MCCSIS 2012

IADIS MULTI CONFERENCE
ON COMPUTER SCIENCE
AND INFORMATION SYSTEMS

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Proceedings of the
IADIS International Conference

e-Health 2012

EDITED BY
Mário Macedo

iadis
international association for development of the information society

IADIS INTERNATIONAL CONFERENCE

E-HEALTH 2012

part of the

IADIS MULTI CONFERENCE ON COMPUTER SCIENCE AND

INFORMATION SYSTEMS 2012

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TABLE OF CONTENTS

FULL PAPERS

SHORT PAPERS

REFLECTION PAPERS

POSTERS

DOCTORAL CONSORTIUM

FOREWORD

These proceedings contain the papers of the IADIS International Conference e-Health 2012, which was organised by the International Association for Development of the Information Society in Lisbon, Portugal, 17 – 19 July, 2012. This conference is part of the Multi Conference on Computer Science and Information Systems 2012, 17 - 23 July 2012, which had a total of 1036 submissions.

The use of ICTs (Information and Communication Technologies) in Healthcare Services is the main mechanism to improve efficiency and effectiveness.

The IADIS e-Health (EH) 2012 conference aims to draw together information systems, practitioners and management experts from all quadrants involved in developing computer technology to improve healthcare quality.

Submissions were accepted under the following topics:

A. Research Issues
- Computers and Primary Care
- Clinical Data Visualisation Standards
- e-Health Architectures
- Healthcare Data Architecture and Terminology Standards
- Federated Electronic Health Records
- Personalized Medicine
- Health Informatics and Education
- Human Computer Interaction
- Infrastructure and Architecture
- Internet and Medicine
- Interoperability issues
- IT and Patient Care
- Nursing Informatics
- RFID and localization techniques
- Usability and Ubiquity in e-Health
- e-Health Virtual Communities
- Business Process Management Systems
- Second Life for Healthcare Support and Education

B. Management Issues
- Case Studies
- Management Change
- Confidentiality and Privacy
- e-Health Collaborative Strategies and Techniques
- e-Training
- Healthcare Management Dashboards
- Legal issues

- Balanced scorecards models to improve Hospital Performance and Productivity
- Business Intelligence in Healthcare
- e-Health to improve Healthcare Quality and Patient Safety.
- Healthcare Information Systems Regulatory issues
- Security in e-Health
- Service Models
- Social implications
- Stakeholders involvement

C. Applications
- Clinical Information Systems
- Data Mining and Clinical Studies
- Medical Guidelines
- e-Health Decision Support Systems
- e-Logistics and e-Pharmacy
- Intelligent Medical Systems
- Mobile Applications
- Patient Electronic Health Records
- Healthcare Portals to inform and connect Patients with Physicians
- Patients and Public Health
- Social Networks in Healthcare contexts
- e-Health Marketing
- e-Procurement and e-Commerce
- Telemedicine
- Automatic Identification and Data Collector Systems
- Unified data processing and communication Systems
- Web Based Applications
- e-Health 2.0

The IADIS e-Health 2012 conference received 112 submissions from more than 32 countries. Each submission has been anonymously reviewed by an average of four independent reviewers, to ensure that accepted submissions were of a high standard. Consequently only 18 full papers were approved which means an acceptance rate of 16 %. A few more papers were accepted as short papers, reflection papers and posters. An extended version of the best papers will be published in the IADIS International Journal on Computer Science and Information Systems (ISSN: 1646-3692) and/or in the IADIS International Journal on WWW/Internet (ISSN: 1645-7641) and also in other selected journals including journals from Inderscience.

Besides the presentation of full papers, short papers, reflection papers, doctoral consortium and posters, the conference also included a keynote presentation from an internationally distinguished researcher. We would therefore like to express our gratitude to Prof. Frank Sullivan, FRSE FRCP FRCGP Director of the Health Informatics Centre, University of Dundee, Scotland.

This volume has taken shape as a result of the contributions from a number of individuals. We are grateful to all authors who have submitted their papers to enrich the conference proceedings. We wish to thank all members of the organizing committee, delegates, invitees and guests whose contribution and involvement are crucial for the success of the conference.

Last but not the least, we hope that everybody will have a good time in Lisbon, and we invite all participants for the next edition of the IADIS International Conference on e-Health 2013, that will be held in Prague, Czech Republic.

Mário Macedo,
Instituto Politécnico de Tomar, Portugal
e-Health 2012 Conference Program Chair

Piet Kommers, University of Twente, The Netherlands
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MCCSIS 2012 General Conference Co-Chairs

Lisbon, Portugal
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KEYNOTE LECTURE

TRANSFORMING HEALTH CARE RESEARCH AND ITS IMPLEMENTATION

By Prof. Frank Sullivan, FRSE FRCP FRCGP
Director of the Health Informatics Centre, University of Dundee, Scotland

ABSTRACT

The underlying concept of TRANSFoRm is to develop a ‘rapid learning healthcare system’ driven by advanced computational infrastructure that can improve both patient safety and the conduct and volume of clinical research in Europe. The EU policy framework for information society and media, i2010 identifies eHealth as one of the principal areas where advances in ICT can create better quality of life for Europe’s citizens. ICT has important roles in communication, decision-making, monitoring and learning in the healthcare setting. TRANSFoRm recognises the need to advance the underpinning information and computer science to address these issues in a European and international context. Providing interoperability between different clinical systems, across national boundaries, and integration of clinical systems and research systems lies at the heart of the eHealth Action Plan 2004. This is however, a two-way street, just as clinical data are needed for research (for participant identification and evaluation of outcomes) research data is needed to support clinical care. In both domains fragmentation of records and proprietary systems that do not adhere to standards within the domain are as much of a challenge as the legal and ethical issues that complicate access to clinical data for researchers. However, significant advances in international standards and in computational technology to support interoperability offer a way to overcome these challenges. Furthermore, advances in the understanding of clinical judgment and decision making, and the possible ways of supporting them via ICT can inform the design of more ‘intelligent’ electronic health record systems.

The single richest source of routine healthcare data lies within the records of Europe’s General Practitioners. Primary Care is responsible for first contact, continuing, and generalist care of the entire population from birth to death. Any project that aims to comprehensively support the integration of clinical and research data should begin with Primary Care. In addition, even in countries where General Practitioners do not fulfil a ‘gatekeeper’ function, controlling access to specialist services, the quality of initial diagnosis at Primary Care level determines much of the future course for an individual patient with a health problem. In order to support patient safety in both clinical and research settings, significant ICT challenges need to be overcome in the areas of interoperability, common standards for data integration, data presentation, recording, scalability, and security. TRANSFoRm brings together a highly multidisciplinary consortium where three

carefully chosen clinical ‘use cases’ will drive, evaluate and validate the approach to the ICT challenges. The project will build on existing work at international level in clinical trial information models (BRIDG and PCROM) service-based approaches to semantic interoperability and data standards (ISO11179 and controlled vocabulary), data discovery, machine learning and electronic health records based on open standards (openEHR). TRANSFoRm aims to extend this work to interact with individual eHR systems as well as operate within the consultation itself providing both diagnostic support and support for the identification and follow up of subjects for research. The approach to system design will be modular and standards-based, providing services via a distributed architecture, and will be tightly linked with the user community. Four years of development and testing will end with a fifth year that will be dedicated to summative validation of the project deliverables in the Primary Care setting.

Full Papers

SECURE DATA COMMUNICATION OVER MOBILE DEVICES IN HEALTHCARE NETWORKS

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ABSTRACT

With increasing adoption of mobile devices in healthcare applications, organizations need to secure the confidential data from unauthorized users and mobile device theft. We identify the vulnerable locations in mobile communication networks that can possibly be exploited to access confidential data, and propose an efficient security architecture that provides end to end data protection in healthcare environments without compromising device's performance. To demonstrate the feasibility of our proposed data sharing architecture, a prototype customized for Point-of-Care-Testing (POCT) scenarios was built. Simulations were performed to analyze and validate our solution against pre-defined requirements criteria. The protocol has demonstrated superior performance than existing solutions.

KEYWORDS

Mobile EMR – Security Measures; Data Protection; Confidential Communications; Medical Data Processing

1. INTRODUCTION

Mobile devices such as smartphones, tablets, and laptops have become very affordable and computationally powerful. These devices have the potential to provide preeminent infrastructure for implementing healthcare applications that would enable physicians, pharmacists and nurses to access patients' health data from any remote location, and share it amongst them. For example, a physician could use a smartphone to access patient's lab results or medical history during a field visit, and share this information with another physician at a remote location. A study from Manhattan Research found that 71% of participating physicians consider smartphones to be essential to their practice and 84% of the physicians confirmed that Internet is critical to their jobs (PortoKalidis, et al., 2009). Using mobile devices in healthcare environments increases the accessibility of clinical data and greatly improves the accuracy and speed with which medical decisions can be made.

While data sharing over mobile devices offers many potential benefits to the healthcare industry, there are several challenges that must be addressed before data sharing solutions can be deployed. Mobile devices have small screen size and limited input capability, which makes designing an optimal user interface difficult. Further, these devices have limited computational and battery resources. It is also challenging to design a single application that would be compatible with mobile devices using different platforms (Yu, 2010). Installation of third party applications with unknown security vulnerabilities, or accidental navigation to untrusted sites introduce security risks such as downloading of malicious code without the knowledge of the user. Furthermore, mobile devices are prone to loss and theft due to their compact and portable nature.

Around the globe, attempts have been made to improve the way in which data can be accessed in terms of location, speed, and convenience; although data security on mobile devices is still an open challenge (Gautam Singaraju, 2008). Due to strict privacy laws that protect patient data, it is crucial that all pertinent data is secured from theft or exploitation by unauthorized users. To fight against spamware, malware or any other malicious code, the existing solution is to install an antivirus application on the mobile device that detects and removes the infection. Scanning mobile devices for malicious code, or having an antivirus program run as a background application can slow down the performance of the device making it unusable for other tasks (Joris Claeassens, 2003) (Forouzan, 2008) (Leavitt, 2005). Antivirus software does not protect against theft or unauthorized access. Even if the mobile device is stolen, there should be no situation in which a patient's data could be compromised. One possible solution to this problem is data encryption, but the encrypted data still remains available to the unauthorized person in possession of the stolen device. There is always a possibility that a brute force attack may be applied and data may be revealed. Most of the existing solutions ensuring data privacy depend on encryption using strong cryptographic algorithms that use large sized keys. The problem with such solutions is high implementation complexity and computational cost that affects the mobile device's performance, making such solutions less desirable. Mobile device security is a crucial area of research, but unfortunately, not many solutions are available that are affordable, efficient and scalable, and almost none are available which could be directly applied to healthcare environment. In this paper, we propose an efficient data sharing solution that is specially customized for healthcare industry, and can be practically applied to provide data security without compromising mobile device's performance.

2. SECURITY ISSUES IN MOBILE DATA SHARING ENVIRONMENTS

The following is a general chain of events that occur when mobile devices exchange data: the sender sends data to the server via a network connection (either wireless or wired). The receiver is then notified about new data, at which point the receiver connects to the server and retrieves the data. The security threats in sending data from one mobile device to another can be classified into three major categories based on the location of attacks (Boukerche & Ren, 2008) (Halpert, 2004) (Peter Tarasewich, 2002):

- Insecure Networks: Data must be protected during transmission requiring encryption of the communication channel. It is important to provide typical cryptographic security services such as entity authentication, data authentication, and data confidentiality in order to protect data [14]. Using standard mechanisms like Secure Socket Layer (SSL) / Transport Layer Security (TLS) at the transport layer or IPsec at the Internet layer can safeguard the network against such threats (Peter Tarasewich, 2002) (Matsunaka, et al., 2008). For this research, we assume that the communication channel is secure and uses SSL / TLS at the transport layer.
- Insecure Servers: "The data server is most susceptible to compromise due to mismanagement, improper configuration or worse, a hacker" (Halpert, 2004). There could be different types of attacks on the server, like a denial of service attack, malware or virus infections, spamware, or a hacker may attack and take over control of a server. Storing data that is encrypted can protect against such attacks. Since servers host large quantities of data, encrypting/decrypting the entire collection of data every time an access is required can be expensive in terms of computational cost. Finding an optimization technique that reduces such costs is an important component of this research.
- Insecure Terminals: The mobile device itself is susceptible to various threats for a multitude of reasons. These devices resemble PCs in that they utilize complex software, which invariably contains bugs and vulnerabilities. These vulnerabilities have been exploited by attackers to take over a device. Security experts are finding growing number of viruses, worms and Trojan horses that target mobile devices (Leavitt, 2005). Using a firewall, access control, or antivirus software protects the mobile device against such threats, but such solutions are too demanding in terms of computational and memory resources for real-time detection and removal of the threats. Mobile devices usually use removal media such as Subscriber Identification Module (SIM) and micro Secure Digital (SD) cards that can store data. This further creates opportunities for sensitive and proprietary data to be removed from a facility and stored insecurely.

In addition to the above threats, the encryption keys must also be secured and any loss of these keys be properly handled.

3. PROPOSED WORK

We propose a Secure Data Sharing Architecture (SDSA) that meets Health Level Seven (HL7) standards (Health Level Seven International, 2011) for exchanging medical data. In order to facilitate data exchange, SDSA integrates with physicians' mobile devices, Electronic Medical Record (EMR) systems, and existing lab delivery networks. SDSA employs standard security mechanisms such as authentication, authorization, and encryption to protect sensitive data and overcome the security issues identified earlier. It has been designed to meet the following fundamental requirements as described in (Matsunaka, et al., 2008):

- Unauthorized access to the data must be denied.

- Lost data should be recoverable to a new mobile device.
- Read/Write operations on the data should occur in a reasonable amount of time.

In addition to the above, our solution accomplishes the following extended requirements:

- Only authorized devices are allowed to access data.
- A user must be allowed to register multiple devices, and data should be synchronized across all devices.
- Mobile devices should be able to securely interact with the registered EMR applications.

With reference to GSM (Global System for Mobile Communications) security standards, GSM Association (GSMA, 2012) provides general security measures to protect confidentiality of a call and anonymity of the GSM subscriber. The standard requires the use of a Subscriber Identity Module (SIM) card that stores sensitive information for authentication purposes. However, the standard just by itself is unable to provide any advanced security functionality such as authenticating users to the mobile device, and protecting data on the device. Anyone who has access the SIM card is able to use the cellular services without any restrictions. SDSA provides an additional layer of security that restricts any unauthorized user to access data even if the device is lost or stolen.

3.1 SDSA Components

SDSA consists of five main components – Client application, Electronic Medical Record (EMR) application, Web Application Programming Interface (API), EMR Data Transfer Agent, and Data Store (Figure 1).

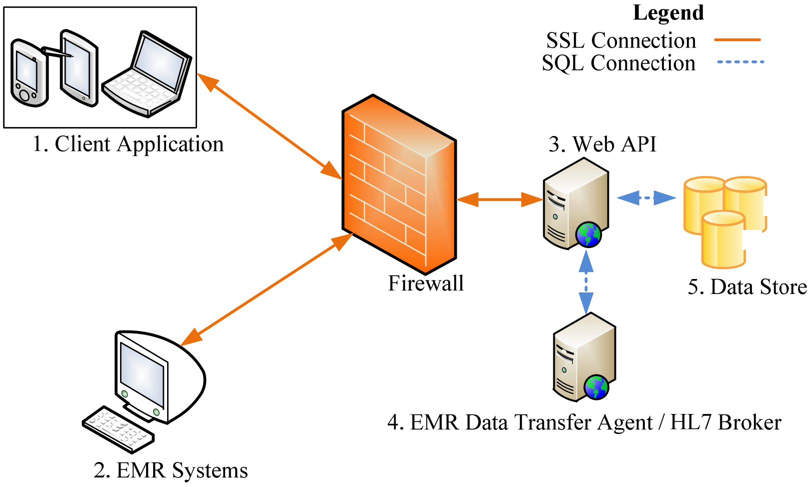

Figure 1. Secure Data Sharing Architecture (SDSA)

3.1.1 Client Application

The client application is installed on mobile devices, and communicates with the Web API in order to securely access data stored on the server. The user is required to provide credentials which are transmitted to the Web API over wired or wireless network encrypted by SSL (Freier, et al., 2011) for authentication. Once the user is authenticated, data access permissions are granted for a fixed time interval. Instead of using native mobile web-browser to access data, we make use of the client application to display the results of various requests (sent to the API) to the user. This ensures that the security of our architecture is not compromised due to bugs and issues that might exist in the device's native web-browsers. The client application is responsible for secure data transmission between the client device and the Web API, secure access to local and server-side data, and sending/receiving of messages.

3.1.2 EMR Application

The EMR application is used by physicians to collect and store patients' medical data in a digital format. It is typically installed at hospitals and physicians' clinics, and may contain complete medical information of patients including their demographics, medical history, diagnosis, treatments, lab results and payment information. Computerizing medical records improves overall efficiency in terms of storage and tracking medical history. SDSA extends the functionality of EMR application by making this data available over mobile devices in a secure way. In order to facilitate this extension, we use an EMR data transfer agent that is responsible for extracting data from the application's database, and loading it into the Data Store located at the server side.

3.1.3 Web API

The Web API is the backbone of our architecture. It has been built to facilitate the secure exchange of patient data among client applications and EMR systems. It is an interface that integrates with all other components of our architecture to enable secure sending, receiving and storing of data. It acts like a security gatekeeper that is situated behind a secure firewall at the server side, and allows only authorized users and mobile devices to access data. It stores the encryption/decryption keys, and is responsible for encrypting data before it is sent to the Data Store, and decrypting it when access is requested. The Web API encrypts data using a symmetric-key encryption algorithm, AES (Daemen & Rijmen, n.d.). When the client application needs to access data, a request is sent to the API which communicates with the Data Store, decrypts the data, and sends it to the client over an SSL connection. Instead of encrypting the entire database, SDSA individually encrypts all messages. Hence, only the requested message needs to be decrypted instead of the entire database, thus improving the overall performance of the system.

3.1.4 EMR Data Transfer Agent

The EMR Data Transfer Agent uses SSL to facilitate a secure connection between an existing EMR system and the Web API. For data exchange between the EMR system and the Data Store, the agent converts data into an XML format using Health Level Seven (HL7) specifications. The agent runs as a background system service at the server side, situated behind a secure firewall, and periodically pulls data from the target EMR in order to keep Data Store updated.

3.1.5 Data Store

Over years, security experts have made their best efforts to consolidate data in a central repository as it is more effective and efficient to protect data stored at a single location versus it being spread out. With mobile devices being frequently used to download and access confidential data, the data is scattered again thereby increasing vulnerability to data theft. Most security solutions propose encryption to secure data on the mobile device. Storing encrypted data ensures data-confidentiality; however, if the mobile device is stolen or lost the encrypted data still remains visible to any unauthorized user that possesses the device. SDSA consolidates all sensitive data into a single Data Store located at the server side.

The SDSA Data Store is a Microsoft SQL Server 2008 database that acts as the central repository for POCT data including users, address books, devices, and messages. Since server has high degree of computational power we can easily apply strong security measures to protect data without compromising the overall performance of the system. This also mitigates the risk of losing data from the mobile devices, and allows organizations to maintain a log of various data access activities on the Data Store. The data must also be secured during the short duration when it is temporarily stored on the mobile device, while being viewed by the user.

3.2 Standards used for Exchanging Medical Data

The organization and delivery of healthcare services is an information-intensive effort. In order to exchange data electronically in healthcare environments, it is essential to use standard data formats that ensure interoperability between different computer applications within an organization. For this research we use HL7 (Health Level Seven International, 2011) standard version 2.3.1 for data exchange between various components of SDSA. HL7 is an American National Standards Institute (ANSI) accredited standard that is compatible with a large variety of programming languages and operating systems. It supports communications in a wide variety of environments, ranging from a full, OSI-compliant network stack to less complete environments such as those using primitive RS-232C interconnections and transfer of data by batch media. HL7 standard specifies the organization structure for XML messages, and enforces messages to use specific data types and field lengths. Every HL7 message has a message header segment that specifies the encoding character used. HL7 specifies few required fields, such as Message Header Segment (MSH), Patient Identification (PID), and Observation Segment (OBX), that must be filled before a message can be exchanged. This ensures maximum interoperability when exchanging data among mobile devices and EMR applications.

3.3 Securing Sensitive Data

SDSA provides adequate security for sensitive data, during transmission, while it is on the mobile device, and while it resides on the server in a consolidated Data Store. The data is made available to its owner (user) as a service. In order to access data, the user must establish a secure authenticated (both user and device) session with the Web API and then send the request. The requested data is decrypted and sent back in HL7 format over an SSL connection.

3.3.1 Authentication

Our protocol follows a two-step authentication process that performs device authentication first, followed by user authentication. This ensures that only authorized users are accessing data using registered mobile devices. Device registration is a one-time requirement; registering devices with the server, allows organizations to control data access and revoke permissions in case the device is lost or stolen. For user authentication, we use username-password based technique due to its simplicity and convenience. Such authentication allows integration with services like Active Directory that makes users-management easy and enables creating user-groups and hierarchies. This allows data abstraction which enforces different data access permissions for different types of users (Microsoft Corporation, 2004) such as physicians, pharmacists, nurses, or administrators. We also assume that the users are pre-verified by the organizations through their internal policies and procedures before signing up for our service.

3.3.2 Device and User Registration

Every user must perform one-time registration for all their mobile devices that would be used for accessing data. In order to register devices, the server generates a cryptographically secure 224-bit long random number for the device which is appended with a four digit number chosen by the user. This string, 256-bit in total, is used as a secret API key that is known only to the user. Next, the server generates a hash on the API key by using HMAC-SHA-256 algorithm (Kelly & Frankel, 2007). The output of this step is a 256-bit long HMAC which is used to verify device authenticity. The server stores the HMAC only. The API key is given to the user and is permanently deleted from the server. Hence even if the server is compromised, the user keys are not revealed. A portion of the API key (28 bytes) is permanently stored on the mobile device whereas the remaining 4 bytes are remembered by the user. This concept is similar to using pins with ATM or debit cards.

3.3.3 Establishing a Session

In order to establish a session for accessing data, the user and the server undergo a simple handshake protocol initiated by the user. During the handshake, server verifies device's and user's authenticity, and determines type of data-access permissions. For the purpose of authentication, the user sends his/her credentials (username and password) along with the device's API key to the server over network using SSL connection. Device's API Key is constructed by combining the partial key stored on the mobile device, with the four digits entered by the user. On receiving this information, the server extracts the API key from the received message and generates an HMAC by using HMAC-SHA-256 algorithm, for device authentication. The new HMAC is compared with the HMAC that was stored on the server during device registration. If the two HMACs match, the device is authentic. Next, user's username and password are extracted from the message and are verified against Active Directory.

3.3.4 Accessing Data on the Server

Once the session has been established between the client and the server, user is allowed to access data until the session is terminated. Currently, data can be accessed only in 'connected mode'. Every user has a data storage space on the server, which we call user's mailbox. User can view data that resides in his/her mailbox only. The mailbox can be accessed over multiple mobile devices that are registered by the user. Currently, SDSA does not support concurrent sessions between different devices and single mailbox. Unlike most commercial data sharing solutions such as Blackberry Enterprise Server (BES), Dropbox, and Apple's iCloud, which downloads a copy of data on the mobile device every time access is required, our solution instead allows client application to directly modify the data on Data Store itself by using various Web API calls. Figure 2 shows process of accessing and modifying data on the server.

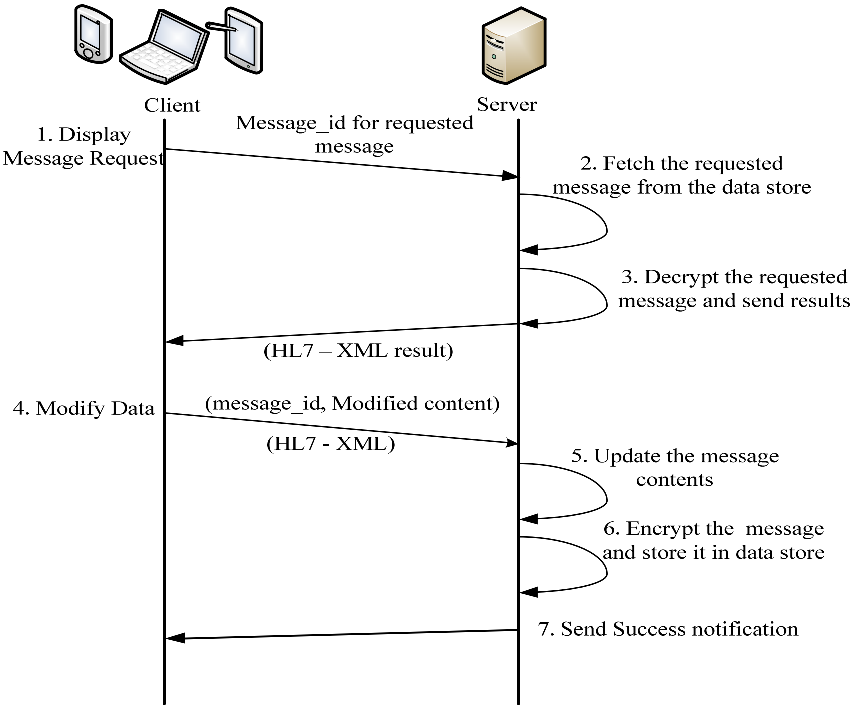

Figure 2. Data modification using SDSA

3.3.5 Exchanging Data with Other Users

A user can either create and send a new message, or forward an existing message to other users. When the message needs to be sent, a request is sent to the Web API indicating the recipient and the data that has to be sent. The data can be shared among registered users only. Figure 3 shows the process of sending a new message to other registered users. A similar protocol exists for sharing of messages amongst different users.

3.3.6 Terminating the Session

The session can be terminated by simply sending a termination-message to the server. In addition to manual termination of the session, we recommend that organizations should enforce time-out policies to terminate session in case of prolonged inactivity. By default we set the time-out to be two minutes. We also recommend organizations to enforce authentication time-outs to prevent brute-force attacks. A user should only be given certain number of attempts to prove identity. If a user fails to identify, he/she must be locked out and must contact the system administrator.

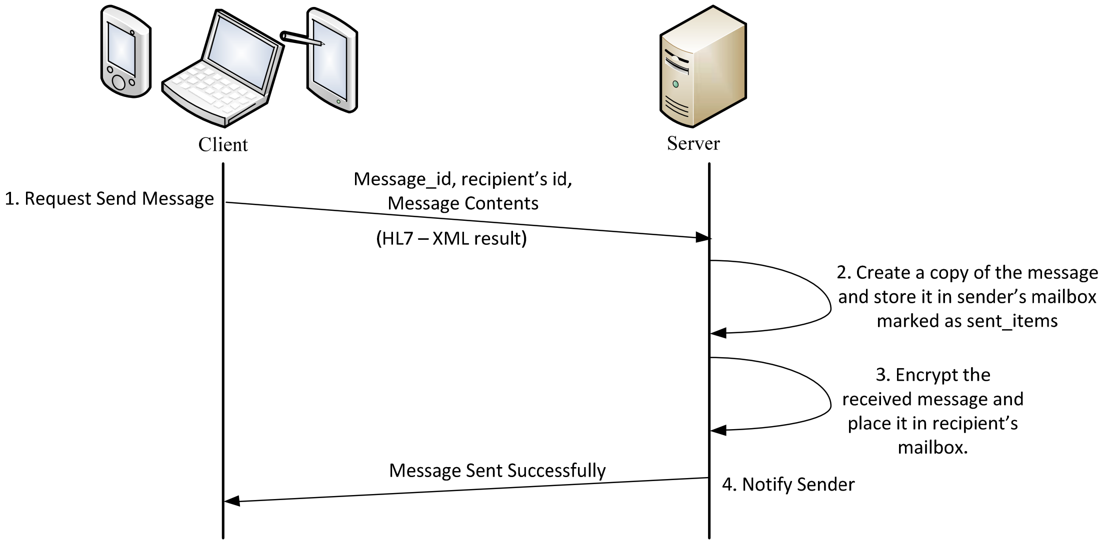

Figure 3. Sending a new message

4. PROTOTYPE IMPLEMENTATION

The Web API has been built as an ASP.NET 3.5 web application to provide various data exchange services to client applications. It uses C# as the underlying programming language, and directly communicates with the EMR data transfer agent and the Data Store using default SQL Server 2008 connection manager. All the methods defined in the API have been written as web methods, which allow us to create a standard service directory by using Web Service Description Language (WSDL). The Web API accepts SOAP based XML requests from client applications, and sends back the service results using the same. Any message/request that contains medical data is formatted using HL7 specifications. We use a third party, Java based open source HL7 broker called mirth-connect (Mirth Corporation, 2011). Another option considered for the HL7 broker was Microsoft's BizTalk (Microsoft Corporation Inc., 2011), but the proprietary nature and licensing cost made it unfeasible for this research.

We encrypt and store all the connection strings from the API to different components in Web.Config file. We have parameterized all the SQL queries used by the API in order to protect our code from SQL injection attacks. Furthermore, we use the SecureString class to store sensitive data. This is a special class that encrypts the text when being used, and deletes it from the memory when no longer needed.

We have implemented an iOS based client application that can be installed on any Apple mobile device including iPad, iPhone, and iPod touch that runs on iOS 4.0 or above. The application is written in Objective-C. It is built upon Model-View-Controller (MVC) design paradigm. where the Model contains classes that encapsulate application data, View is made up of windows, controls, and other elements that user can see and interacts with, and Controller mediates the logic between Model and View. Since iOS Software Development Kit (SDK) does not include constructs to consume SOAP based web service, we use a third party open source tool, called SudzC (sudzc, 2012), to generate the corresponding Objective-C code that allows communication between the client application and the Web API. Objective-C allows manual de-allocation and dereferencing of objects created throughout the application. In order to ensure data confidentiality on the device, we restrict our application to release all objects and dereference them to 'nil', as soon as our application is interrupted by another process running on the device, such as a phone call or receiving a text message.

Finally, we use Medical Office Information System (MOIS) as the EMR application. MOIS is primarily used by physicians for medical office billing, scheduling, and documenting key elements of patient medical records including encounter notes, past procedures, prescriptions, allergies, and consultation and referral reports (Applied Informatics Health Society, 2011). We assume that all lab reports are delivered to MOIS, and it acts as data source for our prototype.

4.1 Experimentation and Results

By simulating a mobile POCT system we have been able to perform series of experiments to determine the feasibility of our proposed architecture. Through these experiments we analyze the usability, deployment cost, security, and scalability of the prototype. Standardized performance monitoring tools and applications, such as Apple's Xcode performance instruments, were used to collect and store our test results. We have divided the evaluation criteria into two broad categories – usability and technical. Usability criteria include requirements that should be fulfilled from user's perspective such as assessing user friendliness, platform independency, and ease of software installation. The technical criteria focus on requirements such as memory and CPU resources consumed by the application to perform various operations. From the usability perspective, we have demonstrated that our proposed solution is scalable, secure and easy to use. It works well with both WiFi and 3G access.

To measure read/write performance of SDSA, we ran series of tests on an iPad. The time taken to perform these operations includes the time spent in performing user/device authentication, time taken to encrypt/decrypt the message, time taken to transmit data over the network, and time taken by the server to format the message with HL7 specifications. We created various tests cases using different parameters, such as number of messages sent/received, message size, and connection type using both WiFi and 3G networks. Four different batch sizes, ranging from 10 to 500 messages per batch were used for testing. The sample message contains textual information, and is 4KB in size. Table 1 shows the network speed that was available for running the tests. Table 2 summarizes the test results.

Table 1. Network Speed Used for Testing

Connection Type	Downstream	Upstream	Latency
Wi-Fi	4.95 Mbps	.733 Mbps	45ms
3G	0.92 Mbps	0.33 Mbps	324ms

Table 2. SDSA Read/Write Time

	3G		Wi-Fi	
	Read	Write	Read	Write
Average Time [ms]	426.25	570.25	42.75	547.25
Min Time [ms]	388.00	516.75	34.25	492.25
Max Time [ms]	709.95	876.00	75.25	759.25

The results show that the write time over Wi-Fi is 23ms (4.03 %) less than 3G, and the read time is 383.5ms (89.97%) less. The improvement in message read/write times when using Wi-Fi is due to its faster downstream/upstream speed and low network latency. Network latency is dependent on many factors such as propagation delay, router delays, computer hardware delays, and interference due to weather and electromagnetic signals. Unfortunately, we cannot control high latency involved with the 3G networks. Eliminating network latency is a broader problem, and is out of scope of this work.

In our testing, we also observed that while reading/writing messages in batch mode, there were few random peaks in read/write times caused due to network latency as well as the application latency. Application latency involves the delay in manipulating and presenting data, caused due to intense disk input/output operations and hardware limitations such as amount of main memory. This caused the maximum time for some batches to be exceptionally large, however, the average time taken for reading/writing always remained close to the minimum range. This implies that most samples were unaffected by random latency peaks.

We also ran simulations to evaluate the impact of message size on read/write performance. We calculate the average time taken by the iPad to read and write sample messages of sizes ranging from 4-100KB. Each test case was run in a loop of hundred, and the average time taken to read and write a message was recorded.

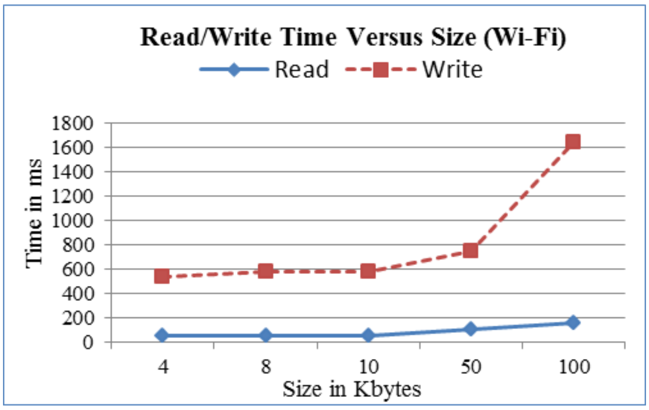

Figure 4. Read/Write Times versus Message Size

Figure 4 shows the results of our tests. We notice that the read/write performance is only marginally affected when message size is smaller than 10 Kbytes. For larger messages, an abrupt increase in the read/write times is observed due to the limited upstream speed of our test network.

Due to unavailability of performance results of other data sharing solutions, we are limited to compare our test results with only Secure Sharing Scheme (SSS) (Matsunaka, et al., 2008). In order to perform a fair comparison, we use Wi-Fi network connection with 2.4Mbps downlink and 153Kbps uplink speed to match the specifications as published by authors of SSS in (Matsunaka, et al., 2008). Since SDSA performs most cryptography operations on the server instead of the device, it significantly outperforms SSS in terms of time required to both read and write data. Table 3 summarizes the comparison for various message sizes.

Table 3. SDSA versus SSS

	SDSA			SSS		
KB	10	50	100	10	50	100
Write	1	3.77	5.45	4.18	11.9	21.5
Read	.05	.09	.15	2.99	3.30	4.91

5. CONCLUSION AND FUTURE WORK

SDSA allows users to securely access data by establishing a session with the remote server. By consolidating data into a single Data Store, SDSA allows more control over data in terms of security and accessibility. Since most cryptography operations are moved to the server side, SDSA minimizes the time and computational resources required by the mobile devices in order to access data. Using HL7 standard for data exchange enables integration with EMR applications and existing lab delivery networks. Data access in connected mode provides more control, but also makes data access limited to network availability. SDSA supports both Wi-Fi and 3G network connectivity which increases availability.

A desirable extension of our proposed architecture is to operate in disconnected mode in order to support usage in areas with no network connectivity. We plan to research and discover possibilities of an effective offline authentication mechanism that would ensure data privacy for such an environment. We would also like to extend our prototype to support connectivity with portable medical devices such as glucometer, and blood pressure monitors. Integration with medical devices involves compatibility and security issues. Few medical devices are currently available that support mobile connectivity and the proprietary nature of their software does not lend well for integration with other data sharing solutions.

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APPLYING SOA AND VIRTUAL ORGANIZATION CONCEPTS IN AN INTERACTIVE TELEMEDICAL CONSULTATION SYSTEM

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ABSTRACT

Development and deployment of advanced teleconsultation systems for medical imaging is a challenging task. This paper explains how the Service Oriented Architecture paradigm can help design and implement a next-generation interactive teleconsultation system and how the concept of Virtual Organizations supports the creation of complex inter-hospital consultation networks. The resulting system, called TeleDICOM II, is fully capable of satisfying the growing expectations of users and system administrators.

KEYWORDS

Telemedical consultation, remote collaboration, virtual organization (VO), Service Oriented Architecture (SOA), medical data distribution

1. INTRODUCTION

In the recent years the concept of medical teleconsultations has resulted in numerous development and research initiatives. Continuous progress in medical science, along with development of even more sophisticated diagnostic equipment, providing access to highly detailed information, means that the knowledge and experience of a single doctor – or even a local team – are frequently insufficient to ensure effective patient care. As a result, remote expert knowledge becomes necessary. Teleconsultation systems are expected to mitigate this issue and result in improved healthcare provisioning. One of the greatest challenges in telemedicine is to provide efficient technical solutions, satisfying the growing demand for remote diagnostic services.

Existing teleconsultation systems typically follow a request-response approach, where one user prepares a case to be consulted and delivers it to another user, who then responds with a diagnosis. Ongoing specialization in medicine often results in situations where teams of multidisciplinary experts are required to handle a single case. To be able to work efficiently, such teams need to communicate in real time. Teleconsultation systems enabling such cooperation are referred to as collaborative. There are many additional benefits of using collaborative systems – among them the ability to observe live collaboration sessions between medical experts during routine consultations, or attend specially organized medical workshops which help disseminate best practices in imaging medicine to other doctors, or even students (Gackowski, 2010). From the technical point of view, collaborative teleconsultation systems are much more complex than their non-collaborative counterparts as they combine advanced medical functionality and real-time image processing with synchronization of views in a distributed networking environment.

Development and deployment of advanced teleconsultation systems is a challenging task and should therefore be divided into a number of aspects. Some of them are mentioned in the following sections (for a more detailed discussion see (Czekierda, 2012)), however, in this paper we intend to focus on two types of issues: architectural and deployment-related. We describe how adoption of the Service Oriented Architecture (SOA) approach has helped design and implement TeleDICOM II – a next-generation collaborative teleconsultation system (Cała, 2008). We also show how the concept of Virtual Organizations (VO) supports complex teleconsultation networks, capable of catering to various scenarios. The resulting system is advanced, standards-based and scalable. Unlike many existing solutions, its functionality can be easily enhanced while the system itself remains straightforward to deploy and maintain. TeleDICOM II has reached an advanced prototype phase and will soon replace its predecessor already deployed at many hospitals in Poland.

The structure of the paper is as follows. In Section 2 we discuss related work, showing that our system represents a novel approach to developing teleconsultation networks. Section 3 enumerates key issues related to development of such systems. In Section 4 the SOA-based architecture of TeleDICOM II is shortly presented. Section 5 concentrates on deployment issues in inter-hospital environments. Section 6 presents case study illustrating the usage of the system and the benefits of our development approach. The paper is concluded in Section 7.

2. RELATED WORK

Most of existing teleconsultation systems for medical imaging offer basic functionality: a single medical center can, on the basis of bilateral agreements, perform analysis of the results of patient examinations, acting on behalf of other institutions with a lower reference level, or even individual doctors (an example of this type of system is the e-konsultant platform[1]). Some systems enhance this simple scenario by offering more advanced communication features: for example, TeleConsult[2] provides a shared mouse pointer and a chat channel. TeleDICOM I (Gackowski, 2010), the predecessor of the presented TeleDICOM II system, additionally supports duplex voice communication and full synchronization of performed actions. Other systems, e.g. Divisy[3], offer videoconferencing capabilities. Collaborative work in a multiuser scenario is rarely available feature (TeleDICOM I being an exception in this regard).

The mentioned systems usually share a simple, centralized architecture. Application of the Service Oriented Architecture in teleconsultation systems is rarely mentioned in literature, mainly in the context of Grid systems, e.g. (Erberich, 2007) which aims at federation of DICOM devices in a healthcare Grid. BioMIMS (Melament, 2011), while not a true teleconsultation system, concerns a similar topic – namely, handling DICOM imaging data. It is sometimes used for research on rare hereditary diseases. BioMIMS is composed of many fine-grained services decoupled by a central bus which orchestrates the existing services according to predefined workflows, following the Message Oriented Middleware concept. The concept of Virtual Organizations in telemedicine is also utilized in Grids: for example, (Florida, 2005) describes a Virtual Organization called MammoGrid, composed of several mammography centers sharing imaging data. A similar concept is presented in (Sicotte, 2010) where the goal is to create an inter-hospital VO for medical imaging (called a virtual imaging department). Unfortunately, none of the presented papers mention dynamic creation of virtual organizations for the purposes of conducting teleconsultation sessions.

3. KEY CHALLENGES IN PROVISIONING REMOTE CONSULTATIONS

A number of issues must be considered while designing and developing a system for medical teleconsultations: these include (but are not limited to) domain-specific, technical, organizational, financial, and legal problems. Non-technical issues are out of the scope of this paper and will be mentioned only in passing.

Systems which span many different organizations always incur compatibility and integration problems (following local regulations, interfacing with legacy systems, etc.) Fortunately, in the area of imaging medicine, there exist appropriate, well-established and commonly respected standards which simplify this process. The most important one is DICOM[4], covering representation, exchange and storage of diagnostic-quality medical images. The existing standard for medical reports (and particularly for diagnoses)

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[1] *E-konsultant*, http://e-konsultant.com

[2] *Teleconsult Europe*, http://www.teleconsulteurope.com/uk/index.php

[3] *Divisy TM21Web Page*, http://www.divisy.com/telemed_en.shtml

[4] *Digital Imaging and Communication in Medicine*, National Electrical Manufacturers Association

in imaging medicine is called DICOM Structured Reporting (DICOM SR). Patient-related administrative data is usually stored in Hospital Information Systems (HIS).

Despite the availability of standards, teleconsultation systems must take into account many aspects which are either not covered by the mentioned protocols and systems (designed for operation in single institution) or not fully standardized (e.g. exact formats of documents used for diagnoses). Creation of a consultation network should obviously be preceded by a formal contract between legally and organizationally independent entities, establishing common cooperation rules. All such technical and organizational issues should be formalized, stored in a common repository and respected within a teleconsultation system.

It is important to note that one healthcare institution may provide consultation services for a number of different institutions. This rule applies both to large medical centers, which can provide specialist consultation services to many smaller healthcare units, and to small ambulatories or clinics which require access to external specialists (cardiologists, orthopedists, neurologists, etc.). Thus, every healthcare institution which either provides or uses remote medical consultations can sign many different contracts with other healthcare providers, as shown in Fig. 1. It would be desirable for the teleconsultation system to respect this model and isolate cooperation performed in the scope of different contracts. This isolation should manifest itself mainly through limited visibility of medical data and consultation sessions. In fact, each contract can result in the creation of a new consultation network, with a dedicated set of infrastructural resources attached.

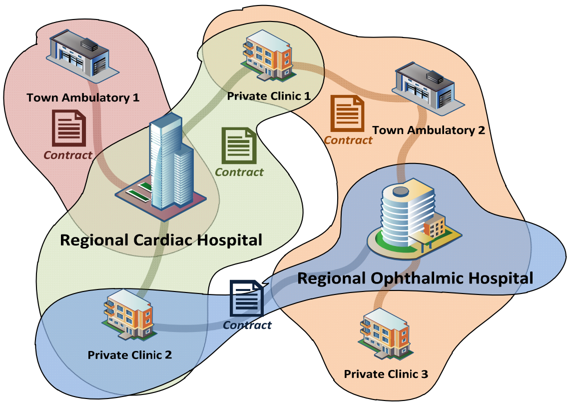

Figure 1. Cooperation among healthcare providers based on signed contracts

Any teleconsultation network comprises three key concepts: a data distribution system, a consultation service and a system for scheduling consultation sessions. In addition, collaborative networks must also support interactive communications. Each of these aspects poses a number of challenges which need to be addressed by the proposed system.

A *data distribution system* is a crucial element of teleconsultation networks designed for imaging data. Its goal is to provide an interface between the teleconsultation system and external data repositories and to deliver data to geographically distributed consultation session participants. This system needs to efficiently handle very large amounts of data (up to 1 gigabyte per case). In addition, when used for multiparty collaborative sessions, it should support multipoint data transfers by avoiding duplication of identical data streams. Crossing the boundaries of local organizations imposes requirements related to security and privacy, all of which should be properly addressed. A very important issue is interfacing the teleconsultation system with repositories storing also non-image patient data which enable proper interpretation of visual information. Moreover, results of remote diagnoses should be put into such repositories for a future reference.

The goal of the *interactive communication system* is to enable many users participating in a common consultation session (hereafter simply referred to as a session) to share a common view–mirroring a local consultation process. As a minimum, view synchronization and voice communication should be provided. The system needs to cope with multipoint real-time transmission. According to the ITU-T G.114 recommendation (regarding voice communication), for good user experience, end-to-end delay should not exceed 150 ms.

Consultation service is provided by medical experts, who must be equipped with an appropriate graphical interface. Such an interface operates on data obtained from the data distribution system and – if used in a collaborative mode – presents a common view of the session.

Scheduling of remote consultation sessions can be a tough undertaking from the logistical point of view. It involves, among others, selection of participants and establishing a date and time for the session. The process becomes much more complex in the case of multi-user sessions, when invited users are permitted to negotiate the date or refuse participation. It would be desirable for teleconsultation systems to assist in this task as well.

4. THE TELEDICOM II ARCHITECTURE

The previous section introduced a number of issues which should be addressed by every enterprise remote consultations system architecture. Thorough analysis of these issues leads us to the conclusion that the most promising approach for developing such systems is to use the Service Oriented Architecture (SOA) paradigm (Arsanjani, 2007), which supports creation of robust, scalable and efficient distributed IT platforms. Under the SOA paradigm, each system is decomposed into several loosely coupled services, which are bound dynamically. In line with this approach, each of the conceptual teleconsultation system's building blocks mentioned in Section 3 has been developed as a separate service with a well-defined interface:

- Data Distribution and Transformation Service (DDTS) is responsible for handling medical imaging data, i.e. the subject of consultation sessions. It is a complex service consisting of remote domains – each designed as a group of well-defined, loosely coupled services used by a group of users (if possible, close to their location). DDTS integrates with already existing storage systems (e.g. PACS) and enables effective and secure data distribution between consultation session participants. Moreover, it provides data transformation features: anonymization[5], 3D reconstruction etc., by means of specialized services called processors.
- Interactive Groupware Communication Service (IGCS) and Voice Communication Service (VCS) implement interactive communication. Both can be used to mediate between multiple session participants, as central elements of a "hub and spoke" topology. Such a topology is well suited to modern Internet infrastructure deployments which make it difficult to communicate directly in a multipoint scenario.

IGCS is backed up by the Interactive Group Communication Platform (IGCP) server. IGCP (described more thoroughly in (Czekierda, 2009)) constitutes a client-server platform for interactive groupware communication. In the presented system every action (e.g. measurement, modification of image properties, interactive pointer usage) performed by one of the session participants is immediately propagated to other users who have joined the consultation session. VCS performs voice mixing – it implements the Multipoint Control Unit feature of the widely adopted H.323 architecture.

Both services provide session participants with a powerful and convenient collaboration environment.

