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Development and trial of ePoint.telemed – An open web-based platform for home monitoring of chronic heart failure patients

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Abstract. In North Norway no routine home telemonitoring services for chronic heart failure has yet been established and hence no investigations in the field have been published, although large distances and a sparse population are causes for extra public and private expenditure on travelling for patients when they make a visit to the hospital. In this paper we describe the ePoint.telemed platform for home telemonitoring of patients with chronic heart failure (CHF). The core of the platform is a dashboard, which is accessible through a browser window. Integrated with the dashboard are a blood pressure meter, a weight scale and a web-based patient questionnaire. The ePoint.telemed platform is a fully automatic internet based system meant for early warning in a CHF rehabilitation program. Unlike traditional remote medical technologies (RMT) building on dedicated medical equipment, we are applying easy-to-use personal health system (PHS) components geared towards the wellness and sports market. A Randomized Controlled Trial (RCT) has been started using the platform. 50 patients will be involved in the study with the aim of finding out if the home telemonitoring of CHF is clinically effective in Northern Norway and if it is cost-effective.

Keywords. Home care, telehealth, telemonitoring, chronic heart failure, randomized controlled trial, telemedicine

Introduction

In Norway the costs for treatment of chronic heart failure (CHF) are vast, both concerning hospital treatment, daily use of medication over years, and loss of quality of life for patients and their family caregivers. Generally there is little knowledge about what is gained for the billions used [1].

Structured telephone systems and remote medical technologies (RMT) for monitoring CHF patients at home have been widely deployed in Europe over the last 20 years or so [2][3][4]. These systems are considered capable of increasing life quality for the patients using them, to lower death rates and to decrease cases of re-hospitalization after heart surgery. However, home monitoring of patients with CHF is still in its beginning in Norway, and little practical experience has so far been gained.

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In fact, to our knowledge no routine telemonitoring services are available in Norway for chronic heart failure are established and hence no investigations have yet been published, although large distances and a sparse population are a cause for extra public and private expenditure on travelling for patients when they make a visit to the hospital. This would be a strong motivation for justifying the usage of telemonitoring from home. Thus, it seems that current evidence of effectiveness and quality is insufficient to recommend usage. The structure and funding streams in Norwegian health services are different from other countries and the conventional services that the intervention has been compared to in previous studies, are most likely heterogeneous. It is thus important to further investigate Norwegian conditions.

The paper describes the technological platform "ePoint.telemed" for the daily monitoring the patients' weight, blood pressure, pulse and self-declared health status, directly from their home; automatically, privately and securely transmit the values to a server at the hospital Heart Polyclinic; and allow monitoring these values by a trained nurse at the polyclinic.

RMT systems for monitoring CHF patients typically use dedicated medical equipment to measure body weight, blood pressure, heart rate, blood oxygen saturation levels and ECG. These systems are comparatively work intensive in terms of set-up and patient training. Compared with net-based solutions, structured telephone support requires synchronous follow-up by health-professionals, and such systems are not remotely configurable. The ePoint.telemed platform is a net-based system that works asynchronously with no need for interventions from health professionals, except on alarms. The platform is remotely configurable and may be individualized and set up without actually visiting the patients' home.

1. Methods

The conception of the platform was, from the start, driven by healthcare professionals. Medical doctors and nurses were involved in the design and implementation of the system from the prototyping stage until the user trials. Moreover, early tests were performed with patients using prototypes.

Two different strategies for component integration are implemented in the platform. The first one based on email parsing using REST API (REpresentational State Transfer Application Programming Interface) [6]. The strategy of using secure email for data transfer allows for the flexible integration of devices not providing other APIs as is the case of the chosen blood pressure meter. This approach is also used in MediBRIDGE [8]. The second strategy is based on the Oauth communication package [7]. Currently three components are integrated: a blood pressure meter, a weight scale and a tablet. However, more and different types of components can be integrated in the platform thanks to its open design. At present, the platform integrates a Withings weight scale [9], facilitating push of data (weight measurements) via the easy-to-use Withings API. Currently, the BP3 blood pressure meter from iHealth [10] is also integrated, which delivers diastolic/systolic blood pressure and heart rate. The tablet currently integrated is the iPad for its compatibility with the iHealth system. The system is open and easily configurable for other types of equipment. The estimated effort for configuring a new device on the system is approximately one to two person.days.

The initial feasibility testing included 3 patients with chronic heart failure and the nurse responsible for the outpatients clinic at the hospital. The platform was then

installed at the patients' homes by a team from the hospital. After the first two months of pilot testing, the patients were satisfied with the usability of the solution. As for the hospital side, the data arrived timely and correctly and the reliability of the system was proven. The nurse also gave positive feedback on the system's usability and functionalities.

After the pilot phase, the planned trial with fifty patients could then take place and the randomized enrolment of patients could start. An application was then sent to the Norwegian Regional Ethical Committee for ethical approval of this larger randomised controlled trial (RCT). After receiving the approval to the project, the final version of the platform was developed and the randomized controlled trial started in January of the current year, 2015, at the University Hospital of North Norway. The research protocol is being submitted to JMIR Research Protocols [12]. The purpose of the trial is finding out if the home telemonitoring of CHF is clinically effective in Northern Norway and if it is cost-effective. All patients admitted at UNN's heart polyclinic, satisfying the inclusion criteria, are randomized into an intervention arm testing the proposed telemonitoring service and a control arm with the treatment usually offered by the polyclinic. Patients assigned to the intervention arm receive a home telemonitoring kit consisting of a tablet, a wireless weight scale and a portable blood pressure meter. The patient is asked to weigh him- or herself every day. In addition, the patient also takes a measurement of the blood pressure and heart rate and answers an online multiple-choice questionnaire about his or her health condition. Patients assigned to the control arm receive treatment as usual.

