© The Journal on Information Technology in Healthcare 2007; **5**(6): 372–378

Homecare Telematics for Peritoneal Dialysis

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ABSTRACT

Homecare telematics is one of the fastest growing healthcare delivery sectors in the developed world. It is further enhanced as the healthcare delivery paradigm is shifting from doctor and hospital-centred care towards a new model where the citizen becomes responsible for the personalised management of healthcare, delivered in their homes whenever possible. An area of homecare telematics that shows potential is the support of end stage renal disease patients on haemodialysis and/or peritoneal dialysis. This paper reviews current trends in homecare telematics for patients on peritoneal dialysis and highlights some problems and design considerations that prohibit the widespread deployment of such services. It also presents a component-based design, founded on Internet communication protocols and standard interfaces, for the development of homecare services for peritoneal dialysis.

INTRODUCTION

Most developed countries are facing important challenges with respect to the provision of healthcare services[1]. This is the result of a direct combination of:

- An increase in the incidence and prevalence of chronic disease such as end-stage renal disease, diabetes, asthma, together with an increasingly ageing population
- Increased demand for providing and sustaining quality of life in patients with chronic illnesses and in the elderly
- Patients' demand and expectations for more convenient services and easier accessibility to care, i.e. a shift from secondary care to community care
- Need for increased efficiency, individualisation and equity of quality-oriented healthcare due to limited financial resources
- Difficulties of recruiting and retaining personnel in healthcare services in general and for home and elderly care in particular

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These challenges are turning homecare telematics into one of the fastest growing healthcare delivery sectors in the developed world. Indeed, it is expected to grow even more dramatically as healthcare provision and reimbursement policies are likely to change as a result of cost-effectiveness evaluation studies[2]. Homecare telematics also fits in well with the new healthcare delivery paradigm where care is shifted from doctor/hospital-centred care to a new model where individual patients become responsible for the personalised management of healthcare which is delivered within their own homes whenever possible.

This paper describes a novel architectural approach for developing homecare telematic services for monitoring, managing and communicating with end stage renal disease patients on peritoneal dialysis. The proposed approach builds on open Internet standards for communication between well defined and self-described functional units, thus supporting solutions based on integration of components from various vendors.

HOMECARE TELEMATIC SERVICES

Homecare telematics (or telehomecare) involves the use of information, communications, measurement and monitoring technologies to evaluate health status and deliver healthcare and support personalised healthcare management. The more modern term *home teleHealth* includes in general any use of telecommunications by a homecare provider to link patients or customers to one or more out-of-home sources of care information, education, or service by means of telephones, computers, interactive television, or some combination of each. Finally, the concept of home based eHealth is sometimes used to include both telehomecare and smart homes[3]. Generally, homecare telematic services can be used to:

- Enhance health maintenance in special high risk groups with pre-existing chronic medical problems
- Assist rehabilitation after disease and major therapeutic interventions
- Support health in both acute and chronic health problems
- Support preventive healthcare through information dissemination and education for self-management

Such services fall broadly into the following categories[2,4,5]:

- Addressing patient and carer anxiety
- Providing patient information and consultation to improve quality of life
- Supporting telemetry of vital signs and related patient data
- Combining some or all of the above to set the basis towards integrated personalised care

However, a recent literature review[1] suggests that most of the work on homecare telematics is towards two dominant services: audio-video teleconsultation and vital sign telemetry, while other added-value services such as decision support for medical staff and advanced information access and communication are sparse.

The most common medical case and disciplines supported by homecare telematics include: cardiovascular disease (monitoring patients with coronary artery disease, rehabilitation after cardiac surgery), diabetes (teleconsultation to enhance adherence to medical regimen), chronic pulmonary disease (chronic patient monitoring, teleconsultation to monitor and enhance adherence to therapy), oncology (homecare and support via teleconsultation and virtual home visits), supporting the elderly (mobility telemonitoring). Home telehealth also includes services to support renal disease: teleconsultations and virtual home visits, education, and vital sign telemetry for haemodialysis[6–8] and peritoneal dialysis patients[9–13].