- Session Service (SS) manages the lifecycle of the main business process of TeleDICOM II – the consultation session. On the one hand, SS provides various end-user features, such as selection of medical data which is going to be discussed and analyzed during a session, negotiation of a session date/duration or invitation of participants. On the other hand, SS also acts as the orchestrator, managing other services: it arranges medical data transfer using DDTS and selects appropriate instances of the IGCS/VCS services for particular interactive sessions (see Section 6.2). Communication between SS and the desktop client is realized using the ICE technology[6] – an object-oriented middleware package for remote communications.
- The client application provides TeleDICOM users with everything necessary to organize and conduct remote medical consultations. It does so by communicating with the appropriate lower-level services. The application is implemented according to composite desktop client guidelines: it consists of multiple independent plugins which can be loaded on demand and communicate asynchronously using an internal message bus. In fact, its architecture is compliant with the SOA paradigm.

From the implementation viewpoint, the services can be divided into two categories – those with a federated implementation and standalone services, respectively. The former category includes DDTS and SS, while IGCS and VCS belong to the latter. In both cases, service integration is facilitated by the SOA approach. The federated services communicate through the Enterprise Service Bus (ESB) (Chappell, 2004) which is the current de-facto standard for integrating systems built in accordance with the SOA paradigm. In DDTS the message-based communication model offered by the ESB has been used for the data transfer between remote domains and between the services residing in a single domain. The Apache ActiveMQ[7] technology has been chosen to implement data transfer. In the case of SS, sophisticated messages routing and delivery mechanisms provided by ESB in the form of Enterprise Integration Patterns (EIP) (Hohpe, 2004) are utilized. For standalone services the SOA approach allows dynamic selection of service instances on a per-usage (e.g. per-session) basis, taking into account user-defined metrics. Choosing an appropriate service instance is especially important in the case of interactive services which should provide the best possible

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[5] The communication in TeleDICOM is cryptographically secured. Nevertheless, in some cases (e.g. for teaching purposes) medical imaging data should be additionally devoid of personal information.

[6] *The ICE technology*, http://www.zeroc.com/

[7] *The Apache ActiveMQ project*, http://activemq.apache.org

quality of experience. Thus, a service selection should be deferred until the beginning of the session, when the number of consultants, their locations and other environment conditions become known.

The above considerations also influence the deployment process. Since federated services can run in multiple instances, they should preferably be deployed at each institution which is party to the contract. The number of standalone services depends only on requirements and available resources, as they can be instantiated on demand.

The Service Repository is a crucial element of any SOA system. In TeleDICOM II it is responsible for two fundamental tasks:

- Storing essential information regarding users and their profiles as well as services. This information makes it possible for users (and for other services) to locate suitable consultants (e.g. cardiologists) and services' instances. Contract statements can impose or exclude some interrelations between services (e.g. on the basis of users' institutional affiliations). As a general rule, the user application exploits DDTS and SS service instances provided by the user's home institution. In addition, the repository stores certificates, which are bound to each physician and each service. Certificates are used for authentication, access control and accounting purposes.
- Supporting automatic configuration of system services. Each of the TeleDICOM II services is able to self-configure using the information obtained from the repository during initialization. The configuration record can include network parameters, dependencies on other services or legacy hospital infrastructure etc. This centralized approach ensures that a service configuration remains valid and up to date, and relieves the system administrator of having to maintain each machine separately.

One repository instance should be deployed by each party to the contract. Its content is replicated among instances to ensure a coherent view of the entire TeleDICOM instance. TeleDICOM II services, along with their integration channels, are depicted in Fig. 2.

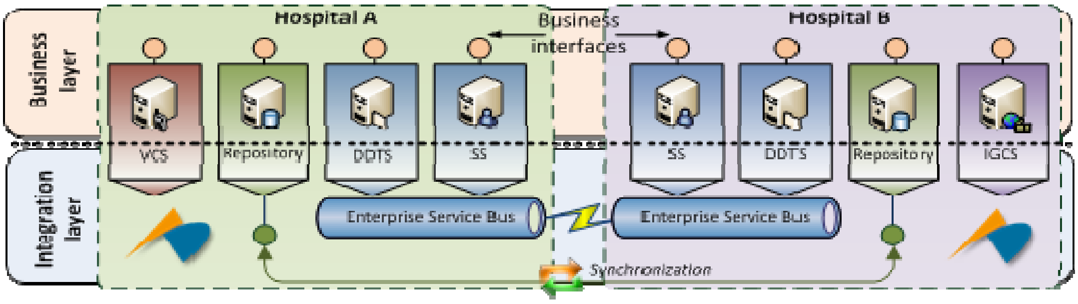

Figure 2. TeleDICOM II server-side services divided into integration and business layers

Fig. 2. presents a sample TeleDICOM II installation which consists of several service instances, deployed by two separate healthcare providers. Each service exposes its business interface using the most appropriate technology offering best QoE. The system repository instances synchronize with each other, using a dedicated protocol designed for distributed database synchronization. Federated services exploit the ESB architecture, utilizing its advanced integration patterns (as mentioned above). Interactive communication is realized through dedicated technologies which are the most suitable for real-time transmission (for example, voice is transmitted using the standard Real-Time Transport Protocol).

5. THE TELEDICOM II DEPLOYMENT MODEL

The architecture and deployment model of TeleDICOM II address the issues mentioned in Section 3, especially concerning isolation of information exchange between the system services (i.e. medical data transfer and the availability of specialists). In order to resolve these issues, the Virtual Organisation (VO) concept forms part of the system deployment model. According to (Camarinha-Matos, 2005) a Virtual Organisation consists of semi-independent entities with separate core competencies, who band together to achieve a prescribed or subscribed business objective supported by information and communication technologies. This definition is very well suited to remote consultations, in which independent healthcare providers with different competencies come together to share medical knowledge and expertise. However, practical realization of the VO concept in the TeleDICOM II system deployment model remains an open problem. Our approach to this issue is depicted in Fig. 3 which presents several VOs with TeleDICOM II services and their shared integration infrastructure (legacy infrastructures such as PACS archives were omitted for simplicity).

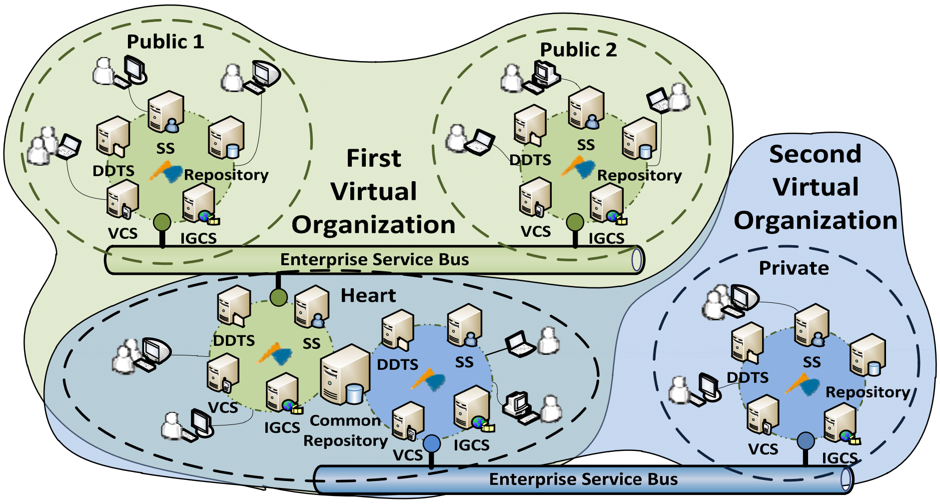

Figure 3. Deployment scenario consisting of four hospitals in two virtual organizations

Fig. 3 shows that in every VO a separate set of TeleDICOM II services is deployed along with a separate ESB instance for integration purposes. A number of client applications is also deployed by every healthcare provider and each of them has access to services from all VOs in which the provider participates. Every VO possesses a dedicated integration infrastructure and a dedicated set of services. Instances of services belonging to different VOs may not exchange information – hence full isolation of scheduled sessions and medical data transfers is ensured. The choice of dynamic services (IGCS, VCS) is also made within a VO, meaning that no service deployed outside of a particular VO can be chosen by that VO. Utilization of a separate set of services for every VO, along with a separate integration infrastructure, provides proper security and privacy for each instance of the distributed system. The only element shared among VOs is the system repository, since it stores information about all VOs to which a healthcare provider belongs. As a consequence, a single repository instance is deployed by each healthcare provider, to be shared between VOs, as shown in Fig. 3. Nonetheless, access to this repository also occurs in the context of a specific VO, thus preserving full isolation and security.

6. CASE STUDY

This section elucidates how the concepts introduced in the previous sections can be applied to a real-life scenario. We will analyze a situation in which four hospitals belonging to different healthcare providers intend to cooperate. Two of them (designated *Public 1* and *Public 2*) are public health units, the third (called *Heart*) belongs to an international network of heart disease hospitals, while the last one (*Private*) is a private clinic providing a limited spectrum of services, mainly related to orthopedic medicine. This scenario is conceptually illustrated in Fig. 3.

6.1 Establishing a Teleconsultation Network

In order to increase productivity and utilize human resources more efficiently, the hospitals' boards of directors have come to an agreement stating cooperation between the presented healthcare providers. Cardiologists working for the *Heart* hospital will provide consultation services to both *Public* hospitals. In exchange, *Public* hospitals' experts in urology and surgery are obliged to consult difficult cases with physicians from the *Heart* hospital. Apart from this agreement, *Heart* and *Private* hospitals have signed an independent contract. Cardiologists from *Heart* will provide consultation services to *Private* doctors while orthopedists from both units will work together on complex cases. Agreements also include technical details specifying the deployment of TeleDICOM II services at each institution.

The contracts signed between the hospitals are reflected in the TeleDICOM II system – they determine the boundaries of cooperation and are mapped to separate VOs. Hospital administrators (members of each VO) are responsible for launching TeleDICOM II services in each hospital domain as well as properly populating the System Repository with information about services and users. Once these tasks are completed, TeleDICOM II is ready to serve its users. In the future, services will be run from a set of predefined virtual machines, making this process even simpler.

6.2 Conducting a Teleconsultation Session

All consultation sessions performed in the TeleDICOM II system begin with specification of input data (see Figure 4., step 1). The referring doctor located in *Public 1* logs into the application using his personal certificate, and inputs patient data. This data can include DICOM documents stored in local PACS as well as raw images available on the doctor's personal computer. In order to provide additional information, the doctor creates a voice attachment and annotates selected images, marking regions of particular interest. Once the doctor finishes data preparation, the dataset is assigned a unique identifier and dispatched to a local DDTS node.

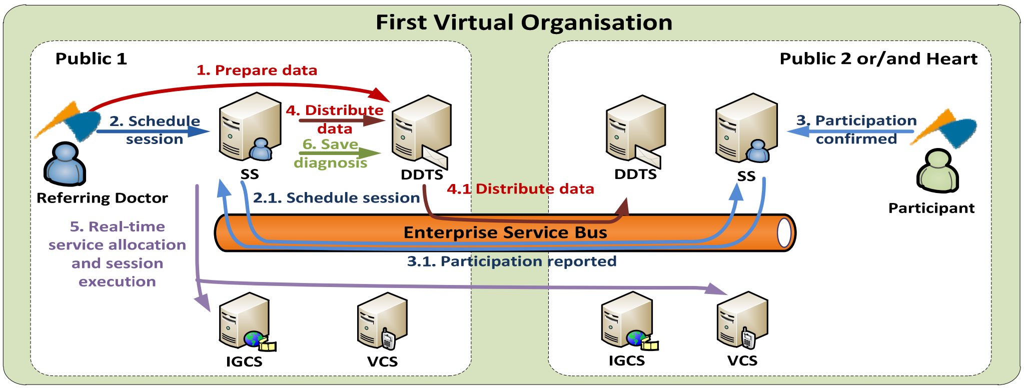

Figure 4. Steps executed by the session service during the lifecycle of a session

The referring doctor can now select remote consultants and set a preferred date of the consultation session. He searches the Service Repository for specialists who match his particular needs, finally deciding that the consultation session requires the participation of an experienced cardiologist from *Heart*, and a surgeon from *Public 2*. Having selected the cardiologist and surgeon, he invites them to a consultation session (step 2). His client application sends the appropriate request to the local Session Service, which forwards it to Session Services at remote locations. Both doctors receive notifications: the cardiologist – on his personal computer (as he is currently logged into the system), the surgeon – on his smartphone. They agree to participate in the session and each replies to the request. This confirmation is sent back to the requesting doctor and the doctors' personal calendars are updated to reflect the new appointment (step 3).

At this point data transfer may begin. The referring doctor's local Session Service initiates remote data distribution by sending a request to the local DDTS (step 4). Due to security restrictions specified in the VO contract, data needs to undergo anonymization before leaving *Public 1*. Thus, data is first processed locally, then sent to both remote locations and temporarily made available to participating experts.

A few minutes before the session starts, the requesting doctor's local Session Service begins to set up interactive services (step 5). It discovers that the primary Voice Communication Service for this location is fully loaded and will remain so for the rest of the day. As a result, a remote VCS needs to be used. The local IGCS service is currently underutilized so it may handle the new session without compromising service quality.

During the session the referring doctor and both invited experts exchange their knowledge and opinions. They make use of voice communications, supported by the previously selected VCS instance, as well as a shared interactive whiteboard offering a synchronized view of imaging data, measurements and marking tools (handled by IGCS). The consultation session ends with diagnosis (step 6): a joint statement worked out by the experts, expressing their opinion regarding further medical actions to be taken. Additionally, the state of VCS and IGCS is saved. The diagnosis is sent back to the referring domain and any data stored at the remote site is purged.

7. CONCLUSION

The paper shows how the SOA paradigm and the VO concept can be exploited to resolve a number of issues inherent in designing, implementing and deploying remote teleconsultation systems. Partitioning the system into a number of services considerably simplifies its implementation and management. SOA facilitates seamless integration of federated services and enables dynamic assignment of standalone services to sessions, while applying the VO concept in the deployment model ensures isolation of cooperation performed in the scope of different contracts and enhances the overall level of security. The proposed approach is not limited to teleconsultation systems – indeed, it can be applied in many other scenarios, where demand for security, isolation and reliability play an important role.

ACKNOWLEDGEMENT

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TECHNICAL EVALUATION OF AN E-HEALTH PLATFORM

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ABSTRACT

Methodologies for evaluation of e-Health platforms are still lacking. We propose an e-Health evaluation framework that aims to provide a concise methodology for the evaluation of e-Health platforms under three main categories: usability evaluation, logistics evaluation and technical evaluation. For the scope of this paper, focus is given on defining techniques to enable the gathering of technical evaluation metrics using our proposed framework. Technical evaluation provides insight on the scalability, response time, functionality and performance of an e-Health platform. Using simulated patient data, preliminary evaluation experiments carried out on an existing e-Health platform, known as the Cloud4Health platform, proves the viability of our defined methodology for gathering of technical evaluation metrics. Experimental results showed up to 100 simulated patient's data could interact with the Cloud4Health platform concurrently with a maximum round-trip time latency value of 6.6 seconds for data samples to be processed. Future work aims to build upon this evaluation framework and develop techniques to gather both usability and logistics evaluation metrics when conducting evaluation of e-Health platforms.

KEYWORDS

e-Health evaluation, methodologies, platforms, simulated data, technical evaluation, evaluation metrics

1. INTRODUCTION

E-Health is the migration of healthcare, from traditional paper-based systems to electronic counter-parts (Haeyrinen *et al.*, 2008). A prime example of e-Health is Electronic Health Records (EHR). Not only has EHRs removed the need for physical storage space, it also enables medical staff to look up a patient's medical record quickly and easily. The Commonwealth, an intergovernmental governmental organisation, in a document published by Rodrigues (2008), has acknowledged further benefits e-Health brings.

However, in the very same document, Rodrigues (2008) also highlights the many challenges e-Health must overcome before this technology is widely adoptable. Key challenges e-Health must overcome, from an organisational perspective, include governance, standardisation and cost (Rodrigues, 2008) whilst from a technical perspective we must consider the functionality, security and scalability of the technology (Pagliari, 2007; Henderson *et al.*, 1999). From a public perspective, a key challenge for e-Health adaptation is in ensuring trust in this technology. Various reports on the inadequacy of e-Health technologies have emerged in UK news these past years. A prime example of this is in 2009, when the National Health Service (NHS) in England lost thousands of medical records (Savage, 2009) due to a lack of security in their computer systems. More recently, in July 2011, the NHS was once again put under the spotlight when computer criminals attempted to gain access to their systems that held patient medical records (Campbell, 2009). Hence, one can understand why patients may feel rather uneasy about medical facilities storing their personal data in an e-Health environment.

Numerous e-Health platforms have been proposed and developed to address the key challenges this technology faces including work by World Medical Card (2012), DOSSIA (2012), HealthVault (2011) Fan *et al.* (2011) and Rolim *et al.* (2010). The contribution this paper makes is in presenting the design of an e-Health evaluation framework that is capable of evaluating these platforms under the categories of usability, logistics and technical evaluation. The design of this e-Health evaluation framework aims to provide answer for the question of whether or not an e-Health platform is capable of overcoming the key challenges it currently faces. For the scope of this paper we focus on methodologies for obtaining technical evaluation metrics.

The remainder of this paper is organised as follows. Section 2 discusses related works in regards to e-Health evaluation. Section 3 presents the current design of our e-Health evaluation framework. Section 4 provides methodologies for obtaining technical evaluation metrics along with design of preliminary experiments. Section 5 presents the results from conducting a preliminary technical evaluation on an existing e-Health platform. Finally, Section 6 provides a conclusion along with future work.

2. RELATED WORKS

Recent literature has shown that the primary method which e-Health evaluation takes place is live clinical trials. This, in essence, involves deploying an e-Health platform in a live clinical environment, e.g. hospital, and obtaining evaluation results from clinical staff and patients using the system on a day-to-day basis.

Research conducted by Cobb *et al.* (2005) present a live clinical trial of an e-Health system that provides support for patients wishing to quit smoking whilst Kessler *et al.* (2009) present a system for the delivery of psychotherapy via the internet. The work of Flynn *et al.* (2009) presents a third example of a live clinical trial in which they evaluate the effectiveness of an e-Health patient booking appointment service. This paper differs from all three authors' work since the proposed evaluation framework considers e-Health from a high-level perspective, i.e. assessing the key challenges of e-Health from an organisational, public and technical perspective rather than how well the technology works for specific healthcare services, i.e. smoking cessation, therapy and appointment booking system.

In regards to evaluating e-Health from a high-level perspective, it has been found that although many propositions have been made on what should form part of an evaluation framework for testing e-Health platforms, little work has been presented on defining a clear methodology to conduct such an evaluation. Dansky *et al.* (2006) has noted "few blueprint for effect evaluation methodologies" (Dansky *et al*,. 2006, p. 397) exist whilst the same backing can be provided in the work of Lilford *et al.* (2009) in which they find that no general consensus can be found in techniques used to evaluate e-Health platforms. Furthermore, although the work of Glasgow *et al.* (2007) highlights some of the key metrics which an e-Health evaluation should obtain, including appeal, use, cost and robustness, no fundamental answer on how such metrics should be measured is given.

The most concise evaluation methodology was found to be in the work of Catwell *et al.* (2009) in which the authors propose that evaluation of e-Health should take place from the very initial steps of designing an implementation. However, although they present workflow on how such an evaluation should take place, Catwell *et al.* (2009) do not provide specific metrics of evaluation. This research differs from the work of Catwell *et al.* (2009) in that the proposed evaluation framework is designed to evaluate already existing e-Health platforms rather than systems that are still in early stages of design along with presentation of specific metrics for evaluation. Our e-Health evaluation framework is presented in the next section of this paper.

3. E-HEALTH EVALUATION FRAMEWORK

3.1 Overview

Our e-Health evaluation framework is designed around three main categories of evaluation: Usability Evaluation, Logistics Evaluation and Technical Evaluation (Figure 1). These three categories are adapted from the work of Dansky *et al.* (2006) where they initially proposed a framework for the implementation of e-Health projects. It is proposed that the definition of these three main categories enables a concise evaluation of e-Health platforms to take place and is capable of answering the question of whether an implementation overcomes the key challenges this technology faces from an organisational, technical and public perspective.

In conducting evaluation of an e-Health platform with groups of clinical staff and patients, i.e. the public perspective, a key question to answer would be the ease-of-use in the system (Usability Evaluation). Having a simple, understandable and intuitive system will most likely result in more trust in the e-Health platform in comparison with a complex system. An evaluation catered towards shareholders and directors of clinical environments, i.e. the organizational perspective, would more likely address questions such as the cost, upkeep and management of the system (Logistics Evaluation). Finally, for developers and IT administrators of e-Health platforms, i.e. the technical perspective, the key questions that should be answered in this category of evaluation is the functionality, security and scalability of the system (Technical Evaluation).

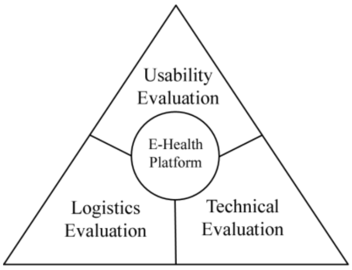

Figure 1. Categories of e-Health evaluation

For the scope of this paper, the primary focus is on defining techniques for obtaining metrics under the category of Technical Evaluation. As our evaluation framework is still under further development, presentation of technical evaluation metrics aim to serve as a proof-of-concept of our design along with validity of this framework. Presentation of the two other categories of e-Health evaluation will be provided at a future date (see Section 6 for details). The next section discusses the design of technical evaluation metrics.

3.2 Technical Evaluation Design

As the name implies, Technical Evaluation focuses on assessing an e-Health platform from a technical standpoint therefore, many pre-existing evaluation metrics used in the testing of computer systems and networks can be used. The following is an outline of technical evaluation metrics which are currently defined as part of this framework:

- **CPU Utilisation:** relates to how much processing time is required for the upload and/or download of health care data along with general interaction with the e-Health platform. The measurement of this metrics provides us with an overview on whether the current hardware infrastructure is up to a sufficient standard for the hosting of a chosen e-Health platform. Results obtained via this metric are dependent on the processor(s) of the hosting platform. CPU utilisation is measured under the unit of percentage (%).
- **Packet Loss:** relates to the number of healthcare data samples that are lost or dropped during an evaluation. A low packet loss (preferably zero) is highly desirable, if not essential, for e-Health platforms since the key attribute in which all interactions take place around is healthcare data.
- **Upload / Download Time:** the duration of time taken for a healthcare data to be uploaded and retrieved from the e-Health platform respectively. Results obtained from this metric are dependent on the network interface cards (NIC) and protocols used by the e-Health platform under evaluation. Measured in units of ms (milliseconds).
- **Round-Trip Time (RTT):** the duration of time taken for healthcare data to be uploaded to the e-Health platform, processed and then outputted to a clinical service, e.g. a patient monitoring system or EHR. As before, results from this metric are also dependent on NICs and the protocol used by the e-Health platform under evaluation. Measured in units of ms (milliseconds).

In order to obtain our defined technical evaluation metrics, it can be seen that some form of healthcare data must first interact with the e-Health platform under evaluation. We have chosen to use patient data for interaction with the e-Health platform under evaluation since this is the primary attribute which clinical environments revolve around. For the current scope of our framework, we have opted to use simulated patient data in place of real world patient data. Justification for the use of simulated data along with design of this software, named the Patient Simulator, is discussed in the next section.

3.3 Patient Simulator Design

To conduct a technical evaluation of an e-Health platform, and obtain results under the metrics defined in the previous section, patient data is required. To enable rapid evaluation of e-Health platforms to take place, we have chosen to simulate patient data instead of using real-world patient data. Simulating patient data also mitigates legal (Madsen *et al.*, 1999) and ethical (Hardiker and Grant, 2011) barriers which real-world patient data imposes. In essence, the Patient Simulator is a software application that models and simulates virtual patient's data and uses this data to interact with the e-Health platform under evaluation. The Patient Simulator was developed using Microsoft .NET C#.

The patient data we have chosen to simulate is known as the vital physiological signs of a patient. This includes the heart rate, blood pressure, temperature, respiratory rate and oxygen levels of a patient. In other words, these are the key attributes of a patient which would interact with an e-Health platform within a clinical environment. For the simulation of vital physiological signs, a Discrete Event-based Simulation (DES) method (Banks *et al.*, 1984) is employed. DES refers to a simulation system in which variables only change at specific points in time (known as the time interval). A vital sign value is generated periodically using random normal distribution techniques (Martin, 1971). Table 1 presents the default mean and arbitrary standard deviation applied to all five vital physiological signs which are simulated in a patient by default.

Table 1. Mean and standard deviation of vital signs

Vital Sign	Mean Value	Standard Deviation
Heart Rate	80 BPM	1.5
Blood Pressure	112 mmHG	2
Temperature	36.8 C	0.2
SpO2	97 %	0.5
Respiratory Rate	12 Breathes Per Minute	1

The mean value of blood pressure is based on the work of Pesola *et al.* (2001) in which they state that a normal systolic blood pressure is found to be 112 mmHg. From studies carried out by both Mackowiak *et al.* (1992) and Shoemaker (1996) the result of 36.8°C is applied for the mean body temperature. O'Driscoll *et al.* (2008) defines normal Spo2 as 96-98%, hence the average value of 97% is used. Finally, both Sherwood (2006) and Tortora and Derrickson (2008) agree that the mean respiration rate is found to be 12 breaths per minute.

In this paper, although variance and randomisation techniques were applied to the simulated patient data, the values generated were found not to be sufficiently realistic in comparison with real-world patient data. However, we propose the data simulated is still valid for experiments presented in this paper since we are evaluating the e-Health platform from a technical perspective, e.g. measuring response time and packet loss of arbitrary healthcare data samples, rather than evaluating the accuracy of clinical services, e.g. patient monitoring systems or EHRs. We outline technical evaluation experiments, conducted using simulated patient data, in the next section.

4. TECHNICAL EVALUATION EXPERIMENTS

4.1 Outline and Methodology

We present two sets of experiments in relation to technical evaluation for this paper. We have chosen to conduct the experiments on an existing e-Health implementation known as the Cloud4Health (Fan *et al.*, 2011) platform (formally known as the DACAR project). Both experiments were conducted using simulated patient data generated on-the-fly at the start of each test. In each experiment, the only variation is the number of patients we choose to simulate. A grey-box testing approach was taken. The Cloud4Health project provided an API in order for the simulated data to interact with the platform but we do not consider the underlying hardware architecture or source code during experimentation. This helps provide a non-bias evaluation of the platform along with ensuring our defined evaluation metrics are not restricted to evaluating only one specific e-Health implementation. The scenario for each experiment is outlined as follows:

- **Experiment 1:** *Baseline Test* - The first test is very simplistic in nature. In simulating 100 samples of a single patient's data, the upload time was monitored for intervals of 0.5, 1 and 3 seconds. In other words, 100 samples of a single patient's data was uploaded with three different time delays in order to evaluate whether any performance impact was found on the Cloud4Health platform based on how "talkative" the client, i.e. Patient Simulator, is. The primary aim of this experiment is establish a baseline result for how well the Cloud4Health platform handles a single patient's data being uploaded.
- **Experiment 2:** *RTT and CPU Utilisation* - The second experiment aimed to evaluate the RTT and CPU utilisation of the Cloud4Health platform. Up to 100 patient's data was uploaded concurrently. Each patient simulates 100 samples of data. The aim of this experiment is to assess the Cloud4Health platform's latency under a more realistic scenario which involves the input, processing and output of patient data

To provide a brief summary, Experiment 1 measures the Technical Evaluation metric of Upload Time whilst Experiment 2 measures the metrics of RTT and CPU utilisation. Furthermore, we monitor packet loss in both experiments. The methodology for gathering these metrics is as follows:

- **CPU Utilisation:** A Microsoft Powershell script running directly on Cloud4Health server was used to obtain this metric. The script monitors the counter referred to as *\processor(_total)\% processor time* (Edmead and Hinsberg, 2011). This counter returns the overall CPU utilisation of the server and the current value is logged to an output file every 1 second interval.
- **Packet Loss:** The total current samples stored in the Cloud4Health platform for each virtual patient was noted prior to the start of an experiment. The *total samples* simulated (100 per patient) is then subtracted from the *current samples* for each patient. A numeric value greater than 0 gives indication on the number of packets lost during the experiment.
- **Upload Time** : We gather upload time directly from the Patient Simulator application via the StopWatch class (Microsoft, 2012) provided by .NET C#. An instance of the StopWatch class is started upon uploading of data, and once the upload operation is complete, the StopWatch is stopped. The elapsed time produced by the StopWatch class results in the time taken to upload a single patient's data to the Cloud4Health platform.
- **RTT:** A push notification (Franklin and Zdonik, 1998) service was implemented on top of the Cloud4Health platform. Via the implementation of a Receiver client (acting as an example clinical service), the RTT metric is calculated based on subtracting the time stamp a packet was received (by the Receiver service) against the time stamp of when a patient data sample was sent to the e-Health platform (via the Patient Simulator). Strong time synchronization was achieved via an Active Directory server acting as time synchroniser (Smith, 2010) between the Patient Simulator and Receiver client machines.

5. RESULTS AND DISCUSSION

5.1 Experiment 1 - Baseline Test Results

Figure 2 provides the average upload time for 100 samples of a single virtual patient's data uploaded at intervals of 0.5, 1 and 3 seconds.

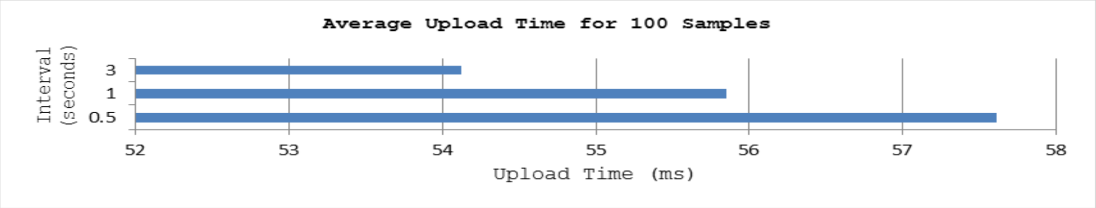

Figure 2. Average upload time

No packet loss occurred during the running of this experiment. As the interval time decreases, the time taken to upload a single virtual patient's data increases. Two conclusions can be made from this first experimental result: 1) talkativeness of a client, when upload a single patient's data, only affects the

Cloud4Health platform in a very minor manner and 2) upload times for a single patient's data is exceptionally good with results of less than 58 ms when uploading data in intervals of 0.5 seconds.

5.2 Experiment 2 – Round-Trip Time and CPU Utilisation Results

As part of the second experiment, we present the technical evaluation results of RTT latency and CPU utilisation of the Cloud4Health platform. No packet loss occurred in the instance of running this experiment. Figure 3 shows the average RTT latency when simulating and uploading 20, 60 and 100 patient's data whilst Figure 4 shows the CPU Utilisation results. Due to wide variance, Table 2 is also presented to give an overview of the minimum and maximum RTT latency values gathered during this experiment.

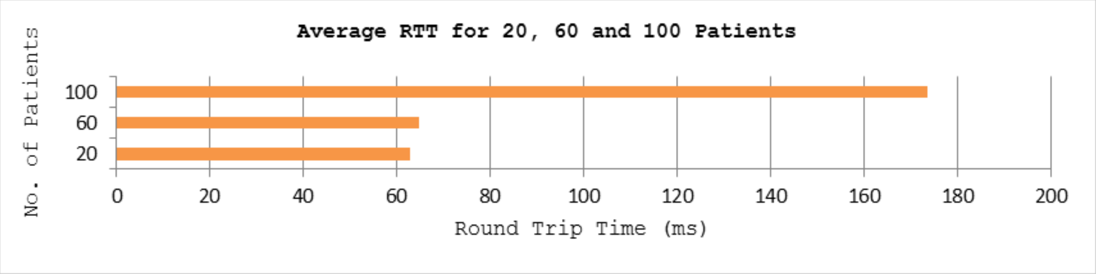

Figure 3. Average round-trip time

The results from the RTT graph show that in the case of simulating and uploading data for 20 virtual patients concurrently, the average RTT latency was very reasonable at 62.93 ms. In simulating 60 virtual patient's data concurrently, the average RTT latency was found to be 64.80 ms – which is only a very minor increase in comparison with 20 patients. On the other hand, simulating 100 patients produced a significantly higher latency of 173.56 ms on average. Furthermore, with a maximum latency of 6674.21 ms and minimum latency of 51.11 ms, there is far wider range of variance in RTT latency when simulating 100 patients. This wide range of variance is an indication that a bottleneck may be present on the Cloud4Health platform.

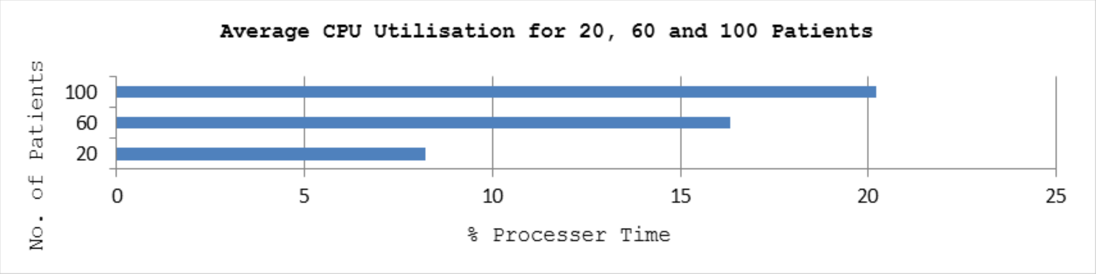

Figure 4. Average cpu utilisation

CPU utilisation was the primary suspect in this increased variance with RTT latency but Figure 4 shows this is not the case. Even in the scenario of simulating 100 patients, the average CPU utlisation of the Cloud4Health platform was only slightly greater than 20%. Hence, it can be concluded from this experiment that although RTT latency values grow as the number of patients simulated increase there is currently no direct evidence to show that this has any correlation with CPU utilisation.

The experiment was stopped at 100 patients data simulated as we found that the Cloud4Health platform was unable to handle any higher volumes of patient data without unexpected errors. Although the experiment has shown that the Cloud4Health platform is generally responsive and uses very little CPU when processing 100 patient's data concurrently, there is still room for improvement and optimisation to ensure this platform is capable of handling higher volumes of patient data.

Table 2. Minimum and maximum latency values

Number of Patients	Min RTT Value (ms)	Max RTT Value (ms)
20	32.57	526.65
60	31.33	578.02
100	51.11	6674.21

6. CONCLUSION AND FUTURE WORK

We have proposed a framework which aims to evaluate e-Health platforms under three main categories: usability evaluation, logistics evaluation and technical evaluation. Methods for gathering of metrics related to technical evaluation are the focal point of this paper. Experiments carried out have demonstrated techniques that enable technical evaluation metrics, including upload time, CPU utilisation, packet loss and round-trip time, to be obtained from an e-Health platform. The primary test bed for conducting these experiments was the Cloud4Health platform and input of patient data was achieved via simulation in order to mitigate legal and ethical barriers imposed when attempting to use real-world patient data.

With capabilities of processing up to 100 patient's data concurrently with no packet loss, the experiments have shown that the Cloud4Health platform is very reliable in ensuring the safe arrival and storage of patient data in a very reasonable time (maximum of 6.6 seconds). However, there is also room for improvement for the scalability of the Cloud4Health platform since a live hospital and clinical environments will most likely have to cater for more than 100 patient's data being uploaded and download concurrently.

For future work, research is underway to define techniques to enable the gathering of metrics from the two other categories of evaluation this framework proposes: usability and logistics evaluation. Usability evaluation will involve a qualitative study on the general usability of a chosen e-Health platform from the perspective of the end-user, i.e. doctors, nurses and patients. The key goal of usability evaluation is to establish metrics that are capable of measuring a user’s perception when interacting with an e-Health platform and, via the analysis of the metrics obtained, determine whether the platform is capable of overcoming the challenge of public trust. We aim to conduct this study via interaction with real world clinical staff along with the completion of surveys and questionnaires.

Logistics evaluation will aim to provide techniques in order to obtain qualitative results on the general cost of using a chosen e-Health platform. This includes the cost involved in purchasing, hosting, maintaining and managing an e-Health platform from an organisational perspective. The Patient Simulator we have developed in this paper will be used for logistics evaluation to provide meaningful metrics such energy usage based on the number patient data interacting with an e-Health platform and hardware costs involved in storing increasing volume of patient data.

Finally, we also aim to improve upon techniques for gathering technical evaluation metrics from e-Health platforms. It is acknowledged that unexpected difficulties may arise in obtaining evaluation metrics from e-Health platforms other than the Cloud4Health platform, i.e. due to the use of different technologies. The grey-box testing approach taken in experiments carried out in this paper was the first step in ensuring our evaluation framework is interoperable with existing and future e-Health platforms. Future collaboration with the healthcare industry and adapting standard technologies will help further achieve this aim of interoperability. The end goal of this research is to provide an evaluation framework with a concise methodology to enable meaningful metrics to be obtained from any e-Health platform under test.

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THE COMPREHENSIVE HEALTH INFORMATION SYSTEM: A PLATFORM FOR PRIVACY-AWARE AND SOCIAL HEALTH MONITORING

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ABSTRACT

Rapid ageing of world population makes the traditional hospitalization therapy more and more expensive, new forms of medical care are hence required. At the same time, the medical community perceives the availability of vital data as an essential prerequisite to acquire objective information about patients. Finally, the patients themselves show willingness to provide such data, in order for their health conditions to be regularly monitored.

This paper presents the last developments of the Comprehensive Health Information System (CHISel'd), a platform for continuous health monitoring whose main goal is to show how information technologies can be exploited to provide a feasible alternative to the traditional hospitalization therapy. Remarkable features of CHISel'd are its capability to process patient data according to a dynamically evolving set of data mining techniques and to share them among stakeholders (doctors, researchers, friends…) according to patient-defined access policies and in the frame of e-communities. These features enable CHISel'd to address the needs perceived by patients and the medical community.

KEYWORDS

Health Information Monitoring, Healthcare Community, Information Processing Platform.

1. MOTIVATIONS

Nowadays, the world population over sixty years old reached 600 million people and about 900 million people suffer from chronic diseases (Kotani et al, 2007), resulting in an increase of medical expenditure. Rapid ageing of world population results in increasing medical expenses, up to the point that nations will not be able to afford them anymore. As an example, in 2007 the percentage of Japanese population over sixty-five years old exceeded 20% and it is expected to exceed 30% by the year 2030[1]. As these data show, a different and more sustainable form of medical care than the traditional hospitalization therapy[2] is required.

At the same time, the medical community sets a strong demand for patients' vital data in daily life, since the information physicians collect during medical interviews is often not objective and the symptoms reported do not necessarily appear during a medical examination. Such data should both encompass long periods and be as detailed as to allow the identification of small-scale discontinuities. Moreover, both physical and psychological characteristics as well as information about the physical activity carried out by the patient should be tracked. If provided with such data, physicians could identify problems timely, devise countermeasures and establish programs tailored to the patient's lifestyle and preferences. On the other hand, data collected during the treatment could be used both to check whether the patient indeed sticks to his/her program and to evaluate the effectiveness of the program itself.

Finally, awareness and interest in healthcare is growing among common people: for three years in a row, "my own health" (resp. "health of my family members") obtained the second (resp. third) position in an

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[1] http://www.ipss.go.jp/p-info/e/psj2008/PSJ2008-02.pdf

[2] *Hospitalization therapy* (a.k.a. *inpatient care*) is the care of patients whose condition requires admission to a hospital.

opinion poll about Japanese people's worries and anxieties[3]. These results seem to indicate that common people would appreciate a steady, accurate and continuous monitoring of their health conditions, which in turn requires the systematic collection of daily-life vital data anywhere and at any time.

Since quite some time, information technologies have been successfully applied to the medical field: applications such as tele-radiology, tele-consultation and tele-surgery are being commonly employed to support wellness and independent living (Hung and Zhang, 2003). *Healthcare sensors* embedded in the environment can provide health information by continuously monitoring people's activity at home (Stanford, 2002). *Wearable healthcare sensors* are non-intrusive wireless microsensors enclosed in items which can be worn (such as a ring–Asada et al, 2003): in comparison to common healthcare sensors, they do not require a closed environment and can sense vital signs directly (Kunze et al, 2002 and Sachpazidis, 2002). Moreover, since patients can wear different wearable healthcare sensors at the same time, these can be exploited in order to concurrently track health data of different kinds.

The goal of this paper is to demonstrate a different way information technologies can prove useful to the medical field: since 2007, the authors have been working on the Comprehensive Health Information System (CHISel'd), a platform collecting, storing and making practical use of health information (Faudot et al, 2010, Lopez et al, 2011 and Shuzo and Yamada, 2009). Remarkable features of CHISel'd are

1. it stores **physiological and environmental data** as provided by (wearable) healthcare sensors. By tracking daily-life health data over long periods of time, it enables the constant monitoring of patients' health conditions
2. it allows to process such data in order to **extract information** any user can understand by means of data mining techniques (Han et al, 2011), thereby making them aware of patients' health conditions and overall status
3. it allows patients to **fully control the sharing of such information** with appropriate stakeholders (doctors, researchers, friends…) as necessary, thereby enabling more effective and efficient health services

CHISel'd is a concrete answer to the research problems we listed at the beginning of this section. Firstly, it provides physicians with a wealth of objective information and hence enables them to precisely identify the patients' profile. Secondly, it meets the desire of common people to be kept up-to-date with accurate information about their conditions and hence helps them to preserve their health and, in the end, improve their quality of life (QOL). Last but not least, by regularly monitoring patients' conditions and providing them with up-to-date health information, CHISel'd fosters disease prevention as opposed to disease treatment, thereby (hopefully) producing a revolution in the patients' way of thinking whose most visible effect should be a reduction of the overall medical expenses.

The remainder of this paper is organized as follows. Section 2 presents the requirements a platform like CHISel'd must fulfill as they are perceived by its end-users. Section 3 outlines the research issues we had to face when designing the platform itself. The architecture of CHISel'd is described in Section 4, whereas Section 5 accounts for related work. We conclude in Section 6 by summarizing our approach and presenting future work.

2. REQUIREMENTS

Whilst being one single system, CHISel'd is supposed to provide as many profiles as roles played by its users. Up to now, four roles have been identified: *patient*, *researcher*, *doctor* and *friend*. For each such role, this section describes the corresponding requirements which a platform like CHISel'd must fulfill. Further roles (e.g., *medical institution* or *health business company*) or specializations of existing ones (e.g., *family member* or *neighbor* as specializations of *friend*) will be added as needed. This will in turn require to: (i) identify the requirements for such roles; and (ii) extend CHISel'd accordingly.

Patients[4] obviously play a central role within the CHISel'd platform, being the main reason which led to its development. In order to regularly monitor their health conditions, CHISel'd must: (i) be able to track their daily-life health data; and (ii) provide sufficient storage capabilities to keep them over long periods of time. On the other hand, patients must be granted the possibility to retrieve their own data. Since it is unlikely

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[3] http://www8.cao.go.jp/survey/h22/h22-life/2-1.html (in Japanese).

[4] By *patients* we do not necessarily mean ill people but possibly healthy people willing to monitor their health conditions.

that common people will understand low-level data like the ones captured by (wearable) healthcare sensors, a suitable presentation facility must be provided. Finally, an easy-to-use interface making patients feel to be the main actors in their treatment would be a plus.

The role of researchers is to make sense out of health data, i.e., to develop algorithms which mine information out of raw data. Some algorithms will simply extract higher-level information out of lower-level one (e.g., overall body activity out of data about chest acceleration). Other algorithms will inspect health data to find out evidences of potential diseases. Such algorithms will play a central role in presenting health data to patients in a way they can understand, but they will be most useful to doctors as well: even assuming that doctors have the competences to extract information out of raw data themselves, the automation of this activity will let them spare time and focus on more important tasks. Obviously, researchers need to access the health data stored within CHISel'd in order to develop their algorithms. Moreover, a seamless integration of newly developed algorithms and already available ones would be desirable: ideally, researchers should only need to upload their algorithms' implementation to CHISel'd in order to make them immediately available to doctors.

Not surprisingly, the role of doctors is to take care of patients by monitoring their health conditions. To accomplish this task, doctors are supposed to make use of the algorithms available within CHISel'd. More specifically, for each patient they must identify the most suitable algorithms according to his/her profile. The higher-level information they retrieve might then be shared with the patient himself/herself. CHISel'd must allow doctors and patients to communicate directly, so that the formers can provide advices to the latters. Finally, doctors must be able to alert appropriate actors in case they detect an abnormal condition in some patient's real-time data.

The role friends play is a social one and is related to: (i) their physical proximity to patients; or (ii) their intention to follow patients' health status. The physical proximity enables friends to spring to their aid in case of an emergency: for this reason, CHISel'd must be able to send them an alert, either if requested by a doctor or if some algorithm running on patients' real-time data detected an abnormal condition. On the other hand, the ability to access patients' health data (as far as allowed by patients themselves) enables friends to support them better (e.g., by helping them following their program). Communities of/around patients may then arise to foster motivation or reassure stakeholders.

3. CHALLENGES

The requirements presented in Section 2 fit nicely into four categories.

1. Tracking of patients' health data
2. Storage of health data and algorithms mining information out of them
3. Access to health data
4. Communication-related requirements

In order to obtain a picture as accurate as possible of patients' health conditions, all of **physical** (e.g., activity and behavior), **psychological** (e.g., stress and emotions) and **context data** (e.g., atmospheric pressure, outer temperature) should be tracked. As described in Section 1, wearable healthcare sensors are the least-intrusive technology available to date in order to sense vital signs. As a consequence, a platform like CHISel'd can be expected to provide as many wearable healthcare sensors as needed to sense all of the health data mentioned above.

Storage of health data and storage of algorithms pose different problems. In the first case, memory is the main concern: regularly monitoring patients' health conditions produces large amounts of data and the ability to keep them over long periods of time makes the availability of huge amounts of memory essential. In the second case, memory is not expected to represent a big issue, not even for a large number of algorithms: whenever untrusted code has to be loaded and executed on a system, the main concern is rather security. Suitable countermeasures should then be taken in order to avoid malicious code to harm the system.

The common label "**access to health data**" refers to a set of different issues. First of all, being health data sensitive information, the privacy of their owners must be taken into account when evaluating access requests: as mentioned in Section 2, the approach most respectful of patients' privacy would probably be to enable them to decide themselves who can access their data. Even independently from privacy concerns, it is not meaningful allowing all users to access all data, since not all users can understand all of them: different access policies should hence be defined according to the role played by the requesting user, so that users can only access data whose granularity level is sufficiently high with respect to the role they play. Finally, “access to data” refers to the format the accessed data are presented to the requesting user: researchers might only need to access (files containing) raw data through a software API, whereas other users might need to access higher-level information (such as the patients’ daily level of activity) through a user-friendly presentation facility.

The last set of requirements is related to **communication**. As outlined in Section 2, CHISel’d must support both *user-triggered communication* (e.g., message exchange) and *reactive communication*. By the latter we mean information exchange which takes place automatically whenever a given event occurs, the prototypical example being the notification of patients’ friends when the formers could be in danger, as detected by some algorithm running on their real-time data. Finally, the ability of doctors to specify which algorithm applies to which patient can be considered a communication-related requirement as well, since the doctor (implicitly) communicates to the patient which higher-level information the system will handle for that specific patient, thereby enabling him/her to define corresponding access policies.

4. ARCHITECTURE

The four sets of requirements described in Section 3 correspond to the main components of the CHISel’d architecture. Beside the components themselves (shown in the middle column), Fig. 1 attempts to depict the main interactions both among them and with system users according to their role. Interactions in which users act as information providers (resp. consumers) are shown in the left (resp. right) column.

