# A Clinical Monitoring and Management System for Residential Aged Care Facilities

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*Abstract*—In response to an extended user needs analysis, a home telecare system designed for the management of patients with chronic disease was adapted for use in residential aged care facilities (RACFs). The system architecture and hardware and software components are described for both the client- and server-side. The client-side includes medication dispensing, scheduled clinical measurements and questionnaire delivery. The server-side supports Web-based administrative tools for scheduling and medications management, as well as automated reporting functions. A brief discussion on a trial of the system in five different RACFs focuses on how clinical information technology can support and improve care standards and deliver better health outcomes for residents in Australian aged care homes.

## I. INTRODUCTION

With increasing demands to exchange clinical information with a range of authorized care providers it is becoming more important for residential aged care facilities (RACFs) to develop their capability to gather, process and exchange clinical and other management information with care providers. The current practices in most countries are predominantly manual monitoring of clinical status with no longitudinal patient record or other electronic health record. However, we have shown [1, 2] that simple records of physiological signs such as heart rate, blood pressure and weight, when graphed over time and viewed in conjunction with other information (such as current medications) can help primary care physicians - general practitioners (GPs) and allied health staff to rapidly identify and manage significant changes in clinical status with an end result of improving the quality, timeliness and appropriateness of clinical care [3].

Telecare has significant potential for contributing to the management of patients with chronic disease as well as at-risk elderly people living either at home or in RACFs. Usability and clinical trials of home telecare technology have demonstrated wide acceptance of the technology by users [1, 3, 4] and enormous potential cost benefits in specific chronic disease target populations – for example, congestive heart failure (CHF) [5].

In this paper we focus on the system architecture of a clinical monitoring and management system for use in RACFs. We also briefly discuss its trial deployment in the RACF setting. This trial follows previous trials conducted by our group in home care settings [1, 2]. The trial involves the use of simple, mobile devices to monitor and electronically record the clinical well-being of residents (e.g. pulse, electrocardiogram (ECG), blood pressure, weight, lung function), to capture the results of health questionnaires and assessments, and to securely store and present this information in a range of easily digestible formats for residents, aged care staff and for health care providers who are located remotely from the home. The information forms the basis of an electronic health record that will assist in care planning and medication management.

The overall aim of this specific trial was to investigate how clinical information technology can support and improve care standards and deliver better health outcomes for residents in Australian aged care homes. As an integral component of the trial, there was an evaluation of the impact of the system on the quality of care in the RACFs.

The first phase of the trial was a six month user needs analysis, which was followed by an eight month technology development and integration phase. The base system unit that was modified was the home telecare system as has been previously trialed in home care settings [1-3]. The next section describes the system architecture that was implemented in response to the user needs analysis.

## II. SYSTEM ARCHITECTURE

The redesigned "TeleMedCare System" (TMS) is illustrated in Fig. 1. The major features of the redesigned TMS in response to the user needs analysis can be summarized as follows:

- Support for multiple residents on the client system. This included being able to rapidly view and select residents from a list based on either their name or room location, thereby allowing for their medications to be dispensed or their clinical information to be recorded. Modifications were made to the single home user's interfaces and to the overlaying software architecture and database systems to support multiple residents.
- A significantly more complicated medications management system compared to the simple medication alerts module for the home user. The client system supports prescribed, Pro-Re-Nata (PRN) and nursing-initiated medication dispensing by RACF staff that are identified using biometric fingerprint recognition. A

Fig. 1. Redesigned TeleMedCare System showing (left panel) the client workstation with laptop and clinical measurement modules (single lead ECG, blood pressure, spirometry, pulse oximetry, temperature, Bluetooth-enabled weight scale (not shown)). The middle panel shows the system mounted on a medication trolley with touch screen and biometric finger print reader for authentication and medication authorization. The right panel is a schematic of the system illustrating the client –side functionality and the clinician access (for management and reporting functions) via a standard Web browser.

medication dispensing history can be viewed similarly to the paper-based medication charts routinely signed by nursing staff in RACFs.

- Login capabilities by the RACF staff using password or fingerprint access into the system, and administrative functions for registering new users and allocating roles or privilege levels. This allows RACF staff using the system to dispense medications and perform clinical measurements on behalf of the residents rather than directly by the residents themselves.
- The client system is fully portable and designed to be taken to the resident during regular medication rounds. The workstation and peripheral sensors have been integrated into a standard medication trolley requiring a lead-acid battery and charging unit for portable power.
- Time-based alerts for representing remotely configured medication and measurement schedules (and Web systems for configuring these schedules) were developed to support a medication/measurement round-based paradigm, rather than restricting events to any particular time of the day – which was the case for the home-based system.
- The support for additional user roles of the nurse, the nurse administrator (NA) and the pharmacist on the client system, in addition to the standard home user roles of the patient (resident) and the carer (usually GP). Both standard and new roles have different levels of access and functionality on the client system and Web site depending on the role.
- Web functionality to assist a GP in the process and communication requirements for a making claim to a specific Medicare Enhanced Primary Care item (a reimbursement scheme in which the Government pays the GP for case conferencing when managing the patient's condition). This was implemented as a demonstration of the business model for GP remuneration as an incentive for reviewing resident health information via the system.
- The addition of a clinical reporting module to the Web site designed to display a summary of a resident's

clinical information in a clear and concise manner as a configurable PDF report. The report can be scheduled to be periodically generated and sent by fax and/or email to the GP, Pharmacist or NA, and can be included as part of the resident's permanent health record.