TELEMATICS FOR PERITONEAL DIALYSIS: TRENDS AND CONSIDERATIONS

The number of patients with chronic renal failure is increasing predominantly as a result of an increase in the incidence of diabetes. End stage renal disease with chronic renal failure is treated with either dialysis or kidney transplantation. Dialysis involves substituting renal function by removing waste products from the blood via a specialised interface, either using an artificial membrane outside the patient's body (haemodialysis in specialised units) or using the patient's peritoneum as a physical membrane (peritoneal dialysis). In peritoneal dialysis (PD), a special fluid (solute) is inserted into the peritoneal cavity, remains there for a certain period of time and is then drained from the peritoneal cavity. The process is performed via a special catheter implanted in the peritoneal cavity with one end of the catheter accessible outside the patient's skin. Peritoneal dialysis can be performed by patients in their own home with regular follow up in hospital. The percentage of patients on peritoneal dialysis differs between countries and is usually about 10–50% of all patients on dialysis. The effectiveness and success of the method depends on the patient's individual dialysis scheme which is determined by a number of factors including physiological parameters, e.g. patient weight, blood pressure, as well as the type and amount of the solute that is inserted and drained during the dialysis. There are 2 main PD techniques. One is Continuous Ambulatory Peritoneal Dialysis (CAPD), where the patient handles the process of fluid exchange manually throughout the day, and the other is Automated Peritoneal Dialysis (APD), where the process is performed automatically by a cycler device during the night.

Since it is performed at home, peritoneal dialysis is a unique candidate for support via telematic services. Teleconferencing has been used by various groups for psychological support, patient retraining, evaluation of problems with the catheter exit site and the presence of oedema[9,10]. More recent studies and pilot implementations involve vital sign telemetry. Mobile telephony and web-based systems have been proposed to monitor CAPD sessions[11] as well as APD[12]. Automated telemetry between the patient's cycler and a computer in the PD clinic is currently supported by most prominent manufacturers of APD equipment, e.g. Fresenious Medical Care[14] and Baxter International Inc.[15]. These allow data transmission and storage, doctor interventions to alter cycler prescription, as well as live patient-physician interaction[13].

Related studies have shown that telemonitoring of dialysis data can be useful in detecting and solving clinical and technical problems associated with APD. Generally, telematic support for peritoneal dialysis has proven to be a low cost solution with the following benefits:

- Easy to incorporate into the daily routine of a clinic
- Saves time for both patients and nurses
- Reduces utilisation of hospital facilities and hospital workload

In general, telematic support has been positively received by patients on peritoneal dialysis. In particular, elderly and handicapped patients benefit from such services. When they become comfortable enough to maintain CAPD and APD without any major problems, their quality of life and that of their families in general is improved.

However, there are some design considerations and technical limitations to existing solutions that prohibit the widespread adoption of such services. Although telematic support has been incorporated into widely used APD cyclers, this service is provided only with a limited range of models. More importantly it is not provided as an open component system, and the APD telemetry data can only be monitored, archived and managed via proprietary software. As a consequence a PD centre would either have to use APD equipment exclusively from a single vendor, or have to cope with different sets of monitoring and archiving software. In either case, monitoring would be restricted to APD patients using certain advanced cyclers, and exclude users of other devices and/or patients on CAPD.

PERKA: TELEMATIC SERVICES FOR PERITONEAL DIALYSIS

In 2006 the School of Medicine in Democritus University of Thrace and two software companies, ALPHA Information Technology SA[16] (Alexandroupolis, Greece) and VIDAVO Information Systems Inc.[17] (Thessaloniki, Greece), formed the PERKA consortium and were granted a competitive Research and Development fund in order to develop a new telemedicine service to support peritoneal dialysis at home, using standard-based integration between individual units developed independently by various vendors.

The PERKA service supports the collection and transmission of data from a patient's home via cellular or conventional phone or data networks to the PD clinic for monitoring and archiving. Transmitted data include:

- Peritoneal dialysis data: PD method, PD prescription, and actual PD daily treatment schema conducted, including number of fluid exchanges, exchange duration, solute type and volume, and ultrafiltration volume.

- General biometric data and biosignals: body weight, blood pressure, heart rate, oxygen saturation, temperature, and, if required, electrocardiogram and blood glucose levels.
- Free text or sound report and/or response to a structured questionnaire. Data are transmitted to the PD Clinic, where they are archived as a patient record segment and processed to create intelligent alarms.

Medical personnel can monitor transmitted data either on schedule or as a result of an alarm, and remotely supervise PD procedure, patient adherence to prescription, reaction to PD and the overall wellness of the patient, and can intervene to change the therapy or communicate with the patient. The service can be applied in any PD technique, including CAPD and APD.