In a bottom-up fashion, patients provide health data to (wearable) healthcare sensors which transmit them to the storage facility. Algorithms developed by researchers in order to mine information out of health data are stored as well. These algorithms can be retrieved by doctors who will possibly assign them to their patients according to their profile. Doctors, as well as friends, patients and researchers, can retrieve (sufficiently high-level) health data by means of suitable interfaces and according to patient-defined access policies. Finally, communication among users can occur through the corresponding component of the CHISel’d platform and the platform itself can contact users upon occurrence of specific events. For generality, CHISel’d: (i) allows communication between any pair of users; and (ii) can issue notifications to any user; although e.g., friend-researcher communication is unlikely to occur, as are notifications to researchers.

The remainder of this section is devoted to the description of the main components of the CHISel’d architecture as well as their interactions. Since the Caption (resp. Storage) component has been already described in (Lopez et al, 2011–resp. Faudot et al, 2010), in this paper we will focus on the Data Access and Communication components (described in Sections 4.1 and 4.2 respectively).

4.1 The Data Access Component

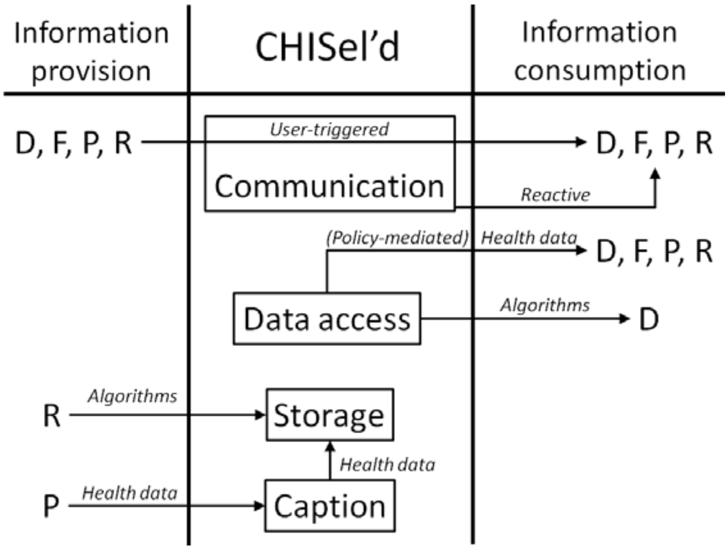

Figure 1. The main components of the CHISel'd architecture as well as their interactions (the letters D, F, P and R stand for Doctors, Friends, Patients and Researchers respectively)

Figure 2. The policy editor of CHISel'd

As described in Section 3, not all users of CHISel'd should be allowed to access all data it stores, since: (i) being health data sensitive information, the privacy of their owners must be taken into account; and (ii) not all users can understand all of them. For this reason: (i) different access policies should be defined according to the requesting user; and (ii) the approach most respectful of patients' privacy would probably be to enable them to decide and control themselves who can access their data.

As for the first point, the need of automatizing policy enforcement is well known in the research community, as witnessed by the *IEEE International Symposium* (formerly *Workshop*) *on Policies for Distributed Systems and Networks*[5] which is being held since 1999. *Policy languages* have been proposed as a solution for such a need: they are special-purpose programming languages which allow defining policies in a formal way. Upon definition, formal policies can be enforced by providing them as input to a compatible *policy engine*.

Formal policies yield many advantages in comparison to natural-language ones. To start with, their semantics is unambiguous: they can hence be shared among interested parties without the risk of misunderstandings. This goal is usually accomplished by grounding policy languages in some mathematical formalism: as a consequence, the same formalism can be exploited in order to infer implicit knowledge out of formal policies (e.g., whether they are consistent or too restrictive). On the practical side, the choice of uncoupling policy definition and enforcement (as opposed to building a specific policy once and for all into the policy engine) is a winning one, since a modification in the policy does not require a completely new engine but only to provide the current one with a different input. Finally, although policy languages are indeed programming languages, they are typically designed as *declarative* ones, i.e., they usually belong to a class of programming languages which is claimed to be easier to learn than alternative ones: as a consequence, writing formal policies may not only be a task for computer scientists.

A number of policy languages have been defined so far. According to comparisons available in the literature (De Coi and Olmedilla, 2008 and Duma et al, 2007), PROTUNE (Bonatti et al, 2010) turns out to be one of the most complete ones available to date and as such it was an obvious candidate for the CHISel'd platform.

As for the second point, although formal policies are not as hard to write as usual computer programs, patients cannot be expected to define them themselves. Fig. 2 shows the editor CHISel'd provides to patients

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[5] http://www.policy-workshop.org/

and other trustworthy users in order to define policies: combo boxes list all users and roles available in the platform. By selecting the appropriate *(user, role)* pairs and clicking on the Associate Contact/Role button, roles can be assigned to users. New roles can be created by clicking on the Create role button: the user will be presented with a screen enabling him/her to specify a name for the role as well as to select: (i) which data the role members will be able to access; and (ii) at which granularity level such data should be accessed.

The solution provided by CHISel'd is intuitive and does not almost require any learning step. Also, the great expressiveness of the PROTUNE policy language overcomes conventional role-based policies by enabling the definition of access rules which depend not only on the role of the requester but also on the granularity level of the data to be accessed and on context information, as shown in Fig. 3.

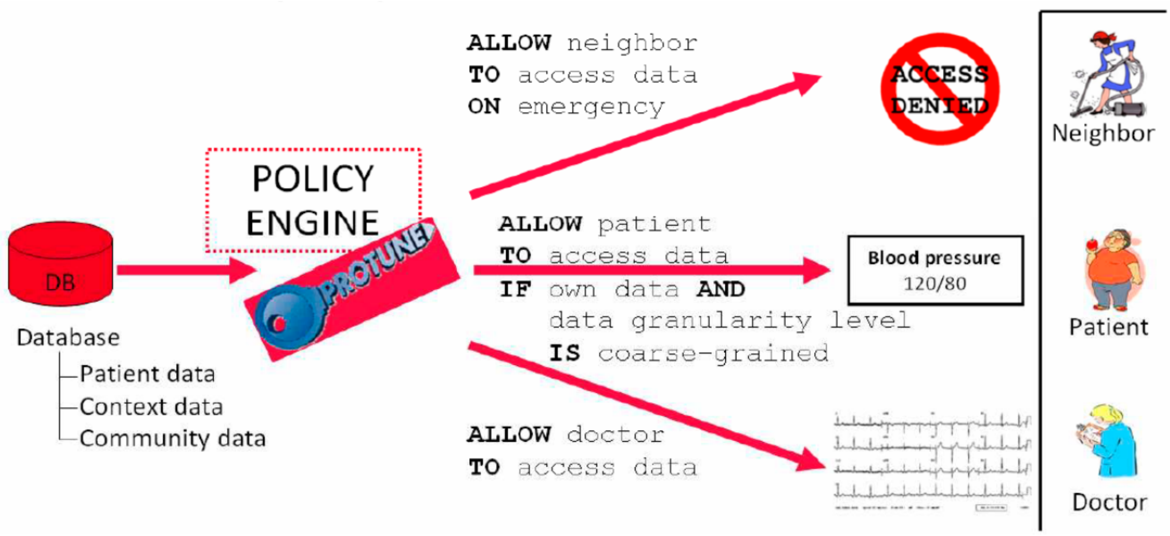

Figure 3. PROTUNE policies allow to specify which requester is allowed to access which data according to which context

4.2 The Communication Component

As described in Section 3, CHISel'd should support both user-triggered and reactive communication, i.e., the exchange of information among its users should be initiated either by the users themselves or by the system upon occurrence of a given event.

User-triggered communication is natively provided by a broad spectrum of technologies which have been developed during the last years and are commonly referred to under the shared label "social software". Social software encompasses a number of technologies which allow one-to-one (e.g., instant messaging applications), one-to-many (e.g., blogs) and many-to-many communication (e.g., online chat technologies, Internet forums, wikis). *Social networking* and *online community* services exploit many such technologies in order to provide their users with an integrated experience.

Social networking and online community services foster the creation of *virtual communities*, i.e., social networks of individuals who interact through specific media in order to pursue common interests or goals. Virtual communities can give users a feeling of membership and belonging and promote the creation of trust relationships among them. As for the medical domain, virtual communities can enhance patients' mood, behavior and willingness to follow a program, thereby improving their QOL (Battles and Wiener, 2002 and Eysenbach, 2003).

Since social networking services: (i) employ technologies which enable user-triggered communication; and (ii) can positively impact their users' QOL; it was an obvious decision designing the communication component of CHISel'd as an enhanced social networking service. When it came to the point of choosing the Social Network Engine to use as a basis for it, extensibility was considered the most relevant factor because of the modifications we planned to do in order to configure the chosen engine toward our needs. According to this criterion, Elgg[6] has been regarded as the open-source Social Network Engine best suiting our requirements.

The most remarkable modifications we made to Elgg are the addition of: (i) plugins to visualize health data in a user-friendly way; and (ii) a mechanism enabling the engine to contact users upon occurrence of a given event. As for the first point, we developed a set of plugins which, if installed on an Elgg instance, integrate health data into its user interface. Data are shown to a user: (i) only if s/he can access them; and (ii) in a user-friendly way, i.e., not as a list of values but in a graphical form. For instance, heart activity is displayed as an ECG, whereas the percentage of time spent by the patient laying, sitting or standing is visualized as a pie chart. As for the second point, we added Elgg a mechanism enabling it to send users messages upon occurrence of a given event: whenever some algorithm running on patients' real-time data detects an abnormal condition, such mechanism can be exploited in order to automatically notify patients' friends according to the scenario described in Section 2.

5. RELATED WORK

To the best of our knowledge, an approach as broad and generic as the one pursued by CHISel'd appears to be unique. On the one hand, a number of platforms make use of social software in order to build virtual communities of healthcare stakeholders. However, such platforms focus on the community aspect and do not provide any means to track patients' health data and provide them to researchers. On the other hand, some systems supporting remote healthcare monitoring have been proposed. However, such systems focus on health data collection and do not provide an overall framework within which captured data can be processed. Moreover, such data are not used in their social dimension, i.e., they cannot be shared within a virtual community and privacy issues appear to be neglected.

As for the first set of platforms, social software in the healthcare domain may serve different purposes according to the point of view one wants to take. For healthcare professionals, it is a means to disseminate peer-to-peer knowledge and highlight individuals as well as institutions. For patients, it offers the chance to connect with others suffering of similar diseases and possibly to gain motivation and encouragement through others' support. Social software itself (namely, a wiki) is exploited to provide the probably most comprehensive list of healthcare-related social software available to date: the goal of the *Pharma and Healthcare Social Media Wiki*[7] is "to house every Social Media project that has been created by […] healthcare companies". Listed social software is classified according to the intended users (patients, healthcare professionals or marketing professionals), the employed technology (blog or wiki) or the hosting platform (Facebook[8], YouTube[9], MySpace[10] or Twitter[11]).

As for the second set of systems, a good overview thereof is provided by (Anliker et al, 2004): as the authors point out, most available systems target a specific environment and can hardly be generalized to support different ones. An approach not described in (Anliker et al, 2004) is presented in (Blount et al, 2007): a major drawback of this proposal is its usage of HTTP to transfer health data, which makes regular health monitoring and reactive communication unpractical. We conclude by mentioning parallel work which is being carried out by a partner of ours: (Rikitake et al, 2009) describes a system which exploits wearable healthcare sensors and mobile networks to support continuous health data capture and storage as well as reactive communication. The technology it is based upon (namely, Next-generation network/IP Multimedia Subsystem) enables it to overcome the shortcomings of (Blount et al, 2007) and provides native support for AAA (Authentication, Authorization and Accounting), QoS (Quality of Service) and event notification.

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[6] http://www.elgg.org/

[7] http://www.doseofdigital.com/healthcare-pharma-social-media-wiki/

[8] http://www.facebook.com/

[9] http://www.youtube.com/

[10] http://www.myspace.com/

[11] https://twitter.com/

6. CONCLUSIONS AND FURTHER WORK

Rapid ageing of world population makes the traditional hospitalization therapy more and more expensive, new forms of medical care are hence required. At the same time, the medical community perceives the availability of vital data as an essential prerequisite to acquire objective information about patients. Finally, the patients themselves show willingness to provide such data, in order for their health conditions to be regularly monitored.

This paper presented the last developments of the Comprehensive Health Information System (CHISel'd), a platform for continuous health monitoring whose main goal is to show how information technologies can be exploited to provide a feasible alternative to the traditional hospitalization therapy. Remarkable features of CHISel'd are its capability to process patient data according to a dynamically evolving set of data mining techniques and to share them among stakeholders (doctors, researchers, friends…) according to patient-defined access policies and in the frame of e-communities.

Not surprisingly for a long-term project far from its end, the current version of the CHISel'd platform can be improved and extended in many ways. A first line of development concerns the roles which can be played by system users. As described in Section 2, CHISel'd currently supports only four roles: *patient*, *researcher*, *doctor* and *friend*. However, evidences are showing that the integration of further roles (e.g., *medical institution* or *health business company*) or specializations of existing ones (e.g., *family member* or *neighbor* as specializations of *friend*) would be beneficial. However, this can be considered a minor issue since Section 4.1 already showed that the CHISel'd technology makes the creation of new roles straightforward.

A second line of development has been mentioned in Section 4.1: the policy editor CHISel'd provides to patients and other trustworthy users is more constraining than it ought to be. We are currently considering replacing it with an interface based on controlled natural languages. Whilst not being much harder to use than the current one, such an interface would enable to fully exploit the expressiveness of the PROTUNE policy language. Preliminary results (De Coi et al, 2009) are encouraging and we plan to pursue this approach further.

Finally, Section 4.2 pointed out that doctors should be able to specify which algorithm applies to which patient. CHISel'd does not provide yet for such a possibility, which is hence regarded as further work.

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ELDERLY PEOPLE'S PERSPECTIVES OF A WSN BASED SYSTEM FOR HEALTHCARE AND SOCIAL INTERACTIONS

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ABSTRACT

We investigate the user's perspectives of a WSN-based health monitoring system which comprises both health monitoring and social interaction functions for the elderly people in geriatric facilities. A WSN-based health monitoring and social interaction system is proposed and a survey of elderly people's acceptance of using it was conducted and analyzed, providing some feedbacks on how could WSN-based system better serve the elderly care.

KEYWORDS

WSN; elderly care; user's perception; social entertainment

1. INTRODUCTION

The aging population is an obvious trend making a big influence on today's healthcare practice. Worldwide, there has been a significant change in the age make-up of world's population, as a result of increased life expectancy both in developed and developing countries. Since there is an increased risk of strokes, falls, and other health problems for old people with chronic illness, constant monitoring is necessary to provide thorough care. Apart from physical health problems, isolation and lack of contact with friends and family in old age is seen as a greater worry. According to *elderlyparents.org.uk –*an organization which provides free advice to children coping with the demands of ageing parents, nearly half of those questioned said being lonely was their main concern in the future. The findings painted a bleak picture of life for Britain's pensioners, with an estimated 300,000 saying they often go an entire month without speaking to family or neighbors.

From this consideration derive wide-ranging research questions: How could information technology (IT) help to provide better healthcare services to an increasing number of elderly people using limited financial and human resources? How could IT help to improve their quality of life by bringing both healthcare supervision and social entertainment support?

Wireless sensor network (WSN)-based system is being increasingly proposed as the solution to healthcare monitoring Problems. It has considerable potential for providing an effective, scalable solution for assisting elderly people achieve a relatively independent life. It offers significant benefits in terms of reducing deployment costs and providing more convenience to elderly people.

Our research project aims to answer the questions above by designing a WSN based health monitoring and social interaction system especially for elderly people living in geriatric facilities. There exist plenty of WSN based prototypes and patents providing health monitoring for elderly people. Nevertheless, very few of them have integrated social interaction design into the system. Several studies have been conducted to investigate elderly people's perspectives into 'smart home' or WSN[3] [5]. Our survey is different from them as we look into the relationships between elderly people's acceptance of certain function and their personal circumstances like health condition. Their attitude towards social interactive design is also investigated. The following section presents a brief introduction of the design of our proposed system and a survey on elderly people's perspective of using it both in UK and China.

2. A BRIEF INTRODUCTION OF OUR PROPOSED WSN BASED HEALTH MONITORING AND SOCIAL INTERACTION SYSTEM

Our intention is to carry out research into developing a monitoring system comprising both health monitoring and social interaction functions for the elderly people in geriatric facilities and similar application scenarios. The monitoring system comprises several subsystems of which the sensor nodes subsystem will be the most fundamental subsystem that interacts with the elderly people. It consists of RF nodes with customized sensors to collect real-time data. Different nodes can transmit acquired data to the sink node via a certain network which is capable of self-healing mesh networking, ad-hoc and advanced routing.

Health condition monitoring would be realized by measuring vital signs such as heart rate, ECG and sending to professionals during necessary period. It is also an interactive social machine which enables the elderly people to publish voice twitter messages among their friends in the geriatric facility or upload to the real twitter to share their thoughts with families and friends. This function does not incur extra spending for each elderly person. In addition, it can also work as a pill taking reminder and a handy talkie through which the elderly people can talk to nurses about their needs. Figure.1 shows main functions of our proposed system.

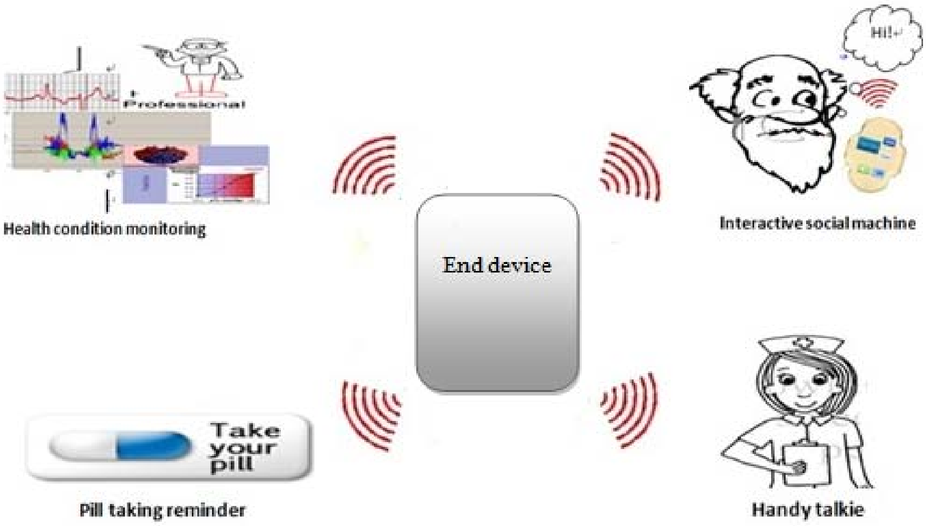


Figure 1. End device design

3. METHODOLOGY

3.1 Purpose

The objective of this survey is to research the user’s acceptance and expectation towards a WSN based monitoring and social interactive system. This work aims to provide feedback on the predesigned dimensions and functions that may be included in the monitoring system.

3.2 Methods

The three steps of the methodology are
(i) developing a questionnaire;
(ii) conducting focus groups;
(iii) data analysis.

3.2.1 Questionnaire Development

In order to study and understand user acceptance behavior and factors, several models have been created. Fishbein and Azjen's Theory of Reasoned Action (TRA), Davis' TAM model, and the Unified Theory of Acceptance and Use of Technology (UTAUT) model developed by Venkatesh et al. [4]. Acceptance determinants described by the abovementioned theories and models have been proven to be effective in evaluating a user's acceptance of a technological system, therefore those concepts are taken into consideration for designing the questionnaire.

The questionnaire is made up of 23 questions categorized into four aspects.

The first part of the questionnaire collects the general information of the participants including gender, age, health condition, IT skill, social networking they use. The participants were asked to rate both their health condition and IT skill on a scale of 1-10, the higher score they chose, the better health condition and IT skill they had. Each question is designed for exploring its relationship between the acceptance and personal circumstances. The second part of the questionnaire is made up of five questions exploring the acceptance of the main functions integrated in the system. The third part of the questionnaire is to measure the perceived social influence of using the system by three questions. The final part of the questionnaire is a System Usability Scale (SUS) which is a simple, ten-item scale giving a global view of subjective assessments of usability. The answers to the questions obtain a lot wanted information such as ease of use, Performance Expectancy and Effort Expectancy.

Before the questionnaire starts, participants were given an introduction to explain the functionality and capabilities of the WSN based health monitoring and interaction system and were shown a wooden model so that they could have an idea of how it looks like and how it works. Each participant took about 20 minutes to listen to the introduction and finish the questionnaire. The author was at present to offer explanations when they came across confusions about the content.

3.2.2 Conducting Focus Group

Focus groups were conducted with elderly individuals who were living in the nursing home or care home in both UK and China.

Group1: 28 elderly people living in a private nursing home, London, UK.

Group2: 30 elderly people living in WUXI City's nursing home, WUXI, China

Both nursing homes are facilities with relatively good reputation which can be pioneers in adopting new technologies to take care of the elderly people. To ensure that all the views about the WSN based monitoring and entertainment system are not affected by different personal living experiences. All elderly participants were living in the nursing home for more than 3 months at the time the questionnaire took place. An effort was made to even the mix of female and male participants in WUXI City's nursing home, China. Informed consent was obtained from all subjects.

3.2.3 Data Analysis

The questionnaires were analyzed, discussed and the findings cross-validated with a professional caregiver with over 10 years experience to help identify key concepts. The questionnaires answers were categorized and calculated to allow for the identification of common thoughts towards the system.

4. RESULTS

4.1 Group1, 28 Elderly People living in a Private Nursing Home, London, UK

Part. 1, General circumstances generated:

27 male and only one female participated in the Questionnaire. The majority of them aged between 60 and 80. (93%) The mode of their health condition score was 5, the minimum and maximum score were 3 and 8 respectively. The mode of their IT score was 5, the minimum and maximum score were 1 and 7 respectively. The primary social networking they use was mobile phone (20 people, 71%) and e-mail (13 people, 46%), there were 5 people (18%) do not use any of social networking mentioned.

Part. 2, The acceptance of main functions:

16 of them (57%) would use the system to measure their physical parameters instead of having a nurse to do it and 23 of them (82%) would carry it around or wear it while asleep to continuously monitor physical parameters if necessary. 19 of them (68%) would share their thoughts and comments on daily life with families and friends via it. 25 of them (89%) would like to talk to the nurse about their needs via the system.

We can conclude from the above results that the general attitude towards the health conditioning monitoring is positive especially when it's necessary to measure vital signs continuously for a period of time. A lot of them were also interested in using it as an interactive social machine. Using it as a handy talkie to communicate with the nurse seem to be the most welcoming function with more than 20(89%) of them agreeing.

Part. 3, Social Influence of using the system:

4 of them (14%) were not willing to let others knowing that they were wearing a health monitoring system. Only one person (4%) would not accept any training on how to use the system. 15 of them (54%) show great concern about privacy issues since the health information will be transmitted wirelessly.

Conclusions could be made that the volume of the end device will be an important consideration as it contributes to both comfortability and people's willingness of using it. The privacy issue is highly valued and great importance should be laid on the information security.

Part. 4, System Usability Scale[2]

The average score of the 28 participants is **77.75**

According to Aaron Bangor[1]:Products which are at least passable have SUS scores above 70, with better products scoring in the high 70s to upper 80s. Truly superior products score better than 90. Products with scores of less than 70 should be considered candidates for increased scrutiny and continued improvement and should be judged to be marginal at best. The final score indicates that participants' attitudes towards the WSN based health monitoring and social interactive system are generally positive and the design of the system is relatively good.

4.2 Group2, 30 Elderly People Living in WUXI City's Nursing Home, WUXI, China

Part. 1, General circumstances generated:

There are 15male and 15 female participating the Questionnaire. The majority of them aged between 60 and 80. (87%) The mode of their health condition score was 6, the minimum and maximum score were 3 and 8 respectively. The mode of their IT score was 4, the minimum and maximum score were 1 and 6 respectively. The primary social networking they use was mobile phone (19 people, 63%) and QQ (a popular Chinese instant messaging program, 8 people, 27%). A big proportion of them don't use any social networking (11 people, 37%).

Part. 2, The acceptance of main functions:

19 of them (63%) would use the system to measure their physical parameters instead of having a nurse to do it and 28 of them (93%) would carry it around or wear it while asleep to continuously monitor physical parameters if necessary. 23 of them (77%) would share their thoughts and comments on daily life with families and friends via it. 29 (97%) of them would like to talk to the nurse about their needs via the system.

We can conclude from the above results that the general attitude towards the health conditioning monitoring is extremely positive especially when it's necessary to measure the vitals continuously for a period of time. A lot of them were also interested in using it as an interactive social machine. Using it as a handy talkie to communicate with the nurse seem to be the most welcoming function with more than 25 (97%) of them agreeing.

Part. 3, Social Influence of using the system:

All of them are willing to let others know that they are wearing a health monitoring system. Only one person would not accept any training on how to use the system. None of them show great concern about privacy issues since the health information will be transmitted wirelessly.

Conclusions could be made that the importance of privacy issue may be varied from culture to culture and different living background may greatly influence the requirements of a certain product.

Part. 4, System Usability Scale[2]

The average score of the 28 participants is **82.5**

The final score indicates that participants' attitudes towards the WSN based health monitoring and social interaction system are generally positive and the design of the system is relatively good.

The following figure gives an overview of elderly people's perspectives into the WSN based health monitoring and social entertainment system.

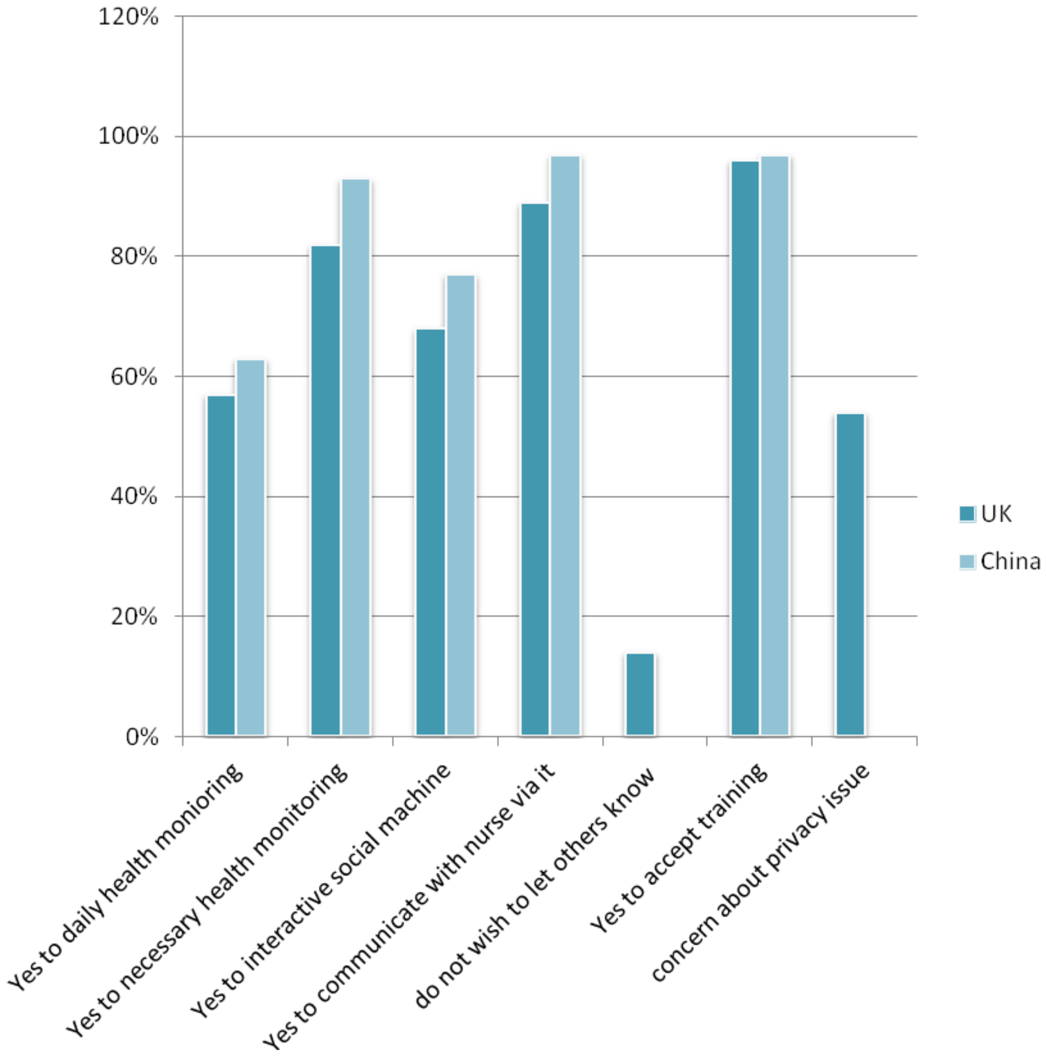


Figure 2. Overview of user's perspectives

4.3 Observations

Relationship between Personal circumstances and acceptance of the system

As table 1, table 2, table 3 shown below, when significance level is 0.05, contingency table analysis shows that the health condition and IT knowledge of the elderly people has significant influence on their attitude towards certain functions.

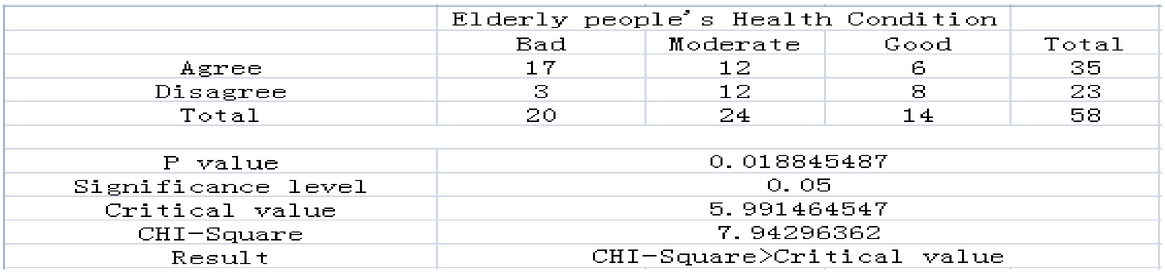
1, Elderly people who are willing to use a WSN based monitoring system to monitor their vitals tend to have lower health score. (The mode of health score for these people is 4 in both UK and China which is lower than the whole group mode 5 and 6)

2, Elderly people who are willing to use a WSN based monitoring system to monitor their vitals tend to have higher IT skill score . (The mode of IT score for these people is 6 in UK and 5 in China which is higher than the whole group mode 5 and 4)

3, Elderly people who would share their thoughts and comments on daily life with families and friends via a WSN based monitoring system have lower IT score (The mode of IT score for these people is 3 in UK and 2 in China which is lower than the whole group mode 5 and 4)

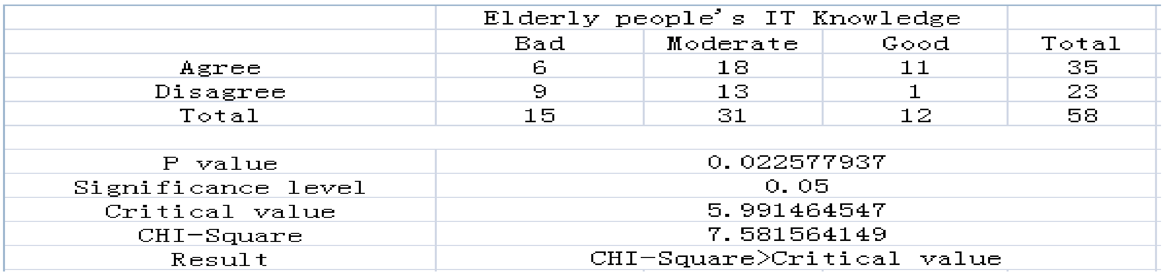
4, Elderly people are more willing to wear a WSN based monitoring system when it's necessary to monitor their vitals during a period of time (UK: 82%, China: 93%) than to wear it every day (UK: 57%, China: 63%).

Table 1. CHI-Square test result of Elderly people's health condition and their attitudes towards daily heath monitoring



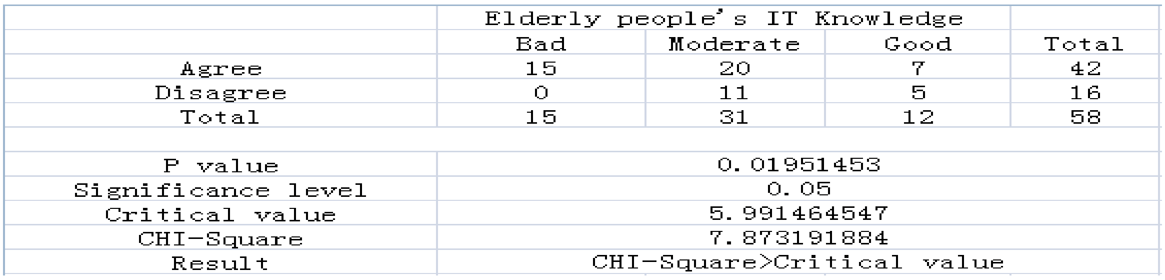
	Elderly people's Health Condition			
	Bad	Moderate	Good	Total
Agree	17	12	6	35
Disagree	3	12	8	23
Total	20	24	14	58
P value	0.018845487			
Significance level	0.05			
Critical value	5.991464547			
CHI-Square	7.94296362			
Result	CHI-Square>Critical value			

Table 2. CHI-Square test result of Elderly people's IT knowledge and their attitudes towards daily heath monitoring



	Elderly people's IT Knowledge			
	Bad	Moderate	Good	Total
Agree	6	18	11	35
Disagree	9	13	1	23
Total	15	31	12	58
P value	0.022577937			
Significance level	0.05			
Critical value	5.991464547			
CHI-Square	7.581564149			
Result	CHI-Square>Critical value			

Table 3. CHI-Square test result of Elderly people's IT knowledge and their attitudes towards interactive social machine



	Elderly people's IT Knowledge			
	Bad	Moderate	Good	Total
Agree	15	20	7	42
Disagree	0	11	5	16
Total	15	31	12	58
P value	0.01951453			
Significance level	0.05			
Critical value	5.991464547			
CHI-Square	7.873191884			
Result	CHI-Square>Critical value			

Relationship between UK and China

1, Chinese elderly people are less concerned about the privacy issue than English elderly people.

2, The overall attitude of Chinese old people towards a WSN based health monitoring and social interactive system is more positive than English old people. The Chinese government made great efforts for the dissemination of "Internet of things" and WUXI City is selected as the pilot city. These may contribute to the Chinese elderly people's knowledge about WSN based system.

5. CONCLUSION

The system design and user questionnaire are our first stage work in developing our proposed WSN based health monitoring and social interactive system. Although it's a survey specially for our proposed system, it still gives some general information of user's acceptance and influence factors for system design and implementation. The most useful findings could be summarized as follows. Most elderly people would accept the WSN health monitoring system when it's necessary for intensive monitoring of their health condition. More than half of the elderly people questioned believe that they can have some interaction with the system and use it as a communication way to other people. They are also willing to have some training for this. Different from the traditional standpoint that privacy issue should be attached great importance to, the importance of information privacy issues can vary from different backgrounds. The social interaction function can be a good addition for WSN system.

6. DISCUSSION

All the answers from the elderly people are based on the assumption that they can easily afford the cost of the system. The funding issue is not considered at this stage. We are investigating their general attitude mainly from a usefulness oriented perspective.

For social aspect of WSN based system, Our proposed system is designed for elderly people without cognitive problems to take part in the social networking with less effort. However, it's still a long way to explore WSN's great potential to provide more social entertainment support for the elderly people, like novel WSN based interactive games, WSN based pet etc.

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PROVIDING PATIENTS ONLINE ACCESS TO THEIR LIVE TEST RESULTS: AN EVALUATION OF USAGE AND USEFULNESS

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ABSTRACT

Background: A system which enables patients with long term conditions to access their live test results online may lead to better self-management and improved health. Renal PatientView (RPV) is an internet based system that provides kidney patients with secure access to their live test results. The system also offers an online discussion forum, and tools to help patients add self initiated data such as blood pressure, glucose and weight readings to their live test records.
Purpose: This study aims to; (a) assess the usage and usefulness of RPV to patients and healthcare professionals, and (b) examine its impact on self care motivation, and quality of patient care/care planning.
Design: Online survey of 507 registered users of RPV in 10 kidney units in England. Data on value of RPV, pattern of use, perceived benefits, and demographic characteristics of respondents were collected and analyzed using descriptive frequency tables and charts.
Findings: A total of 257 (50%) invited patients completed the user survey. The majority (70%) of patients were between 26 to 65 years old, with the highest proportion (39%) in the 51 to 65 year age group. Most patients (71%) have been using RPV for more than one year. Nearly all users agreed they were more likely to use RPV when expecting the results of a recent test (97% "Agree" or "Strongly agree"). Respondents were very positive in their opinion about the empowering outcomes of using RPV and agreed that using RPV makes patients feel more in control of their medical care (88%); gives patients a better understanding of their kidney disease (86%); helps patients find it easier to communicate with their healthcare team (79%); makes patients more prepared for hospital visits (69%); reassures patients about their treatment (77%); and helps patients to be more involved in decisions about their care (75%). Only a few of the respondents believed that using the system makes patients worry (14% agreed).
Conclusion: Patients' attitudes about the use of a system designed to help patients with kidney disease access their live test results online were mostly positive. Patients found the system very valuable. A minority of patients was concerned that using the system makes their lab results confusing or makes them worry.
Relevance: This study offers insight into the value of a system designed to help patients with kidney disease access their live test results online, and its impact on their participation in decision making and capacity to self-care.

KEYWORDS

Electronic Health Records; Patient Empowerment; Self Care; Patient safety

1. INTRODUCTION

There is a growing public demand for patients to have access to their personal health information (Pagliari *et al*, 2007). This may have followed from a general assumption that enabling people to view and share their medical data will result in better self-care, reductions in treatment and medication errors, and improved health (Mandl *et al*, 2007; Detmer *et al*, 2008; Bourgeois *et al*, 2008). The emergence of the personal computer, internet, and the World Wide Web in the last two decades has made it technically feasible to provide patients access to their health information online (Ross *et al*, 2004; Donna *et al,* 2001). However, there is very little research on how such personal health information systems are used and how they benefit the users (Frost & Massagli, 2008).

Renal Patient View (RPV) is a secure internet based system that enables kidney patients to view their live test results online and obtain information about their kidney disease. The system was designed specifically for patients to use and is available to all kidney patients at participating kidney units in the United Kingdom (UK). The system also offers an online discussion forum, and tools to help patients add self initiated data such as blood pressure, glucose and weight readings to their live test records. Patients who are logged in can see a visual display of their test results history over time on their profiles. Access to the site is controlled by the patient who may choose to give permission for family, health care professionals and others to view their data. RPV is now available in 43 of the 52 kidney units in England with over 16000 registered users.

An evaluation by NHS Kidney Care was developed to assess the utility and usefulness of RPV to patients and health care professionals. This will contribute to an increased understanding of how patients and healthcare professionals perceive this model of data access, and its impact on patient participation in decisions about their own health and their capacity to self-care. The aims of the evaluation were:

(a) To assess the usefulness of RPV to patients and healthcare professionals

(b) To examine its impact on self care motivation and quality of patient care/care planning.

2. BODY OF PAPER

2.1 Methods

2.1.1 Recruitment

There are up to 16,500 registered users of RPV in the UK, of which some have never logged in since registration (Taylor et al. 2010, personal communication). Invitations were sent out to 507 users registered in ten of the 52 kidney units across England. This would represent around three per cent of the total potential study population. A local staff (evaluation collaborator) in each of the selected units helped to identify and invite patients registered on RPV in their unit to participate in the surveys. The survey was hosted online in Survey Monkey. Email invitations were sent to potential participants with embedded link to the survey URL.

2.1.2 Analysis Methods

Survey data were extracted from Survey Monkey into an Excel spreadsheet. Data on value of RPV, pattern of use, perceived benefits, and demographic characteristics of respondents were collected and analyzed using descriptive frequency tables and charts. Duplicate and invalid responses were excluded from analysis following data clean up.

2.1.3 Governance

The NHS Research Ethics Committee reviewed the evaluation proposal and advised that no formal ethical approval was required as the proposed work is classified as a service evaluation. However, local governance arrangements and consent was sought and gained from all ten participating kidney units prior to participating in the evaluation.

2.2 Results

A total of 257 (50%) validated responses were received from the 507 users who were e-mailed an invitation to participate in the survey at nine kidney units across England. One kidney unit declined from participating in the survey. 28 responses had to be excluded from analysis because the participants accessed the survey but failed to answer any further questions. It was unclear how many of the 507 invitations were not delivered because e-mail addresses had changed, were cancelled, or were incorrect from the outset.

Table 1. Demographic and health characteristics of respondents

Characteristic	*n* (%)
Age (yr) ***(n = 235)***	
25 or under	11*(5)*
26-50	81*(34)*
51-65	92*(39)*
66 or over	51*(32)*
Gender ***(n = 234)***	
Female	93*(40)*
Male	141*(60)*
Ethnicity ***(n = 235)***	
White British	204*(87)*
Other	31*(13)*
Duration of access to RPV ***(n = 257)***	
Less than 1 month	16*(6)*
1-6 months	25*(10)*
7-12 months	33*(13)*
>1 yr	183*(71)*
Treatment modality ***(n = 236)***	
Haemodialysis	30*(13)*
Peritoneal dialysis	20*(8)*
Kidney Transplant	106*(45)*
Conservative care	6*(3)*
I have kidney disease but my own kidneys are functioning	74*(31)*
I am a ***(n = 257)***	
Patient	228*(89*)
Partner of a patient	11*(4)*
Parent/guardian of a patient	7*(3)*
Carer of a patient	11*(4)*

Respondents' demographic characteristics are displayed in Table 1. More than 70 per cent of the respondents were 26 to 65 years of age, with the majority (39%) in the 51 to 65 year age group. The smallest percentage of respondents came from the 25 years and under age group. Respondents were mostly male (60%) and British whites (87%). Length of access to RPV ranged from less than a month to over one year with the majority (71%) reporting using the system for over one year.

The majority of respondents were patients (89%). Among the 11 per cent who responded to the survey on behalf of a patient, 4 per cent were partners of a patient, 4 per cent were carers of a patient, while 3 per cent were parents of a patient. Two-thirds of respondents have had a form of renal replacement therapy (RRT), including kidney transplantation (45%), haemodialysis (13%) and peritoneal dialysis (8%). Nearly all of the respondents who were not RRT patients reported having functioning kidneys, although 3 per cent were in conservative care pathway.

2.2.1 Access and Usability

Patients were asked how they rated the RPV login procedure and the ability to move around information on RPV. Table 2 shows the distribution of responses. 81 per cent of respondents found the login procedure easy or very easy while only 4 per cent rated it as hard or very hard. Likewise, the ability to move around the information on RPV was rated as easy or very easy by 85 per cent of respondents while 2 per cent rated it as hard or very hard. Nearly all respondents found the display of information on RPV very clear or quite clear (Table 3). More than half (55%) had never experienced difficulties with accessing the system (Table 4).

Table 2. Patients' rating of RPV access and navigation

	Very easy	Easy	OK	Hard	Very hard
How would you rate RPV's login procedure?	126 (53)	67 (28)	38 (16)	5 (2)	4 (2)
How would you rate ability to move around information on RPV?	110 (46)	93 (39)	33 (14)	2 (1)	2 (1)

Data are expressed as *n* (%)

Table 3. How would you rate the display of information on RPV?

	n	*%*
Very clear	126	52.5%
Quite clear	107	44.6%
Quite unclear	6	2.5%
Very unclear	1	0.4%

Table 4. Have you experienced any difficulties accessing RPV?

	n	*%*
Never	133	55%
On one occasion	66	28%
On more than one occasion	41	17%

2.2.2 Content of RPV

Nearly all the patients found it valuable to have access to information from their own health records available over the internet (Fig 1). With regard to the specific sections of RPV, most respondents felt the Results section was very valuable (94%); this is followed by Medicines (47%), Letters (43%) and 'Enter My' (38%). A greater percentage of respondents reported the Forum section of little or no value (51%) compared to the percentage that found it at least quite valuable (49%).

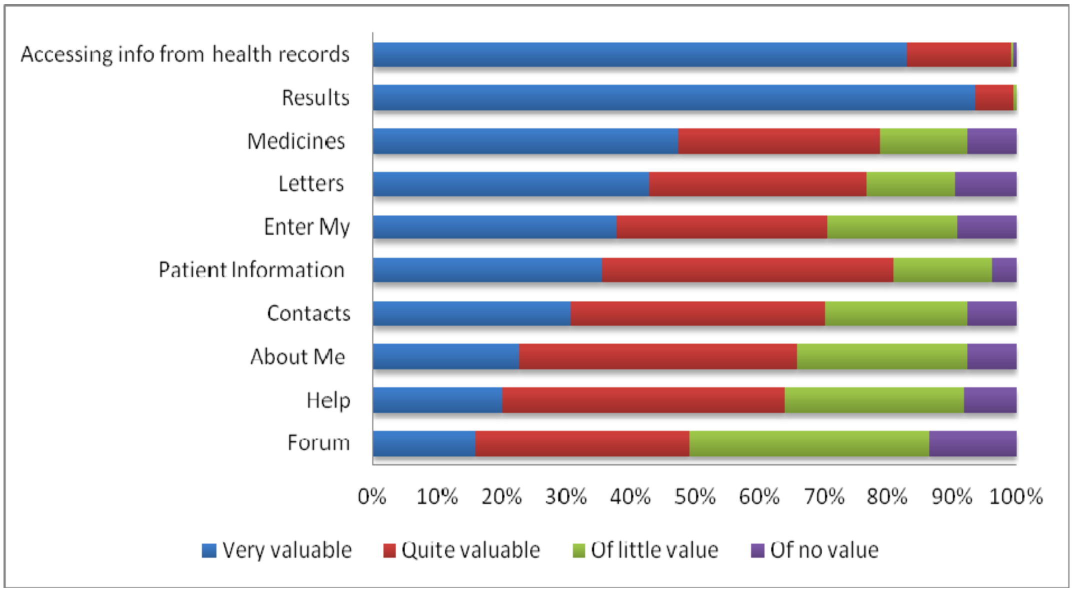

Figure1. Value of RPV to users

2.2.3 Pattern of Use

Respondents were asked to indicate the extent to which they agree to statements about when they are most likely to use RPV (Fig 2). A high proportion of respondents strongly agreed with the statements that they are most likely to use RPV when expecting the results of a recent test (88%), or when they received a result that made them worried (62%). Also, 56 per cent strongly agreed that they are most likely to use RPV after a visit to their hospital or General Practice (GP). More respondents strongly agreed or agreed that they will use RPV when their blood pressure reading is abnormal (45%) than when their blood pressure is normal (20%). Nearly half (49%) of the respondents disagreed or strongly disagreed that they will most likely use RPV when reminded.