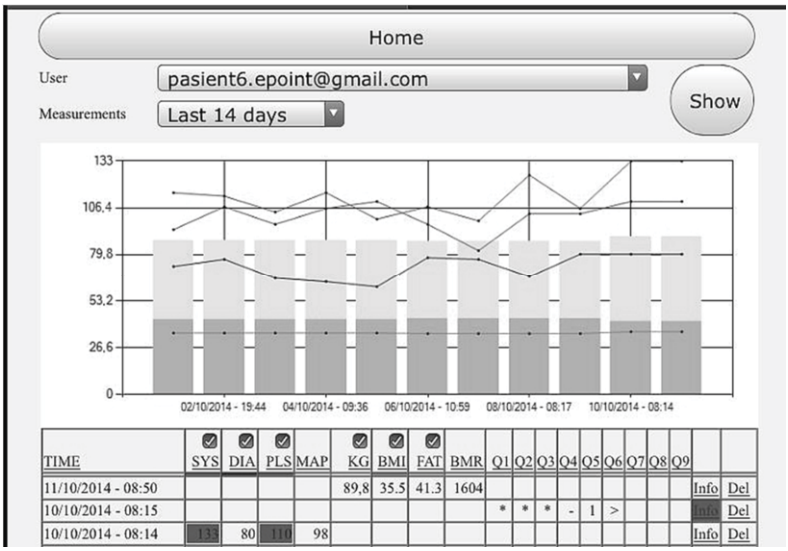

Figure 1. Dashboard screenshot.

2. Results

The ICT platform developed for the RCT is web-based and it follows an open strategy of component integration. Patient data is accessible through a browser window (see figure 1). Health data is stored in a secure server. The details on each component, the

platform conception and design, and a description of the dataflow will be given below. Considerations on the implemented privacy and security measures are also presented. Finally a list of the most relevant and innovative aspects is offered.

Unlike traditional RMT based systems building on dedicated medical equipment, the ePoint.telemed platform uses easy-to-use personal health system (PHS) components geared towards the sports and wellness market [5]. The inbuilt internet connection of the components used in the platform implies a seamless communication with a central server placed in a local health service centre or in a hospital. Vital data can be collected according to medical needs. User-specific thresholds can be set, by the medical staff for any parameter, such as blood pressure or weight. The system will automatically send email-based alarms to health professionals for any data out of range as specified by the thresholds. The measurement of both the blood pressure and heart rate are collected by the iHealth App on the tablet. The iPad tablet was selected because of its compatibility with the iHealth System. The collected data is then sent through an email to the ePoint.telemed back-end by a secured socket layer channel. Triggered at regular times (at the moment 9am and 3pm, although these can be configured), a PHP script parses the CSV-file in the email using queries for insertion of the data in the MYSQL database. A REST API is used to parse the CSV-file. The parsed data collected by the iHealth, i.e. blood pressure and heart rate, is then presented in the dashboard. The user is required to fill in a web-based questionnaire daily. This is accessed through a link icon in the iPad. Once the questionnaire is completed, an email is automatically composed with the answers. This is sent by an anonymously to the central dashboard as a CSV-file. This file is parsed in the same way as the process with iHealth, using the REST API. The use case shown in table 1 describes the user interaction with the platform.

Table 1. Use Case: Patient measurements

Use Case Patient measurements
Summary - The patient, at home, is requested to interact with the system daily, if possible in the morning, so that this becomes part of her/his routine. Measurements and questionnaire answers are securely sent through the internet into a dedicated server and then exported to the system dashboard.
The patient stands on the Wi-Fi connected weight scale. The weight scale sends the weight together with the device ID to a cloud server.
The patient measures blood pressure by placing the cuff on the upper arm and by opening the iHealth app on the iPad and pressing the start measure button.
After controlling the measurement, the patient sends results by email using the built-in sharing system (note that this is anonymous as the identification is done by coding as mentioned elsewhere in this paper).
Finally the patient answers the daily questionnaire regarding general health status and sends the results.

3. Discussion

With recent events and advances in information technology and the Internet, confidentiality regarding handling of patient private data has become a critical aspect of a study design, as privacy is a fundamental right in the public healthcare domain. In this

project, confidentiality of private health information is ensured according to [11]. All private personal data is de-identified: every unique identifying number, characteristic, or name which can be of the individual or of relatives of the individual are removed so that the information can be used alone or in combination with other information. Moreover, the written consent of participants is required by means of providing a letter of informed consent to be signed.

All data transfer is anonymous as the patients identification is done by coding. The relation between the codes and the patients' names are kept on paper in the Heart Polyclinic with a backup stored in a hospital PC not connected to any network.

The success of ICT based health interventions are strongly dependent on user acceptance, both from the professional side as from the patient side. Usability issues in the ePoint.telemed platform were given careful attention. The platform is validated in real clinical testing and following the approved clinical procedures. The openness of the platform allows for the future inclusion of other devices. Its applicability in other pathologies, such as diabetes or COPD can be supplementary tested with the inclusion of a glucose meter and a pulse oximeter, respectively.

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