, tailored to the user's needs and abilities. The actual functionality needed will depend on the disease in question and the eHealth service delivered to the users in their home environment.

Adhering to our patient-centric view we keep the Patient Health Diary stored in the Residential Patient Device. In this way the information is easily available to the patients at home and not "lost" into the information space of healthcare e.g. the EHR, which traditionally makes it difficult, if not impossible, for the patients to get access to their information later on. This approach also allows the chronically ill to register more information in a self management perspective than otherwise would be possible in a hospital maintained EHR. However, both locally and remote stored educational material can be accessed and visualised by the Residential Patient Device.

Secure message transmission is used to transfer information in the Patient Health Diary to the Hospital Information System (HIS). The patients do explicit select and authorize the submission of information to the HIS – keeping the patient in control. However, the Residential Patient Device can be configured to also support remote access by healthcare personnel, giving us flexibility when configuring the system.

1.2. Security and Privacy

Information is stored encrypted in a database on the Residential Patient Device, and we use encrypted message transmission, and audio and video conferencing over an encrypted virtual private network (VPN) connection.

Authentication at home is based on pin codes, and if the system has not been used for a predefined period of time, the user is logged out, and has to enter the pin code again. This is done in order to avoid non-authorized persons to get access. Password authentication is used at the hospital for the healthcare workers.

1.3. Implementation

The current system is implemented on a form factor PC platform running Linux and following a basic Web architecture, where most of the application functions and logic are provided from a local web application server. The user interacts with the

application through a standard web browser and separate applications for video viewing and video conferencing. Patient generated information is encrypted and stored in a local SQL database, from which data may be aggregated and transmitted using the hospital messaging platform.

For the setup with TV and remote control we configure the computer to start up with the web browser in full screen mode, render the information especially for the TV, and use a browser plug-in for mouse-less browsing that enables automatic link numbering (recommended by the BBC style guide for interactive TV). In addition we provide the user with easy switching between browsing, video viewing and videoconferencing.

1.4. Services for COPD and Diabetes and the Trials

To validate our approach and prototype we designed home based services for education, exercises and following-up for both COPD and diabetes.



Figure 2: A field trial participant during an individual consultation at home

The COPD services are based on the COPD rehabilitation program at the University Hospital of North-Norway. The patients participated in weekly group-based TV-meetings with education and discussions. One or more thematic educational videos were to be watched before these meetings. Every week they also participated in a group based exercise sessions on TV. They registered daily information in the Patient Health Diary (questions, heart rate and oxygen saturation), and this was used as a basis for a weekly individual TV-consultation with healthcare personnel. In addition the Patient Health Diary was used for self management.

The diabetes services are based on the patient education and consultation services for Type 2 diabetes at the University Hospital of North-Norway. As with COPD, the patients participated in weekly TV-meetings with healthcare personnel and peers, and educational videos were to be seen before the TV-meeting. Their Patient Health Diary (questions and blood glucose values) was used as a basis for the individual TV-consultations, in addition to be used for self management.

Both the COPD and diabetes participants submitted last week's entries in their Patient Health Diary to the healthcare personnel by explicit action each week prior to their consultation.

In order to evaluate the prototype and services we ran a field trial lasting two months where five users with COPD and five with diabetes participated from their own homes. In addition, nurse, physiotherapist, doctor and dietician participated from the healthcare site. The patients and healthcare personnel were interviewed after the trial.

2. Results and Discussion

High usability was our main goal when choosing the TV and remote control as user interface in our current prototype. All of the participating patients did for instance find the TV and remote control very easy to use, both those who had been using a PC before and the non-PC users. Several of the informants expressed: “very easy to use”, “easy to navigate”, and “no problems”. They also found it easy to both enter and retrieve data in the Patient Health Diary, and to view the educational information and videos. Time to learn and amount of training required were also at a minimum level. Even though the duration of the trial and the number of participants is limited, it shows a promising tendency. Other studies on TV-based homecare systems do also report high usability [12,13].

The need for providing advanced services through an easy to use TV interface, instead of using a general personal computer, is supported by a study on computer usage and skills in Europe performed in 2005. This shows that 65% in age group 55 – 74 have “no basic computer skills”, and 14% have “low level computer skills”. Even in Norway the corresponding numbers are 30% and 30% respectively [9].

We experienced that it is possible to build an easy to use e-health system out of mostly free open source software (FOSS). Using a PC platform and web technology we implemented several functions for the TV that achieved high user acceptance.

Another approach is the traditional digital interactive TV-based systems. However, they often use technology that is quite expensive, builds on special hardware, and requires proprietary software [14]. Such systems could be difficult to customize for a specific service, have limited possibility to be expanded with new hardware components, and are difficult to integrate with open source systems. Our technological platform is PC based, where it is much easier to add hardware components, and where free open source software can be used. Using FOSS gave us access to existing software that we could customise and configure to our specific need and setup.

Another reason is the price. Healthcare systems are well known to be expensive but free open source software offers an opportunity to challenge this and to make affordable systems.

3. Conclusions

We have shown that it is possible to make a comprehensive, flexible and low cost home based eHealth system using affordable components and mostly free software. By using Internet technologies the Residential Patient Device can be accessed from mobile phones, Ultra-Mobile PC and laptops – in addition to the TV. The evaluation shows high usability of the system, and the trial participants found the system easy to learn and easy to use by means of a TV and a remote control.

The current technology is under market validation in Better Breathing, an eTen project. Future work includes the support for wireless and mobile solutions, advanced processing of sensor information and decision support. We will also focus on prevention and disease management for people with more than one chronic condition. This work is performed in MyHealthService, a project in the Tromsø Telemedicine Laboratory, a Norwegian Centre for Research-based Innovation co-funded by partners and the Research Council of Norway.

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