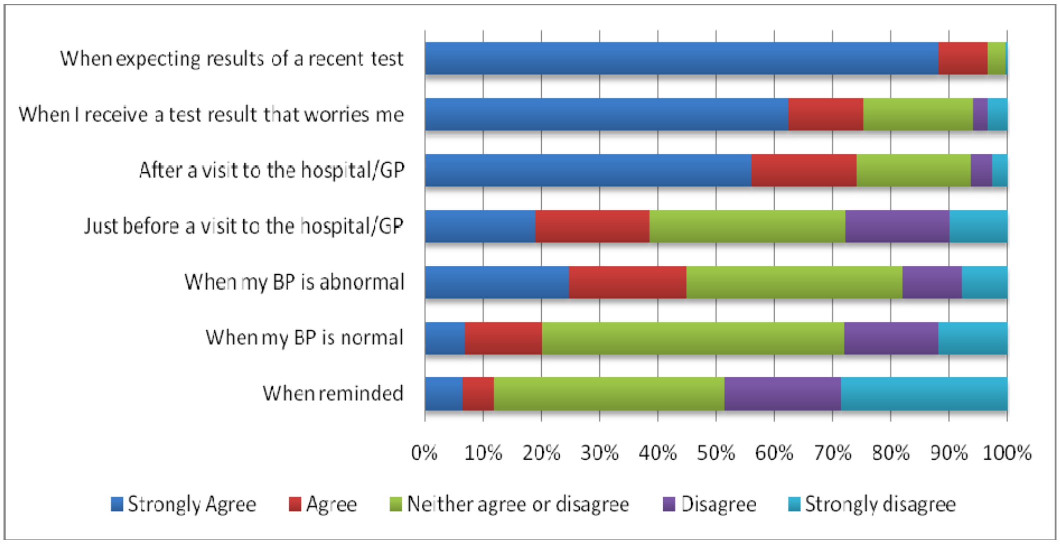

Figure 2. Pattern of use

2.2.4 Empowering Effects of using RPV

Table 5 presents the extent to which patients agreed or disagreed with statements relating to the impact of RPV on their understanding of their condition and level of engagement in their own care. Respondents were overwhelmingly positive in their opinion about the empowering outcomes that has followed from their use of RPV. 88 per cent of patients strongly agreed or agreed with the statement that using RPV makes them feel more in control of their medical care. Also, 86 per cent of the patients agreed or strongly agreed that using RPV gives them a better understanding of their kidney disease. Similarly, more than 70 per cent of patients agreed or strongly agreed that using RPV helps them to communicate better with their doctor (79%), helps them to be more involved in decisions about their care (75%), and reassures them about their treatment (77%).

Table 5. Level of patients' agreement with statements about the empowering effect of using RPV

	Strongly Agree	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly disagree**
Statements	***n (%)***	***n (%)***	***n (%)***	***n (%)***	***n (%)***
Using Renal Patient View ...					
Makes me feel more in control of my medical care	139 (60)	65 (28)	25 (11)	0 (0)	2 (1)
Gives me a better understanding of my renal disease	137 (59)	62 (27)	26 (11)	1 (0)	5 (2)

Helps me to communicate better with my doctor	106 (46)	76 (33)	40 (17)	6 (3)	3 (1)
Helps me to be more involved in decisions about my care	104 (45)	69 (30)	48 (21)	7 (3)	3 (1)
Reassures me about my treatment	102 (44)	77 (33)	47 (20)	3 (1)	2 (1)
Makes me more prepared for hospital visits	91 (39)	70 (30)	56 (24)	10 (4)	4 (2)
Helps me to follow my doctor's recommendations better	78 (34)	73 (32)	65 (28)	11 (5)	5 (2)
Raises questions about my treatment between visits	53 (23)	77 (33)	84 (84)	11 (5)	6 (3)
Helps me to find errors in my record that can be corrected	52 (23)	54 (23)	103 (45)	14 (6)	8 (4)
Makes me worry about the things I read	15 (7)	17 (17)	75 (33)	68 (2)	56 (24)
Makes me confused about my lab results	7 (3)	5 (2)	45 (20)	89 (3)	85 (37)

Data are expressed as *n* (%)

A high proportion of patients were also in agreement that using RPV makes them more prepared for hospital visits (69% agreed or strongly agreed), helps them to follow their doctor's recommendation better (66% agreed or strongly agreed), and raises questions about their treatments between visits (56% agreed or strongly agreed). While more respondents agreed than disagreed to the statement that using RPV helps them find errors in their records that can be corrected (46% versus 10%), almost the same proportion could not agree or disagree with this statement (45%).

Seventy-six per cent of patients disagree or strongly disagree that their usage of RPV makes them confused about their lab results. More than half (53%) of patients disagree or strongly disagree to the statement that using RPV makes them worry about things they read (compared to 14% who agreed or strongly agreed).

2.2.5 Security and Confidentiality

Twenty-eight per cent of patients indicated that they were concerned about the security of their health records when they first heard about RPV, with only 15 per cent being concerned since using the system (Fig 3). Also, the proportion of patients who were not concerned about the security of their health records increased from 69 per cent when they first heard about RPV to 84 per cent since they started using the system.

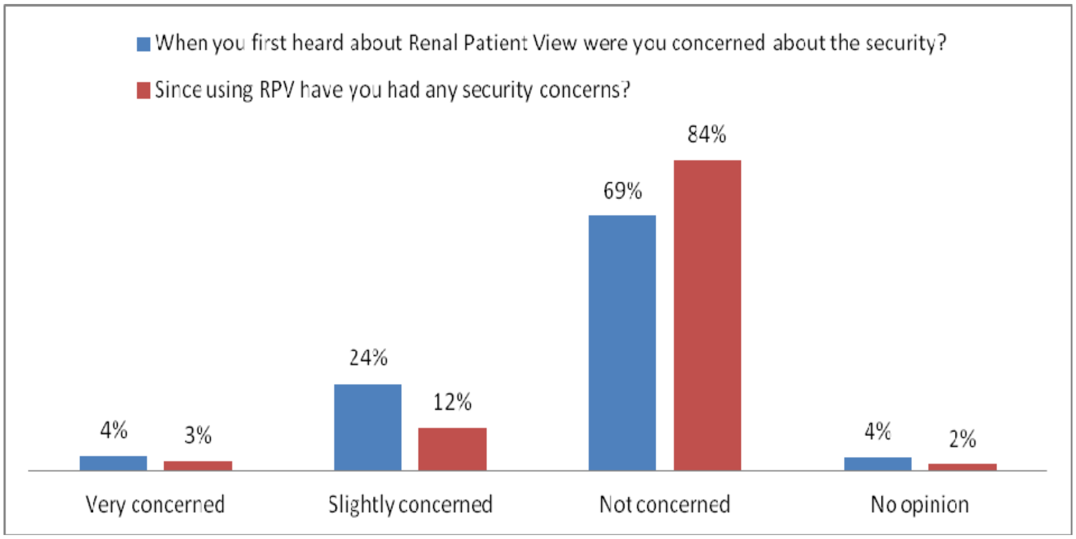

Figure 3. Security concerns

Patients are able to give consent for others to access their records on RPV by sharing their password and log in details. Respondents were asked if they had shared their password with others and also, if those they have shared their password with use their log in details to access their records (Fig 4). Of those who acknowledged sharing their password with others, the highest proportion had shared their password with a member of their family (31%). More patients had shared their password with their GP (9%) than with other healthcare staff (7%). Only three per cent of patients had shared their password with a friend.

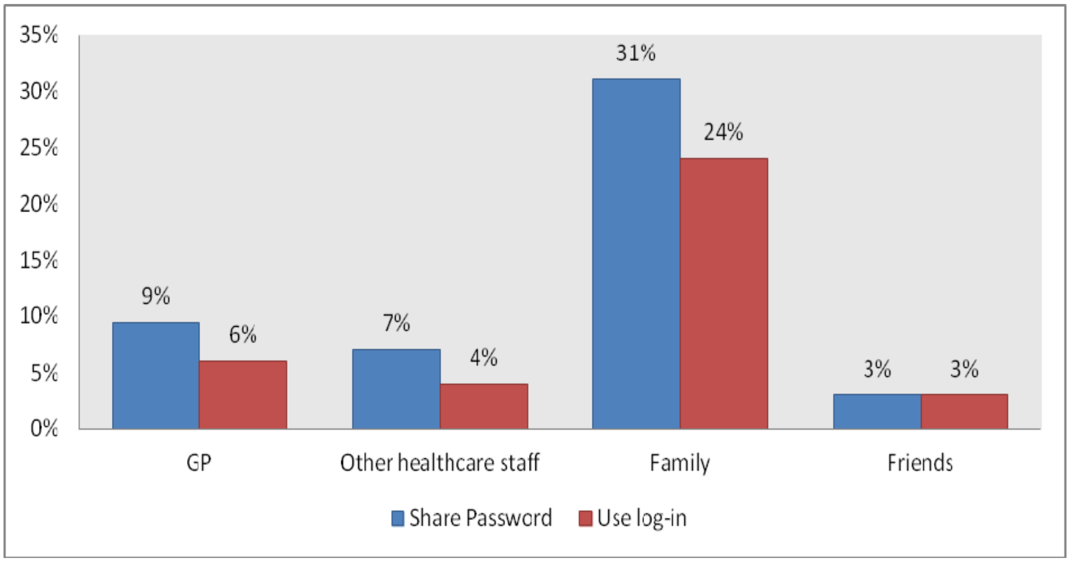

Figure 4. Share password

Regarding the issue of who had used their login (Fig 4), again the highest proportion of respondents who acknowledged that their password had been used by someone else indicated that their family members had used their password (24%). Those who’s GPs or other healthcare staff have used their login made up six per cent and four per cent respectively. Three per cent acknowledged that their friends had used their login.

3. CONCLUSION

RPV is a novel system allowing kidney patients to access their live test results online and share with whoever they choose. This evaluation has demonstrated the efficacy of this system for improving the users' understanding of their kidney health and increasing their sense of control over their care. The results reported here suggest that having access to their results has enhanced the users' ability to self-care, enabling them to feel more involved in decisions about their care, as well as leading to improved patient-professional communication. These findings are in line with findings from previous studies that showed providing patients access to their records lead to greater patient empowerment, better self management, and improved health (Pagliari *et al*, 2007; Mandl *et al*, 2007; Detmer *et al*, 2008). The cumulative effect of such provision could impact on patient outcomes including improved patient satisfaction, better patient experience, and potentially, improved patient safety.

This evaluation contributes further to the understanding of how this model of data access impacts patient participation in decisions about their own health and their capacity to self-care. Similar systems could be particularly valuable to other patients with long term conditions such as diabetes, where better self management and improved patient experience is highly desirable.

3.1 Limitations of Evaluation

There are a number of limitations inherent in the evaluation design that should be noted. First, the cross sectional design of the survey does not allow comparison of perceptions or changes in outcomes with any other population or measure change as it occurred over time. For example, a control study comparing users with non users may offer more insight and evidence of the effects of using RPV. Second, the size, spread and characteristics of the survey sample may mean that the results may not generalise to a broader population. For instance, it is possible that the sample is biased in favour of those who were already enthusiastic about RPV and might therefore be more confident and willing to complete the surveys, which may therefore inflate the findings reported here. Third, association or causality cannot be assumed meaning RPV usage could be the result of patients being empowered rather than a contributing factor. As RPV is just one of the many tools patients could use to improve empowerment, it is difficult to ascertain the unique influence of RPV usage.

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DEVELOPMENT APPLICATION FOR ENVIRONMENTAL T-HEALTH DIGITAL TV

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ABSTRACT

Present in more than 90% of Brazilian homes, television is one of the most important information source, culture and entertainment of the Brazilian population. In this scenario, the Digital TV (DTV) emerge as an important tool to combat social/digital exclusion, differentiating from other technologies because have ability to reach places of difficult access, due its capillarity, for these reasons, explore the DTV with purpose of inclusion is a strong tendency. This paper presents an application for digital TV environment, following to concept of *t-health*, at which refers to any service in health area provided by interactivity of DTV. The main objective is show a platform where the televiewer can have access to contents that seek at awareness, health, welfare and development of digital applications and services in order to facilitate the digital inclusion for the underprivileged population, showing features of the development and the results obtained.

KEYWORDS

Interactivity, Digital TV, *t-health*, Digital inclusion.

1. INTRODUCTION

The rapid dissemination of information brings new features on the world stage, making access to technological resources a need arises mainly in places where social inequalities are growing increasingly latent. In Brazil, social inequality is still a burden considering the digital/social inclusion. In the process evolution, two aspects are directly related: exclusion technology and digital inclusion. A promising alternative when talking about digital inclusion, because, beyond television is present in more than 90% of Brazilian homes (IBGE 2007), also is accessible to practically all social classes, in all regions of Brazil, what does not happen with the computer.

The Digital TV has considered an environment conducive to offer various kinds of services, leading to digital interactivity to the user making them the main character, no more seeking a one-way communication and massified. This way, the main current goal is to enable population mainly located in poor areas and of difficult access, the possibility of enjoyment of technologies that have high capillarity and easy access, in order to include digitally the majority of the population.

According to (Parker 1999), DTV is more than just cleaner images and better sound quality; is a eventual convergence of television, telephony, Internet and personal computer in a simple box, with the promise of extraordinary access to all kinds of information and interactive communication unimaginable. More than this, the deployment process BSDTV was concerned with the end-user interactivity, main differentiation factor between these systems of others found. The decree number 5.820, of June 29, 2006 (SBTVD 2010), which provides for the Brazilian System of Digital Terrestrial Television (BSDT-T), evidencing that this technological advancement not restricted to a simple change of equipment to attend market interests or economic.

The decree cited shows interest in the development of national industry and digital inclusion (and social) by means of the TV, which tends to become a tool with social purposes, with the creation of channels for the executive power, citizenship, education and culture.

The perspective that the new information technologies directly affect to all areas of the humanities, and sharing of information has been acting increasingly rapid and in greater quantity through innovation in the means of communication, as the Internet and digital TV. With the area of health would not be different, because the accessibility and dissemination of information enable a direct impact on the welfare and health of patient. Against this backdrop comes a new concept known as t-health, that according (Abajo et. al 2011), refers to all health services offered by Digital TV interactive.

The main objective of this paper is to present an application to DTV based on the concept of t-health. The application called ZéGotinhaTV has main objective is to inform, teach and population awareness about epidemiological disease, and how to prevent them, principally through vaccination. As has been designed for use with BSDTV, achieves locations difficult to access, using the capillary action of the television.

It is intended to show concepts aimed at encouraging the development of applications and services to facilitate the digital inclusion for the less favored population, that have lower cognitive ability of new technology and educational perspectives, establishing the importance of interactivity is directly related to the applications that will be developed.

In the next chapter will show the theoretical foundations and related work. Therefore the method used to development the work, followed by the chapter of results. Finally, the final considerations about the work, future work and references used to prepare the text.

2. THEORETICAL FOUNDATIONS AND RELATED WORK

The daily life of individuals, regardless of their social class, suffers the influence of technological developments. The difficult access to new technologies is only one example of such evolution may not be beneficial to all, because many industrial products eventually become inaccessible for much of the population.

The importance of television in society can be found, for example, through the Ministry of Communications in a letter of intent addressed to the Presidency of the Republic says (MC 2003): About 90% of Brazilian households have television receivers. However, more than 81% receive only television open signals. The programming transmitted to viewers is one of the most important sources of information and entertainment of the Brazilian population, corresponding to an undeniable responsibility with regard to national culture and citizenship.

To (Wierner 1970), “information is the term used for content what we exchanged exchange com o outside world to adjust ourselves to it, which makes our adjustment it is perceived”. Knowing that this definition not summarize all the senses the substantive information, just taking it as a base and considering there are more than 65 million television receivers in the country, equivalent to almost one TV for every three inhabitants, e that disadvantaged social classes, have on TV the main source of contact with the world, Brazilian society is informed considerably through TV.

It can be stated that the technology deprivation generates a vicious circle in which the difficulty of mastering the resources of modern technology generates a poorer quality of life. This, in turn, decreases the job opportunities, devaluing the hand labor and reducing the gains. In this way, deprivation to the technology generates a poorer quality of life, consequently increasing social/digital exclusion.

The relationship between this discussion and television is in transition to the digital model, the government wager in that new market to reverse the process of digital exclusion of Brazilian society. According data to Anatel (Brazilian agency of telecommunication), only 7.5% of the population have internet access, and only 10% have computer at home (Becker 2008). In a first moment is technologically impracticable, due to the absence an interactive channel universal, provide Internet access through television. But services such as e-government, health, education, between other, can be offered of additional form of the simple way of transmission unidirectional of video. This initiative can now take some citizenship and improve the lives of millions of people, hitherto unassisted by the government.

Interactivity on TV is the possibility of the televiewer work closely with television program watched, sending requests for additional information to the TV station via the TV remote control or keyboard (since many receptors have USB ports). Then the transmitter is capable of receiving the information requested, or is, interactive digital television proved several facilities to televiewers, among them, chat, interactive games, make purchases, recording a television program, access channel programming and multiprogramming.

As the deployment of BSDTV is a very recent, still many other possibilities may arise, opening a wide range of possibilities for interactivity, therefore, any class of application that aims to reach the success level of interaction with user can not neglect the stage of the relationship between man-machine. Second (Becker 2008), as well as the Internet, interactive digital TV represents the possibility of access to a virtual world of information and services.

According (Costa 2001), even with the history of delay in the use of new technologies, the health area is increasingly adhering the internet and doing use of this under different aspects, from processes administrative to patient care, such case as telemedicine. Through this context, arose the concept of e-health, which covers all applications related to health on the Internet, featuring among several benefits, content as the main artifice exploited.

On the other hand, Digital TV interactive has a great advantage, which is not a requirement for computer and easy accessibility. As a result of, a new term was born named t-health, of according to (Abajo et. al 2011), through the interactive any ordinary citizen with the tools necessary, could make an appointment with your GP with the same equipment in which he sees his program favorite. Furthermore, viewers would have access via a TV channel to any type of medical information such as, information about diseases, nutrition and so on.

Despite this, Digital TV interactive "hide" a computerized system which is operated as a TV, by a remote control and according (Souza et. al 2008), usability becomes a critical factor for programs and applications Digital TV interactive, such need shows still greater, because digital converter may be used by millions with variable profiles, with habits and expectations crystallized on what is “watching television”.

After thorough review of the bibliographic, found several articles pointing to digital TV as an effective tool in the process of information dissemination. However, few articles have functional applications designed for environments already marketed in the market for the concept of t-health. Thus, the proposed article aims to innovate, presents an approach where the viewer watches a program for TVD and by interactivity provided by the same, can view information and warnings relating to health as vaccination campaigns, and ways of preventing diseases, among other options. Furthermore, it may be identified in the system and view information regarding your vaccination card and their dependents, as registration data and vaccines already taken.

3. METHODOLOGY

The application’s development for Digital TV requires differentiated behavior from the traditional, because it has its own characteristics. Among the main application’s features for digital TV distribution are the format of distribution and the used technologies According (Soares & Barbosa 2009), the digital TV applications can be divided in two groups: Declarative applications and imperative applications.

The main component responsible for the execution of digital TV applications is the middleware Ginga, the different manufacturers can implement the middleware Ginga and then, any Ginga interactive application can be executed.

The distribution format is also differentiated, because it can be accomplished through data carousel, which sends the application asynchronously, from the broadcaster to the viewer (Soares & Barbosa 2009). Therefore, all applications that intend to make accessible to the viewer should be hosted at the station. The utilized resources have computational power much lower than computers, called set-top boxes. Every handling of these devices and resources is different from that used in the development of applications for computers.

The main focus of several studies have been the user needs, aiming interactivity improve and usability of applications. Due to these factors, the complexity of development of interactive applications for Digital TV goes beyond technical issues. In The following topics will be shown the development applications steps.

3.1 Architecture

For the development of ZeGotinhaTV application, was created a three logical layer execution system which are: presentation, control and persistence. Each layer has different responsibilities in the system. This architecture also allows split the functions between the set-top box user and the server that will host the application, with the greatest burden on the server, leaving the client application with the minimal possible burden.

In a top-down approach, we can indicate the first layer as the presentation. It talks about the visual presentation of the system data where the user has direct contact with interactions such as data entry in forms and the rescue of them. Between the edge's layers is located the control layer that works providing access between interface and the data, reviewing the data collected in the upper layer and manipulating them in a storage unit. At the lowest level is the data layer, which takes care of persistence, integrity and management of all the data handled in the application.

The system is also divided into three subsystems. The first subsystem is the ZéGotinhaTVClient, which consists in an interactive application Ginga, responsible for performing queries to ZéGotinhaServer, through web services, and display results to users. Correspond to the application for the television environment to common users. This module operates mainly in the presentation layer and has communication with the control layer via the return channel of digital TV and the module ZéGotinhaTVWebService.

The second and most important subsystem is the ZéGotinhaServer, responsible for all the persistence of data, business rules and request services. It is formed by the union of components, ZéGotinhaTVWebService, ZéGotinhaTVWeb and persistence, which is being shown in a separate module for easy viewing with the component database. The ZéGotinhaTVWebService performs the intermediate between the ZéGotinhaTVClient subsystem and the database, integrating the persistence layers and control of the application, through the module's interface of Digital TV.

For administrative users there is the subsystem ZéGotinhaTVWeb which is an interface that works in a web environment. Through this, all data management operations are handled in the system, such as insertion and deletion of records.

3.2 Technologies

In developing the ZeGotinhaTV, we tried to use technologies that could be executed by most devices available on the market. To meet this objective were used several technologies. In the development of the subsystem ZeGotinhaTVClient was used the NCL / LUA language and in the others, the Java language.

As the NCL / LUA environment is obligatory in the specification of BSDTV, any equipment prepared for the DTV will be able to use the system.

3.3 Scenario Test

To study the behavior of the proposed application was created in LPRAD (Planning Laboratory for High Performance Network) a scenario that contains complete infrastructure, needed to provide full interactivity for the Digital TV users. This infrastructure can be divided into 4 parts: Transmission Infrastructure, Reception Infrastructure, Return Channel Infrastructure, and Service Infrastructure. That scenario can be view on Figure 1.

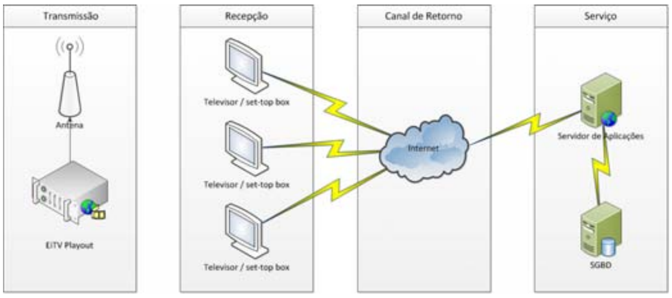

Figure 1. Infrastructure tests.

Initially the transmission infrastructure has as main objective to provide an environment for transmission of TV signal similar to that found in a broadcast of BSDTV, making the spread of television content and of interactive applications, including the ZeGotinhaTV. This infrastructure includes an equipment EiTV Playout (EITV 2010), which does the encoding and transmission of the TV signal. The Playout is connected to a signal amplifier antenna, and this has low amplification power to do not cause interference to local stations.

Initially the transmission infrastructure has as main objective to provide an environment for transmission of TV signal similar to that found in a broadcast of BSDTV, making the spread of television content and of

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The reception infrastructure is composed by a TV with digital reception and interactivity, 3 set-top boxes connected to analog TV, a computer running OpenGinga and another computer running the Virtual set-top box available by PUC-Rio. These devices are responsible for representing the environment of the user's home, which contains basically the equipment listed here.

To provide an environment that receives the data sent by users, a service infrastructure was created. This infrastructure is the point where the data of interactivity with the user are received. Usually this infrastructure is provided by a hosting service, but can also be located in a company that does not have the location's server as a business focus.

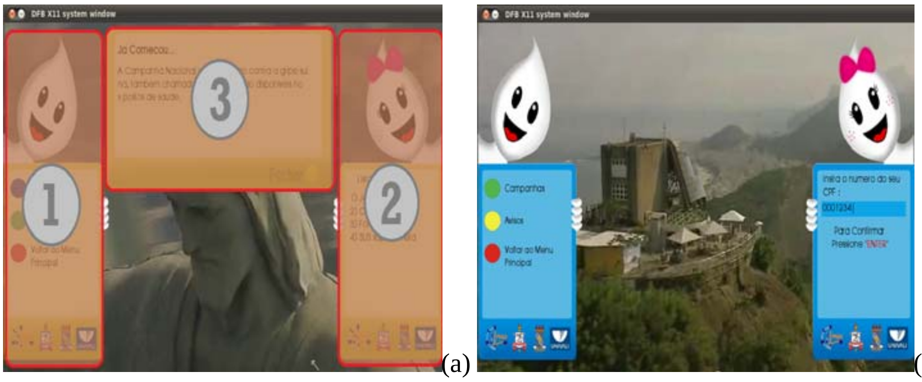
Although the two infrastructure services servers may be on the same machine, we chose to separate them to keep the division of responsibilities. This division of responsibilities allows the refined monitoring of infrastructure and better identification of points of slowness (Haines 2006), as the number of hits can be quite significant.

4. RESULTS

This article presents as result the ZéGotinhaTV application in its three modules: ZéGotinhaTVClient, ZéGotinhaTVWeb and ZéGotinhaTVWebService. The system was implemented in a production environment, tested on the platform Open Ginga (platform that enables running Ginga applications on a computer) and the validation on through tests made with students in computer engineering from UFPA, just by the observation method.

4.1 ZeGotinhaTVClient

This module contains three panels organized as shown in part A of figure 2. The panel displays options for a task with their respective keys to drive. The second panel validates the user and displays the lists of individuals, campaigns and warnings. The navigation through lists is performed by the number keys of the TV remote control. The third panel displays information corresponding to the selected option on the second panel, beyond show options like, close the third panel and view vaccines taken by the patient. The remaining area is called the video area.



(a) (b)

Figure 2. Layout and application screens.

The ZéGotinhaTVClient has four options related tasks of the four colors of presents in the remote control keys, which are blue ("Carteira de Vacinação" - Card of Vaccination), green ("Campanhas" - Campaigns), yellow ("Avisos" - Warnings) and red("Créditos" - Credits). Each task has its own menu. With the purpose to make the navigation between menus simplest and perceptible, each task has its own menu with the color for the button to operate it.

As shown in Part B of Figure 2, by pressing the blue key, the user will be redirected to the task menu "vaccination card", where it will need to enter their CPF number to have access to information about themselves and their dependents about vaccines taken and registration data. After the validation of identification, the user will see a numbered list with the proprietor and their dependents. Pressing the number corresponding to the desired person, registration information will be provided. Note on this screen that is available the option to preview a list of vaccines already taken by the patient selected, by pressing the right arrow control. You can also return the registration information again by pressing the number corresponding to the option or close the third panel pressing the color of their selected task, valuable resource for all menus.

By pressing the green button will be displayed vaccination campaigns that occurred on the numbered list format, when a user selects different campaigns in the list, the information will be displayed on the third panel screen. By pressing Yellow key on the remote control, the second panel displays a list of notices and news about issues relating to health, like for example, date of vaccinations and information about diseases and preventions.

4.2 ZeGotinhaTVWeb

This module has a main screen and control screens. All screens have a bar at the top option to access the homepage, control screens and management options. The general options are actions of insertion, editing, deleting, and viewing detailed tables, beyond the upgrade option and export data in spreadsheet format to open in other software.

A pesquisa retornou 4 registros | Imprimir

Id	Descrição	Restrição	AÇÕES
1	Gripe	acima de 60 anos	
2	Tetano	criancas ate 5 anos	
3	hepatite B	todos	
4	Rubéola	mulheres	

Figure 3. Screens Control and Registers of Vaccines.

The control screens available with their respective functions are:

- Control Notices: Has a list of alerts registered.
- Control Agents: Has a list of registered agents. A post and a user should be selected among those available in the database.
- Control of history: Has a list of people who visited the post and which participated in the campaign. The table displays the person's name, the city where the post is located, and date of visit. A person and a campaign should be chosen among those available in the database, the date of the visit must also be completed.
- Control Campaigns: Has a list of registered campaigns and displays its type, description, start date and end date.
- Control of Vaccines: Has a list of vaccines and displays its description and restriction.
- Control Points: Has a list of registered stations and displays the city name and address.
- Control of users: Has a list of registered users and displays their CPF, name and profile.
- Control relationship: Has a list of people registered who have dependents. The table displays the type of family relationship (spouse, married. Father, mother), and a list shows the available options for the type of family relationship, as well as a list of persons is charged for the selection of the person and dependent.

- Control of People: Has a list of people registered and displays your CPF, name, phone number, address and city.
- Control Types of Campaigns: Has a list of registered types of campaigns and displays the description of the type.

4.3 ZeGotinhaTVWebServer

The communication interface ZeGotinhaTVWebServer module is done through URLs established to rescue resources, which are returned in JSON format. The following entities may be redeemed of the service, all correspondence with the database, it is assumed that the URLs listed below are preceded by HOST/ZeGotinhaWebService, where HOST is the IP address of the server:

- /api/pessoas/: containing a complete list of all persons registered in the database. Should be used together with a parameter, which can be the 'Id', 'RG' or 'CPF'. For the first option, simply add the number after the slash the desired Id, like on: “/api/pessoas/1”. This example would rescue the first element of the database (Id indicated by '1 '). To redeem the RG or CPF is required after using the bar, for indication that which the document is being requested: “/api/pessoas/rg/1111111” and “/api/pessoas/cpf/11111111111”. These addresses would recover the possession of the documents numbering 1111111 and 11111111111 respectively.
- /api/ avisos/: Contains a list of active warnings, can recover only one, passing the Id which you wish to have highlighted the way: “/api/avisos/1”.
- /api/dependentes/: This URL is dependent on the particular user account. To find its entirety, you must access theURL format “api/dependentes/1”.
- /api/campanhas/: Where are the campaigns listed in force, a vector being returned.
- /api/historicos/: The history of vaccine for a particular user is returned via this address, followed by the Id of the individual, according to the example: "/ api/historicos/1." This example would recover a list of vaccinations already consumed.

5. CONCLUSION

The new forms of interaction with the television production and will enable access to content more interesting and creative, expanding the potential users, including content aimed at awareness, health and welfare of the viewer.

By providing these contents by an issuer, the users possess an experience that combines comfort, practicality and learning, allowing a logical construct, cognitive and non-linear will accord the interests of the televiewer.

However, between these features, interactivity appears to be most relevant in creating new paradigms for the use of television. Because it tends to enhance this dialogue process television, transforming the mass transfer in a unidirectional and bidirectional communication based on individual preferences and personalization of programming.

Before the deployment of services and applications BSDTV in the model, it is necessary to analyze various factors such as the technological resources available to more and more in this tool can help combat the digital exclusion. For future work we intend to integrate the system *t-health*, a term little known by the community health and education, with new devices to interact with the TV, such as mobile phones and tablets.

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A COMPARATIVE ANALYSIS FOR CREATING TEST-DATA IN E-HEALTH INTEGRATED INFORMATION SYSTEMS

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ABSTRACT

Testing of database-intensive e-health applications has unique challenges that stem from hidden dependencies, subtle differences in data semantics, target schemes, and implicit business rules. These challenges become even more difficult when the application involves integrated databases or confidential data. Proper test-data that can simulate real-world data problems are critical to achieving reasonable quality benchmarks for functional, input-validation, load, performance, and stress testing. In general, techniques for creating test-data can be classified in two board areas; test-data generation and test-data extraction that differ significantly in their basic approach, runtime performance, and the types of data they create. This paper describes a theoretical study that establishes guidelines for software tester in making informed choices about various test-data creation techniques. We start with a more detailed categorization of different kinds of test-data creation techniques. We also illustrate the use of these techniques in existing test-data creation tools and discuss their usefulness in the context of an integrated database system with confidential data. Next, we present a method for comparing the relative strength and weakness of the different test-data creation techniques. Finally, we present the result of a comparison based on this method and analyze those result. At the highest level of analysis, we found that test-data extraction can produce more realistic test-data, whereas, test-data generators can be more efficient. However, we present a number of more specific conclusions that will help testers make appropriate choices.

KEYWORDS

Testing e-Health Systems, Test-data Extraction and Generation, A Comparison study for test-beds, Federated Databases

1. INTRODUCTION

Getting the right dataset for testing standalone e-health applications is hard enough, but doing so for integrated applications using heterogeneous databases is even harder. The prime motivation in writing this comparison study is to provide a comparison framework that helps testers in identifying the test-data requirements for the system and then assists them in selecting an appropriate test-data creation approach. The right selection of a test-data creation technique can deliver rich, appropriate, and domain-specific test-data that can significantly simplify and improve the overall testing process. A well-established testing process thus ultimately reduces testing time through availability of large test-beds in development environment. It also improves the quality of testing by providing quality test-data. These two critical testing parameters (i.e., time and quality) thus become the contributing factors in cutting overall development and maintenance costs.

This paper presents an innovative comparison scheme for analyzing the two fundamental test-data creation approaches, namely test-data generation (*TDG*) and test-data extraction (*TDE*), which are commonly used in the testing of data-intensive health systems. Section 2 provides some additional background information about these approaches, and section 3 describes the comparison scheme in more detail. Section 4 includes the results of theoretical comparison of *TDG* and *TDE* using this scheme. This comparison not only serves as an example of how the scheme can be ably used, it also contains the author's conclusions about the relative strengths and weakness of both approaches.

2. TWO GENERAL APPROACHES OF TEST-DATA CREATION

A review of related literature and existing off-the-shelf software for creating the test-data reveals a wide range of approaches that vary in scope, strategy, testing features, price, and platform. However, they all fit into one of two general categories based on whether they utilize existing real-data (*TDE*) or generate the data (*TDG*). The following sub-sections analyze and compare these techniques and their tools. In general, *TDG*s can quickly generate large datasets with limited capabilities to produce real-data characteristics such as personal identifying information [16, 15, 14]. On the other hand, *TDE*s have real-data characteristics but have issues regarding extraction time, are less resilient to data changes, and can compromise data privacy.

Test-Data Generation: Generation techniques create test-data by executing various construction methods within the constraint of target database scheme. The study explored various research-based generation theories and eight tools that support test-data generation. A survey of the literature uncovered six techniques that represent fundamentally different ways of generating test-data. Other techniques certainly exist, but they can be viewed as variations or compositions of these core ideas.

Among industry-supported data generation tools, we identified six common data generation methods. First method typically allows the tester to specify some simple range limits or length constraints using some random number generation. Six of the eight tools [2, 3, 4, 7, 6, 5, 9, 19] support random generation for numeric data. Next method discusses some random-string generation. It can create string data for names or address fields containing characters a-z or A-Z. Five tools [4, 6, 5, 9, 19] provide support for this method. Third is percentage-based generation method. It creates a percentage-based distribution of different data values for a field. Only three tools [2, 9, 19] support this type of random data generation. Another method talks about generation of data according to user-defined patterns or grammars. For example, let '9' represent a digit, 'A' represent a capital letter, and 'a' a lower-case letter. A tester could use the pattern '9999-AaA-99' to create 11-character strings consisting of 4 digits, dash, an upper-case letter, a lower case letter, another dash, and two more digits. Four of the eight tools [2, 7, 9, 19] support this technique. Fifth is about generating data from predefined domains or dictionaries. A tester could use this method to populate a first name field with values from pre-defined domain of common person names. Six tools [1, 3, 7, 6, 9, 19] support this method and provide rich libraries of pre-defined domains. Last method discusses generation records for tables that have a master-child dependency. For example, testers can use this technique to create data for an inventory system consisting of order records, which in turn contain line item records. Three tools [6, 9, 19] support this technique. Among the research approaches, [9, 11, 12, 13, 19, 20] are interesting test-data generation schemes, but their data-generation capabilities do not cover challenges of integrated systems.

For our comparison, we choose two prototypical tools that represent the full range of test-data generation techniques, which are documented in [10]. These two tools are *DBTestGen* [13] and *AGENDA* [19].

Test-Data Extraction: The second general approach creates test-data from real sources rather than through generation methods. One of the most common data extraction problems is type of data access, i.e., random access versus sequential access. Data in text files only allow sequential access; therefore, coordination between records to get a correlated data set is hard. Also, full structure of the text file is difficult to be captured in the file itself; thus, more external definition is needed. On the other hand, databases have support for random access, and by enforcing the intended structure, the actual dataset can easily be extracted and correlated. Another problem is multiple data structures. The extractor needs to have flexible data structures that can support different types of data sources, e.g., multiple text files or multiple tables in a database. By having support for multiple data structures, an extractor can retrieve consistent (internally complete) data slices by joining the data structures in appropriate ways. Last but not least, heterogeneity is one of the hardest challenges for extracting appropriate and synchronized datasets. While extracting similar data from multiple data sources, an extractor can come across different data integration problems, e.g., dealing with heterogeneity in the data sources, record matching and merging capabilities. These problems are considered among the hardest research problems in systems integration [21].

A review of nine tools that support test-data extraction (many of which also support test-data generation) uncovered five basic extraction methods. First is the extraction of data from data files in a variety of storage formats. Five tools [2, 3, 5, 10, 17] support it. Another method is the extraction of correlated test-data from multiple tables in a single database, preserving inter-record dependencies within tables and across tables. Five tools [2, 3, 8, 10, 17] support this method. The next method is the extraction of data from multiple uncorrelated databases, running on different platforms, but without any cross-correlation of data between the databases. Three tools [8, 10, 17] support it. A fourth method extracts data from multiple correlated databases. Testing an integrated system and its constituent components requires correlated slices of data that preserve inter-database relationships and hidden dependencies. For example, while testing a record matching component in a person-centric e-health application, it would be meaningless to extract one set of person records from one database and a non-overlapping set of records from another database. Such test-beds would not be able to verify the results of any actual data integration. Two tools [10, 17] support this method. The fifth is an extension of the fourth that works with confidential data to preserve privacy. For example, if person data is used outside a secure environment, it must not include any recognizable personal identifying information. This method manipulates the extracted data to de-identify sensitive personal information without compromising the real-data characteristics. Two tools [10, 17] support this method.

The above paragraphs discuss different data extraction techniques and related tools. For our experiments, we selected *iSTDE* [10] as a prototypical tool for comparison, because it supports all of the above data-extraction techniques. It can appropriately extract synchronized datasets from multiple data sources, can handle data transformation complexities from different types of database managers, and provides a good solution to deal with confidential data by applying data masking strategies.

3. COMPARISON METHOD

An exhaustive comparison of test-data creation tools or techniques using empirical methods would be impractical because the cost of acquiring a comprehensive set of tools and experimenting with them is prohibitive. Even if we could obtain a larger number of tools, there would be so many extraneous variables related to integrated environment that it would be difficult to formulate creditable conclusions from the experimental data. Therefore, our comparison method uses a theoretical approach which consists of the following five-step process:

1. Establish comparison criteria that focus on the inherent difference between *TDG* and *TDE*.
2. Select representative tools that support the common *TDG* and *TDE* techniques.
3. Set a test environment for exercising the same tools.
4. Formulate theoretical statements about *TDG* and *TDE* with respect to each of the criteria.
5. Draw conclusions.

The six areas of comparison form a framework for comparing the two test-data creation approaches in integrated systems for e-health. Section A compares inter-database dependencies. The target-scheme (Section B) is related to database objects that do not contain data. Comparisons on non-functional requirements (such as database access, usage and performance) is described in Section C, database refactoring related comparison is discussed in Section D. Testing techniques sensitivity is defined in Section E. Social and time factors effect on data requirements are discussed in Section F.

Selectin*g* an environment for comparing test-data creation techniques is in itself a significant challenge. At minimum, it must have the following characteristics: a) an integrated environment with at least two data source operated by independent agencies, b) each system manages a non-trivial set of confidential data, c) at least two different database managers, d) overlapping data across the data sources, e) each data source contains duplicate and bad data, and f) each data source contain data not found in any the other data sources.

Utah Department of Health’s Child Health Advance Record Management (CHARM) [10] is integrated public-health information system that possesses all the above challenging. As such, it is an excellent platform for trying out and comparing test-data creation techniques. To keep the study within reasonable limits, this study only considers five of CHARM’s data sources. These systems hold overlapping person demographics and public health data. Some of them have less-than-ideal legacy database schemes whose syntax and semantic have evolved over the years. All of them contain some amount of duplicate, incomplete, and bad data. Finally, they support varying degrees of access to their metadata. In particularly, at least one of the systems does not allow any direct access to its metadata.

4. COMPARISON RESULTS

Using the comparison method described in Section 3, the three representative tools, and the CHARM system, we evaluated the test-data creation approaches in five different areas. In our theoretical comparison, the test-data creation tools were used to prepare test-beds and then these test-beds were sampled and evaluated.

A. Comparisons in the Context of Federated Databases

This section compares test-data creation approaches against correlations among federated/integrated databases. (See Table 1 for a comparison summary). These days, organizations are stressing building applications on integrated databases (by creating mappings among different standalone databases). When we talk about data integration for different databases, we are in fact talking about resolving the issues related to matching, linking, merging, and resolution of records among these data sources.

The challenge for test bed creation is to provide a testing environment wherein developers can have opportunity to test their applications for the challenges mentioned above. These challenges can be met when we have synchronized datasets across data sources. In *TDG*, incorporating these characterizations into databases is very hard, especially when we already have bulk of characterizations related to standalone database testing. So far in our survey of research literature, we came across no data generation scheme that claims to generate the synchronized datasets for multiple databases.

However, *TDE*s have the flexibility to extract the synchronized datasets from federated databases. In the CHARM environment, *iSTDE* is able to extract the synchronized datasets among seven data sources. Additionally, datasets from these data sources are also automatically transformed to PostgreSQL database semantics so that integrated databases can be simulated in a local development environment.

Though *TDE* gives us a solution to create synchronized test-beds for integrated databases, we cannot ignore the time factor and complexity drawbacks. Adding a new data source to get a synchronized dataset requires adding a complexity factor for inter-database correlation, as well as another complexity factor for extracting data just related to its standalone extraction.

B. Comparisons Related to Target Schemes

This section provides a comparison of handling conversions related to different types of target schemes, such as database objects, data types, and database managers. Table 6 compares the two approaches.

Handling of Views. Database views do not contain the data and are snapshots of database tables. Normally, both *TDE* and *TDG* (that rely on metadata schemes) support automatic handling of views and are extracted, along with database tables in metadata generation process. However, in some situations, pointing views to tables is difficult, particularly when the actual table is not included in the test-bed generation scheme. Some *TDE*s, especially *iSTDE,* deal with it by implementing a view as a table. However, it is difficult for *TDG* to deal with this challenge, unless it defines generation rules for view source table.

Handling of Database Objects Other Than Tables and Views. Providing automatic syntactic-conversion support for handling database objects, such as procedures, functions, triggers and sequences, is hard for both *TDG*s and *TDE*s as these objects are usually dependent on the underlying semantics of their database managers. Thus, both *TDG*s and *TDE*s require manual support to define of procedural transformation.

Handling of Variations in Database Managers. In an integrated database environment, we can have data sources with a variety of database managers, i.e., Oracle, SQL Server, PostgreSQL etc. This variety may raise a certain degree of syntactic heterogeneity, such as differences in data types, internal data representations, and certain queries support. To simulate homogeneous integrated database environment on a local machine for testing purpose, overcoming syntactic heterogeneity is a challenge for both *TDG* and *TDE*.

In our literature survey, we came across hardly any techniques where *TDG*s can sufficiently overcome handling of various data types in database managers. However, in case of *TDE* [10], this data type conversion is partially solved by maintaining a repository of transformation rules.

C. Comparisons Related to Set-up, Use, and Performance

Non-functional based comparison of the two approaches is presented in this section (see Table 3).

Need for Access to Existing Databases. Normally *TDG*s are database dependent for generating metadata schema. Once they have schema, generation-based characterization rules would be enough to create test-bed. However, *TDE*s completely depend on database access for metadata and data generation. This heavy database-access requirement makes *TDE* susceptible to data interruptions due to network or database server problems, whereas *TDG*s are resilient to these errors and add lesser load on the database servers.

*Ease of Deployment. TDG*s are easier to deploy than *TDE*s. Once *TDG* is installed on developer’s machine, it is supposed to automatically create test-data and populate the test database. However, in *TDE*s, the task is not trivial, especially in a data-sensitive environment, where access of real-data to outside world is restricted. Additionally, developer needs to specify target and source database connection information, the volume of data to be extracted and other instructions related to data migration in unsecure environment.

Table 1. Comparisons in Context of Federated Databases.

Check List		Test Data Extractor	Test Data Generator
1	Support for inter-database dependency	• Support exists with compromised speed. • Promises correlated datasets across data sources.	• Hard to incorporate this characterization • Does not promise quality test-data.

Table 2. Comparisons Related to Target Schemes.

Check List		Test Data Extractor	Test Data Generator
1	Handling of views	• Automated support.	• Automated support but less efficient • Hard to generate the view when source table is not included in testing domain.
2	Handling of database objects other than tables and views	• Manual intervention is required.	• Manual intervention is required.
3	Variations in database managers	• Supports transformation rules repository.	• Insufficient support.

Table 3. Comparisons Related to Set-up, Use, and Performance.

Check List		Test Data Extractor	Test Data Generator
1	Need access to existing database	• Heavily database dependent.	• Slightly database dependent
2	Easy to deploy	• Easier to deploy.	• Have deployment issues
3	Meeting users' expectations for speed	• Meets user expectations within constraints.	• Does not meet user expectations
4	Defining data characterization	• Required.	• Not required

Table 4. Comparisons in Context of Database Refactoring.

Check List		Test Data Extractor	Test Data Generator
Refactoring of Database objects that contains data			
1	Addition, update or deletion • Key columns, Non-Key columns, Independent tables, Dependent tables	• Support without adding complexity, requires data re-extraction. • Overall less complex but an inefficient process.	• Support exists but needs to redefine scheme and regenerate data for all related tables. • Overall complex process but efficient.
2	Replacement [table-to-column vs. column- to-table, keys-replacement], split or merge operations on database objects	• Support without adding complexity, requires data re-extraction. Overall, less complex but an inefficient process.	• Support exists but needs to redefine scheme and regenerate data for all related tables. Overall complex process but efficient.
3	Migration and reordering	• Slow process, data re-extraction is required.	• Comparatively fast and easy process.
4	Renaming of database objects	• Slow process, data re-extraction is required.	• Comparatively fast and easy process.
Refactoring of Database objects that do not contain data			
1	Addition, update or deletion of triggers, constraints and indexes	• Automatic support but inefficient approach. • Needs data re-extraction.	• Efficient approach without the need of data regeneration. • Includes manageable complexity to incorporate these characteristics.

Table 5. Comparisons in Context of Testing Techniques.

Check List		Test Data Extractor	Test Data Generator
1	Unit testing versus regression testing	• Not very useful.	• Useful
2	Functional testing of standalone modules	• Sufficient support that promises quality data, but data extraction speed is inefficient.	• Insufficient support, not quality data either but generation speed is fast.
3	Integration testing	• Sufficient support that promises quality data, but data extraction speed is inefficient.	• Insufficient support, not quality data either but generation speed is fast.
4	Performance testing versus stress testing	• Least preferred.	• Preferable due to capability of quickly generating large amounts of data.
5	Data validation testing	• Preferred choice due to automatic support for rich data rules.	• Less preferred choice, involves a lot of complexity to inject data validation rules.

Table 6. Comparisons Related to Social and Time Factors.

Check List		Test Data Extractor	Test Data Generator
1	Semantics changes due to domain evolution	• Provides support without complexity, needs data regeneration. • Promises quality data. Speed is an issue.	• Insufficient support. Needs to redefine complex characterization rules. • Does not promise quality data.
2	Social factors that affect data	• Default support that promises quality data.	• Insufficient support.
3	Data generation dn't expose privacy	• Support exists but is less efficient.	• Efficient support.

Meeting Users' Expectations for Speed. The amount of time it takes to create the test-bed is another important factor in the choice of test-data creation approach. Normally, it can be assumed that *TDG* takes significantly lesser time to generate the test-data than *TDE*. However, a *TDG*'s speed is affected by the complexity of characterization rules. For example, a simple *TDG* can quickly generate a set of unique values than a *TDG* that is generating unique values using semantic-number generation and partitioned class-based generation scheme respectively. On the other hand, the extraction time of *TDE* is not dependent on characterization rules, but it is dependent on the volume of data, federated data sources, load on the data managers, query joins, and network speed. *iSTDE* takes almost two days to extract two-weeks dataset from seven data sources. However, this performance can be enhanced by concurrent extraction from multiple data sources and data loading strategies (i.e., post-enabling of data constraints with batch-loading strategies).