### A. Client system interface

The interface on the client system is made up of a series of PC screens that allows the RACF staff to control the system, and makes available functions for taking clinical measurements, managing medications and other functions while interacting with the residents on the wards. The interface begins with a login screen to which staff can access using either a pre-entered login password or fingerprint. After successful access into the system, a choice of functions in the Main Menu appears that can be selected by pressing the relevant button on the touch screen. The functions that are available in the Main Menu are shown in Fig. 2 and include the following.

#### 1) Selecting residents

Residents can be selected either by their names or room locations and the list of resident names also has their portraits attached to assist in identifying the resident. Color coded symbols are displayed with each resident (or room) indicating at a glance if there are scheduled medications or measurements that need to be carried out for the particular ward round selected.

#### 2) Changing a round

The number and types of rounds are preconfigured remotely by the NA for a particular RACF on the Web. These rounds provide the basis for selecting when medications are to be dispensed or clinical measurements are to be taken.

#### 3) Updating data (synchronizing)

The process of synchronization allows a two-way information exchange between the client system and the central data repository linked to the Web site. New information entered via the Web site including medication changes and measurement schedules will appear on the client system only after successful synchronization has
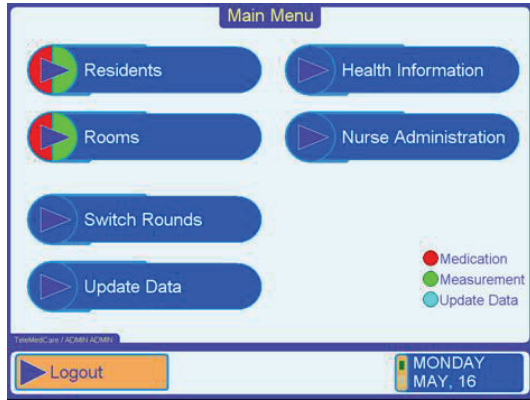
Fig. 2. Client-side main menu indicating that both medications and measurements are due and the user has permission to dispense the former.
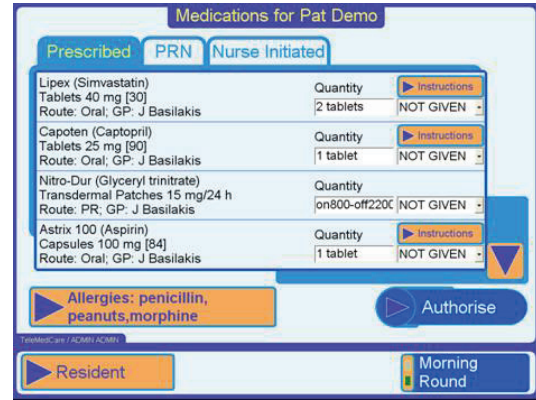


Fig. 3. Interface for dispensing of medications.

occurred. Similarly, synchronization allows any new clinical information collected on residents in RACFs to be available for viewing on the Web.

*4) Display of health information*

The display of health information is intended as a simple means of remotely broadcasting messages or educational material to the staff that was not operation for the trial.

*5) Administration functions*

If the user has administration rights, an additional 'Administration' button appears that allows this user to register other users into the system and give them the appropriate access permissions according to their role.

Once a resident is selected from the Main Menu, the Resident Menu appears containing a new set of buttons for resident-specific functions, including, medications, measurements, medication chart, measurement results and a resident's log. This page also contains a larger portrait of the resident.

Resident medications can be dispensed via the interface shown in Fig. 3. The interface gives information on the relevant medications that need to be administered to the resident for a particular round and at the same time is used to authorize the person administering the medication using fingerprint identification. Information about a medication's trade name, generic name, the quantity, dose, frequency, route and prescribing doctor are all included as details for each medication. The medications are separated into prescribed, PRN (as required) and nursing initiated medications on separate panels separated by tabs.

There are methods for updating information on medications signed for in previous rounds because either they were signed in error or there is a change in dispensing status for the medication. This can be done through the medication chart. The medication chart shows a list of medications that are prescribed together with the dispensing history record.