The proposed approach builds on open Internet standards for communication between well defined and self-described functional units, thus supporting solutions based on integration of components from various vendors. The basic functional units, shown in Figure 1, include:

- A patient unit, a PDA-based mobile application that undertakes local data collection, either automatically from various medical devices with digital output or as manual patient entry.
- A data collection unit, which is implemented as a web service, with standard self-describing interface methods that among other features describe the type and details of telemetry data required. This web service collects, manages and processes telemetry data.

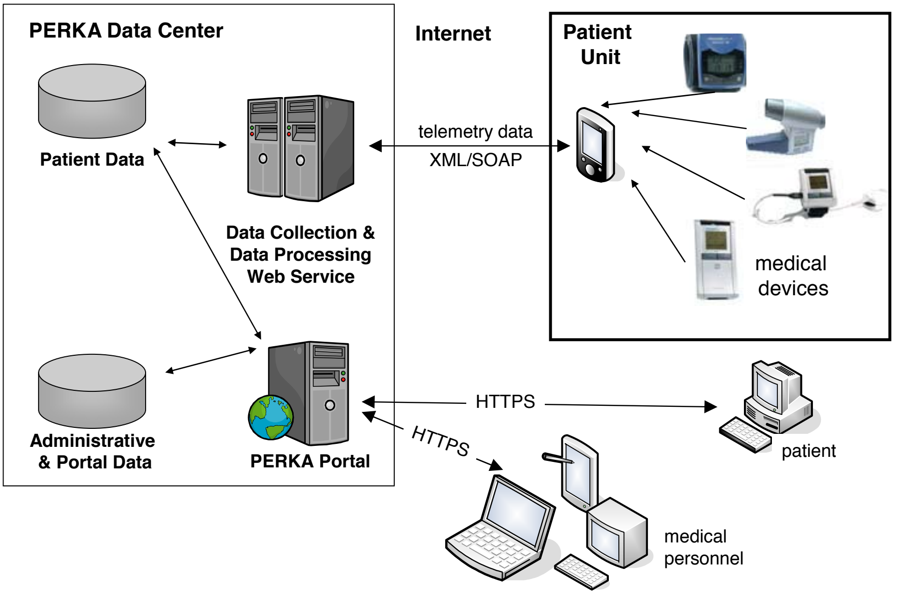

Figure 1. *The PERKA Service Architecture Overview*

- A web-based portal application that provides different views of the telemetry data, according to the user (patient, doctor, nurse, administrator, etc) via secure Internet protocols.
- A database for patient telemetry data that corresponds to a patient record segment.
- A database for administrative data (user definitions, roles, permissions and other information) as well as content for general information of the medical personnel, patients and the public (which is organised by a content management system).

Communication between the patient unit and the data centre is based on XML/SOAP (Extensible Markup Language/Simple Object Access Protocol). The published interface methods of the data collection web service allow for third party vendors (including vendors of peritoneal dialysis cyclers and other supportive medical equipment) to develop their own proprietary units for local collection from the patient and thus provide a generic standard interface for integration with special purpose mobile units and medical devices alike.

DISCUSSION

For many patients with end stage renal failure, peritoneal dialysis is a suitable alternative to regular haemodialysis in hospitals and offers patients better quality of life. However, as peritoneal dialysis is performed solely at home, patients have to do everything themselves, including solute exchanges, catheter site care, recording of dialysis session parameters and related biometric data, etc. Telemedicine can support these patients either by teleconference consultations or through session telemonitoring via telemetry.

A major problem associated with the widespread adoption of such services is that existing solutions involve proprietary systems implemented from end-to-end by the same vendor. Thus users have to use a particular machine supplied by a particular vendor to be able to use the telemedicine service. To address this problem we have developed a novel architectural approach to enable homecare telematic services for all peritoneal dialysis patient irrespective of the equipment they are using. The system is based on open Internet standards for communication between well defined and self-described functional units, thus allowing for potential solutions based on integration of components from different vendors. We are currently working on deploying and evaluating our solution with components developed independently by three different partners.

ACKNOWLEDGEMENT

We thank Exedron Incorporated, Alexandroupolis, Greece, for technical support related to the functional analysis and architecture design of the PERKA service. This work is supported by a

Regional Operational Programme, East Macedonia and Thrace, Ministry of Development, Greece fund under the project: "PERKA – Supporting Peritoneal Dialysis at Home".

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