Defining Data Characterization. Almost every *TDG* that we evaluated, supported the characterization of field-level generation rules using data types, value templates, and/or constraints. *TDG*s would lose their efficiency if database scheme is very large or data-generation rules are very complex. For example, in a CHARM data source, we found a table with four hundred columns. Defining characterization for every column in such table along with constraints can seriously affect the motivation for using *TDG*. A *TDE* neither requires characterization rules for tables metadata, nor can complex set of constraints affect its speed.

D. Comparisons in Context of Database Refactoring

In perspective of testing, database refactoring can have a significant impact on the choice of test-bed creation approaches. In this section, we discuss a few important databases refactoring processes. (Table 4 provides a comparison summary of two approaches).

Refactoring of Database Objects That Contain Data

1.Addition or deletion of key columns. A *TDE* needs to re-extract data if key columns are added or deleted where a *TDG* redefine the database scheme and then re-generate the data for whole referenced data entities.

2. Addition or deletion of non-key columns. In addition, partial re-generation for non-key columns would work for *TDG* because existing data in other columns would remain intact. In deletion, even re-generation is not required, just a schematic modification (delete non-key columns) would be enough. However, a *TDE* would require re-extraction for both addition and deletion cases, if data exist. Overall, *TDG* and *TDE* performance in context of complexity and generation time is comparable for refactoring of non-key columns.

3.Independent tables. Independent tables can be either mirror tables, log tables, lookup tables, or parent tables. Both *TDE* and *TDG* are adaptable to these changes without any major complexity.

4.Dependent tables. In tables with column referencing key-columns of other tables, a *TDE* needs to re-extract the data for these tables. *TDG* requires defining the target scheme and re-generating the data. Overall *TDG* would be preferable to *TDE* in terms of time, even though *TDG* process is more complex.

5. Column replacement. TDE is a better choice as it automatically supports replacement instances and their dependencies on other tables and columns. However, once characterization rules are defined, a *TDG* will supersede *TDE* in terms of time factor.

6. Split operation. During database refactoring, we come across three types of split operations.

6.1. Splitting tables: Address tables can be split into address and state tables.

6.2. Splitting columns. Customer name columns can be split into first name, last name.

6.3. Splitting large objects (LOB) to table. Mailing address columns in customer tables can be split as a separate table address (id, street, city, state, zip).

Causes of these splits are to enhance design, performance, sharing, or privacy issues. As *TDGs* are not dependent on the data sources for generation, data generation is very fast once schemes and characterization rules are defined. *TDE*s, need to re-extract the datasets, which can consume a significant amount of time. Merging-based refactoring problems also have a similar type of comparison for extractors and generators.

*7. Migration and reordering. TDG*s are adaptable to reordering of columns, without undergoing any major changes in database schemes. However in migration; it may require incorporating modifications in database schemes, as migrated columns can affect dependencies. *TDE*s, on the other hand, can automatically adapt ordering and migration issues but extraction of data can take a considerable amount of time.

8. Renaming. Performance of *TDG* and *TDE* is comparable for renaming columns.

Refactoring of Database Objects That Do Not Contain Data.

8.1.Triggers. Both *TDG*s and *TDE*s are adaptable to this refactoring without re-generation/re-extraction.

8.2.Constraints. Constraints can be of three types; primary-key, referential-integrity, and business-rule constraints. If it is required for a *TDG*, to add constraints to an existing database scheme, it also needs to re-generate existing data because new constraints can conflict with existing dataset. However *TDE* data extraction will ensure compatibility with new constraints without any additional cost.

8.3. Indexes. Both *TDG*s and *TDE*s will not be affected by refactoring of indices on the tables.

E. Comparisons in Context of Testing Techniques

This section discusses different testing methodologies in context of test-data creation approaches (Table 5 provides a comparison summary).

Unit Testing versus Regression Testing. Few studies [19], demonstrates generation of automated unit tests along with test-data generation for databases but their effectiveness is very limited. In practice both *TDG*s and *TDE*s proved not very useful for unit testing and regressing testing. These techniques generate large datasets that are comparatively difficult to test at unit level. A widely acceptable method for unit and regression testing is manual data generation. This way, unit test level values can be easily injected. Similarly, in regression testing, we need to clean and populate the fresh database state after every test. This requirement is difficult to be maintained for datasets generated through *TDG*s and *TDE*s. However, *TDE*s can be useful in certain situations, wherein testing of a unit level functionality needs hundreds of rows to check the comparison result. For example, in CHARM matcher, we need many records as inputs to get a person match.

Functional Testing of Standalone Modules. Database functional testing is about maximizing feature coverage. It requires a dataset which should be rich enough in terms of integration, business rules, good, and bad data. A *TDE*'s performance is better than a *TDG*'s for functional testing because it is very difficult to simulate all above data characteristics in *TDG*. Doing so requires a good understanding of application domain and database schemes along with managing a complex set characterization rules.

Integration Testing. Few important integration testing techniques are big-bang, top-down, bottom-up, and sandwich-based integration testing. Normally, developers first develop and test their standalone modules in individual testing environment. These modules are then tested for integrated issues. Integration can be either at application-level or data-level. But in both cases, data somehow needs to be integrated. In the CHARM integrated environment, components use seven different data-sources. For integration testing purposes, *iSTDE* proved very useful test-data creation approach in this environment. Additionally, its complexity is not affected by the integration of new data sources for inter-tables or inter-database relations. A rich test-bed repository, extracted from *iSTDE*, is well-maintained and repeatedly used for achieving better test coverage. On the other hand, a *TDG* did not prove a useful resource for integration testing. First, it is very hard to generate correlated datasets for different data sources along with other quality-data testing characteristics. Additionally, complexity increases multiple times when additional data sources are integrated.

Performance Testing versus Stress Testing. Normally, data-with-semantics is not a major requirement for performance testing, but it needs large datasets. A *TDG* is a preferred choice, because it can quickly generate large number of data rows [22], though in some cases defining database schema might be a non-trivial task.

A key requirement for stress testing is the number of datasets that can be added to increase load on database managers. Here again, *TDG* would be a preferred choice, as it can easily generate a number of datasets. However, in case of a rich test-bed repository[10], managed by a *TDE*-driven process, that has a reasonable number of test-beds, the performances of both techniques are comparable.

Data Validation Testing. Input for data validation testing can either be from the user-end (top-down approach) or database-end (bottom-up approach). From a database testing point of view, we are concerned with bottom-up data validation testing. Here, the challenge is to have a rich dataset that contains sufficient data validation testing characteristics. *TDE* is preferable to *TDG* because it inherits all the real-data characteristics from actual data sources, thus providing the perfect environment for data validation testing. In *TDG*, however incorporate all the real-data characteristics in test-data, which is a difficult task.

F. Comparisons Related to Social and Time Factors

This section deals with changes in data and schemes related to social and time factors, and how these changes can impact the choice of test-data creation approaches. Table 6 provides a summary of comparison.

Semantics changes due to domain evolution. Database schemes (syntactic) and data definitions (semantics) evolve over time as organizations grow or shrink. This change does not affect the database scheme, but it can affect information context and integration testing. As per experience, we found that *TDE* would perform better for handling these domain evolution changes because actual extraction of real data from data sources would always be in harmony with domain evolution. However, a *TDG* needs redefinition of characterization rules because of domain evolutions that requires good understanding of data.

Social factors that affect the nature of data. Often data definitions are dependent on social or cultural aspects. For example, patient names in United States hospital have a higher proportion of English names whereas a hospital in India has more Hindi names. Apparently, this is not a severe testing problem, but it can be a problem in context of integration testing. Consider a situation wherein we need to match a person from some independent data sources that contains real addresses or names. *TDE* is a better choice than a *TDG* because its data source is production data that would always be consistent with social or cultural aspects. A possible solution for *TDG* is to use *TDE* for building domains that can later be employed for data generation.

Data generation that does not expose privacy. Organizations often implement security policies to cope with external data threats, but they neglect internal security loopholes. One such internal data threat is the access of real-data to software teams. These people can compromise sensitive and private information about persons or organizations. In perspective of test-data creation approaches, *TDG* would be a better choice as it does not compromise data sensitive. *TDE* approach is certainly a risk to internal data security; however, with some data scrambling techniques, we can overcome this threat. *TDE*s [10, 17] provide a secure way to use the sensitive data from integrated data sources both inside and outside the organization.

5. SUMMARY

This paper provides a comparison study on two test-data creation approaches for e-health integrated systems. These approaches are analyzed using prototypical tools against five areas of comparison and then specific conclusions are drawn. Our theoretical experiment reveals that *TDE* has potential to create more realistic test data and especially suitable for federated databases, but it can compromise data confidentiality and require more system resources and time than *TDG*. On the other hand, *TDG*s might be a choice for person-centric applications that do not have many hidden dependencies and complex data-schemes.

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THE CHANGE CHALLENGE: RESULTS FROM THE USE OF EHR (ELECTRONIC HEALTH RECORDS) IN TWO CLINICAL UNITS OF A GREEK PUBLIC HOSPITAL

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ABSTRACT

Implementing change represents a major challenge in almost every organizational setting. When change involves incorporating new technologies into an organization’s working practices the degree of complexity in managing change becomes even higher. Public sector organizations in particular, such as hospitals, have been struggling to engage effectively with technological innovations, such as Electronic Health Records (EHR). While there is an urgent call from governments around the globe to modernize the healthcare milieu, driving organizational change via information technology (IT) innovations is documented as problematic. This paper aims to explore how an EHR system may shape organizational change and identify the ‘soft’, human-side factors that facilitate and hinder the organizational change process. To achieve this aim the paper reports on empirical evidence collected from two clinical units (departments) of a public hospital in Greece. The results from the research findings may inform the future trajectories of policy makers and other healthcare stakeholders in planning organizational change initiatives at worldwide level.

KEYWORDS

Change management, Electronic Health Records (EHR), hospital, Greece, public secondary healthcare sector

1. INTRODUCTION

Implementing change in organizational settings is a rather challenging task. When change is triggered by the introduction of information-related technological innovations an additional challenge in managing the transition to the new era is often involved. This is especially true for public sector organizations, such as hospitals, which are often characterized as ‘change resistant’, ‘sluggish’, and ‘inept’ (Peled, 2001). The healthcare domain at a global level is confronted with a number of intensive changes, primarily technological, social, and economic, and faces urgent calls for innovative solutions in all healthcare aspects, from its delivery to consumers, its technology, and its business models (Herzlinger, 2006). Electronic Health Records (EHR) is a specific information-related technological innovation that is considered to be a cornerstone technology that promises to modernize the healthcare milieu and bring valuable benefits to all stakeholders. Kukafka et al. (2007) identify among the main benefits an EHR system may bring the opportunity to improve patient care and outcomes, increase efficiency and lower costs, improve billing procedures, reduce the frequency of lost records, data, and medication errors, and provide better access to patient histories.

Based on these points two fundamental questions arise. The first is how an information-related technological innovation, such as EHR, may shape organizational change in the context of a public secondary healthcare institution, namely hospital. The second is which ‘soft’, human-side factors facilitate and hinder the organizational change process. This paper aims to provide some empirical evidence on the influential role of EHR and the associated ‘soft’, human-side parameters upon organizational change in the context of a public hospital. While the research findings are drawn from two clinical units (departments) of a Greek public hospital, there are broader implications. Consequently, the evidence presented in this paper may provide some useful insights for policy makers in developing future change management roadmaps for the wider public secondary healthcare milieu. The study employed a qualitative research approach, involving 10 interviews, 5 from each participating clinical unit, with healthcare professionals from different levels. To ensure confidentiality and anonymity neither the hospital name and participating clinical units nor the names of the research participants are revealed. The remainder of the paper is organized as follows: section 2 provides a discussion of the context of study and the key issues stemming from the literature; section 3 indicates the research methodology approach and presents the research findings; and section 4 concludes with a summary of the main themes that the paper addresses.

2. EHR IN THE GREEK HEALTHCARE MILIEU AND LITERATURE-RELATED THEMES

The European Commission (EC) eHealth Action Plan is setting the agenda for its Member States as well as Greece. In 2006 the Greek Ministry of Health and Social Solidarity launched a national eHealth Roadmap that laid priorities, strategy, and action plans for the period 2006-2015 (EC, 2007). The roadmap was based on a critical review of the national 2002-2006 Information and Communication Technology (ICT) Action Plan 'ICT in healthcare' and includes appropriate re-orientation to accelerate national progress and incorporate new policies aligned with the 2004 European eHealth Action Plan (Aggelidis et al., 2010). One of the areas of focus within the policy paper is EHR. However, the current financial turbulence and the need to cut public spending comprise fundamental obstacles in obtaining sustainable eHealth financing for a number of countries including Greece as indicated by Stroetmann et al. (2011).

The development of EHR has been identified as a key strategic target and top priority for the National Health System in Greece (Aggelidis et al., 2010; Frangidis and Chatzoglou, 2011). Within the eHealth ERA report (EC, 2007) it is stated that Greece has established projects for electronic patient records or a summary thereof and is one of the four European countries, the others being Denmark, England, and Estonia, that are working concurrently on electronic health records and national eHealth networks. Nevertheless, the published literature on EHR studies within the Greek healthcare context is limited. Two studies are indicative in this field; one from Goulas et al. (2001) entitled 'EPIRUS-Net: A wireless health telematics network in Greece' and another from Katehakis et al. (2000) entitled 'An environment for the creation of an integrated Electronic Health Record in HYGEIAnet, the regional health telematics network of Crete'. Both studies discuss EHR as part of a wider health telematics network and focus on system architecture, design, and infrastructure as well as work in progress and future implementation plans. The case of HYGEIAnet has a relatively high rate of subsequent publications with a key study that of Tsiknakis and Kouroubali (2009) which investigates the organizational factors influencing the adoption of the HYGEIAnet innovative services. A discussion of some fundamental themes emerging from the literature on organizational parameters affecting change in healthcare institutions is presented in section 2.1. While the underlying principle in this review is the influence of information technologies and EHR in particular, on organizational change some additional more generic themes are also included.

2.1 Key Literature Themes

Orfanidis et al. (2004) highlight that EHR and particularly integrated EHR systems involve aside of technological also organizational and political challenges. Campillo-Artero (2012) signifies that for health technologies to be efficacious it is necessary to change the behavior of the health professionals who will use the technologies and modify certain environmental elements. Empirical evidence from Tsiknakis and Kouroubali (2009) over an 8-year period, from 1998-2006, during various implementation phases across different levels of healthcare services suggests that in the case of HYGEIAnet, the adoption of the system was not holistically successful. The two most influential factors that explain this situation appeared to be training and organizational support (Tsiknakis and Kouroubali, 2009). In terms of organizational support in those healthcare institutions that the implementation was successful, a local champion could be spotted whose role was to act as a change agent by actively promoting innovation, adoption, and diffusion of information systems and had an influential role in the organization's strategy and decision-making (Tsiknakis and Kouroubali, 2009).

Based on a systematic review of the literature Lluch (2011) provides a comprehensive categorization of the organizational barriers related to health information technologies. Lluch (2011) groups barriers into five main categories: 1) structure of healthcare organizations, 2) tasks, 3) people policies, 4) incentives, and 5) information and decision processes, with each of these categories encompassing specific elements. The first category, structure of healthcare organizations, includes hierarchy, teamwork, and cooperation as well as autonomy (Lluch, 2011). Healthcare organizational systems typically follow a hierarchical model seniority based on clinical experience (Lluch, 2011). Yee et al. (2008) claim that healthcare organizational systems with strong hierarchical traditions, such as hospital settings, are likely to conform 'change agents', such as younger professionals to the hospital's existing culture rather than embrace changes. A number of studies have found that the current structure does not encourage teamwork between different tiers of healthcare organizational systems, for instance primary care with hospitals (Lluch, 2011). Threats to autonomy refer to the need for organizing cooperation with other healthcare professionals in such a way so that it does not conflict with the autonomy of most healthcare professionals, with primary care being a representative example of autonomy (Lluch, 2011).

Tasks, the second main category, involve changes in work processes and routines as well as face-to-face interaction versus new ways of working. Changes in work practices and routines emphasize the importance of designing technologies to adapt to the roles, tasks, and workflow of the healthcare setting (Lluch, 2011). Whilst healthcare has been traditionally delivered face-to-face, clinicians are concerned that the new imposed ways of working lead to the depersonalization of healthcare (Lluck, 2011).

Under people policies there are six elements identified: 1) training/IT skills, 2) support, 3) trust and liability, 4) lack of legal framework, 5) accountability to their employer and policy makers, and 6) centre of gravity and autonomy (Lluch, 2011). Poor training and lack of computer skills are indicated as major barriers (Lluch, 2011). Support involves support from management and colleagues in integrating health information technologies in healthcare professionals' daily practices, their professional role, and service delivery (Lluch, 2011). Trust regarding healthcare-related data communicated among healthcare institutions and the legal liability of physicians who rely on data from other providers are both issues of concern for healthcare professionals (Lluch, 2011). The lack of a legal framework related to liability issues places further concerns (Lluch, 2011). While integrated care requires teamwork and information sharing, Rigby et al. (1998) point that for most team members there will be a three-way split between their autonomous professional commitment to patients, their loyalty to the team, and their formal accountability to their employer. Additionally, physicians are concerned that policy makers will utilize EHR as a proxy mechanism to restrict or dictate the practice of medicine (Lluch, 2011). The centre of gravity is a supplementary reward and career systems determinant in organizations (Lluch, 2011). As Lluch (2011) highlights a shift downstream necessitates also a shift in the organization's power base away from the dominance by top and middle management.

Incentives involve financial benefits, career development opportunities, managerial praise, and recognition as well as intrinsic rewards emanating from job satisfaction (Lluch, 2011). The last main category, information and decision processes, suggests that the application of health information technology, such as EHR, entails the overall modification of information and decision making processes leading to workload concerns that create substantial barriers to IT penetration (Lluch, 2011).

The hierarchy point indicated as part of the healthcare organization structure category may be associated with and expanded to organizational culture and what Bellou (2008) identifies as sub-cultures. The term sub-culture suggests the existence of variations in the behavioral norms and practices across organizational sub-units (Martin, 1992). The primary difference between culture and sub-culture is that the former refers to the overall organization and the latter to the presence of multiple small cultures within an organization (Hatch, 1997). Based on this interpretation sub-cultures may contain elements of the main culture, for example core values, practices, and behaviors but also distinctive characteristics that reflect the values of the particular sub-unit.

3. RESEARCH METHODOLOGY AND FINDINGS

The fundamental questions that this paper tackles are how an EHR system may shape organizational change in a public hospital and the 'soft', human-side factors that enable or disable the overall organizational change process. These questions are addressed using primary data from two clinical units of a public hospital in Greece. The specific clinical units have been selected to participate in the study due to their lifelong experience, more than 10 years, with EHR systems. Sections 3.1 and 3.2 provide a description of the research sample and methods employed respectively. Sub-sections 3.2.1 and 3.2.2 discuss the study's findings, particularly the organizational changes that have emerged from the use of the EHR systems and the 'soft' factors that play an influential role on organizational change at two levels of analysis, the clinical and the hospital level.

3.1 Research Sample

The study involved conducting 10 interviews, 5 from each clinical unit, with healthcare professionals (doctors, nurses, and administrative personnel) from different levels (junior and senior). A summary of the respondents' demographics is depicted in Table 1. All participants have been chosen based on a non-probability sampling technique that married purposive and theoretical sampling. The combination of these two techniques was valuable for two reasons. Purposive sampling allowed identifying those participants that were both appropriate and important to the research as they had sufficient experience with the EHR system. Theoretical sampling allowed flagging a research sample diverse enough that permitted to search for different properties within the main identified research themes.

Table 1. Demographics of respondents

Clinical units	Respondents	Number
Clinical unit A	Senior level doctors	2
	Junior level doctors	2
	Nurse with an administrative role in the clinical unit	1
Clinical unit B	Senior level doctors	1
	Junior level doctors	3
	Nurse with an administrative role in the clinical unit	1
Total		10

3.2 Research Methods

The study employed semi-structured interviews as an 'ideal' between structured and unstructured interviews. Semi-structured interviews offer the flexibility of approaching every respondent slightly different while covering the same set of questions. This way participant subjects could elaborate further on certain issues and raise additional points as the conversation was flowing. Interview questions included determining how the specific EHR system has influenced the healthcare professionals' work within their clinical unit and their collaboration with other units in the hospital as well as the factors that empowered and impeded the change process at both clinical and hospital level. The study was carried out between August and September 2011 and the length of the interviews varied from 45 minutes to 1 hour and 15 minutes. With the permission of the interviewees interviews were tape recorded.

3.2.1 Organizational Changes at Clinical and Hospital Level

Most respondents in both clinical units (A and B) indicated that the organizational changes they experienced with the introduction of the EHR systems are of limited impact. This is due to three reasons. First, not all clinical personnel utilizes the EHR system, second the system is a supplement to the paper-based records, which are still used in parallel to the electronic ones, and third the system has more functionalities and potential than the current usage in the case of clinical unit A. Despite the fact that the noticed organizational changes are narrow in scope, all subject participants agree that the changes experienced within their clinical units are overall positive. With the EHR system, there is instant and fast access to the patient's medical information thus saving significant working time. In addition, it is possible to efficiently and effectively confront patients, follow-up a patient's health condition, coordinate the work of medical and administrative personnel, alleviate the clinic's personnel in processing patients during their hospitalization resulting in providing a better service as well as plan systematically the clinic's services. The utilization of the system has also some more practical implications, such as saving space and assisting in locating easily a patient's paper-based record, which contains all his/her examinations and is used in doctor visits during a patient's hospitalization.

As opposed to the limited but positive changes that respondents observed in their clinical units, the changes that they encountered in terms of their collaboration with other clinical units within the hospital are generally marked as negative. This is because the hospital's clinical units use incompatible, non-integrated EHR systems. As one respondent places it "There is no 'electronic collaboration' between the hospital's clinical units so that doctors from one clinical unit can view the complete picture of a patient who has been hospitalized in another clinical unit" (Junior doctor2, Clinical unit A); a view that most respondents adopt. However, two respondents (Senior doctor1, Clinical unit A and Junior doctor1, Clinical unit B) posit a different stance on this stating that with the use of the EHR system in their clinical unit collaboration with other clinical units has become more efficient and effective. This is can be explained as a patient's medical information can be retrieved quickly in the clinical unit where the patient has been hospitalized before and could then be provided to healthcare professionals in other units where the patient is hospitalized at that moment. These patients according to one respondent (Junior doctor1, Clinical unit A) are known as 'multi-organic', they are patients that have been hospitalized from time to time at different clinical units requiring every time a different type of medical care and hospitalization, and represent a high percentage of the hospital's patients. An interesting view on the effect on the collaboration with other clinical units is expressed by another respondent (Nurse with administrative role, Clinical unit A) who states "It really depends who is collaborating with whom… I have provided information for my patients to other clinical units instantly when requested, but when I needed, for example the history of a patient that has been hospitalized in another clinical unit in our hospital…they have been searching the patient record for days and days and they could not find it".

Table 2. Summary of perceived organizational changes and issues at clinical and hospital level

Positive	changes/issues Negative	changes/issues
Clinical unit level	Coordination of medical and administration personnel work Easiness in locating the paper-based record More efficient and effective confrontation and monitoring (including follow-up) of patient conditions More efficient and effective services provided to patients Saving significant time Saving space Systematic and streamlined planning processes	EHR in parallel with paper-based records No 'holistic' adoption from all clinical personnel
Hospital level	Easier access to a patient's record in a clinical unit may result in more efficient and effective collaboration among the different units of the hospital (essential for 'multi-organic' patients)	Variations of the EHR systems used within the hospital's clinical units do not permit 'electronic' collaboration thus limiting organizational effectiveness

3.2.2 'Soft' Factors Affecting Organizational Change at Clinical and Hospital Level

The empirical evidence shows that there are two major drivers for organizational change within clinical units, personal incentive and middle level management. The notion of incentive here does not exactly correspond to the interpretation provided by Lluch (2011) that was discussed in section 2.1. It is rather used to reflect the human-centered factors that drive change, such as the individual motivation and genuine interest which are further encouraged by the positive organizational climate within the two units. Research participants from both clinical units underscore that there is a strong interest from the clinical unit's personnel to employ the EHR system and modernize the clinic's processes. The other positive driver, middle level management, in this research context refers to clinical unit directors. All subject participants underline the role of the clinic's director as instrumental in accelerating change. Both directors are characterized as innovators, supportive of any new initiatives and among the first to introduce in the hospital an EHR system. In particular, a respondent (Nurse with administrative role, Clinical unit B) denotes "we were one of the first clinical units in our hospital that introduced it [EHR]… we are actually one of the best clinical units in the wider geographic area because the [EHR] system has a holistic acceptance as it is used by all doctor and nurse-administrative personnel… the role of the clinic's director has been a catalyst… depending on how intense the personality of a clinic's director is he/she can achieve certain things". Nevertheless, the shift to the computerization of both clinical units has been accompanied by a structural professional change. In both cases nurses were placed in an 'administrative role' and became responsible for managing the electronic records.

The vast majority of respondents indicate that organizational culture is of paramount importance in enabling changes to occur at an organizational level. However, the current underpinning culture is considered to be problematic. In particular, within the existing culture there is a high level of bureaucracy integrated that needs to be left behind if valuable changes are to occur as one participant (Junior doctor1, Clinical unit B) notes. Another respondent (Junior doctor2, Clinical unit A) reports on this issue that "there is an urgent need for a change in the [organization's] culture… whether we like it or not there exists an established ground [in a hospital] and this is why the culture does not change… they exist 'cliques' that hold family traditions". From a similar perspective, another respondent (Senior doctor, Clinical unit B) states that resistance to change is incorporated in the employees' DNA and continues "it will require about 25 years to change… for change to occur there is a need for deep access in the [personnel's] value of protocols". Both these views can be fitted under the heading of the generic organizational culture. On the other hand, there is also the element of sub-culture. The existence of sub-cultures is shaded by one respondent's (Junior doctor1, Clinical unit A) view who underlines "I am very open and ready to move on, but there is still a long way to go with the culture that underpins some colleagues in particular…the snobbish attitude will need to be left behind".

Top level management in the context of the Greek public secondary healthcare sector includes a chairman responsible for governing a hospital. Many research participants feel that there is a mismatch between the goals, needs, and priorities set by the hospital's top level management and those required by each clinical unit and the entire hospital. Characteristic of this is the opinion of one respondent (Junior doctor2, Clinical unit A) "our hospital's priorities are primarily shaped by the political party in power and the corresponding assigned hospital chairman… a 'transitory' chairman who has no relevance with the healthcare sector and human resource management cannot understand and deal efficiently and effectively with the everyday needs and issues the hospital, the individual clinical units, and the healthcare professionals face". Both nurses emphasize that there is a need for a close engagement of top level management with every clinic's requirements and a close collaboration with middle level management and healthcare professionals within each clinical unit to modernize the hospital's services on the whole by accelerating organizational level changes and innovations through the employment of technological innovations and EHR in particular.

A graphical representation of the 'soft' enabling and disabling parameters affecting organizational change are shown in Figure 1.

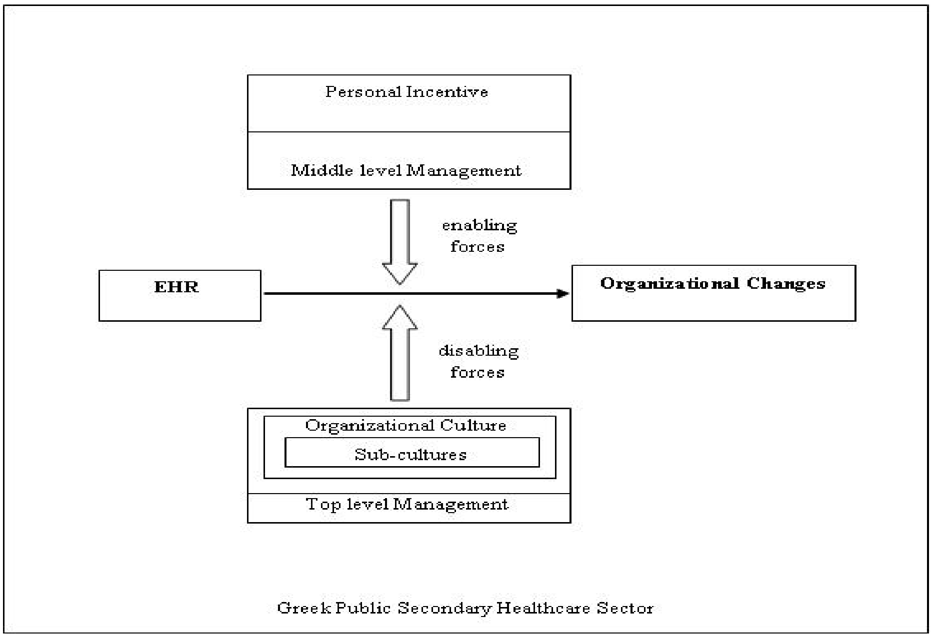

Figure 1. 'Soft' enabling and disabling forces for organisational changes triggered by an EHR system

4. CONCLUSION

It is apparent that information-related technological innovations, such as EHR systems, alone are not adequate to bring organizational changes in a secondary healthcare setting. The study whose findings have been discussed in this paper focused on investigating how an EHR system may affect organizational change at both clinical and hospital level and identify the ‘soft’, human-side determinants that may empower and impede the organizational change process. The study’s empirical evidence derived from two clinical units of a public hospital in Greece. The effect of EHR on organizational change at a clinical unit level is reckoned as positive and particular themes among others include more efficient and effective patient confrontation and follow-up, saving significant time, coordination between medical and administrative personnel, and systematic and streamlined planning processes. However, the EHR effect on organizational change at a hospital level is generally recorded as negative. This is because of interoperability issues arising from the use of different EHR systems within the hospital’s clinical units that do not provide a single point of access to patient electronic records for all personnel involved in the delivery of healthcare provision. ‘Soft’ factors that have been identified to reinforce organizational change at a clinical level are personal incentive that is the individual’s motivation and genuine interest to actively engage with changes, and middle level management, in this case clinical unit directors. Factors marked as organizational change hindrances are organizational culture and the related sub-cultures, as well as top level management which in this research context refers to hospital chairman. The aim of the paper with the discussion of the study’s empirical findings was to provide some useful insights to healthcare policy makers and other stakeholders with respect to the planning of change management strategies at both departmental (clinical unit) and organizational (hospital) level. Future work in this area may include aside of ‘soft’, human-side, also the exploration of ‘hard’, technology-related influential parameters on organizational change. ‘Soft’ and ‘hard’ elements can be integrated into a framework that will provide a complete picture of the change management dynamics in the secondary healthcare setting.

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HANDHELD ELECTROCARDIOGRAM: DOES ICT CONTRIBUTE TO INNOVATION IN HEALTHCARE DELIVERY?

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ABSTRACT

The use of IT-based applications to innovate the delivery of health services has been suggested as an enabler to improve both patient health outcomes and reduce the burden of care. Many studies have focused on the impact of ICT on health outcomes with limited research examining the innovative effects of ICT in the delivery of care. The purpose of this study was to explore collaborative innovation effects in the delivery of care for both caregivers and patients as a consequence of the use of an ICT-based device by patients with atrial fibrillation. Semi-structured interviews were conducted with the caregivers involved in a specialized care program while questionnaires were mailed to 75 patients enrolled in the program querying them about the use of a handheld ECG device for remote monitoring. Findings indicated that cardiologists considered the device as an enabler that contributes to increased quality of clinical decision-making. Patients generally found the device to be useful and felt more involved in their own care. However, the introduction of the device presented work overload for the caregivers due to the need to check data frequently. As a result, the facilitation of timely diagnostic and decision-making were not realized. ICT is an enabler through which innovation in services developed for patients can be realized. However, integration of ICT-based applications into work practices with a specification for division of labor, and responsibilities for patients and healthcare providers is central to realizing potential benefits.

KEYWORDS

Collaborative innovation, atrial fibrillation, handheld ECG

1. INTRODUCTION

Atrial fibrillation is arguably the most persistent cardiac arrhythmia in primary care practice and it is associated with increased mortality and morbidity (Dell'Orfano et al., 2000; Braganca et al., 2010) as well as with a large percentage of cost due to the relative high frequency of hospitalizations and emergency visits (Mensah & Brown, 2007; Paré et al., 2007; Pinna et al., 2007). The progressive introduction of ICT as tools to innovate performance and outcomes of healthcare services is becoming increasingly significant in the management of cardiovascular diseases such as atrial fibrillation (Cordisco et al., 1999; Boriani et al., 2007; Huddleston & Kobb, 2004) because of its contribution to the automation of manual processes, enabling innovation in clinical work-practice, as well as changes in division of labour and responsibilities for both healthcare personnel and patients.

How ICT can support services for patients with cardiovascular diseases has been previously discussed in several studies (Pinna et al., 2007; Benatar et al., 2003; Scalvini et al., 2004; Smart et al., 2005; Schofield et al., 2005). Most of the studies have however, seen ICT as a technology capable to support remote monitoring or consultations at a distance, and been mostly concentrated on the contribution of ICT to speeding up the diagnostic and therapeutic processes (Nikus et al., 2009; Artinian et al., 2003; Winkler et al., 2010; Giordano et al., 2007, Shacham et al., 2010).

To our best knowledge, there has been limited research examining the ways in which healthcare professionals embrace technologies to innovate service delivery. In this study we explore collaborative innovation effects in the delivery of care for both caregivers and patients as a consequence of the use of an ICT-based device by patients with atrial fibrillation.

2. THE CONTEXT OF THE STUDY

Since the end of 2009, the Ryhov Hospital at Jönköping County Council in Sweden has been running a care program called SMaC-PAF (Structured Management and Coaching - Patients with Atrial Fibrillation) within the cardiology department with the aim to offer patients suffering from atrial fibrillation the possibility to report data and information related to the management of the disease using an ICT-based application. Two cardiologists and two nurses are responsible for the program. Physicians at either the emergency room or from the cardiology department can select patients for this program. At the time of this study, 140 patients were enrolled in the program. Selected patients accept to participate in the program for a period of one year. They are also asked to make three mandatory scheduled appointments with the program team during their enrolment. During these appointments, the patients meet with a nurse and a cardiologist who assess their condition through laboratory tests and physical checks. They also receive a handheld electrocardiogram (ECG) device that records the electrical activity of the heart to help monitor atrial flutters, and a telephone number (a helpline) on which they can call concerning any problem related to the disease. Only patients suffering from paroxysmal atrial fibrillation whereby episodes of irregular heart rhythm occur periodically and are over 18 years old are considered for the handheld ECG; and it is normally given to patients three months after their enrolment during their second appointment with the program team.

Nurses involved in the program are responsible for training the patients on how to use the ECG device; this implies how to register and send ECG data. The nurses are also required to frequently check and monitor the ECG data patients send from the device. In addition, they have the responsibility of educating the patients and their families about the disease including its symptoms; prevention, treatment, quality lifestyle and providing postoperative care. The cardiologists are primarily responsible for deciding on treatment options for their patients based on factors like symptoms, patient’s age and history and through discussions with the patients. The cardiologists are also responsible for selecting patients into the SMaC-PAF, and monitoring the ECG data patients send.

Patients perform ECG registrations by placing both thumbs on the device for 10-30 seconds and pressing the send button. They are requested to send registrations twice daily, and anytime they experience cardiac symptoms. The ECG data is sent to the care provider automatically and are accessed and analyzed by a nurse or cardiologist over a secured network. Patients can call the SMaC-PAF helpline to enquire about the results of their ECG registrations.

3. THEORETICAL FRAMEWORK

Innovation has long been cited as essential for organizational competiveness and success (Edward et al., 2005; Smith et al., 2010) and it is defined as a result of the combination of different knowledge and expertise that exist within and outside of the organization (Johnsen and Ford, 2000). Utterback (2001) stated that innovation is most often the result of the communication of a need followed by the search for information.

Collaborative innovation has been defined as a distributed form of innovation in which multiple actors, empowered by IT work together and share ideas, driven by a common vision (Gloor et al., 2003). Emerging technologies enable novel perspectives of collaboration, with regards to the agreement on common visions and the regular exchange of information, but also the conjoint performance of actions to realize innovation (Lau et al., 2009). In collaborative innovation, there is interaction between actors and processes and it is imperative to characterize which segments of the organizational processes that will be enabled through IT-based applications in addition to specification of roles and functionalities. In collaborative innovation, ICT systems support dispersed actors to exchange information.

Labatut et al. (2012) assert, “technologies should not be considered only as artifacts but as a combination of three dimensions comprising technical substrate, managerial philosophy and organizational model” (pp 44). The organizational model may describe the roles and division of labor within the organization when technologies are introduced (Becker et al., 2005).

From this viewpoint, it is apparent that technologies affect the most detailed practices in terms of their use as tools or applications to support routines. The introduction of technologies into established systems of practice may constrain or enable processes with the possibility to produce unexpected outcomes that vary from the initial objectives. Understanding these unforeseen complexities entails a comprehensive approach at how technologies interact with routines, actors, execute actions and eventually contribute to the reconfiguration of new practices into core organizational practices. According to Labatut et al. (2012), a technological change with its constraints and potentials affects and is influenced by the collective action defined in the attributes of managerial philosophy and relations including social roles, and division of labor expressed through the organizational model. However, redesigning practices in the advent of technology adoption can be challenging.

From healthcare perspective, replacing face-to-face patient-physician contact with remote technology support can provide significant potentials but may also present challenges for both patients and healthcare personnel, for instance a modification in skill-mix, work overload, etc. when the ICT-based solutions are not integrated as part of formal core organizational practices.

4. METHOD

Data were collected in two phases. In the first phase, semi-structured interviews were conducted with all the caregivers involved in the program, which comprise of 2 cardiologists and 2 nurses. Questions asked were related to their opinions about the use of the ECG device by patients in the management of atrial fibrillation, how they believe the use of the handheld ECG affects processes and the interaction with their patients. They were also asked to reflect upon factors that affected the significance to receive and accumulate more and more accurate patient related data. The caregivers were also asked to make comments on issues such as: importance of accessing real-time data in the decision making process, effects on service quality and safety or security for the patients. The interviews were recorded and transcribed in its totality. In order to validate the results, transcriptions of the interviews were sent back to interviewees for eventual further complementary information or corrections.

In the second phase, a questionnaire containing ten closed and open-ended questions were mailed to 75 selected patients enrolled in the SMaC-PAF program for at least three months. Respondents were queried about their previous knowledge and use of an ECG device or similar technologies, their opinions about the use, benefits and limitations of the device, and about their intention to regularly use the device in the future. The questionnaires were mailed to the respondents with cover letters explaining the purpose of the study and instructions to complete the questionnaire. Anonymity was ensured for all respondents. Sixty-five patients responded to the questionnaire after three weeks. Reminders were sent to the respondents who did not reply on time to increase the response rate. Five more patients responded to the questionnaire after the reminder letters were sent. To enhance credibility of the study, documentation on the device that was available to the researchers were reviewed as secondary data to develop converging lines of inquiry.

5. RESULTS

From the 70 patients that responded to the questionnaire, 44 were males and 26 were females with a total average age of 69 years old. 14 patients responded that they had used or were using the handheld ECG device. Out of this number, 12 patients had no previous experiences with the device or similar technologies.

5.1 Cardiologists and Nurses: Impact of Technology on Decision-Making, Interaction and Work Overload

The cardiologists agreed that the ECG device was useful for enhancing decision-making. They said:

"The device is useful for identifying asymptomatic or silent episodes of atrial fibrillation." (Cardiologist 2)

"Previously if you want to address the issue of monitoring you need to have the patient do a 24hr recording at the hospital and I think it is the main benefit with this device." (Cardiologist 1)

One of the cardiologists pointed out the possibilities to innovate the delivery of services. He said:

"The device changes the communication process in the sense that if they have symptoms or we have seen any health risks then we could contact and discuss treatment in a much faster way but this cannot be generalized to all patients." (Cardiologist 1)

They both were of the opinion that the handheld ECG device helped in their interaction with patients regarding their condition. The cardiologists also believed that the ECG device provided some form of safety for patients due to the possibility to record cardiac activity at moment the symptom occurs.

"I think the positive thing about the device is that you can get clinical data and direct feedback from patients remotely". (Cardiologist 1)

"Most patients I think feel more secured to have it…"(Cardiologist 2)

An interesting issue is the fact that the cardiologists admitted that they did not have time to check frequently the data that patients sent but agreed on its continued usage. They said:

"I obviously check the data patients send but I do it whenever I have the time, maybe once every two or four weeks..."(Cardiologist 2)

"I do not check the ECG data often and have not once alerted a patient about a health risk alert." (Cardiologist 1)

"I believe the device has a place in the management of atrial fibrillation..." (Cardiologist 1)

The nurses on the other hand believed that the device did not affect either their decision making process or their interaction with patients. Nevertheless, one nurse was of the opinion that the device created the possibility to better guide patients while the other believed the contribution of the device was that it helped avoid unnecessary emergency visits. In similar opinion with the cardiologists, the nurses mentioned an increasing workload. They noticed that the introduction of the technology to the patients required time and efforts and they were not able to check the data sent to them by the patients frequently, as they were required to do. They said:

"Introducing patients to the device and checking the ECG data sent in are new to me". (Nurse 2)

"Due to my tough schedule, I do not frequently check the data as required."(Nurse 1)

5.2 Patients: Benefits and Limitations of the handheld ECG Device

The analysis of the data showed that the patients in general believed that the device helped them to accumulate data and contribute in this manner to improve their knowledge about the disease and their own health conditions. Patients' opinions about the usefulness and limitations of the handheld ECG device are shown in table 1.

Table 1. Patients' opinions: use, usefulness and constraints of the handheld ECG device

Statements (%)					n
	Strongly agree	**Agree Neu**	**tral opinion**	**Disagree S**	**tron gly disagr ee**
Use of the device					
The device is easy to use	**11 (79)**	**3 (21)**	_	_	_
I receive adequate instructions on the use of the device	**14 (100)**	_	_	_	_
It requires little effort and time to complete ECG registration	**12 (86)**	**2 (14)**	_	_	_
I am satisfied with the use of the device	**8 (57)**	**6 (43)**			
I would continue to use the device in the future if available	**14 (100)**	_	_	_	_
Usefulness					
I feel more safe having the device	**6 (43)**	**1 (7)**	**3 (21)**	**4 (29)**	_
It is convenient to be able to send my data anytime	**7 (50)**	**5 (36)**	_	**2 (14)**	_

It helps to improve my condition	**1 (7)**	_	**11 (79)**	**2 (14)**	_
It makes me feel more involved in my own healthcare	**8 (57)**	**2 (14)**	**4 (29)**	_	_
It helps to improve knowledge of my health condition	**6 (43)**	_	**5 (36)**	**3 (21)**	_
It helps me to better discuss my condition with the caregiver	**5 (36)**	_	**8 (57)**	**1 (7)**	_
It helps to reduce my visits to the hospital	**11 (79)**	_	**3 (21)**	_	_
Having the device makes me feel too conscious of my condition	**3 (21)**	_	_	_	**11(79)**
Constraints					
The technology is difficult to use	_	_	_	_	**14 (100)**
Inconvenience (e.g. Carrying it around with you)	**3 (21)**	_	_	_	**11 (79)**
It is not capable of continuous recording	**14 (100)**	_	_	_	_
I do not find the device useful	**1 (7)**	_	**5 (36)**	_	**8 (57)**

A large percentage of the patients felt that the device was easy to use and required a short time to perform the registrations. At least half of the respondents said they felt safe using the device while most of them cited the convenience it provided, both as a tool to improve knowledge of their health condition and as a tool to use for further discussion with the caregivers. Most of them also agreed that using the device made them feel involved in their own health care and helped to reduce the frequency of visits to the hospital. All respondents replied, however, that the device was not capable of continuous monitoring while a few others reported the inconvenience of carrying it around with them. One patient did not find the device useful. All patients reported that they were satisfied with the device and would use it in the future.

6. DISCUSSION

The use of IT-based applications to innovate the delivery of health services has been suggested as an enabler to improve both patient health outcomes and reduce the burden of care. In this paper, we found that the handheld ECG device helps improve the delivery of care to patients suffering from atrial fibrillation by enhancing early detection of potential health risks to intervene effectively, a possibility that might help to reduce the frequency of hospitalizations and emergency visits (Scalvini et al., 2004).

The ECG device was considered by healthcare personnel, and specifically, the cardiologists as an enabler that contributes to increase quality of clinical decision-making in two ways: real-time access to patient information and patients' access to appropriate and individualized care. An interesting issue is the fact that the cardiologists believe the handheld ECG device stimulates patients' security due to the capability to continuously report information and data about their health status. However, at the same time, they report an increasing work overload due to the need to check data frequently. This results complement existing literature in exploring the integration and use of ICT to support practices in different settings. Successful integration of ICT into clinical work practice emerged as a consistent theme regarding ICT adoption and realization of potential benefits. While information overload, and demand on reading and controlling new information is a new task and an unexpected effect, the facilitation of timely diagnostic and decision-making are not realized. This implies that the effects of collaborative innovation in terms of the delivery of care and interaction between patients and healthcare personnel have not achieved the expected impacts. Even more important, patients have taken new responsibilities namely, to send their ECG data and to call healthcare personnel to enquire about their data.

While the nurses are of the opinion that the device does not have any impact on their interaction with the patients, the cardiologists believe that it affects the interaction process. Whether this is a consequence of current division of labor between cardiologists and nurses, it has not been possible to state in this study. It seems, however, reasonable to assume that due to the nature of issues these two groups handle, the ones that receive the real effects of the use of the ECG device are the cardiologists due to the fact that the device helps patients understand their conditions and become better informed to deliberate with cardiologists concerning their choice of treatment plans.

From the perspective of the patients, the findings indicate that the usefulness of the device evidently lies in its effects on patient health management. In essence, most of the patients appreciate the convenience the device provides to send their data remotely without a trip to the hospital, which consequently reduces the frequency of hospital visits. This is consistent with the opinions of the caregivers. The feeling of being involved in their own healthcare, improved knowledge about their conditions, enhanced patient-physician communication and the feeling of security represent the benefits of the device to the patients. Interestingly, only one patient believes that the use of the device actually helps to improve his condition; a situation that is possibly due to the current ineffective manner of remote monitoring that impedes timely intervention. While all the patients cite the unsuitability of the device to continuously record data, and few others report of inconvenience and the feeling of anxiety as downside to the use of the device, all the patients are satisfied with the use of the device and intend to use in the future if available. These results are consistent with collaborative innovation theory in the sense that patients act as actors in this collective effort with the caregivers through the use of an IT-based application as an enabler to help innovate the delivery of care. As they become more involved in their healthcare and empowered, patients are better informed about their condition and treatment options and this helps to improve the patient-physician relationship and subsequently the quality of care provided.

In healthcare, innovations in work practices are equally as imperative as any exclusive innovative product. It is important to deem IT-based applications that support innovations such as remote monitoring as services because the devices may not have any functionality as stand-alone products. The major potential benefits from such innovations are liable to originate from reconfiguration of clinical practices or through alterations in skill-mix and specialization of roles. The fundamental innovation is the capability to provide a tailored healthcare that meets the needs of patients and health personnel. In this study, the remote monitoring device serves as an enabler or a tool to facilitate the collaborative innovation between patients and caregivers to innovate the delivery of healthcare through reconfiguration of core practices. The technologies and clinical work practices that eventually predominates as part of a holistic approach to care enabled through ICT will be achieved through the collective efforts of healthcare providers and patients.