The measurement modules have all been retained from the single user system and all operate in a similar way [1-3]. Most measurements are taken while interacting with the

peripheral sensors attached to the unit. Each of the measurement modules provides a clear display of the waveform data during the measurement, an indication of progress, instructions for performing measurements, and a final display of the parameters extracted from the data. This display of waveform data provides good feedback to the user on the accuracy and reliability of the measurement being taken.

The blood glucose and questionnaires require user interaction for entering results via the interface instead of the peripheral sensors. The value for the blood glucose can be entered via a key pad that appears on the touch screen, whereas the questionnaire responses are recorded while questions appear on the screen. The questionnaires can be entered into the system via the Web site. Those questionnaires that had been selected for the trial and are relevant to the RACF setting include; the COOP/WONCA scale, Geriatric Depression Scale, Modified Mini-Mental State Examination, and the Abbey Pain Score.

*B. Web interface*

The Web interface is essentially the portal that allows remote communication and control of all linked client systems. Access to this secured Web site requires a username and password that determines the level of privileges and functions available to the user depending on their role, including access to allocated residents.

All resident clinical measurement results can be viewed in graphical trend form including questionnaire data, over a variable period of 1, 3 or 6 weeks. Points on the graph can be selected to find more out more information on the specific measurement, including timestamp and parameter values. All available waveform data for measurements like the ECG and lung functions can be viewed using the graph functions, which is important for providing feedback to the user on the quality of the measurement taken and reliability of the results.

A significant amount of modification to the Web interface occurred to accommodate medication prescribing in the multi-user RACF environment which is by far more

complicated than the medication management functions for the single user system. The GP is the only user who has privileges to remotely prescribe and change a resident's medication, while only the NA is able to prescribe the nursing initiated medications to apply to all residents in the RACF. The Pharmacist has an additional interface that aggregates a view of medications changes for all residents in the RACF. This allows immediate notification of a change to a resident's prescription by the GP that the Pharmacist would need to be notified of, and respond to as quickly as possible.

The reports are configurable to display the clinical measurement results (graph and/or table format) and/or the medication details (current and recent changes to medications). In order to generate the reports for the trial a Reporting Server was designed to interact with the Web site to collate and display medical information acquired from the client system. This server also provides a Web interface for a nominated reviewing/reporting clinician, (who has overall access to all the resident data in the trial) to review the results for the purposes of notification of concerning results to the relevant health care worker should any concern arise.

### III. TRIAL METHODOLOGY

The trial of the TMS was conducted in five separate RACFs in three states (ACT, NSW and VIC) of Australia and involved approximately 75 residents. The RACFs offered a variety of services to residents from a wide range of ethnic, cultural, religious and socio-economic backgrounds, and together reflected a good cross-section of the industry. RACF staff used the client system integrated into a medication trolley during ward rounds to assist in dispensing medications to residents and to measure their physiological parameters as ordered by the appropriate health professional. There was also the capacity to enter questionnaire data and log events that were relevant to the resident on the round. The actual deployment was phased in over a 12 month period with each RACF using the system for approximately 3 months.

### IV. CONCLUSION

To briefly summarize the outcomes of trialing the system, it was found that senior management in the RACFs' were generally very supportive of the project and could readily identify the benefits of the telecare system in promoting clinical care, supporting the involvement of the residents' GP, and potentially reducing legal liability because of the existence of audit trails.

The user needs analysis phase identified computerized medications management as a key user requirement. Whilst a rudimentary medications management system existed in the previous system, the requirements in RACFs were significantly more complex and required a complete redesign of the system. This became a significant part of the software development phase, before the trial could take place.

Nursing staff found the computerized medications management very intuitive and easy to use. Biometric signatures were seen as very important to expedite the medications round and provide an audit trail of all medications dispensed.

Somewhat unexpectedly, clinical measurements were not seen as a normal part of the RACF medications round, and would not necessarily be initiated by the nurse unless the GP requested the measurement. This may suggest that uncoupling clinical measurements from the medications round, whilst counter intuitive, may enhance use of the clinical measurement facilities by the nursing staff.

To obtain maximum benefit from the TeleMedCare System, all residents in the medications round need to be enrolled. In this trial, because of the requirement for informed consent both from the resident and their GP only a fraction of subjects in a particular round were enrolled. This meant that duplicate trolleys were often used, and separate rounds put in place for the participant group.

It was not possible to categorically demonstrate that the TMS trialed contributed to improved clinical outcomes and to improved communications between GP, nursing staff, residents and their carers, because of (i) the brevity of the clinical trial phase, (ii) the small number of subjects enrolled over a number of different RACFs and (iii) the subject selection criteria that mixed participating and non-participating residents in the same institution. We believe these factors also influenced user and patient perceptions' of the system.

However all the evaluation instruments are now in place for a larger clinical trial operating over at least one year to attempt to achieve and statistically demonstrate this important objective.

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