7. CONCLUSION AND FUTURE RESEARCH

ICT-based applications facilitate enhanced timeliness and quality of diagnostic and therapeutic decision-making. Possibility to sample real-time patient data within the area of atrial fibrillation management was judged to support and improve the quality of communication between healthcare personnel and patients, and thus to facilitate team-based holistic care. Posited at the nexus of ICT and clinical practice in the area of atrial fibrillation is a new paradigm set to transform the landscape of care provision. ICT is an enabler through which innovation in service developed for patients can be realized. However, integration of ICT into work practices with a specification for division of labor, and responsibilities for patients and healthcare providers is central to realizing potential benefits.

The findings of the present study indicate that there could be significant advantages from the utilization of IT-based applications to innovate service delivery for patients with atrial fibrillation. More research need to be conducted on how these applications affect organizational activity structures in order to obtain evidence required to employ them in routine healthcare. It is also necessary to discuss effects to increase empowerment of patients and the effects of this for the healthcare system.

Qualitative exploratory studies looking at the innovation effects of ICT and their associated impacts are scarce. Studies have sought to examine the relationship between ICT use and clinical indicators or outcomes (Wilkins et al., 2007; Bowles and Baugh, 2007; Zarter et al., 2008; Trief et al., 2007). This study aimed to explore the use of a remote technology support and to provide a more in-depth insight into the effects of the technology at the healthcare and patient levels. The findings present a new insight into the usefulness and impact of the technology in decision-making. However, the study was conducted at an early stage and with a reduced number of users and in a limited time. It is possible that findings may vary as both the division of labor of the healthcare personnel is more structured and the use of the system become established in work routines.

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STRUCTURED APPROACH TO THE ADOPTION OF INFORMATION TECHNOLOGY GOVERNANCE, RISK AND COMPLIANCE IN HOSPITALS USING DESIGN SCIENCE PRINCIPLES

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ABSTRACT

Against the background of the current reforms and an aftermath of increasing regulation in the health care sector, hospitals enhance and integrate concepts of IT Governance, Risk and Compliance (IT GRC). Based on experiences with isolated and often immature partial concepts in these fields, the major challenges for the adoption of IT GRC in hospitals are close-meshed organisational structures, legal restraints and over the years increased heterogeneous IT systems, which are just a few aspects that make hospitals a sensible field for the implementation and governance of IT. In this paper a method that supports the adoption of integrated IT GRC concepts is been developed. The proposed method is comprised of different method elements that support the relevant conceptual, organisational, technical, and cultural aspects of the hospital environment.

KEYWORDS

Method, Design Science Research, Health Care, IT Governance, Risk, Compliance, Hospital.

1. INTRODUCTION

The Swiss health system ranks among the best health care systems in the world but is at the same time one of the most expensive ones. That concludes the actual review on health care systems by the Organization for Economic Cooperation and Development (OECD) and the World Health Organization (WHO) (OECD and WHO, 2011). The price for outstanding health care services, however, is significant. As many developed countries, Switzerland is facing increasing expenditures for their health system: 11.4% of the Swiss gross domestic product (GDP) in 2009 has been spent on health care – the OECD average was 9.6%. The Swiss health system is characterised by three key features: the first is its federal structure and a complex system of powers and responsibilities by level of government; the second is a political tradition of direct democracy and governance through consensus; and the third is an emphasis on managed competition within the health system rather than state-run (e.g. integrated health care model) arrangements. The finance of the health system is governed at the federal level while cantons are central to delivering health services needed by the population. Most hospitals – the major economic entities in the Swiss health system – are owned by cantons and municipalities. Legislative reform efforts therefore primarily aim at increasing productivity within health care, while ensuring the quality of care. The on-going reform activities of the legislation and the thereof resulting changed conditions issue continually a challenge to actors in the hospital market. Central catalyser of these changes is the setup of incentives in in-patient care by diagnostic related groups (DRGs) in many European countries. Since 2009, hospitals in Switzerland have been transitioning to a new remuneration approach which provides case-based payments. This new system is been introduced in 2012 and is becoming the dominant payment mechanism for hospitals in Switzerland. As in many other countries which have already introduced DRGs (e.g., Germany and Austria) the new tariff system promises transparency and comparability of in-patient services across hospitals. For the affected hospitals it is necessary to develop concepts and reforms to work more efficient and have control of their business (medical and administrative) processes. As in many other industry sectors, when it comes to optimisation and reorganisation of processes, information technology (IT) can be an effective instrument for improvements (Berensmann, 2005). IT can be a driver for diversification in competition and creation of innovative strategic competitive advantages (Piccoli and Ives, 2005). This endeavour requires besides a vast understanding of the related business processes and the ability to deal with innovation, a goal-oriented effort of given resources. This calls for IT governance in terms of an integrated and comprehensive approach to effectively align, invest, measure, deploy and sustain the strategic and tactical direction and value proposition of IT in support of the business with respect to the management of risk and compliance issues (IT GRC) (Weill and Ross, 2004).

1.1 Problem Statement and Objectives

Although the paper at hand focuses on the Swiss health system it may be applicable to different countries which share the same problems. In addition to the given fact of an aging society other challenges to be met by the endeavour to fundamental reorganisation of the health care sector are, e.g. close-meshed organisational structures within the hospital and between its stakeholders, legal restraints based on a concurrent federal and decentralised structure and over the years increased heterogeneous IT systems (VIG, 2005) which are just a few aspects that make the health care sector a sensible field for the implementation and governance of IT (Porter and Teisberg, 2004). In the last years a range of best practice models (e.g., Control Objectives for Information and Related Technology (COBIT) or Information Technology Infrastructure Library (ITIL)) as well as proprietary frameworks have been developed (e.g., Microsoft Operations Framework (MOF)), which are also summarised under the topic of IT governance and describe goals, processes and organisational aspects of IT management and control. However, these frameworks promises that they can be implemented independent from the size, industry sector and status of IT innovation of the enterprise (Johannsen et al., 2007). Representative studies which have been conducted in both, Switzerland and international let assume that the concepts and models meeting the multi-layered challenges in hospitals so far can be classified as inadequate and non-sustainable (Hoerbst et al., 2011; Krey et al., 2010; Koebler et al., 2010). Reasons for a less comprehensive spread of best practices in the hospital environment are as varied as the challenges do deal with. In the case of COBIT the lengthy documentation which consists of several hundreds of pages can be seen as an obstacle therefore plain and simple ask too much of IT executives or the circumstance that a COBIT implementation approach starts from the premise that a basic understanding of IT governance principles, issues and presuppositions like an IT strategy, corporate goals or a process-oriented IT department are already defined or still in place. According to Krey et al., an inadequate maturity of these issues right up to a complete lack however can be found in Swiss hospitals which make a “one size fits all” approach questionable and calls for an anticipative and more fundamental approach to the implementation of IT GRC (2010). The main objective of this research work is therefore to develop a design artifact for the adoption of IT GRC in hospitals taking domain specific requirements, limitations and considerations into account. Based on the previous problem statement the following research question is addressed:

“How can the adoption of IT GRC in hospitals, with respect to domain-specific characteristics and requirements, be systematically supported?”

The paper at hand is structured as follows: In the second section the methodology and research framework are presented. In Section 3 related work on the definition and implementation of IT GRC are discussed. The related domain-specific requirements for the adoption of IT GRC are presented in Section 4. Section 5 discusses the derived meta-model of the method and its method elements. In the final section, conclusions are drawn and an outlook on further research is given.

2. METHODOLOGY AND RESEARCH FRAMEWORK

The domain-specific problem and the thereof derived objectives are assigned to the research discipline of information systems (IS). Although IS has been affected by different sciences, a common opinion about adequate research methods to be used, is still missing. Hence, two research paradigms are currently discussed in IS: 1) behaviour-oriented research (BS) and 2) design science research (DSR). Whereas BS aims at the description and prediction of phenomena through the application of appropriate theories, DSR aims basically at the understanding of the truth in relation to a natural object of observation, and causes artificial changes on the research object itself (March and Smith, 1995). March and Smith have proposed a list of four general artifacts which can be classified in terms of DSR output: 1) constructs, 2) models, 3) methods, and 4) instantiations (p. 256).

- Constructs are the common vocabulary of a subject area and thereby describe problems and their solution. They come up during the formulation of the problem and are further developed during the research process.
- Models are “a set of propositions or statements expressing relationships among constructs” (March and Smith, 1995). Models can be understood in terms of “how” things are.
- Methods describe a number of activities (e.g., guidelines or algorithms) used to carry out tasks or develop findings. “Methods are goal directed plans for manipulating constructs so that the solution statement model is realised” (March and Smith, 1995).
- Instantiations represent operationalization constructs, models, and methods in their environment and thus express their applicability and demonstrate effectiveness.

Because of their problem-solving feature, methods are considered as an appropriate artifact of this research work. The method to be developed is thereof the artifact of the development process in terms of DSR and is been understood as a systematic guidance, which describes in a comprehensible way how to address IT GRC principles considering possibilities and constraints in hospitals. In order to systemise the DSR development process, the approach by Hevner et al. (2004) has been applied. The following phases and their purposes have been identified for this research work (cf. Figure 1). Within the (1) “problem identification” phase, the weaknesses of existing approaches and the thereby arising possibilities and goals of new artifacts are derived. In this work, the lack of dissemination of IT GRC methods in the health care sector is the initial problem. The research gap is characterised by the lack of methods and practices that meet the identified characteristics and requirements. Phase (2) includes the “requirements analysis” and the review of alternative solutions. The actual development of the artifact which includes the definition of related elements and the rigor application of research methods are part of the third phase (3) “method development”. The testing of the proposed method aims to point out its utility through suitable domain experts (hospital executives) and is part of the “evaluation” phase (4). The (5) “communication and reflexion” of the research results towards hospital executives is already part of the phases “problem identification”, “method development” and “evaluation”. Towards the science community the communication and reflexion of the results takes place through the publishing of academic papers. The “environment” describes the subject area of research in the dimensions people, (business) organisation and technology. In the research work at hand the environment is represented through the hospital and its particularities (cf. Section 4). The “knowledge base” provides the underpinnings and methodologies for the implementation of the research such as the principles of method engineering (ME) (cf. Section 5). However, the proposed research process distinguishes between the development phases (1) to (3) and the consequently related evaluation of the artifact and the interim research results of the related phases (1) and (2) (cf. Section 6). Based on the approach by Bucher et al. (2008) the evaluation process is sequentially organised and differs between a “cognisance goal” and a “design goal”. The sequence underlines that the “cognisance goal” of a research work is logically prior to the “design goal”. The method, as a design-oriented artifact, can therefore on the one hand be evaluated compared to the cognisance goal (requirements analysis IT GRC, research gap) and on the other hand compared to the real world (environment acceptance). The interim results of the research processes can be objects of the evaluation process (cf. Figure 1). *Type 1* rated the developed method to the research gap. This can be done by an analytical evaluation, in which the solution proposal is been assessed regarding the requirements. The research gap itself is not been assessed, as little as the use and application of the framework under real world conditions. *Type 2* analysis the method with regard to its contribution to the problem solving and its benefits. The method is been used under real world conditions (empirical evaluation). *Type 3* assesses the identified research gap compared to the realised problem of the real world.

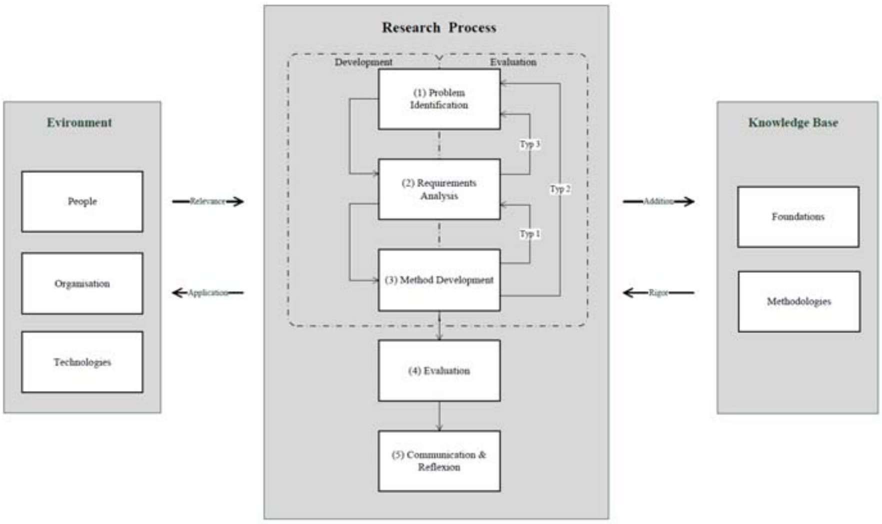


Figure 1. Overall research process, according to Hevner et al., 2004

The following section aims at the investigation of existing approaches and reflects therefore on the first research phase "problem identification" (cf. Figure 1). The review on the different IT GRC areas has been conducted with regard to their ability to provide methodical support for the adoption of IT GRC concepts.

3. IT GOVERNANCE, RISK AND COMPLIANCE – A LITERATURE REVIEW

In this research work the GRC context means IT related governance and describes the topics and methods that IT executives needs to address to govern IT within their hospital under consideration of imminent risks and legal requirements. As stated by PWC (2006) "GRC is not new. As individual issues, governance, risk management and compliance have always been fundamental concerns of business and its leaders. What is new is an emerging perception of GRC as an integrated set of concepts that, when applied holistically within an organisation can add significant value and provide competitive advantage". Driven by the current economic situation, an integrated approach to IT GRC is emerging rapidly (Gill and Purushottam, 2008). This organisation-wide approach "help all stakeholders collaborate effectively, reduce overall business risk, ensure better compliance and establish competitive advantage in the market place" (Gill and Purushottam, 2008, p. 38). When it comes to a methodical support of IT GRC, the approach by Gericke et al. proposes a situational method engineering (SME) approach for the implementation of GRC IS (2009). Over the years a considerable community has been built-up which promote the idea of creating method fragments rather than complete methodologies and tailoring them to specific situations at hand. The thus originated discipline of SME is based on the project-specific usage of methods, where different parameters (i.e. stakeholders, organisational culture, applications systems, competencies of in involved parties, and focus of the project or complexity) make a fitting of a method necessary. Within the work by Gericke et al. (2009) 21 method fragments have been identified for the support of GRC solutions in large companies. These method fragments have been classified into conceptual, strategic, organisational, technical and cultural aspects and finally roles have been defined and assigned to corresponding method fragments. Although each method fragment describes important activities, techniques and results, they lack of a defined process model in order to specify the sequence of activities needed to maintain the GRC system. Furthermore, as part of the development process of situational methods, Mirbel and Ralyté (2006) claimed for a derivation of rules for the assembly of method fragments (rule base). The approach by Gericke et al. (2009) did not meet this obligation and makes it still an open issue. In the following section, the different elements of IT GRC found in literature are examined. This step can be understood as part of requirements analysis described in Chapter 4.

3.1 IT Governance

IT governance is recognised as an integral part of enterprise governance today. It “consists of the leadership and organisational structures and processes that ensure that the organisation’s IT sustains and extends the organisation’s strategies and objectives” (IT Governance Institute, 2003, p.10). IT governance has been defined in various ways (e.g. Haes and Grembergen, 2008, Weill and Ross, 2004). These definitions differ in some aspects; however, they focus on the same issues, such as including management oversight, processes and rules for conducting various activities and a measurement and reporting mechanism of status and quality. However, a variety of concepts have been developed in the field of IT governance and value-based management (e.g. Arnold and Davies, 2000, Strenger, 2004) without elaborating on implementation or adoption issues. COBIT is one of these concepts and seeks to ensure that IT resources are aligned with an organisation’s business objectives in order to balance IT risk and returns. COBIT has been developed based on practical experiences from business which have been consolidated to generally accepted rules, processes, and characteristics. While a few method elements can be found in the COBIT framework (process, activity, role, goal, result, metric etc.) it lacks of a defined underpinning meta-model in order to present the logical and semantic relationships between the elements. The existing structures and tools within the framework make it a holistic concept, which provides the user navigation through the different aspects but at the same time hamper the integration of new framework elements or organisation specific issues. Such an approach was even performed in the aftermath by Looso (2010).

3.2 IT Risk Management

In the field of IT risk management a view contributions can be found dealing with risk management frameworks which allow for the identification of and response to risks in organisations (e.g. Jallow et al., 2007; Steinberg et al., 2004). Well known frameworks are, for example, the COSO framework or the risk management framework of the Software Engineering Institute. However, only few sources (e.g. Bruehwiler, 2003) address the implementation of such risks management frameworks and the challenges to overcome. These sources provide some valuable instructions, but lack of a structured and methodical contribution to the problem-solving.

3.3 IT Compliance

Recent regulations such as SOX, Basel II or Solvency II have driven research in the field of compliance management. Such research usually focuses on the identification of appropriate controls (Proctor, 2005) or on instructions on how to integrate controls into business processes (Rausch, 2006). However, only little advice is given for the integrated implementation of appropriate compliance concepts. Sharing of sensitive health information has been a concern for regulators for years. Different approaches have been taken: the U.S., e.g. relies on a sectoral regulation, which specifically protects health information through legislations such as the Health Insurance Portability and Accountability Act of 1996 (HIPAA) (USDHHS, 2003). The HIPAA is a regulative framework that includes among other things a privacy standard as well as a security standard. Covered organisations are health care providers, health plans, health care clearinghouses, as well as their business associates. However, many hospitals in Switzerland are owned or partly financed by the government; a stricter regulation applies for them. Data is protected in a similar manner as in the U.S., it is distinguished between sensitive data and profiles and non-sensitive data (EDOEB, 2012) However, the Swiss health system is based on a federal and decentralised structure at the same time. The twenty-six cantons in Switzerland are responsible to implement federal laws and ordinances, provide health care and cover parts of the hospitals costs (Walter, 2008). The high degree of cantons independence enables them to supplemented federal regulations by cantonal legislation. This partial autonomy has led to a great fragmentation with slightly different health systems across Switzerland and eventuated in twenty-six health departments which make additional co-ordination efforts between the federal and cantonal entities necessary. For that reason, the health care sector in Switzerland needs to confirm compliance of, e.g. IT policies, standards, procedures and methodologies with legal and regulatory requirements. Taking the characteristics of the IT GRC approaches and their methodical support into account, it becomes obvious that existing approaches from the disciples of SME and best practice do not suffice for the defined problem at hand. The following section picks up on the topic of tailored approaches to a given context and aims at the investigation of the hospital environment and IT GRC approaches and therefore reflects on the second research phase "requirements analysis" (cf. Figure 1).

4. REQUIREMENTS ANALYSIS

Since the method in this research work does not seek for the design or reorganization of the hospital, its departments or its organizational principles directly, but rather aims at the support to the adoption of IT GRC, requirements in this work describe given circumstances, principles as well as limitations in order to ensure the completeness and consistency of the method as such and its elements as well as ensure the method`s applicability and acceptability. Based on these understandings requirements engineering (RE) can be described as a totality of all activities for "finding out, analysing, documenting and checking" requirements (Sommerville 2011, p.83). The use of the term "engineering" is intended here to imply the systematic application of repeatable techniques to ensure that requirements have been elicited complete, consistent and with high context relevance. Therefore a structured approach following RE principles is crucial for this research work to guarantee on the one hand the completeness and relevance of the requirements in terms of its purpose and the application within the desired environment and on the other hand to comply with the demand for scientific rigor of the whole research project (cf. Figure 1). Following the approach by Sommerville (2011) RE process of this research work consists of three high-level activities: (1) requirements elicitation, (2) requirements specification, and requirements validation.

4.1 Requirements Elicitation

The (1) requirements elicitation describes the discovering of the related characteristics and then taking this unstructured collection and organises them in to coherent clusters. In doing so, domain-related restrictions, influences as well as peculiarities of hospitals (cf. Figure 1 "market view") are identified and applied to various enablers and inhibitors to IT GRC approaches. The reviewed characteristics are building the basis, which might help to understand the challenges that a sustainable IT GRC adoption has to meet within hospitals. The following list of characteristics is not exhausted but helps to understand the specific challenges to an IT GRC adoption (cf. Table 1).

Table 1. Characteristics of IT GRC approaches for health care

Characteristic (C.xx)	Description
C.01 Autonomy	"A life of its own" can be found in different organisational units within health care organisations as a result of the specialisation and division of labour, which are based on the complexity of medical services provided by physicians (e.g., internal medicine, surgery, radiology, etc.). The autonomy of organisational units lead consequently to decentralised decision-making, management of structures, information and authorities (Rockwell and Johnson, 2005).
C.04 Variety and complexity of IT GRC approaches	The variety and complexity of IT GRC approaches relates to the several frameworks, reference models and best practices, issued by both international standardisation organisations and private organisations exist in addition to the de facto standard COBIT for managing the different aspects of IT (Haes and Grembergen, 2008).
C.05 Management responsibility	The effective establishment of senior management support is seen as a key to success by various researchers who investigated IT governance adoption across different branches (Koebler et al., 2010). An increase of senior management involvement and support could minimize the weaknes of a low acceptance rate.
C.06 Role of IT	The CIO position within the organisation must develop a trusted relationship with top management to succeed in this responsibility. The health care organisation is a political arena (Hoerbst et al., 2011). An IT department has relatively little influence compared to other (medical) organisational units within the organisation. With limited organisational influence, the IT department with the CIO must educate management on the necessity of an integrated IT architecture to avoid bounded rationality during IT development.

4.2 Requirements Specification

The (2) requirements specification describes the process of putting the various characteristics into a standard which guarantees the unambiguity, completeness and consistency of the derived requirements. This activity is taking the investigated relations between hospitals and its particularities and IT GRC approaches and their characteristics and analysis the requirements needed to the adoption of IT GRC in the hospitals. As this research is assigned to the discipline of DSR, just a few contributions can be found dealing with the systematisation and provision of patterns/principles supporting the actual method development process. The following requirements analysis is based on the approach by Gericke (2009), who has expanded existing DSR patterns for the artifact construction by including patterns from engineering. The derivation process consists of three steps and aims taking all described characteristics into account. In the first step (1), the given similarities and different levels of granularity of the identified characteristics will be balanced logically (generalisation). The generalisation is a common methodology in DSR, as it reduces on the one hand the complexity and number of relations between characteristics and guarantees on the other hand the validity and traceability of requirements through logically identifiable relationships. As a final outcome, a list core statement (categories) is obtained. Based on the core statements in the *second step (2)* the central requirements can be derived. In the *third step (3)* it will be examined, if each characteristic is addressed through minimum one requirement. However it is not mandatory that all characteristics of a category address the particular derived requirement. It is more important that all characteristics are considered. The relationship between characteristics, their core statements resp. categories and the requirements are illustrated in Figure 2.

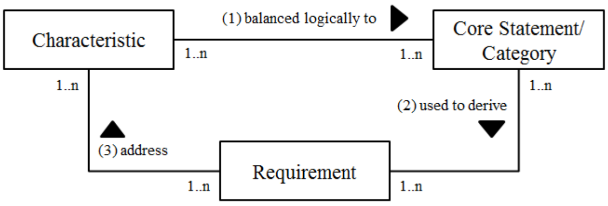


Figure 2. Requirements specification

As an output of this analysis the following list of requirements to a method for the adoption of IT GRC within the hospital environment is obtained (cf. Table 2):

Table 2. Requirements to a method for the adoption of IT GRC within the hospital environment

Requirement (R.xx)	Description
R.01	The method has to take existing power structures and ways of decision-making adequately into consideration.
R.02	The method has to give strong support to the different maturity levels of the areas of IT Governance, IT Risk Management and IT Compliance by making them individually appraisable and improvements predictable (adjustment between AS-IS and TO-BE structures)
R.03	The method requires both an initial phase of the project, as well as the establishment/transition into defined sustainable structures (project→operational)
R.04	The method must be able to rely on existing, practical concepts and tools (use of tools within the method)
R.05	The method must support a stringent view on GRC, however, allow an appropriate use (flexibility in dealing with GRC)
R.06	The method must have adequate conditions for their use. The conditions for the use of the method must not hamper the general discussion of IT GRC (benefit contribution must be greater than the threshold, e.g. the lack an IT strategy as a precondition of IT GRC may not in general prevent the examination of the topic as such)
R.07	The method must provide ways to take existing best practices already in use (e.g. ITIL or COBIT) adequately into account (openness of the method)

4.3 Requirements Validation

In the (3) requirements validation the derived requirements from the specification are reviewed according to existing approaches grounded in science and practice. The structured requirements engineering process leads to the circumstance that only at this time a justifiable and precise research question can be formulated. Emerged from this analysis, the research gap can be identified and thus the need for the development of an appropriate artifact becomes obvious. As the research question and the defined requirements have a significant influence to the development of the method, this chapter has to be understood not only as a basic discussion, but rather as the initial phase of the "method development" (cf. Figure 1). As implied in the previous sections it became obvious that the hospital environment is a highly meshed and heterogeneous system and the main challenges in order to establish IT GRC are primarily non-technical issues but rather social ones. In the next chapter the actual development of the method for the adoption of IT GRC within the hospital environment will be presented.

5. METHOD DEVELOPMENT

Before the actual method for the adoption of IT GRC in hospitals will be presented a conceptual background to ME and the meta-model of the method are given. ME as a research discipline deals with the systematic development of methods. According to Braun et al. methods are characterised through a clear goal orientation, systematisation and repeatability (2005). In addition, Greiffenberg lays a special emphasis on the guidance character of methods (2003, p. 11). Gutzwiller has analysed numerous approaches to ME and has derived generally applicable method elements (1992, p. 12). According to his analysis a method is represented through five generic elements: 1) activity, 2) result, 3) role, 4) technique and 4) data model. His method approach is characterised on the one hand through an universal usability e.g., the conscious omission of cardinalities between the method elements allow a certain level of latitude in terms of the purpose of the specific method elements and their arrangement and on the other hand show a wide acceptance in the IS world as it has been applied by various researches for different purposes (cf. Gericke et al., 2009; Wortmann, 2006) and therefore promises a successful implementation within the hospital environment. For the research work at hand, the contribution by Gutzwiller (1992) is been adapted and modified. To meet the requirements the following adjustments may have been carried out compared to the initial approach by Gutzwiller:

- Cardinalities have been used between the method entities in order to underline the significance and scientific rigor of the method.
- Additional method elements were added such as "phase" and process model to express the stronger relation of a task to a process phase (cf. Figure 3).
- The definition of "hierarchy conditions" is deliberately omitted. According to the understanding of the present work decomposed activities may be at the same time part of different aggregated activities (reuse), which would contradict a strict hierarchy.

However, it seems to be useful and necessary to elaborate the meanings of the single method elements as well as their interaction explicitly in order to derive an underlying method understanding for this research work. The names and definitions of the method elements to be used in this research work are provided in Table 3. In order to demonstrate the interaction of the different method element within the whole method, Figure 3 provides the meta-model of the method.

Table 3. Definition of method elements for the adoption of IT GRC in the hospital environment

Method Element	Definition
Activity	Task (e.g. assure support of top management) which create certain results. Task uses various techniques and can be assigned to an IT GRC area. In order to integrate existing best practices – activities of the method can be mapped to given approaches. Each task has a sequence and is hierarchically structured. Furthermore each task is performed by a role and belongs to a project phase.
Role / Stakeholder	Describes which organisational unit or person is applying the technique or activity. With regard to the hospital environment the roles will be performed by members from the medical or administrative departments. As IT GRC plays a minor role in hospitals is can be assumed that e.g.

	a chief physician of a clinic as a stakeholder is performing a temporary role as a project member. This element refers to requirement R.01.
Phase / Process Model	A phase is the result of “bundled“ activities. The sequences of activities are assigned to self-contained phases which allow the project-driven view on each IT GRC area independent of the maturity of each area. These elements refer to requirement R.02, R.03, R05 and R.06.
Result	Results are recorded in previously defined and structured documents and can be taken to pieces. According to the activity “assure support of top management” the result can be a reduction of resistance and increased project support.
Technique (Formal / Soft)	Techniques are assigned to formal tools or soft factors used in specific situations in order to deal with e.g. continued and hardened situations that require more sensible tools. Techniques can be understood as a detailed instruction for the development of a certain type of result. Techniques for the given activity “assure support of top management” are e.g. gain top management as project sponsor or establish regular meetings to elicit top management requirements. The distinction between formal and soft tools refers to requirement R.01 and R.04.
IT GRC Area	This element allows the hierarchical order of dedicated IT GRC areas in order to handle each aspect in more detail. E.g. in the area of IT governance further aspects of strategic alignment, value delivery, resource management or performance measurement can be supported with each activity. This element refers to requirement R05 and R.06.
Best Practice Model	This element refers to the requirement R.04 and R.07 and allows e.g. based on the approach by Looso (2010) the systematic adoption of existing best practices such as COBIT.

The different method elements are modeled according to the UML 2.0 class diagram.

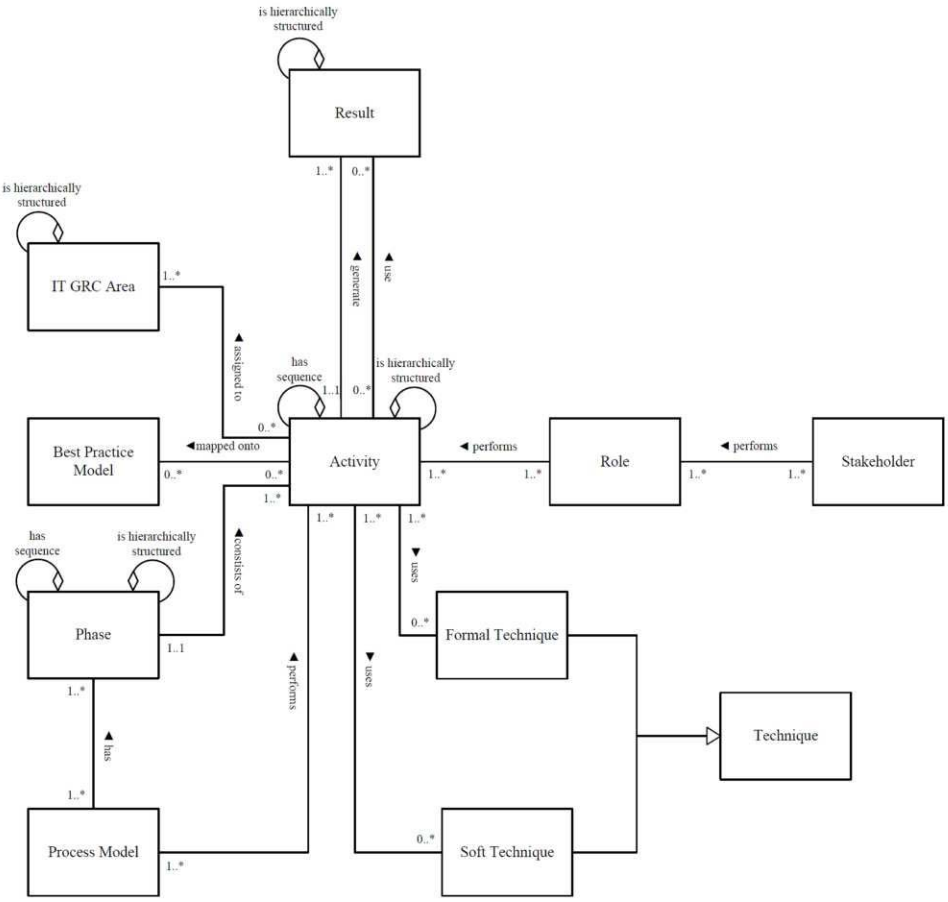
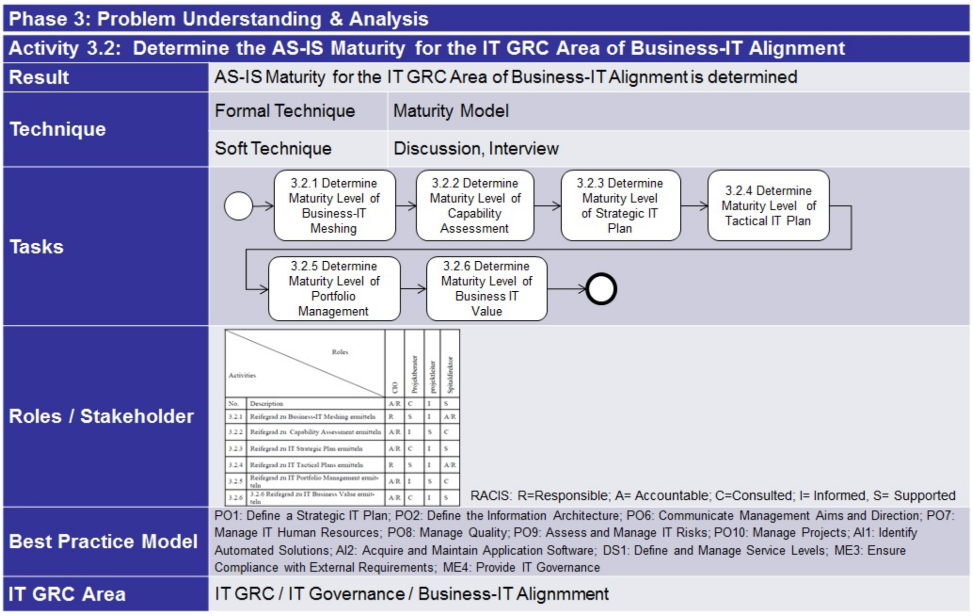


Figure 3. Meta-model of the method for the adoption of IT GRC in the hospital environment

Table 4 aims at giving the reader an understanding of the practical relevance and the final outcome of the application of the meta-model. The different activities needed for the adoption of IT GRC are preformed according to the proposed spiral model by Boehm (1986) as it combines advantages of top-down and bottom up approaches. At the same time the iterative process model allows the hospital organisation to become accustomed to the changed situation e.g., through quick wins and prototyping and thereby reduces the risk of broad resistance up to a complete failure of the project. For the adoption of IT GRC six phases have been defined (cf. Figure 4). The first two phases of the process model represent an initial setting of the IT GRC topic. As the majority of the Swiss hospitals have an underdeveloped maturity of IT GRC processes the actual process model starts amongst other things with the establishment of a common IT GRC understanding and a detailed stakeholder analysis including the various inhibiting and enabling power structures which might influence the adoption of IT GRC. Phase 1 aims therefore at a common understanding of IT GRC issues within the hospital IT department, seeks for the mitigation of project risks by conducting a structured stakeholder analysis and furthermore aims at the official commitment by the hospital senior management. After dealing with the topic internally, the second phase aims at the establishment of IT GRC issues with dedicated favourable business partners from clinics or wards. This phase includes therefore the project marketing and lobbying with the business. After these two initial phases the iterative part of the process begins. In the third phase the actual structured analysis of the different IT GRC areas and their maturities are investigated. Based on the agreed concept as a result of the third phase, phase 4 aims at the planning of concrete actions in order to achieve the defined goals. The actual implementation of the agreed actions is performed in phase 5. Phase 6 turns the project result into operations and guarantees the consistency and sustainability of the achieved results by provided the resources in term of organisational capabilities or budget to make IT GRC an on-going and lasting approach for hospitals. However, the innermost loop is the actual staring point of the process, and thus emphasises the organisational, financial or even “political” considerations (uncertain power structures and resistance) which may influence the design of the first prototypes (quick-wins). Each activity performed in one of the previous described six phases is subdivided into tasks which themselves are following a defined sequence. The roles and responsibilities according to each activity are documented according to a responsibility assignment matrix (Jacka and Keller, 2009). The actual RACI matrix has been expanded by adding a “support view” which expresses the possibility that a role may assist in completing the task. The adoption of existing best practices such as COBIT 4.1 is been guaranteed by a mapping of the IT GRC area to related COBIT 4.1 processes.

Table 4. Phase, activity and further method elements according to the IT GRC Area of Business-IT Alignment



Phase 3: Problem Understanding & Analysis		
Activity 3.2: Determine the AS-IS Maturity for the IT GRC Area of Business-IT Alignment		
Result	AS-IS Maturity for the IT GRC Area of Business-IT Alignment is determined	
Technique	Formal Technique	Maturity Model
	Soft Technique	Discussion, Interview
Tasks	3.2.1 Determine Maturity Level of Business-IT Meshing 3.2.2 Determine Maturity Level of Capability Assessment 3.2.3 Determine Maturity Level of Strategic IT Plan 3.2.4 Determine Maturity Level of Tactical IT Plan 3.2.5 Determine Maturity Level of Portfolio Management 3.2.6 Determine Maturity Level of Business IT Value	
Roles / Stakeholder	RACIS: R=Responsible; A= Accountable; C=Consulted; I= Informed, S= Supported	
Best Practice Model	PO1: Define a Strategic IT Plan; PO2: Define the Information Architecture; PO6: Communicate Management Aims and Direction; PO7: Manage IT Human Resources; PO8: Manage Quality; PO9: Assess and Manage IT Risks; PO10: Manage Projects; AI1: Identify Automated Solutions; AI2: Acquire and Maintain Application Software; DS1: Define and Manage Service Levels; ME3: Ensure Compliance with External Requirements; ME4: Provide IT Governance	
IT GRC Area	IT GRC / IT Governance / Business-IT Alignmment	

Activities \ Roles		CIO	Projektberater	projektleiter	Spitaldirektor
No.	Description	A/R	C	I	S
3.2.1	Reifegrad zu Business-IT Meshing ermitteln	R	S	I	A/R
3.2.2	Reifegrad zu Capability Assessment ermitteln	A/R	I	S	C
3.2.3	Reifegrad zu IT Strategic Plan ermitteln	A/R	C	I	S
3.2.4	Reifegrad zu IT Tactical Plans ermitteln	R	S	I	A/R
3.2.5	Reifegrad zu IT Portfolio Management ermitteln	A/R	I	S	C
3.2.6	3.2.6 Reifegrad zu IT Business Value ermitteln	A/R	C	I	S

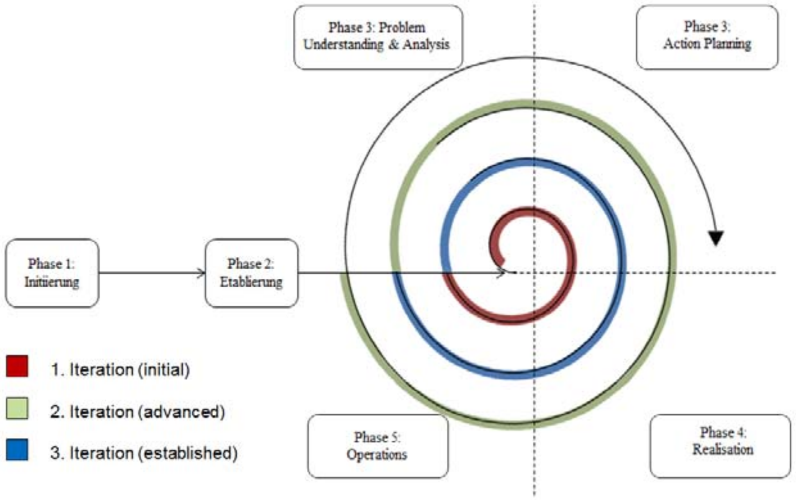


Figure 4. Process model for the adoption of it grc in hospitals

6. CONCLUSION

As ascertained by Krey et al. (2010) the self-contained organisational responsibility, the complexity of the processes and the lack of cross-organisational coordination make an overall comparable approach to management of assets, information and IT difficult. A great variety of responsibilities, notations, level of abstractions, tools and terminologies are the result. The present paper provides a brief introduction into the key concepts of IT GRC and the current debate about the reforms within the Swiss health system. It shows the drivers and benefits of both and leads to the research objective, i.e., the application of IT GRC to the field of health care. The proposed meta-model is a first approach to challenges at hand. However, its evaluation is still subject to further research (cf. Figure 1). It becomes obvious, that the selection of relevant validation criteria and the use of an appropriate validation method are crucial for the result. On the other hand the validation framework (cf. Figure 1) should not only include the review of the validity of the IT GRC method but furthermore evaluate the previous identified research gap and its correctness. The development of the IT GRC method refers to an identified problem in the real world, in addition to Cole et al. the proof of its "utility" can therefore be brought through its application in the real world (2005).

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DESIGNING PERVASIVE TELEMEDICINE APPLICATIONS USING VARIOUS GAMING PLATFORMS

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ABSTRACT

Modern gaming platforms combine computing power, sensors, remote connectivity and ubiquitous user interfaces representing a typical pervasive technology. Pervasive computing technologies have been successfully introduced to promote health and monitor chronic diseases. However, the potential of gaming platforms to serve as a building framework for pervasive telemedicine applications has not been fully uncovered. Existing telemonitoring systems provide limited support in implementing personalized treatment plans on pervasive videogame consoles. The goal of this project was to compare the functionality of the most widely used gaming platforms in terms of their applicability for telemedicine applications and to demonstrate the possibility of implementing a comprehensive telemedicine system using these platforms. We developed a Home Automated Telemanagement (HAT) system for patients with congestive heart failure (CHF) to provide support in following their individualized treatment plans as well as to monitor symptoms, weight changes, and quality of life, while educating the patient on their disease. The system was developed for use on the Nintendo Wii, the Microsoft Xbox 360, and the Sony Playstation 3. All three current generation videogame consoles allow for development of pervasive applications designed to be run in the console's web browsers. The systems were designed to be placed in the patient's home and to communicate all patient data to a central server implementing real-time clinical decision support. The system questions CHF patients daily on their condition, monitors their weight, and provides the patient with instant feedback on their condition. The systems were designed to be as simple as possible, making it usable by patients with no prior computer or videogame experience. Cognitive walkthrough was used to see what challenges were posed by each platform and interface. Comparative experience in using various platforms for pervasive telemedicine applications is reviewed in the article.

KEYWORDS

Telemedicine, gaming platforms, pervasive technologies, congestive heart failure, self-management.

1. INTRODUCTION

Modern gaming platforms combine computing power, sensors, remote connectivity and ubiquitous user interfaces. Provided wide availability of the gaming platforms and success these platforms enjoy in different age groups and populations, they represent a powerful pervasive computing technology. Pervasive computing technologies have been successfully introduced to promote health and monitor chronic diseases. However, the potential of gaming platforms to serve as a building framework for pervasive telemedicine applications has not been fully uncovered. Existing telemonitoring systems provide limited support in implementing personalized treatment plans on pervasive videogame consoles. The goal of this project was to compare the functionality of the most widely used gaming platforms in terms of their applicability for telemedicine applications and to demonstrate the possibility of implementing a comprehensive telemedicine system using these platforms. We used congestive heart failure as an example for demonstrating the potential of gaming platforms for pervasive telecare applications.

Telemedicine approaches will be useful in patients with CHF for several reasons. First, telemedicine will improve disease monitoring through more frequent assessment of symptoms. Second, use of patient self-management plans will accelerate treatment in the setting of CHF symptoms and thus decrease the utilization of health care resources [1]. Home Automated Telemanagement (HAT) is a telemedicine system designed to assist health care practitioners treat patients according to current clinical guidelines, to assist clinicians in educating patients, to assist providers in monitoring patients, and to assist patients in following individualized self-care plans [2-8].

Gaming platforms have gained significant acceptance in different population sub-groups including elderly [9, 10]. However, the feasibility of telemanagement application development targeting such gaming platforms as Wii, Xbox 360, and Playstation 3 for chronic disease management has not been explored systematically.

The Nintendo Wii, Xbox 360, and Playstation 3 are pervasive videogame consoles which all have options for browsing the web and navigating web applications. These widely available current generation consoles can potentially provide access to different interactive experiences. Adobe Flash allows content to be created and viewed on the Wii console through the Wii Internet Channel and on the Playstation 3 through the Playstation 3 browser. ASP.NET allows dynamic content to be created that can be browsed through the unofficial MCE Browser 2.2 plugin. We attempted to take advantage of the simplicity, popularity, and low cost of these current generation videogame consoles to deliver a comprehensive telemanagement system capable of being placed in a patient's home. Our aim was to design a low cost telemanagement system using three different videogame consoles, conduct a comparative analysis of development environment, and identify usability issues related to each interface. Since previous studies demonstrated potential of telemanagement in patients with CHF [11], this study used CHF telecare to demonstrate universal approaches for designing pervasive telemedicine applications delivered by various gaming platforms [12-13].

2. SYSTEM DESIGN

The HAT system is based on Wagner's model of chronic disease care [8] and supports patient self-management, comprehensive patient-provider communication, and multidisciplinary care coordination. The CHF HAT system comprises a home unit (Wii, Xbox 360, or Playstation 3 videogame console), a decision support server and a web-based clinician portal. The HAT home unit consists of a videogame console and an electronic weight scale. CHF patients answer questions regarding symptoms, side effects, adherence, and receive disease-specific education using the home unit. The home unit automatically transmits the results to the decision support server after each self-testing session. Data transmitted from patient's home are de-identified and encrypted. The videogame console home units transmit the information securely over the internet.

The web portal provides an interface for the collected patient data for all platforms. The web-based care management portal is used to set up customized clinical alerts and individualized action plans based on patient disease severity and other individual factors. The care management team individualizes alerts and action plans for each patient on-line whenever warranted. The updated action plans are automatically updated on the patient home units. If specified clinical conditions are met, email alerts are sent to the nurse coordinator. The coordinator reviews the information and if necessary consults the medical provider and the patient for management changes.

The HAT server runs Internet Information Services 7 (IIS 7) on Widndows Server 2008 which collects the patient's data and integrates it into a website which can be accessed by the patient's primary care management team. The web page was developed using Microsoft's .NET framework. This is a framework for developing dynamic websites which offers extensive built-in functionality and is supported by most browsers.

The CHF HAT Wii and Playstation 3 home unit applications were developed using Adobe CS3 with Flash 7.0 and runs on the Wii Internet Channel and Playstation 3 browser respectively. Using the Wii Internet Channel with an active internet connection allows the user to access Adobe Flash content up to version 8 through the internet. The Playstation 3 browser also allows the user access to Adobe Flash content up to version 9. The Wii system uses the motion controlled Wii Remote for navigating the application and browser while the Playstation 3 uses a traditional button and directional pad based controller. For the Wii, the positioning of the controller moves the cursor while the A button selects options. For the Playstation 3, the left analog stick controls the cursor while the X button selects options.

The CHF HAT Xbox 360 home unit application was developed using Visual Studio 2005 with ASP.NET 2.0 and runs on the Xbox 360 MCE browser 2.2 plugin for Windows Media Center. The system must be linked through the network to a computer running Windows Media Center with the MCE browser plugin. The MCE browser is not supported by Microsoft and is a third party plugin. The system uses the Xbox 360 controller for navigating the application and browser. The directional pad allows the user to select controls on the page while the A button confirms your choice.

Table 1. Relevant Game System Specifications

	Wii	**Xbox 360**	**Playstation 3**
Official browser available?	Yes (customized version of Opera 9)	No	Yes (customized version of NetFront)
Out of the box support	Must download Wii Internet Channel	Must be connected to a Windows Media Center computer with MCE Browser Plugin (not supported by Microsoft)	Comes with full browser installed
Processor	729 MHz IBM Broadway processor with 5 execution units	3.2 GHz PowerPC with 3 dual-threaded processor cores	3.2 GHz Cell processor with 7 single-threaded synergistic processing units cores (not directly comparable to Xbox 360 processor cores)
Main System RAM	64 MB GDDR3 RAM	512 MB GDDR3 RAM (700 MHz), shared with GPU	256 MB XDR RAM (3.2GHz)
Storage Space	512 MB of internal flash memory (expandable up to 32GB with SD or SDHC card)	256 MB onboard –320GB HD depending on model	20GB HD-320 GB HD depending on model
Ethernet Port	No; optional with USB-based add-on.	1 port (100 Mbs)	1 port (1 Gbps)

3. RESULTS

The Wii HAT, Xbox 360 HAT and Playstation 3 HAT home units were successfully designed and implemented. The Xbox 360 HAT home unit was successfully linked through a wireless G router to a Gateway M-6864 latop running Windows Vista Home Premium with Windows Media Center. A Lifesource CHF-321P digital scale was used for weight measurement in all systems.

Information was successfully sent and received from a remote location to the IIS 7 server using an active wireless internet connection. The web portal was successfully launched and provides full functionality. All three home units run the HAT program when it is selected from the browser’s favorites menu and the user can navigate through the menus using the standard controller for each system. All 3 systems provide identical functionality through different interfaces. The text is large and easy to read while all the instructions are kept as simple as possible.

Table 2. Browser Multimedia Support

	Wii	**Xbox 360**	**Playstation 3**
Flash	Yes, Flash Lite 3.1 (up to version 8)	No	Yes, up to version 9
Quicktime (.MOV)	Only files compressed with MJPEG format	No	No
WMV	No	No	No
MP4	No	No	Yes (H.264/MPEG-4 AVC High Profile (AAC LC))
AVI	Only files compressed with MJPEG format	No	Only files compressed with MJPEG format
Streaming MP3	Only within Flash player	No	Only within Flash player (can be downloaded and played)

Table 3. Browser Web Standards Support

	Wii	Xbox 360	Playstation 3
W3C HTML 4.01	Yes	Yes	Yes
W3C HTML 5	Some (Canvas and Forms mostly supported, video/audio not supported)	No	No
Javascript	Yes	Yes	Yes
CSS	Yes	Yes	Yes
AJAX	Yes	No	No

The home unit main menu displays several options to the user. The main menu as seen on all 3 systems is shown in Figure 1.

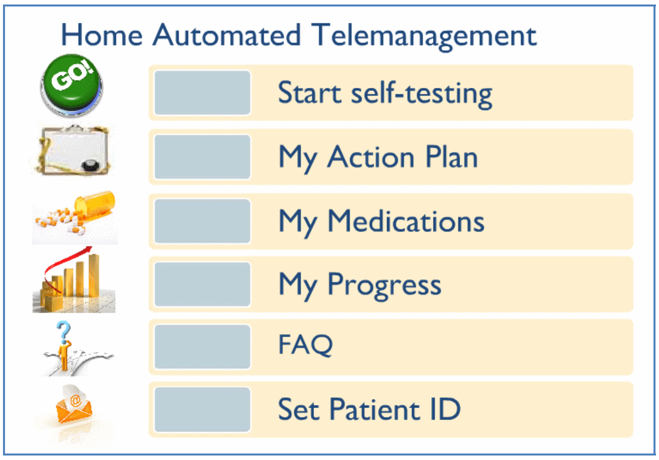


Figure 1. Home unit main menu.

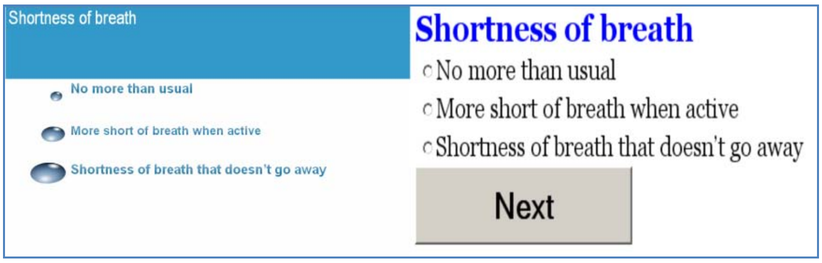
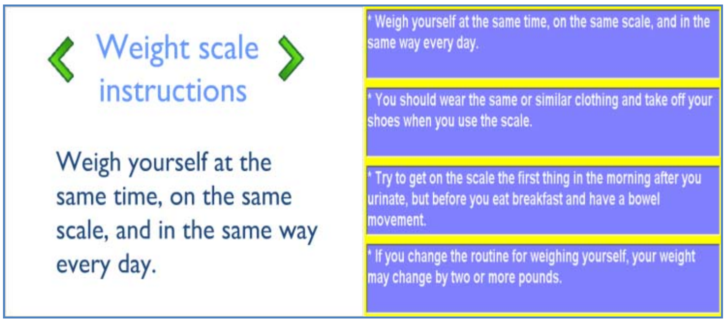


Figure 2. Wii and Playstation 3 Flash (left) and Xbox 360 ASP.NET (right) Symptom Diary Question

The first section is self-testing. In this section the patient will begin with a self-testing portion where they answer a series of questions pertaining to their chronic condition. A symptom diary question screen is shown for each platform in Figure 2.

The responses are used to gauge the overall health of the patient, as well as to raise flags when the patient may be experiencing congestive heart failure symptoms that require immediate attention and treatment. After answering general symptom questions the patient is prompted by voice and text to correctly mount a weight scale. On the home units the patient uses a digital scale to weigh themselves, then enters the data through an on-screen interface. On the Wii and Playstation 3, the weight is entered by selecting up and down arrows until the correct weight is shown, while on the Xbox 360 it is entered into a text box using the on-screen keyboard. The scale instructions for the home units are shown in Figure 3.



Weight scale instructions

Weigh yourself at the same time, on the same scale, and in the same way every day.

* Weigh yourself at the same time, on the same scale, and in the same way every day.

* You should wear the same or similar clothing and take off your shoes when you use the scale.

* Try to get on the scale the first thing in the morning after you urinate, but before you eat breakfast and have a bowel movement.

* If you change the routine for weighing yourself, your weight may change by two or more pounds.

Figure 3. Weight scale instructions for Wii, Playstation 3 (left) and Xbox 360 (right)

The current patient's action zone is then immediately calculated and displayed. A screen displays weight and an absolute weight change from the previous day. The zone of the action plan is determined using the information provided earlier in the self-test. A sample action plan as seen on all 3 systems is seen in Figure 4.

After completion of the self-testing portion the patient is given an educational "Tip of the day." Each successive educational portion will end with a question about the previous day's tip. The question will be repeated each session until the patient is able to answer correctly. Then a new question is offered during the next self-testing session. At the end of an educational section, the patient will be asked several questions from the specific section. Upon completion of the educational portion, the symptom diary responses as well as the results of weight monitoring are stored for transmission. Each system sends data to the server through a wireless connection and relays all stored results/messages.

The HAT system also allows the patient to access their Action Plan. The patient can view their current action plan and their other plans for different zones. They can also view a graph of their recorded weights or action plan zones and the medications currently prescribed to them. The patient can also send either a personal or pre-written message to the care management team.

The CHF HAT web portal is hosted on our servers and can be accessed securely by the care management team using any computer with a web browser and an internet connection. The care management team can also view a monthly report which displays graphs and statistics of the patient's information collected over the past month. A section of a sample report is seen in Figure 5.

yellow zone ACTIONS

1. Keep all your medical appointments
2. Follow a low-salt diet
3. Weight yourself each day
4. Keep taking your medications as prescribed

If you've been doing all of these, call your heart failure doctor

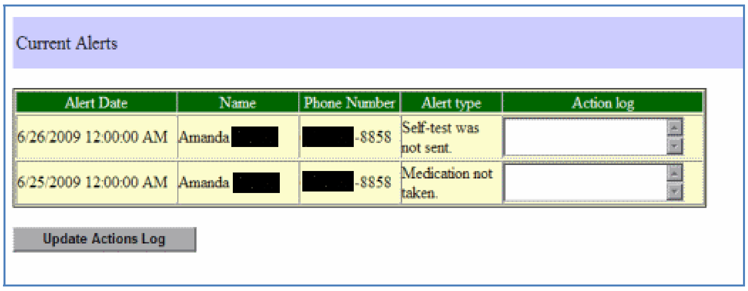
Figure 4. Sample "Yellow Zone" action plan

Period: 5/29/2009 - 6/28/2009

Number of Alerts	Self-Test Compliance	Medication Compliance
2	60.00%	-
Mean Score	**Mean Subscore**	**Mean Weight**
16.67	5.00	125.67

Figure 5. Sample monthly report data

The website also shows any current alerts for the patient and allows the care management team to log their response to the alert as shown in Figure 6.



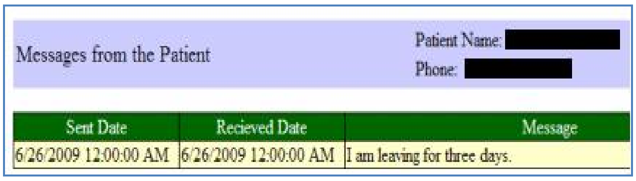
Current Alerts

Alert Date	Name	Phone Number	Alert type	Action log
6/26/2009 12:00:00 AM	Amanda [redacted]	[redacted]-8858	Self-test was not sent.	
6/25/2009 12:00:00 AM	Amanda [redacted]	[redacted]-8858	Medication not taken.	

Figure 6. Current Alerts

The care manager can change their alert parameters for the patient, send a message to a patient, or view a list of the messages sent from the home unit to the server as seen in Figure 7.

Our investigation of each development platform revealed different development challenges. Adobe CS3 provided a simple and visually powerful development environment for the Flash application used on the Wii and Playstation 3. Slick visual transitions and effects were easy to integrate in the system while audio support allowed for sound effects and audio feedback as well as options for the visually impaired. The Wii browser had issues running larger Flash applications with audio and video due to low system memory. Visual Studio 2005 with ASP.NET and VB.NET used in the development of the Xbox 360 application allowed for quick development of dynamic web applications for systems which do not support the Adobe Flash Plug-in.



Messages from the Patient

Patient Name: [redacted]
Phone: [redacted]

Sent Date	Recieved Date	Message
6/26/2009 12:00:00 AM	6/26/2009 12:00:00 AM	I am leaving for three days.

Figure 7. Messages from the patient

While development was straightforward and suited towards creating an application which would run on a feature sparse browser, lack of audio and visual effects seemed to lessen the impact of the feedback the system provides.

The interfaces for each system each provide unique challenges in navigating the applications and completing daily monitoring. Major differences are outlined in Table 4.

Table 4. System Interface Differences

Interface	**Wii**	**Xbox 360**	**Playstation 3**
Controller Type	Motion controller	Standard Gamepad	Standard Gamepad (No current browser support for Move controller)
# of buttons	8 + directional pad	11 + directional pad + 2 analog sticks	11 + directional pad + 2 analog sticks
Cursor Navigation	Cursor navigates using motion control	No cursor, directional pad for selecting controls	Cursor navigates using analog sticks
Responsiveness of controls	Very responsive	Slow, often a lag between pressing a button and system response	Very responsive
Audio Playback	Yes, using Adobe Flash Player	No	Yes, using Adobe Flash Player

We administered a cognitive walkthrough protocol to identify usability issues related to remote controls. Participants commented about the Playstation 3 that the system was "… extremely easy to navigate," and that compared to the Xbox 360 system that "The controls were loose and fluid. I wasn't constrained by the choppy controls like the Xbox system. It makes it much clearer what you're selecting than the Xbox." Comparing the Playstation 3 to the Wii they said, "Because I don't have to deal with hand movement it's much easier to use. The controls don't rely on your physical movement."

Comparing the similar Playstation 3 and Xbox 360 controllers they remarked, "It's pretty much the same layout [as Xbox 360]. It (Playstation 3 controller) fits in your hand much better than the Xbox." Comparing the Wii controller to the Xbox 360 and Playstation 3 controllers, participants commented, "The Wii controller is not for shaky-handed people."

When evaluating the visual design of the Flash Playstation 3 and Wii systems they commented, "It's (Wii and Playstation 3 systems) much better to look at than the Xbox program. The colors look good. This one definitely looks better."

The overall consensus was that the Wii and Playstation 3 versions of the system had superior interface and controls to the Xbox 360 system which suffered from slow responsiveness and clunky controls within the browser. The Playstation 3 controller fared better than the Wii controller as it was simpler to navigate the cursor with the analog stick than the Wii's motion dependant controller. The visual style of the Wii and Playstation 3 flash application was preferred to the sparse visual options supported in the Xbox 360 version. The lack of audio playback through the Xbox 360 browser also contributed to the poor response towards the system by participants.

4. CONCLUSION

The CHF HAT system's ease of use and convenience can provide reluctant patients with an easy way for care management teams to receive daily feedback from the patient. While care management team visits would still be important to the patient's care, allowing the patient to monitor their health frequently and educating them on their condition will hopefully increase their condition awareness, self management, and quality of life. The CHF HAT system can successfully provide support to patients in following their CHF action plans and to aid them in being adherent to their treatment regimens. Providing the system on different platforms can help to reach as many patients as possible. We are also looking toward expanding the HAT system to other computer platforms. Today's pervasive current generation videogame consoles provide a simplified interface combined with web connectivity have created more potential environments for the HAT disease management system. Systems such as the Wii, Xbox 360, and Playstation 3 are becoming viable options for the CHF HAT platform.

The CHF HAT Wii, Xbox 360, and Playstation 3 systems are viable systems to test in the management of CHF patients. These systems can be efficiently implemented for CHF, as well as other conditions, and is recommended for future use and expansion. Each system provides different development, interface and web connectivity challenges for accessing HAT systems. A comprehensive evaluation using a clinical trial design is warranted for pervasive telemedicine applications based on modern gaming platforms.

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AUDIO CONTEXT CLASSIFICATION FOR DETERMINING BLOOD PRESSURE SELF-MEASUREMENT ADHERENCE

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ABSTRACT

Blood pressure self-measurement (BPSM) is used in the diagnosis of hypertension and requires the patient to follow a range of recommendations in order to be considered valid for diagnostic use. One recommendation specifies that the patient must remain silent during measurements as talking may bias the measurement. Current state-of-the-art blood pressure (BP) devices cannot verify whether the patient complies. We suggest using audio context classification based on feature extraction and classification using an artificial neural network classifier to detect patients talking during measurement. For this purpose, we have developed an experimental algorithm and a software evaluation framework to obtain experimental data. We trained the algorithm using machine learning techniques with voice data from 80 unique test-subjects recorded in the laboratory setting, in order to classify talking and silence as two distinct modalities. Laboratory data from another 20 test-subjects were used to evaluate the algorithms efficiency. The algorithm was integrated into an integrated BPSM solution and evaluated with further 22 test-subjects. Results indicate that audio context classification is feasible with 99.0% correctly classified results in the laboratory and 97.3% in the integrated BPSM solution evaluation setup.

KEYWORDS

Blood pressure, self-measurement, machine learning, pervasive healthcare, data quality.

1. INTRODUCTION

Blood pressure above 140 mm Hg systolic and 90 mmHg diastolic is defined as hypertension and is a well-known risk factor for heart attacks, strokes, heart and kidney failure and other heart and circulatory diseases (Campbell and McKay, 1999). Blood pressure self-measurement (BPSM) is used to diagnose patients suspected of hypertension, as well as for long-term monitoring of several other chronic patient groups. It is considered a valid method for determining the blood pressure (BP) providing that the best-practice recommendations for obtaining the measurements are followed (Pickering, 1991, Pierdomenico et al., 2009). These recommendations are defined by a range of national and international hypertension associations (Pickering et al., 2005, Bang et al., 2006, Frantz et al., 2010). The list of recommendations varies amongst the organizations, but all of them recommend that patients should not to talk during BP measurement. Talking during measurement has been reported to raise the measured BP levels by 6.7 - 9.5 mm Hg, and higher if it is work related. Consistent overestimation of diastolic blood pressure by 5 mm Hg or more is reported to more than double the number of patients being diagnosed as hypertensive. Patients identified incorrectly as being hypertensive could experience adverse effects of unnecessary medication as well as higher treatment cost (Campbell and McKay, 1999). The use of information technology for obtaining BPSM has been investigated in several studies without verifying patient adherence to the recommendations (Huniche et al., 2010, AbuDagga et al., 2010). Current state-of-the-art BP devices are not capable of sensing incorrect usage (Wagner et al., 2012). As only measurements following the recommendations are considered reliable (Pickering, 1991, Pierdomenico et al., 2009), it may be argued that the quality of data from the reported studies (Huniche et al., 2010, AbuDagga et al., 2010) could be indeterminate and the clinical use of such systems could lead to over or under medication of the patient (AbuDagga et al., 2010, Pickering et al., 2008). As a strategy for overcoming these challenges we have previously suggested utilizing intelligent environments to detect user context to determine the level of user adherence (Wagner et al., 2011). Context-aware technologies (Dey, 2010) have been used in a number of healthcare related studies (Varshney, 2007, Bardram and Nørskov, 2008, Bardram, 2008), including as an intervention strategy for improving medical adherence (de Oliveira et al., 2010, Wan, 1999).

The aim of this study is to determine whether audio context classification as a method can be used to detect whether BPSM users talk during measurements. Specifically, we suggest developing an audio classification algorithm and supporting platform for performing context classification experiments.

2. METHODS & MATERIALS

2.1 Study Design

We followed an iterative experimental research agenda designing a proof-of-concept prototype in order to evaluate the feasibility of the suggested solution (Bardram, 2008). Initially, we developed an experimental audio context classification algorithm (ACCA) and evaluated its performance and feasibility in a controlled laboratory setting in a pilot study with 17 test-subjects, based on using the supporting experimental software application tool (SESAT). We iteratively evaluated and refined ACCA using SESAT until we reached satisfactory performance levels in the laboratory. Following this, we integrated ACCA into an existing experimental BPSM evaluation solution (EBSMES). EBSMES is based on the Reliable Evaluation Infrastructure (RELEI) and OpenCare platform (Wagner and Nielsen, 2009), and was used in conjunction with relevant context sensors in order to evaluate system performance and feasibility.

2.2 Audio Context Classification Algorithm (ACCA)

2.2.1 Audio Classification Method.

The standard approach to audio classification is feature extraction followed by classification with a classifier such as an Artificial Neural Network (ANN) or Hidden Markov Model (HMM) classifier (Bishop 2006). Typically, such classifiers have to be trained on a training set of data and can then afterwards be used on new data. The performance of the classifier is evaluated on a (separate) test set of data. The training data set typically has a large influence on the classifier performance.

2.2.2 ACCA Design Decisions

Feature extraction for audio classification is often based on the spectral (or cepstral) content over short-time windows such as 50 millisecond windows. Other features could be short-time energy or zero-crossing ratio (Rabiner and Juang ,1993). In our work, we used the so-called Mel-Frequency Cepstral Coefficients (MFCCs) which have been used to represent both music and speech successfully (Davis and Mermelstein, 1980). For each 50 millisecond window, 13 MFCCs are extracted using Matlab software found in (Brookes, 2006). Besides, a hopsize of 20 millisecond was used between windows such that 50 13-dimensional feature vectors are extracted each second. There exist an abundance of different classifiers and classification methods. We settled for the Artificial Neural Network classifier (ANN) which has been implemented in Matlab (Ashton University, 2012). One of the advantages of the ANN as compared to more advanced classifiers is the low computational demands to classify new data. Although the training phase takes a significant amount of time, classifying new data can easily be done in real-time on even small embedded platforms. The ANN classifier is a 2-layer feed-forward ANN (i.e. a single layer of hidden units) and uses the so-called Softmax function as output function. A regularization term was added to the classifier cost function to avoid over-fitting. We used 160 sound recordings of the environments “silence” and “speech” to train the classifier and 40 separate samples to test the classifier. The output from the ANN classifier is an estimate of the probability that the current 50 millisecond time window will belong to a given class. Instead, we would like to reach decisions on a 2 second time window since this time window is more appropriate in our application. To achieve this, hard assignment is performed on the short-time windows and combined with majority voting. Hence, each short-time window is assigned to exactly one class and each 2 second time window is assigned to the class with the majority of short-time “votes”. A hopsize of 1 second is used between the 2 second windows to get 60 classifications per minute.

ACCA was developed and trained using MatLab. In order to be integrated with the SESAT and EBSMES platforms, it was adapted and compiled into an assembly dynamic link library, allowing for integration into our two test-bed applications.

2.3 Supporting Experimental Software Application Tool (SESAT)

We developed SESAT as an experimental application to obtain training and evaluation data from test-subjects and perform evaluation experiments and statistics. SESAT is designed to gather audio data recordings of 1 minute in length for training and evaluation purposes, while also allowing the test-leader to attach meta-data that will pre-classify data as either talking or silent. Other meta-data recorded include: date and time, as well as age and gender of the test-subjects. Furthermore, SESAT can apply the audio context classification algorithm (ACCA) on data and provide statistics on ACCA classification performance.

2.4 Experimental BPSM Evaluation Solution (EBSMES)

In order to evaluate the feasibility of using ACCA as part of an integrated BPSM scenario we developed an evaluation prototype that can provide the necessary components and functionality: EBSMES. We based EBSMES on the RELEI infrastructure which provides us with a touch screen computer interface and access to the needed sensor components. This includes the ability to communicate with different types of BP devices, both wired and wireless, as well as relevant context-aware sensor technology for detecting test-subject presence. We chose the A&D UA-767PBT (used: A&D Digital Blood Pressure Monitor UA-767PBT, A&D Company Limited, Japan) BP device for the solution, as A&D devices are well-known from current clinical praxis as well as from clinical trials (Huniche et al., 2010, AbuDagga et al., 2010). We utilize the sensor chair (Wagner et al., 2011a) and associated software components in order to register test-subjects getting seated, and later standing up. This is used to determine when to start recording audio data, and when a measurement session should be considered complete. The sensor chair appears as a plain white chair, as can be found in normal Scandinavian households (see Figure 1-2).

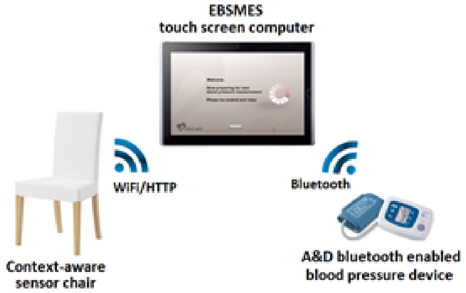

Figure 1. The EBSMES research solution running on a touch screen computer. When a test-subject is seated it starts recording audio data. When a BP measurement is received the recent audio data are processed using ACCA.

The A&D BP device, touch screen computer, sensor chair, and ACCA proxy components are integrated and a user interface was created allowing the test-leader to follow the status of a test session, as well as access results easily (see Figure 1 and 2). Also, all BP measurement data and contextual meta-data are collected in a structured format using extensible markup language (XML), and all audio data are stored as raw PCM files for later review.

2.5 Determining Algorithm Timing and Rules of Outcome

The European Society of Hypertension recommends that: “Patients should be encouraged to relax and be advised that neither they nor the observer should talk for the few minutes before or during the blood pressure measurement.” (O'Brien et al. 2003). Other hypertension organizations do not specify the timing, other than stating that no talk is permitted during measurements (Bang et al. 2006, Pickering et al. 2010).

Figure 2. The touch screen computer running EBSMES next to the A&D blood pressure device (left picture, above) and the sensor chair (left picture, below). User interface (right picture) and the A&D blood pressure device (below).

We have decided to define operating time span to begin when a user is seated in the sensor chair, and end when the user rises from the chair. The A&D BP device is not a real time device, and delivery of a BP measurement must be considered to be non-deterministic. By experimentation we have measured the typical timing from when the user activates the BP device by pressing the start button, to the time when the measurement is received at the client device to be typically 30 seconds, and up to a maximum of two minutes. As such, we have chosen to define the operating time span we are interested in to be the latest two minutes timespan in which we have received the current BP measurement. This should include the time immediately before the measurement, the measurement itself, and the time immediately after. We argue that this is a good indicator for the speech level during the measurement phase. All BP measurements performed within this time span will either be classified as “talk detected” or “silent”. Also, we include a percentage of talk detected, which we will use to verify interpreted data against the audio recordings using manual inspection of the audio data in case of misclassifications.

2.6 Study Design of Laboratory Experiments

2.6.1 Gathering Experimental Data

We invited 100 test-subjects (ages 19 to 64) to our laboratory to obtain training and evaluation data for ACCA. Each test-subject was individually instructed on study purpose and protocol by the test-leader, and age and gender was recorded. Data are kept anonymous and confidentially. Each test-subject was asked to speak uninterrupted for 1 minute. SESAT allows the test-leader to categorize a recording as either talking or silent. Following this, a 1-minute data sample was automatically recorded as an 8-bit 11 KHz PCM audio file, along with the meta-data acquired during the interview. The same procedure is repeated, with the test-subject being asked to remain silent, in the sense not to talk during the 1 minute interval. Other activities were allowed, including reading the paper and similar. The outcome of each test case is two audio samples with the collected meta-data.

2.6.2 Training ACCA with Experimental Data

ACCA was trained with the data from 80 test-subjects manually selected from the data set to provide a broad sample size on parameters age and gender. Training was performed using MatLab 2010, and produced an ANN classifier file. The ANN classifier is used by ACCA as runtime parameters during classification of new data sets.

2.6.3 Evaluation of Classifier with Test Data

We evaluated ACCA performance with the test data set consisting of the remaining 20 test-subjects. SESAT automatically applies ACCA to each set of evaluation data, and provides a classification success parameter from 0 to 100%. After having processed all 40 samples, it provides statistics on the results.

2.7 Study Design of Integrated BPSM

2.7.1 Experiment Design

ACCA performance may differ when used as part of a BPSM solution rather than stand-alone. In order to evaluate ACCA performance in a realistic BPSM context, we invited 22 test-subjects to perform three BPSM measurements, using a state-of-the-art BP device as used in current clinical praxis (see Figure 2 and 3).

Each test-subject was briefed on how to perform a correct BPSM, both using a paper-leaflet, as used in current clinical praxis, as well as with an oral instruction. Test-subjects were then asked to sit in the special sensor chair that is part of EBSMES and mount the BP device. An audio recording was performed of the measurement process. All recordings were treated confidentially. Test-subjects were provided with both an informed consent form and the experiment protocol.

The test-subjects were instructed to perform a total of three BP measurements. They were encouraged to rest up to three minutes before the first BP measurement, talking both before and during the first two measurements. If a participant does not follow the given instructions, the test-leader will note this, but not enforce protocol. If test-subjects are not talking as instructed, a natural conversation is started engaging the test-subject in a dialog to keep the talk flowing.

2.7.2 Evaluation of Results

Test-subjects were instructed to talk continuously during the first two measurements and stay completely silent during the third. Therefore, it was expected that each experiment would classify close to 100% as talking for 2/3 of all measurements performed, and close to 0% (silent) for the remaining. It is unlikely that test-subjects can manage to remain completely silent, respectively talk continuously during all measurements.

By examination of the data from the pilot study we found that all session measurement samples would either be less than 10% talk (user keeping silent) or more than 90% talk (user talking). We therefore suggest categorizing 90-100% percentage talk detected by the classifier as a successful session classification of a “talking measurement session”. Similarly, we categorize 0-10% to be a successful session classification of a “silent measurement session” and 11% to 89% will be considered an indeterminate classification result. We have performed manual inspection of all successful measurements to determine whether the recording actually contains talking or silent respectively. For indeterminate classification results, we have manually inspected the audio recording to find an explanation. Explanations could include: users not talking when required, users talking when not required, as well as recording, conversion, or transmission errors.

Indeterminate classifications (from 11-89%) was summed and divided with the sum of all the samples to form the error rate parameter. The remaining successful classifications form the accuracy parameter as a measure for the integrated systems performance.

3. RESULTS

In Table 1 we present the results from the laboratory experiment. In table 2 we present the results from the integrated BPSM experiment.

Table 1. Results overview, laboratory experiment

Parameter Value	
Average age of test-subjects	31
Minimum age	19
Maximum age	64
Audio samples in test set	40
Unique test-subjects in test set	20
Total of 50 ms samples in test set	128007
Error rate on 50 ms samples in test set	10.1%
Total of 2 s samples in test set	2559
Error rate on 2 s samples in test set	1.0%
Accuracy on 2 s samples in test set	99.0%

Table 2. Results overview, integrated experiment

Parameter Value	
Average age of test-subjects	35
Minimum age	22
Maximum age	67
Obtained BP measurement samples	74
Unique test-subjects in test set	22
Test-subjects, ≥ 3 BP samples	17
Test-subjects, 1 or 2 BP samples	5
Successful session classifications	72
Indeterminate classifications	2
Error rate	2.7%
Accuracy of session classifications	97.3%

4. DISCUSSION

4.1 Classification Performance and Accuracy

The solution presented in this paper achieved 99.0% correct classification of test samples and 97.3% correct classification rates in the integrated BPSM scenario. Only during two "observed silent measurements" did we reach indeterminate classification results. The two related audio recordings were manually inspected to find an explanation. In the first, the test-subject talked during the "silent" measurement. This did not account for the entire misclassification however. In the other related audio sample, no apparent reason could be found. One successfully classified sample (90% talk detected) contained an intense static noise of 5-6 s in duration. This could be due to recording problems, or codec conversion error. Other undetected classification errors could exist in the remaining data sets, but these would require additional manually inspection of the audio samples to determine and was not deemed relevant.

As such, results indicate that it is possible and feasible to detect users talking during BPSM, even though minor incidences of misclassifications can occur with the present evaluation prototype. However, we found no significant issues with regard to false negatives or false positives during the experiments.

4.2 Experimental Setting

Even though the test-subjects were allowed to perform the BPSM autonomously, they were in fact test-subjects being part of a controlled experiment rather than patients self-diagnosing in a fully unsupervised in situ and real world setting. Thus many other factors could exist in situ affecting the unsupervised measurement process, which we have not addressed in the current study. As such, we cannot be certain that our results are generally applicable, until the solution has been tested in the real world setting.

4.3 Potential Future Use

The ability to verify whether a measurement was taken following the published recommendations or not, is relevant for securing high quality measurements (Wagner et al., 2012). The ACCA algorithm could be used for quantifying the quality of the individual measurements, providing better decision support for the treating physician or healthcare professional. ACCA could also be used to provide feedback to the user during measurements. The solution could warn the user that the measurement data might be subject to bias due to the user talking, or it could even require the user to remain completely silent before it would allow a measurement to be taken. This kind of brute force enactment might however meet resistance with the users, confusion over device intensions, or even fears and anxiety. Therefore, we argue that such strict adherence aid strategies should be used with care, and may not be the best first application for this novel technology. Instead, we suggest considering employing it as an adherence verifier that would allow the treating healthcare professional, relatives, or other support persons, to identify weaknesses in the post-measurement process, and point them out to the users.

Furthermore, we have considered whether automatic correction facilities could be implemented based on the increased contextual knowledge from this solution. However, from both literature (Campbell and McKay, 1999, Pickering, 1991, Campbell et al., 1990) and our experimental results, we have seen that bias levels can vary considerably from user to user. To exemplify, the systolic blood pressure could be raised with 5 mmHg on average when comparing test-subjects talking vs. not talking. But for individual users, this could vary from a fall of 7 mmHg to a rise of 17 mmHg due to talking. In other words, automatic adjustment of the measurement does not appear feasible. Rather, a kind of confidence interval parameter might be used, e.g. indicating the reduced validity of a measurement with a confidence interval, for instance 140 mmHg ±15 mmHg, indicating that the measurement may have incurred potential bias of such magnitude. Previously, we have suggested using a red, yellow, green metaphor as a basic indicator of the adherence level.

4.4 Additional Environment Audio Bias Sources

There are several potential sources of bias that could impact ACCA classification performance; including a range of audio signals that are frequent in the home context: radio, TV, music, children playing, friends and family talking. This is important when considering in situ evaluation of the suggested solution, as such audio signals can be mistaken for the user talking, thus rendering the classification result invalid. We have already considered the relevant options to mitigate such bias, including extending the audio context classification to also be able to distinguish alternative audio sources and classify them accordingly. In a small pilot study we have successfully classified music distinct from talking and silence. However, achieving the ability to detect users talking required numerous audio samples to obtain the relevant precision, and we would arguably be required to gather an even larger data set in order to be able to successfully classify all common audio sources, if feasible at all. It appears more relevant to collect data from the real world setting as part of the clinical study, updating the ACCA classifier iteratively.

Rather than relying on creating more sophisticated classification algorithms, we could also consider using more advanced microphone sensor technology that would allow us to only sample sound within the immediate vicinity of the BP device. Usually we would expect the user to be facing the BP device, and utilizing a unidirectional microphone may help us reduce bias levels from e.g. television or radio. The microphone could also be built into the sensor chair. In this case, we would know the exact position of the user allowing for more precise measurements. Also, it could be considered whether a simple sound pressure sensor could be used to achieve the same results as the more advanced audio classification algorithm, simply by detecting the noise levels in the room.

4.5 Limitations of User Population

The solution has been proven to work for users in the age group 22-67. However, older and younger patients have not been included in the sampled data, which is a study limitation. While only very few children and younger people below 22 are being diagnosed with hypertension, the group of above 60 years of age is estimated to suffer from hypertension with an incidence of over 50% (Wagner et al., 2012). Also, the group above 60 years of age have a higher probability of being mildly cognitive impaired, which further supports the relevance for constructing intelligent adherence aids to assist reliable use of the BP device in the unsupervised setting.

4.6 Related Work

Audio context classification is closely related to areas such as voice activity detection for use in cell phones (Benyassine et al., 1997) and has previously been used for improving the sound quality of hearing aids (Nordqvist, 2004). However, it has not previously been employed to improve BPSM validity.

While state-of-the-art commercial BP devices do not provide methods for detecting contextual bias, such as user talking during measurement, some devices do have the capability of detecting user-error in the unsupervised setting. A&D features the “intellisense” feature, which will sense excessive body movement during the measurement (A&D 2012). The Omron 10 Series BP device (Omron 2012 I) will ensure that three measurements are taken 1 minute apart, but will not validate for other contextual factors. The wrist worn Omron Premium HEM-262 BP device (Omron 2012 II), ensures that the arm is kept at heart level which is very important for obtaining a standardized and valid blood pressure with wrist worn devices. Likewise, for this device, there is no further validation of user context.

Two recent studies have investigated how context-aware pervasive healthcare systems could improve the quality of healthcare data in the home setting. Copetti et al. (2009) investigated using fuzzy logic to provide a reasoning agent for ambulatory blood pressure measurements in the home setting, investigating whether a user is resting during BP measurement, eating, or performing domestic activities, allowing them to increase the limits for raising an external alert call. D’Angelo et al. (2011) presents a system for monitoring the user's motions and postpones planned ambulatory BP measurements if proper rest is not detected. Also, the system detects whether the user is in the proper upright position during measurement, as required by the recommendations on ambulatory blood pressure measurement. Again, neither of these studies addresses talking as a bias parameter.

4.7 Inadequacies of the Evaluation Prototype

The current evaluation prototype has several shortcomings that should be rectified before commencing full scale clinical trials. First, the distributed nature of the solution incurs multiple points of failure. As such, the sensor chair uses WiFi (802.11) and the A&D devices uses Bluetooth. Such elaborate infrastructural requirements are not a problem in a limited evaluation proof-of-concept setup. However, we need to reduce the solution to an easy to transport and deploy form-factor with few points of failure if we want to feasibly integrate it into daily clinical praxis. Current state-of-the-art usage of a blood pressure device for diagnostic use mainly consists of the general practioner lending out a device for 3-4 days to the potential hypertensive patient, letting him fill out a paper log book of the measurements (Wagner et al., 2012). As such, relying on an elaborate hardware infrastructure is most likely not a feasible option. Also, the total equipment cost would be multitudes more expensive than current day stand-alone blood pressure devices. In an attempt at simplifying the current solution, we have also constructed an Android smartphone based client classification device, and replaced the full sensor chair with a small Bluetooth based sensor seat. While this is easily transported to and from the clinic, it still requires the user to be able to operate the smart phone. Creating an integrated device, where all sensor and interface technology resides in the blood pressure device appears to be the most practical and feasible solution. However, this remains to be studied in further detail.

4.8 Future Work

The constructed evaluation prototype has proven the concept to be feasible. However, in order to deploy it at a general practioner's clinic for lending out to patients for use in the home setting, the solution needs to be reduced in size and complexity. Storing and transporting a full size chair is a suboptimal solution. Also, ACCA, once having proven to work and provided the expected benefits should be ported to an embedded device, preferably a low cost signal processing platform. We have already provided the means for sending data and meta-data over the air to a web server. However, as most general practioners today do not employ telemedicine solutions in their diagnosis of patients, and web enabled technology increases costs and points of failure and also incurs a higher power drain it may not be relevant to include web support for all usage scenarios. We have planned several clinical trials for evaluating usage in the unsupervised outpatient clinical setting as well as in the unsupervised home setting of the patients. Results from these studies will be pivotal for validating the suggested solution for real world use and guide our future research efforts.

5. CONCLUSION

We have suggested using audio context classification for detecting whether the user is talking during unsupervised BPSM. An evaluation prototype, EBSMES, was built using a touch screen computer. This was integrated with an A&D blood pressure device, a sensor chair, and the ACCA classification algorithm placed at a remote server as a web service.

The prototype was trained using 160 audio samples of talking and silence from 80 unique test-subjects, and evaluated in the laboratory with 40 audio samples from 20 unique test-subjects in order to determine laboratory system performance.

Furthermore, we tested ACCA in an integrated pervasive healthcare BPSM scenario with 22 additional test-subjects, as could be conceived in clinical praxis as an unsupervised tool for autonomous patient usage. Both the laboratory and integrated BPSM scenario evaluation indicated that such a system is feasible to construct, that it is able to detect users talking during measurement, and that it may be useful as a tool for physicians and patients using BPSM in order to obtain higher quality data. This could lead to more reliable diagnosis, reduce medication errors and optimize treatment efficiency.

Further work includes resilience testing to environment audio bias sources, reducing the evaluation prototype in size and complexity, and finally evaluating the solution in a longitudinal clinical trial.

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A WEB-BASED PLATFORM FOR COLLABORATIVE DEVELOPMENT OF A KNOWLEDGEBASE FOR PSYCHIATRIC CASE FORMULATION AND TREATMENT DECISION SUPPORT

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ABSTRACT

Whilst the authors have previously described a formal model for case formulation and treatment decision support in psychiatry, this paper presents the translation of this formal model into a computational model and its implementation as a prototype. The resulting web-based system utilises a collaborative approach for developing the knowledgebase through online participation of clinicians. It is expected that the implemented system will serve not only as a useful decision support tool, but also an educational resource for clinicians.

KEYWORDS

Medical expert system, Clinical decision support in psychiatry, Collaborative development of knowledgebase, Psychiatric case formulation.

1. INTRODUCTION

Psychiatric case formulation is a complex process that involves identifying key issues related to the patient's predicament, and understanding them using explanatory models. In general, these issues span across biological, psychological and social domains, and each issue can often be explained using more than one explanatory model that can be derived from various etiological theories. The understanding provided by explanatory models assists the clinician to evaluate different treatment options and develop an individualised treatment plan for the patient. Therefore, case formulation in psychiatry that allows understanding the patient as a unique individual, can be considered to have higher clinical utility than arriving at a diagnosis that is generic.

Nonetheless, the clinical reasoning involved in psychiatric case formulation is a complex process characterised by a high degree of subjectivity and ambiguity. It requires highly developed clinical skills in order to filter out less relevant information, and to integrate knowledge derived from various theoretical models and clinical experience. Understandably, psychiatric case formulation is considered to be a daunting task for trainee clinicians(McDermott, Streltzer et al. 1996), and it has been a key area tested in specialist clinical examinations. As a solution, the authors have introduced a structured methodology for psychiatric case formulation(Fernando, Cohen et al. 2012). Furthermore, a formal model, in which the subjective and ambiguous nature of its reasoning is formally defined has been iteratively developed and published elsewhere(Fernando, Henskens et al. 2011),(Fernando, Henskens et al. 2012).

This paper describes the process of translating the formal model into a computational model, and its prototype implementation, which will continue to be reviewed and refined iteratively. One of the main hurdles encountered by knowledgebase system developers is the difficulty of developing and maintaining a sufficiently large knowledgebase due to apparently insurmountable manpower requirement. Fortunately, the success of Wikipedia and other social networking sites, gives the hope that similar web-based approaches can be used for knowledgebase development(Richards 2007). Therefore, the computational model has been designed as a web-based system that allows clinicians to collaborate with each other in developing and maintaining the sufficiently large knowledgebase required for psychiatric case formulation. Importantly, once the knowledgebase is sufficiently developed, clinicians can use the resulting web-based system as a decision support system for psychiatric case formulation and treatment decision support.

It needs highlighting that the case formulation is a feature that has not been implemented in previous medical expert systems or decision support systems. Whilst most decision support systems in psychiatry involve automating prescribed treatment guidelines (for example, (Shelton and Trivedi 2011),(Sucher, Moore et al. 2008)), the small number of known expert systems address only the aspect of diagnostic reasoning(Werner 1987),(Hardt and MacFadden 1987) and were developed more than two decades ago.

2. SYSTEM ARCHITECTURE

The prototype was implemented using Java Web technology, and the system architecture was designed by adopting the Model-View-Controller (MVC) architecture pattern(Stearns, Murray et al. 2002). The model component of the architecture encompasses the business logic, which includes the inference in diagnostic formulation and knowledgebase operations. The business logic is implemented using Java Beans technology. The View component involves Human Computer Interface (HCI) that deals with user requests and server responses that are mediated through the Controller component. The system architecture is described in figure-1. NetBeans 7.0.1 bundled with GlassFish server 3.1 was used as the development environment, and the knowledgebase was implemented using MySQL sever.

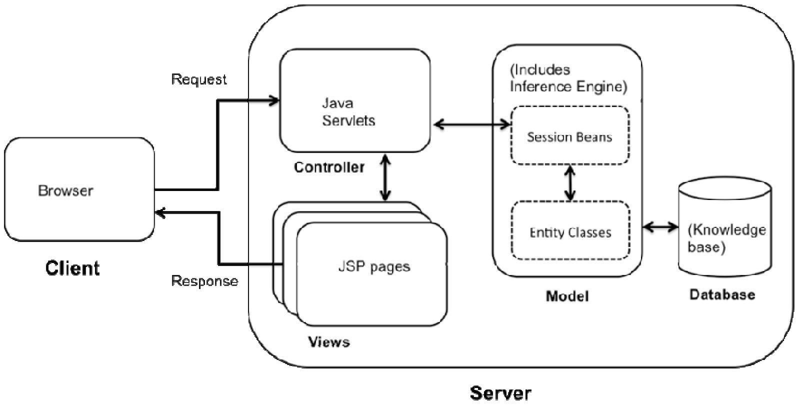


Figure 1. System Architecture

3. KNOWLEDGE BASE

The knowledge base was conceptualized as a four-layer graph that involves a hierarchically organised set of entities including, symptom attributes, symptoms, clinical phenomena, explanatory models and diagnoses. Each symptom consists of one or more symptom attributes, and each clinical phenomenon consists of one or more symptoms. Similarly, each explanatory model consists of one or more clinical phenomena, and also each diagnosis consists of one or more clinical phenomena. Clinical phenomena play a central role in the knowledgebase by connecting other knowledge entities together. A key aspect of the knowledgebase is the functional relationships between the individual entities. Inference in diagnostic and case formulation involves calculations that are based on these functional relationships. The detail of the inference process is presented in a separate paper(Fernando, Henskens et al. 2012), and readers are requested to refer to this paper for more information. Inference rules express the conjunctions of different subsets of knowledge entities within a same set, and the implications of these conjunctions in relation to an entity in a different set. Inference rules and the functional relationship between different knowledge entities are further elaborated later in the paper under section 4.2.1. In the current prototype implementation, the conjunctive associations between knowledge entities and their implications are stored in tabular form in a relational database. The design of the knowledgebase as a relational database, and its implementation using MySQL server in NetBeans IDE is shown in figure-2.

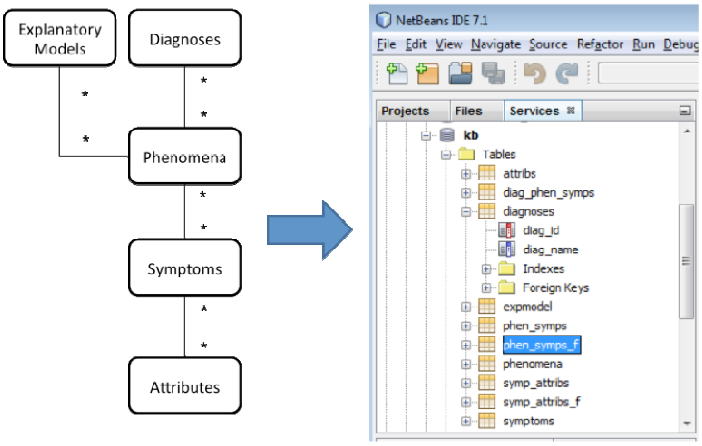


Figure 2. Design and implementation of knowledgebase as a relational database

4. USE CASES

For the initial prototype three main use cases that are described in figure-3, have been identified. The main actor is the clinician who is involved in the process of knowledge base development and consultations. Clinicians, who are willing to develop the knowledgebase collaboratively online, need to register and obtain permission to edit the knowledgebase. This process is depicted as the ‘Sign in’ use case, and involves filling in an on-line registration form, and then manual verification of the clinician’s level of expertise before allowing access permission. The activities related to development and maintenance of the knowledgebase is encapsulated in the “Edit Knowledgebase” use case, whilst the activities related to clinical inference in case formulation is encapsulated in the “Consult” use case. The following section elaborates these later two use cases.

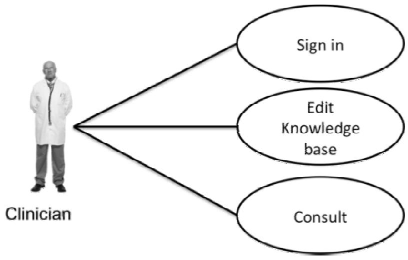


Figure 3. Main Use cases

4.1 Use Case: Edit Knowledge Base

The use case, ‘Edit knowledge base ‘ involves displaying the entities of the knowledgebase and allowing the user to add new entities or modify the existing entities. When there are controversies in relation to certain knowledge entities or their functional relationships, clinicians can initiate or participate in online discussion forums that are linked with these entities and their relationships. The process flow involved in this use case is described in figure-2.

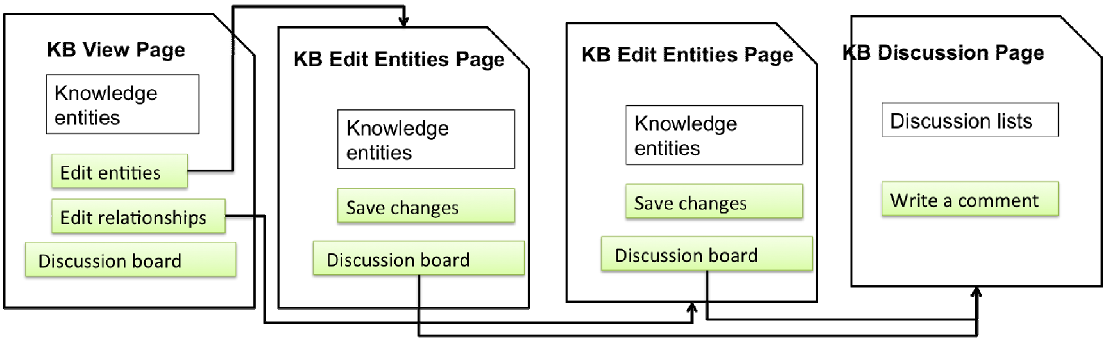
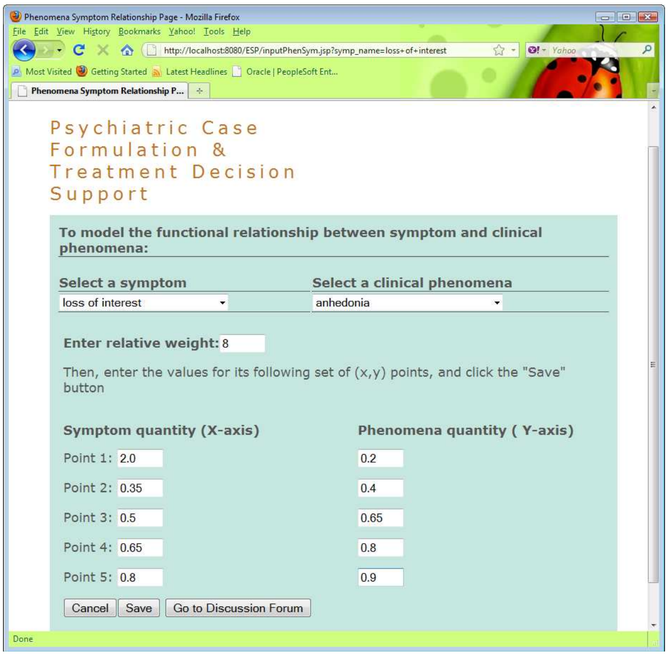


Figure 4. Process Flow diagram for Edit-Knowledge-base use case

An important feature of the use case, ‘Edit knowledgebase’ involves describing the functional relationship between the various knowledge entities using a set of $< X, Y >$ coordinates. For example, let S_i be a symptom entity and D_j be a diagnosis entity in the knowledgebase. Given their respective quantities, $Q(S_i)$ and $Q(P_j)$, the functional relationship between the symptom, S_i and the diagnosis, D_j are described using a function, F_{ji} as $Q(D_j) = F_{ji}(Q(S_i))$. Whilst $Q(S_i)$ corresponds to X coordinates, $Q(D_j)$ corresponds to the Y coordinate. The relative importance of S_i in relation to D_j is described using a weight parameter, W_{ji}. Figure-5 shows the prototype implementation of this feature.



Psychiatric Case Formulation & Treatment Decision Support

To model the functional relationship between symptom and clinical phenomena:

Select a symptom: loss of interest

Select a clinical phenomena: anhedonia

Enter relative weight: 8

Then, enter the values for its following set of (x,y) points, and click the "Save" button

	Symptom quantity (X-axis)	Phenomena quantity (Y-axis)
Point 1:	2.0	0.2
Point 2:	0.35	0.4
Point 3:	0.5	0.65
Point 4:	0.65	0.8
Point 5:	0.8	0.9

Figure 5. User interface for editing the functional relationship between a symptom and a diagnosis.

4.2 Use Case: Consult

The use case, “Consult”, encompasses the inference algorithm that includes four stages: abstraction, abduction, deduction, and induction. These stages are based on the ST model(Ramoni, Stefanelli et al. 1992) that has been proposed for medical reasoning, and the last three stages involve the logical inferences introduced by Charles Pierce(Peirce 1931). Each stage is outlined in the following sections, and the process flow of the “Consult” use case is described in figure-6.

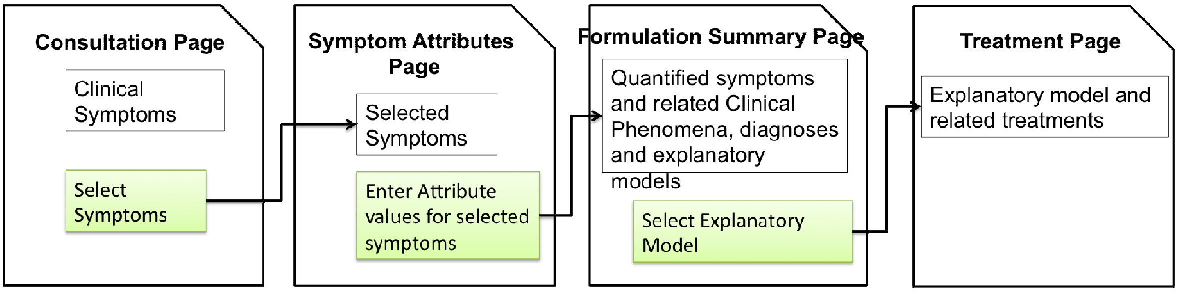


Figure 6. Process flow diagram for Consult Use case

4.2.1 Abstraction

Abstraction involves mapping the symptoms reported by the patient in his/her own language into symptom knowledge entities in the knowledgebase, and quantifying them. In the current version of the prototype, the mapping process is by-passed, and the clinician is allowed to select symptom knowledge entities from a list. Then, the quantification process involves, entering the values for the relevant attribute knowledge entities for each symptom. The function, Q that does the quantification is defined as $Q: X \to [0,1]$, where X represents any entity set in the knowledgebase. Given a set of attributes, $A_1, A_2, \ldots, A_n$ and their respective quantities, $Q(A_1), Q(A_2), \ldots, Q(A_n)$, in relation to a symptom, S_j, a function, F_{ji} used to describe the functional relationship between the quantity of a given attribute, $Q(A_i)$ and the corresponding quantity of S_j, is as follows.

$$Q(S_j|A_i) = F_{ji}(Q(A_i))$$

The relationship between a set of quantities of some attributes with a given symptom is expressed in the form,

$$IF\ \ Q(A_1)\ \wedge Q(A_2) \wedge \ldots \wedge Q(A_n)\ THEN\ Q(S_j) = Q(S_j|A_1 \wedge\ A_2\ \wedge \ldots \wedge A_n)$$

The resulting quantity of the symptom, $Q(S_j) = Q(S_j|A_1 \wedge\ A_2\ \wedge \ldots \wedge A_n)$ is calculated using the relative weight, w_{ij} that is associated with each attribute, A_i in relation to the symptom, S_j using the following equation.

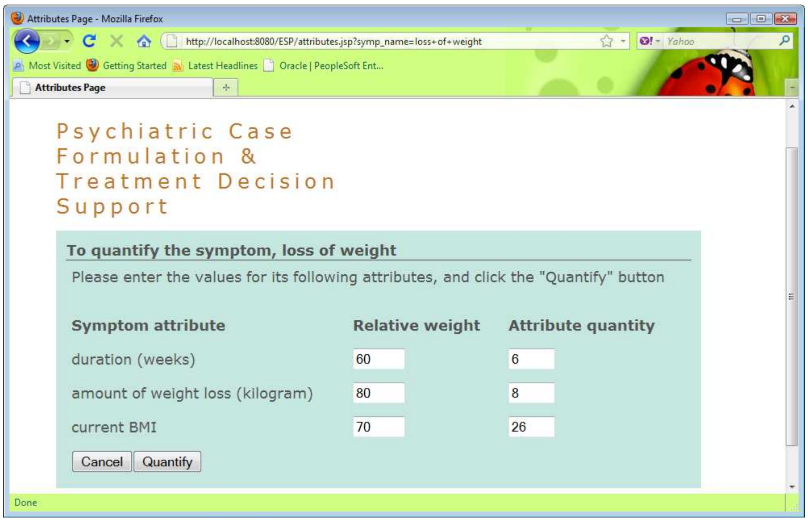
$$Q(S_j|A_1 \wedge\ A_2\ \wedge \ldots \wedge A_n) = \left(\sum_i^n F_{ij}(Q(A_i)).w_{ij}\right) / \left(\sum_i^n w_{ij}\right)$$

The above equation applies only if the condition $Q(S_j|A_i)\ \geq 0\ \forall\ Q(A_i)$ or $Q(S_j|A_i)\ \leq 0\ \forall\ Q(A_i)$ is satisfied. Otherwise, given a set of attribute quantities, $Q(A_1^+) \wedge Q(A_2^+) \wedge \ldots \wedge Q(A_n^+) \wedge Q(A_1^-) \wedge Q(A_2^-) \wedge \ldots \wedge Q(A_m^-)$ where $Q(S_j|A_i^+)\ \geq 0\ \forall\ Q(A_i^+)$ and $Q(S_j|A_i^-)\ \leq 0\ \forall\ Q(A_i^-)$, both $Q\left(S_j|\ A_1^+ \wedge A_2^+ \wedge \ldots \wedge\ A_n^+\right)$ and $Q\left(S_j|\ A_1^- \wedge A_2^- \wedge \ldots \wedge\ A_m^-\right)$ are calculated separately using the above equation.

Finally, $Q\left(S_j|\ A_1^+ \wedge A_2^+ \wedge \ldots \wedge\ A_n^+ \wedge A_1^- \wedge A_2^- \wedge \ldots \wedge\ A_m^-\right)$ is calculated as follows:

$$Q\left(S_j|\ A_1^+ \wedge A_2^+ \wedge \ldots \wedge\ A_n^+ \wedge A_1^- \wedge A_2^- \wedge \ldots \wedge\ A_m^-\right) = Q\left(S_j|\ A_1^+ \wedge A_2^+ \wedge \ldots \wedge\ A_n^+\right) + Q\left(S_j|\ A_1^- \wedge A_2^- \wedge \ldots \wedge\ A_m^-\right)$$

As an example, the screen shot in figure-7 describes the attributes and their quantities and weights in relation to the symptom, ‘loss of weight’.



Psychiatric Case Formulation & Treatment Decision Support

To quantify the symptom, loss of weight

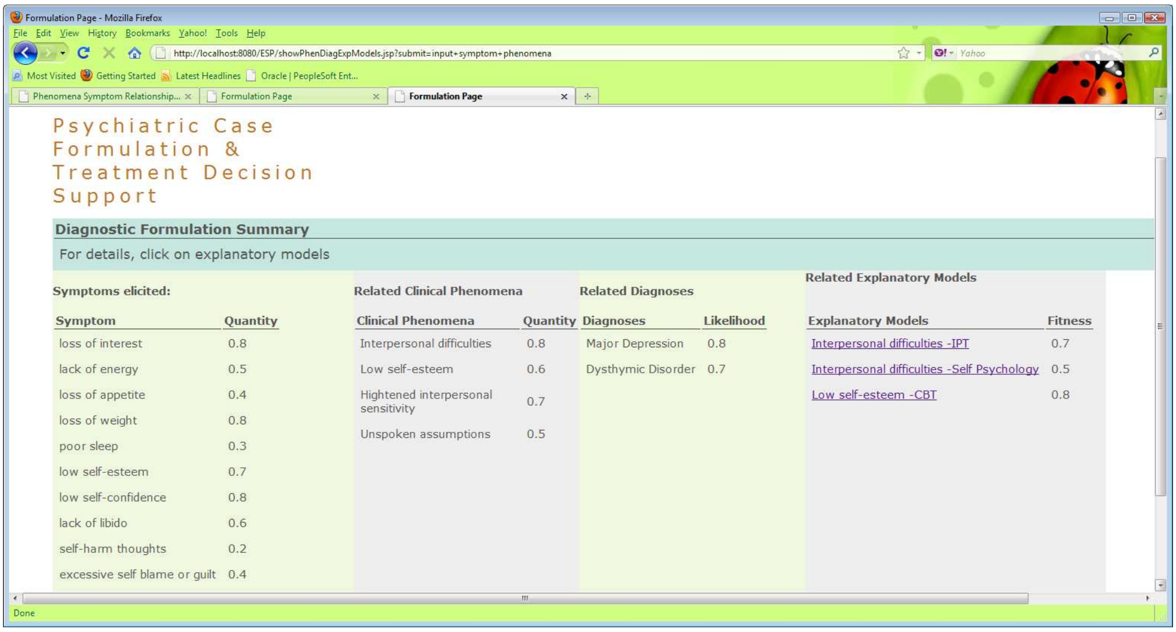
Please enter the values for its following attributes, and click the "Quantify" button

Symptom attribute	Relative weight	Attribute quantity
duration (weeks)	60	6
amount of weight loss (kilogram)	80	8
current BMI	70	26

Figure 7. An example of the quantification of the symptom, ‘loss of weight’

4.2.2 Abduction

Once the symptoms elicited in the patient are quantified, abduction involves extracting the related clinical phenomena, diagnoses, and explanatory models from the knowledgebase. Based on the quantification of each symptom each of the corresponding phenomena, diagnoses, and explanatory models are quantified in a similar way as explained in the previous section. However, these related clinical phenomena, diagnoses and explanatory models can be considered as working hypotheses at this stage, because their quantifications are based on partial information (i.e. only few elicited symptoms out of many). Figure-8 shows the screenshot of the outcome of the abduction stage.



Psychiatric Case Formulation & Treatment Decision Support

Diagnostic Formulation Summary

For details, click on explanatory models

Symptoms elicited:		Related Clinical Phenomena		Related Diagnoses		Related Explanatory Models	
Symptom	Quantity	Clinical Phenomena	Quantity	Diagnoses	Likelihood	Explanatory Models	Fitness
loss of interest	0.8	Interpersonal difficulties	0.8	Major Depression	0.8	Interpersonal difficulties -IPT	0.7
lack of energy	0.5	Low self-esteem	0.6	Dysthymic Disorder	0.7	Interpersonal difficulties -Self Psychology	0.5
loss of appetite	0.4	Hightened interpersonal sensitivity	0.7			Low self-esteem -CBT	0.8
loss of weight	0.8	Unspoken assumptions	0.5				
poor sleep	0.3						
low self-esteem	0.7						
low self-confidence	0.8						
lack of libido	0.6						
self-harm thoughts	0.2						
excessive self blame or guilt	0.4						

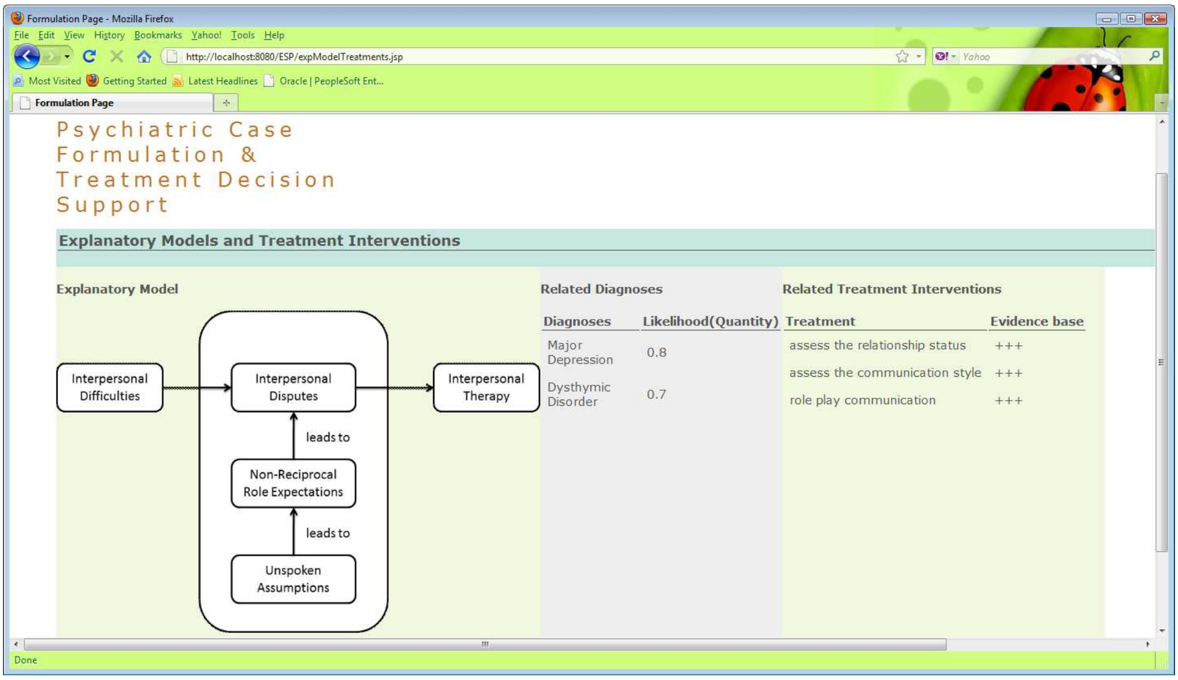
Figure 8. An example of the abduction

4.2.3 Deduction

Deduction involves exploring the rest of the symptoms required for complete evaluation of the related clinical phenomena, diagnoses and explanatory models. For example, the clinician may have elicited only one symptom, “loss of interest” that indicates the likelihood of the diagnosis of depression. Then, deduction involves directing the clinician to explore rest of the symptoms of depression, which include ‘low mood’, ‘loss of interest’, and more symptoms. It allows the clinician to choose the clinical phenomena, diagnoses and explanatory models that he/she would like to explore. Once the choices are made, it requires the clinician to go back and quantify the necessary symptoms in the same way as described under the abstraction stage.

4.2.4 Induction

Induction is the last stage of the process and involves recalculating the quantities of corresponding clinical phenomena, diagnoses and explanatory models. These quantities can be interpreted as the likelihood of the presence of the related clinical phenomena and diagnoses, and fitness of the explanatory model. A threshold value is used to evaluate their significance, and only the significant entities are presented to the clinician after sorting them in descending order. The diagnoses and explanatory model entities provide links to respective treatment options.



Psychiatric Case Formulation & Treatment Decision Support

Explanatory Models and Treatment Interventions

Related Diagnoses

Diagnoses	Likelihood(Quantity)
Major Depression	0.8
Dysthymic Disorder	0.7

Related Treatment Interventions

Treatment	Evidence base
assess the relationship status	+++
assess the communication style	+++
role play communication	+++

Figure 9. An example an explanatory model and its treatment options

5. FURTHER WORK

The current version of the prototype will be continually refined through iterative development before being made available for clinicians to access. The user interface is expected to be enhanced by incorporation of improved graph visualisation techniques so that the users are allowed to zoom in, zoom out and navigate through the network of entities in the knowledgebase. Also, the same techniques will allow the user to visually track the paths of the knowledge entity network that are involved in clinical reasoning.

In the current stage of development, it is intended that the system will only be used by clinicians for completing the knowledgebase, and then as a pilot of the final educational and decision support tool. Ultimately, there is a potential for making this available to the public for use as a self-assessment tool. Prior to that occurring, a module for mapping the patient reported symptoms to symptom entities of the knowledge base must be developed. Also, the system requires further assessment in relation to social, organizational, ethical and medico-legal issues before it is made available for public use.

6. CONCLUSION

This paper presents the design and prototype implementation of a web-based platform for collaborative development of a knowledgebase for psychiatric case formulation and treatment decision support. The prototype implementation is based on a theoretical foundation, which attempts to capture a sufficient depth of clinical reasoning, and model it in an intuitive way for clinicians. It utilises the concept of collaborative knowledgebase development in order to overcome the difficulties in developing a sufficiently large knowledgebase that have been experienced by medical expert system developers in the past. Through the online platform for collaboration, it is expected that clinicians with diverse areas of expertise will be able to collaborate and contribute towards developing and maintaining the knowledgebase. Whilst the platform already serves as a useful educational resource for clinicians to improve their psychiatric case formulation skills, it will continue to be developed, and evaluated before it is ready to be used as a decision support tool.

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CHALLENGES OF ELECTRONIC RECORD DEPLOYMENT: WHAT DO EXPERTS REVEAL IN THEIR ONLINE DISCUSSIONS

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ABSTRACT

Information Systems (IS) innovations in healthcare sector are seen as panacea to control burgeoning demand on healthcare resources and lack of streamlining in care delivery. One particular manifestations of such innovation is electronic records in its two forms: the Electronic Medical Records (EMR) and the Electronic Health Records (EHR).
However, deployment efforts concerning such innovations have encountered a rough terrain and have been slow. This paper investigates the issues that affect IS innovation deployment in the field of healthcare.
This research adopted qualitative longitudinal case study methodology, which involved the deployment of electronic records in the US. Data was collected through online discussion threads; and was analysed thematically.
This research indicates that there are nine attributes of IS innovation deployment in healthcare; and these are design, efficiency, optimality, legitimacy, acceptance, demand and efficacy, expertise, interaction, and trust.

KEYWORDS

Innovation deployment, Electronic Medical Record Electronic Health Record, Online discussion forums, qualitative research, case study

1. INTRODUCTION

The need for IS innovations in healthcare is driven primarily due to the extreme and disproportionate pressure on healthcare resources and the escalating costs needed to maintain care delivery while meeting the desired standards and public health demands (Greenhalgh and Russell 2010).

To facilitate deployment of such innovations, many steps have been taken. For example, in the U.K., a fund of £80 million was set to be invested for procuring and establishing IS-innovation based services between the year 2005-2008 (DoH 2010, Barlow, Burn and Lockhart 2008). Similarly, in USA, special health care reforms resulted in warranting new policies pertaining to innovation procurement (PCAST 2010).

However, despite such efforts to provide monetary incentives and policy changes, the integration of IS innovation into the care delivery service has been rather disappointing (Anderson 2007, Davidson and Heslinga 2007, Heeks 2006, May et al 2007, 2009). One particular manifestations of IS innovation that is noteworthy in experiencing such resistance is the electronic records in healthcare.

Taking this into account, the case study employed here, looks at the efforts of electronic record deployment in U.S. It aims to gain a deeper insight into the reasons preventing successful deployment, and why such an innovation has not yet been assimilated into daily work practices of healthcare professionals. In the following part of this section, we briefly outline what are electronic records and the structure of US healthcare system.

1.1 Electronic Records

Electronic records, both EMR and EHR, from IS perspective, can be broadly understood as information systems that facilitate clinical decision-making based on evidence and aim at streamlining care (Boonstra and Broekhuis 2010, Greenhalgh et al. 2008, 2009). Although many definitions exist in theory, in practice the definitions can be used to differentiate dimensions such as scope, ownership, and interconnectivity.

The scope and ownership of EMR and EHR can be defined separately. For example, it is understood that EMRs are created and maintained by the patient or institutions that have any involvement in the patient's care and therefore, are used by individual organisations (Clarke and Meiris 2006, Garets and Davis 2006). On the other hand, EHRs are used to collect data on the investigation and prevention of disease and the overall health (wholeness) of an individual over the course of their lifetime. These have much broader scope, of which the patient's EMRs health-related data are just a component.

The difference in the connectivity requirements of the EMR and EHR enables further distinction between the two. The EHR requires being interoperable so that EMRs of different organisations can be accessed, whereas EMRs require to be integrative so that departments within an organisations can be connected to provide an integrated patient health record.

The advantages of electronic records include streamlining care by ensuring provision of information related to clinical encounter and health updates to clinicians, patients and the organisations involved, reducing chances of error in care delivery, and improving billing and reimbursement procedures (Anderson 2007, Boonstra and Broekhuis 2010, Hayrinen Saranto and Nykanen 2008, Yamamoto and Khan 2006).

Reported disadvantages of electronic records include failure to meet the specified requirements through technical design, high cost of deployment, change in work practices and standardising care delivery (Boonstra and Broekhuis 2010, Hayrinen Saranto and Nykanen 2008).

1.2 Electronic Records Deployment in US

The U.S. healthcare system is complex. It is a mix of private and public funded systems, and comprises primary, secondary and tertiary care organisations. Generally, different organisations provide care at different levels and cluster together to form a regional healthcare system. Often, in one region, there can be more than one healthcare system (Roe and Liberman 2007).

Healthcare systems are largely insurance based with two third of the coverage sponsored by employers. Government funded insurance includes Medicare and Medicaid programmes (Roe and Liberman 2007). This complexity of the system, due to its structure and different types of insurance models requires delivery of care to be streamlined. This necessitated the need for electronic records that would help improve care delivery processes, improve patient experience of receiving care and save cost (PCAST 2010).

We now move towards presenting the method that this research adopted and elicit the findings. This is followed by discussion and conclusion.

2. METHOD

In this research, a qualitative longitudinal case study was conducted. Case studies are used to observe change over time, understand events that evolve over time, allow examining the complex web of meanings, feelings, beliefs and preconceptions that human agents weave; and are argued to be an ideal research method for complex "*mega-systems*" such as the healthcare, where boundaries are often complicated and fuzzy (Pettigrew 1997, Fitzgerald, Ferlie and Hawkins 2003, Murphy et al. 1998, Myers 2009, Yin 1999). The data was collected from an online discussion forum, a topic that is discussed next.

2.1 Online Discussion Forums as Documents

Online discussion forums are described as "*computer supported communication technologies that facilitates virtual interaction on the internet*", and act as a platform for information sharing, coordination, and emotional support (da Cunha, Orlikowski 2008: 134). Each discussion forum can contain a number of different discussion threads, and these comprise comments that participants post pertaining to a specific question or subject. Participants are normally free to participate in any of the threads at any given time.

The advantages of this platform include lacks of face-to-face interaction which allows participants to be open, press forward with their opinions, and discuss details (sometimes intimate and personal) whilst being relaxed. In addition, as this platform overcomes temporal and spatial boundaries, it enables inclusion of participants who are located in different countries (Adair et al. 2006, Seale et al. 2010).

This platform also facilitates articulation and access to immediate subjective views as opposed to reconstructed views. This for example, is not possible in case of interviews where participants recollect past events that can be vague due to tacit and ephemeral nature of feelings (Seale et al. 2010).

However, there are limitations of using this method and it includes that the participants are self-selective. A further limitation is that use of computer and Internet access is required and those with no access, or unable to use computer and those with aversion to technology in general are automatically excluded from the sample of participants. Both limitations will contribute to bias and therefore should be accounted for.

In addition, there are also ethical concerns pertaining to use of data from online discussion forums as the ethics on use of such data is currently not agreed and, consensus and guidelines are sought. One opinion is that ethical approval to use online data should be required. Alternatively, ethical approval might be required but without consent, or there might simply be no ethical approval or consent required (Sarwar and Robinson 2011, Wignia 2004).

The approach adopted in this research was that participants had knowingly and of their own volition placed opinion in the public domain. Consequently that opinion was open to whomever wished to view it and for any purpose. Therefore, no ethical approval was sought nor consent gained. However, it is recognised that opinion of participants is being used in way not originally intended by the participants and being transferred outside of the domain in which it was originally placed. For this reason, all opinion is used anonymously, the exact nature of discussion is not expressed in order to protect the participants, and no information of personal nature is used (Eysenach and Till 2001).

2.2 Approach to Collection and Analysis

The data for this research was collected from discussion forum available on LinkedIn. LinkedIn is "*a business oriented social networking site*". It was launched in May 2003 as a job seeking tool. Its role since, has diversified and it has become a popular platform for organisations and individuals to share knowledge and information on various topics. One of the distinguishing features of LinkedIn is that the participants who engage in the discussion threads are experts in their field and have prior knowledge of the topic from their education or work experience.

In this paper, the discussion threads chosen was from Healthcare Information Management Systems Society (HIMSS) group which is defined as the group that facilitates "*constructive and stimulating discussion regarding the optimal use of health IT (HIT) and management systems for the betterment of healthcare worldwide.*" The discussion encouraged participants to share their experiences around challenges of electronic record deployment in the U.S. The thread included 1,019 comments posted by 336 participants. Majority of the participants were U.S. based, with minority from other European and Asian countries. The discussion thread grew over 13 months (24th Nov 2009-24th Dec 2010), and was still active at the time the research concluded. Due to time restrictions, the researchers had do agree on cut-off point.

The data was analysed as document, using the thematic analysis, which "*involves searching across the data set…..a range of texts-to find repeated patterns of meaning*" (Braun and Clarke 2006: 86). A hybrid approach of induction and deduction was adopted where one is allowed to "*examine the underlying ideas, assumptions and conceptualisations-and ideologies-*" (Braun and Clarke 2006: 84). Once the initial themes were outlined, an independent researcher revised the template. After iterative cycles of data analysis, and long discussion session, the final themes were agreed.

3. FINDINGS

Nine themes emerged from data analysis: design, efficiency and effectiveness, optimality and equity, legitimacy, acceptability, demand and efficacy, expertise, interaction, and trust.

3.1 Design

The design of IS innovation was seen to be affected by many factors, and was the most commented upon topic in the discussion. Two main sub-themes emerged: the technology design, and the vendor procurer relationship.

3.1.1 Technology Design

Many participants reported that the EMR/EHR design features were the most contentious area. On one side were those who maintained that customisation of applications solved the issue of acceptance, whereas on the other were those who maintained that customising was a waste of resource and resulted in applications being rejected due to the added complexity. However, it was argued that customisation done after taking end-users need into account can be useful: “*In my previous job; I needed to accept a gynecologic EMR with more than 200 fields. The manager refused to simplify and for sure we build the best gynecologic EMR. One year after the beginning, 10% of the data were fulfilled. The medical manager accepted to simplify and we transformed 200 fields to less than 40. One year later we had 89% of the data collected. It was a success*” #714 Consultant in health ministry.

3.1.2 Vendors

Vendors were argued to be solely concerned with making profit as they sold old systems wrapped in new packages. Participants further commented that vendor solutions were designed by people who had no sense of real workflows, and without understanding what clinicians wanted:

“*1. Doctor asks "I want a machine that hits the road!"*

2. Informaticist develops a plan for a machine with a hand that hits a few square feet of pavement on a table.

3. Informaticist develops the training plan, curriculum, figures out where the machine can be used clinically, tests the machine with whatever clinical staff are willing to be available (often not a physician), and develops the go-live plan.

4. IT expert builds the machine with a little cartoon hand that hits the few square feet of pavement on a table.

5. Go-live plan is activated.

6. Doctor, on seeing the machine, says, "That's not what I meant - I wanted something that I can drive away from here, quickly!"” #747, MD and chief medical informatics officer.

3.2 Efficiency

Efficiency included assessing how the intervention improves current working practice, and was argued to be affected by gaining expertise in using the package. In addition, efficiency was also argued to be affected by the apparent need of the package: “*If it takes 3 minutes to perform an action in an EMR vs 1 minute on paper, and the patient is already complaining about getting shorted because the insurer pays based on a 10 minute exam time, and the doc doesn't want to go broke, what's gonna happen*?” #576 Hospital and healthcare professional.

Another factor that influences efficiency is the lack of support for clinicians in data entry which increased their workload.

3.3 Optimality

Defined as balancing improvements in health against cost, optimality encompasses the relationship between evidence and the cost associated with intervention. Therefore, to be considered as an optimal solution, the intervention needs to show that it facilitates attaining health benefits and also is cost effective. From the discussion, it emerged that with regards to EMR/EHR, so far there is no clear benefit in terms of monetary or health improvements achieved through its use. Such lack of evidence is not conducive to EMR/EHR acceptance. However, when benefits are realised, assimilation is greatly increased: “*Early on I worked with a small group of Docs, 110, in driving best practices around a disease management program. Success and buy in came when they were shown their outcomes after practicing a best practice and the difference in outliers that did not accept the program*” #175 RN, Senior consultant and project management

3.4 Legitimacy

Legitimacy issues surrounding EMR/EHR implementation arise due to the legislative requirements that govern areas of data capture, storage, sharing and extraction; and because of the ethical dilemmas experienced by the potential user.

3.4.1 Legislative Requirement/Standards

Failure to fulfil the requirements laid out by various standards and legislation such as the HITECH Act and HIPAA, can cause conflict over liability and negligence, thereby leaving the establishment with a hefty bill to pay as well as a potential fine. Many participants argued that compliance and adherence to these legislations was cost intensive. In addition, iterative changes in legislations meant every time a change in a standard was made an update had to be brought.

Participants ushered to the fact that the legislation was complex due to the privacy rules involved (inter and intra) and this confused procurers, potential users, and vendors alike. Moreover, commentators argued that the regulations themselves are driven politically and have no real focus: "*Physicians have not rebelled against regulations regarding CT scanners because they were directed primarily towards patient and operator safety. There is no equivalent argument for EMRs - only the demands by the bureaucracy to meet regulations designed for the bureaucracy*" #869, Hospital and healthcare professional.

3.4.2 Ethical Dilemma

It was argued that sometimes using technological IS innovations works against the medical professional's ethics: "*when I was hospice nursing we implemented specialized hospice software, were given these great little computers and blackberries as our new "pager" essentially.. sent off with them and told to get our charting done DURING our patient visit!!!! Can you imagine? I refused to take my computer or my phone into the house when I was caring for dying patients and their families*" #578, RN, Subject matter expert and business analyst.

3.5 Acceptability

Acceptability is an attribute that evaluates personal attitude and motivation for accepting EMR/EHR by its primary user - the clinician. Acceptability is affected by disturbance to workflows and increased workload.

It is argued that workflows are the least researched topic within EMR/EHR deployment despite being the backbone on which the application design is based. The cause for this is attributed to the highly individualised and ephemeral nature of workflows. It exposes many issues for software coders and vendors as a typical workflow might consist of "*100-200 steps and there might be 50 of them*" that need to be mapped. These workflows are not just clinical but administrative too, and capturing and versioning the workflow is tricky: "*Patient A is on workflow W1 at step 50 and we make a change to that workflow at steps 20 and 70. If the nature of the change at step 20 is to add several new data elements, then switching your patient from step 50 of W.1 to step 50 of W.2 will now fail at step 70 because the data needed at step 70 on W.2 will not have been collected*" #150 EHR managing director.

3.6 Demand and Efficacy

One of the most important reasons that resulted in undermining the value of EMR/EHR was lack of consensus between what the clinicians want and what the providers present.

In addition, some argued that the real value of EMR/EHR was lost as clinicians perceive it as a tool to facilitate billing and thus use it as an administration tool or a back office tool to standardise care rather than as an application that provides better care delivery: "*EHR/EMR is a significant outlay of cash for something that is not directly a medical product. EHR/EMR is not treating patients, it is not a Swan-Ganz catheter that facilitates understanding a patient's physiology, but rather it is something more easily understood as administrative, and thus not a conventional priority*" #6 IT and economics expert.

Also, participants argued that there was perceived lack of scientific evidence on the benefit of EMR/EHR applications for care delivery. Moreover, not all accepted the rigour of the evidence that is available and provided, and were sceptical. They questioned its authenticity and suggested external interference in order to influence evidence reporting.

3.7 Expertise

Introducing a complex automation such as EMR/EHR marginalises clinicians' expertise in various ways. These include change in skill set, unfamiliarity with modern technology or digital divide and changes in the clinical encounter.

One participant notes that nurses and doctors are not "*equipped or trained to deploy this complex automation*" (#7, Healthcare practice leader and founder), yet they are expected to use it without encountering any problems and instantly accept it within their work routine. In addition, expertise was affected due to training that was inadequate, irrelevant, too short, and in some instances, not provided at all. Moreover, even after initial provision of training, clinicians often needed to learn again due to change/updates in application features or because they had forgotten how to use it due to a "*piecemeal*" style of implementation.

Participants further argued that EMR/EHR applications dictate the clinician-patient relationship and sideline the intuition of the clinician due to the use of preformatted template: "*if we look at a drug/drug interaction problem, it is easy to say that if we see the possibility of a negative outcome, don't mix drugs. But sometimes the benefit of mixing the drugs is worth the risk of the negative outcome. And if the negative outcome is certain, but not immediate death, plans can be made to treat that, in order to gain the benefit. GOOD EMR's SHOULD capture documentation and contain overrides, so this should still be a physician's call, and not implicate the user as a bad practitioner*"#392 MD, senior medical consultant.

3.8 Interaction

It is argued that clinical encounter is very complex, highly individualised, and emergent: "*If you take a billion separate little entrepreneurial businesses and tried to figure out a billion customer interactions you'd be on target for what you are up against in figuring out the Doctor/Patient interaction.*" (#157 RN, Senior consultant and project management).

Introduction of EMR/EHR changes the way in which information is captured during the clinical encounter. This new setup, in most cases requires clinicians to type in the information within the consultation such that :"*It takes ......almost 20 minutes to type the information in EHR. They (clinicians) hardly spend 10 to 15 minutes with each patient* " #359, Chief strategy officer. In other cases, involvement of scribes, who follow doctors and took notes, is needed. Such changes to interaction and the way in which information is captured are accused of taking the subjectiveness away from the clinical notes and instead are argued to represent patients as graphs and charts.

3.9 Trust

The notion of trust is used by participants to convey the feeling of being assured that their actions and the other person's actions with whom they are interacting, will cause no harm. In this study, it was noted that various features, internal and external to technology are perceived harmful. For example, it was highlighted how inefficiently written medical notes might cause in medical errors while delivering treatment:

Notes as written by a physician: "*14 wm presents with a possible. wound infection. the right knee was opened up with sdliding into a base. iNITIALLY IT was 2 weeks ago. This AM there were pustules that developed this AM. There is redness surrounding the wound. there is no real pain with the infection.*"

And as written by medical transcriptionist:

"*This is a 14-year-old white male with a possible wound infection. The right knee was opened up 2 weeks ago when he slid into a base. Pustules developed this morning. There is redness surrounding the wound. There is no real pain with the infection.*" #687 Technology consultant.

Participants further argued that applications such as EMR/EHR are perceived to be driven by the "*assumptions that doctors and nurses are a) incompetent and b) cheaters drives the demand for documentation*" #675 Hospital and healthcare professional.

4. DISCUSSION

The study reveals that of the nine attributes of IS innovation deployment, the design of IS innovation is an important attribute. Poor design was frequently the cause of failure; and with severe impact on efficiency and optimality (inclusive of cost), and such applications were often abandoned.

Failure to capture design requirements occurred due to misalignment in aims and goals of users, procurers and vendors. This affected trust, undermined legitimacy and threatened expertise. In addition, it can be argued that trust, design and legitimacy influence and are also influenced by user expertise, their acceptability and the way they interact. Such influences can originate at different levels and examples include change in governance and policy at organisational level, and changes due to IS innovation in clinical routines, clinical encounter and familiarising with functionalities of the innovation at individual level.

4.1 Implications of this Research

This research outlines various attributes that impact the assimilation of IS innovation, and informs how the complexity due to iterative nature of IS innovation impact users' decision to use it. In addition it contributes to the field of qualitative research through the use of online discussion forums as a source of qualitative data. The use of discussion forums to understand IS innovation deployment in the field of healthcare is believed to be previously unused approach. Guidelines on use of this method and ethical considerations are presented.

4.2 Limitations and Future Research

This research used pre-established and active discussion thread. Establishing dedicated discussion thread in desired website, with time limits specifying start and end dates, has a potential to overcome issues around data saturation and ethical dilemmas such as consenting.

Also this research uses the qualitative data analysis method. However, using a quantitative data analysis method that involves statistical analysis would have enabled evaluating the strength of relationships between the attributes and express them as dependencies.

In addition, although this research considers the view of many of the stakeholders, it does not consider any patient perspectives. Future research could consider how to include the views of patients, how this influences the outcome, and how it compares to the perceptions of other stakeholders.

5. CONCLUSION

This research reveals that the processes of IS innovation deployment has nine attributes attached to it. It is important to acknowledge these attributes as they highlight that in addition to being a lengthy, very disruptive and at times very slow, the deployment efforts are also context specific. This is especially significant in the case of healthcare as it is a complex and constantly evolving field.

In addition, deployment processes involve many stakeholders, ranging from vendors, procurers that include management at all levels, users that include healthcare professionals, administrators and patients. It is vital to acknowledge the views of all these stakeholders, as bypassing them might impinge on the success by leaving gaps in knowledge and expectations, incomplete design and violated trust.

Findings from this study can inform stakeholders involved in designing, procuring, using and assimilating innovation not just in U.S., but also other countries that are journeying towards integrating electronic records.

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AN ASSISTED LIVING SYSTEM FOR THE ELDERLY - FEARLESS CONCEPT

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ABSTRACT

Elderly usually have fears arising from themselves and their home environment. About 50 percent of the elderly suffer from fear of falling. A number of them suffer from fear of cooking as they can cause fire, fear of using water as they can cause flooding and so on. These fears in general yield in a low self-efficacy causing less activity. This paper presents the FEARLESS (fear elimination as resolution for loosing elderly's substantial sorrows) system that will help enhance the participation of elderly in social life and their mobility at home. Robust detection algorithms for falls, smoke and fire based on fusion of audio and image processing approaches, enable the emergency services and relatives to get automatically alerted in case of urgency. The system applies passive sensors for it to remain effective even in case of inability of pressing an alarm button and not to impair the mobility of the user as the wearable sensors do. The system able to detect automatically falls, fire, smoke and unusual behavior in the elderly environments will be developed. This system is conceived for a global deployment. The implementation of such a complex system will be enabled thanks to the features of the robust telematics platform. Moreover, the strategy for the fast adoption of the product by the market which consists of integrating an important part of the supply chain will be described. The proposed system will improve the feeling of safety for the elderly, thus reducing their fears. As a result, elderly will participate actively in the self-serve society which directly will influence their wellbeing.

KEYWORDS

Assisted living, fall detection, fire detection, smoke detection, smart home, telematics platform

1. INTRODUCTION

Health care expenditures on the elderly have drastically increased in recent decades. This situation is partly attributable to demographic change, with the number of elderly growing about 1.0 percent per year faster than the rest of the population [1]. Moreover, a huge number of elderly suffer from fear arising from themselves and their environment [2, 3]. This fact results in less activity, as elderly are afraid and thus try to reduce the risks. This has motivated researches in the development of smart environments.

The entire domain of home care systems can be split into four directions: Emergency, Assistance, Autonomy enhancement and Comfort. Depending on the aim of the system and the target group, a direction or a combination can be chosen. While smart living or smart home concepts mostly focus on comfort, Ambient Assisted Living (AAL) puts autonomy enhancement and especially emergency assistance into the focus [4]. Thinking about the installation of ambient assisted equipments in apartments and houses, there are two fundamental approaches: AAL can be integrated into the planning, simulation and construction phase of new constructed apartments and houses or it needs to be installed later on into already existing homes. The second one is more complex as people are already living there and existing furniture has to be considered as well. These facts result in the demand of a robust low-cost system, which is easy to install but flexible enough to detect many different types of risks.

Another important reason for the lack of adoption of AAL technologies is the complexity of the different sensor systems and even more relevant: the lack of expertise at the supplier side. If an enduser is willing to use AAL technology two problems occur: to be aware of existing solutions and to find the right company in order to install it. In FEARLESS, a different approach will be adopted in order to solve the above mentioned problems met by the AAL.

Several papers have addressed issues dealing with solutions for health monitoring of elderly in independent and assisted living [5-12]. A number of researches have paid attention on events detections in the elderly environment. In [13] an acoustic fall detection using a circular array of 8 microphones has been designed. Since falls have most of the energy concentrated between 0-300Hz band, their detection is possible if combined with other parameters such as motion detection. In [14] an investigation of an inexpensive depth camera for fall detection purpose was performed. A Microsoft Kinect was shown to be better candidate compare to camera units. 3D information can be obtained from a single Kinect. Moreover, the depth image works in the dark. An automatic fall detection based on Doppler radar motion signature is developed in [15]. The results obtained using the mathematical coefficients for sound modelling Mel-frequency cepstral coefficient (MFCC) features and two other classifiers: k-nearest neighbour and support vector machine (SVM) are encouraging. The above investigations in [13, 14, 15] are being tested at the Tiger Place, which is an assisted living community located in Columbia Missouri, USA.

FEARLESS will utilize the flexibility of vision based sensors and combine it with acoustic event detection. This combination will significantly enhance the reliability of the overall system. The potential dangers, which can be detected with FEARLESS include smoke, fire, falls or sudden changes in daily life caused by a deterioration of the health condition. The overall aim of this project is the reduction of barriers which impedes the mobility of elderly people, often suffering from dementia or light loss of cognitive activities.

The challenges of facilitating independent living at home with integrated sets of methods and technologies require a holistic and interdisciplinary approach. For this reason, in FEARLESS a consortium has been formed by joining the expertise and know-how of ten organizations from four different European countries. The consortium is formed by four renowned research organizations: Vienna University of Technology (Austria), University of Bamberg (Germany), Fraunhofer-IPK (Germany), i2CAT Technological Center (Spain); three small and medium enterprises: CogVis GmbH (Austria), Infokom GmbH (Germany), Linkcare Health Services (Spain) and three end user organizations: TeSAN (Italy), Samariterbund Wien (Austria), Medical University of Vienna (Austria).

2. MATERIALS AND METHODS

2.1 Event Detection

The FEARLES system will be able to detect a number of events in the elderly home environments. These include falls, fire, smoke and unusual behavior in the daily activities. If a risk (i.e. fall, fire or smoke) is detected, an event is sent to the telematics platform. Depending on the confidence value provided within this message, different escalation levels are addressed. High confidence values requires immediate response to the event, lower confidences requires a verification or falsification by the call center agent, illustrated in Fig.1. If an event is detected, a simplified illustration of the scene, shown in Fig. 3, is transmitted to the call center.

2.1.1 Fall Detection

The combined visual and acoustic detection of risks in a fusion approach, as illustrated in [16, 17], will serve as basis for detecting falls events. However, compared to standard IP cameras, the use of the kinect for Xbox/Asus Xtion Pro (Live) has been proven to suit better for this project. This test comparison between the two different hardware sensors was conducted at the Vienna University of Technology, Computer Vision Lab. The performance metrics were among others the image quality, robustness against varying lightening conditions as well as suitability for fall detection. The summary of the study demonstrated that Kinect is more robust against changing lightening conditions and works also during the night. It provides depth information of the scene which enhances the robustness of the person tracker. Using the Skeleton Tracking algorithms provided by OpenNI, a person is robustly tracked in a range from 0.5 meters up to 4.5 meters. For lower or higher distances, the track of the person is lost. Regarding the use within the fearless project, this fact should be considered by implementing alternative tracking mechanisms when exceeding the distance of 4.5 meters.

Figure 1 illustrates the workflow in the case of fall detection: the event together with the anonymized reconstruction is sent to the telematics platform. The reconstruction is repeatedly sent after a defined interval of time (e.g. every minute), this is done to check the previous state. After e.g. 5 minutes and 5 verified fall events, proper actions are taken to ensure the safety of the elderly person. Due to this process, latency is added into the overall process. This latency is required to ensure that a situation where help is needed occurred and the person is not able to get up on their own within this latency. Without this latency, unnecessary actions might be taken. After providing help, the ticket is closed by the dispatcher and the system does not send any further illustrations.

The depth images and acoustical sounds provided by the Kinect/Xtion Pro Live serve as input to the fall detection algorithm [17].

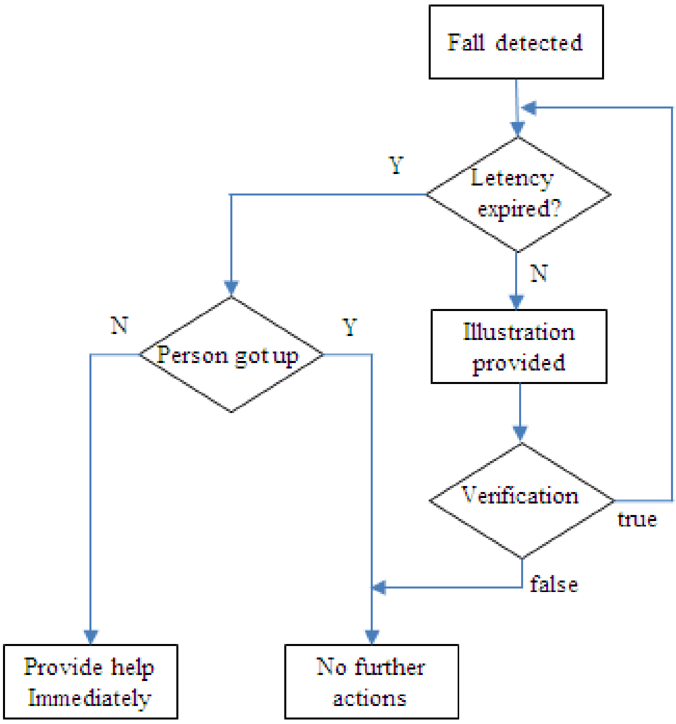

Figure 1. Workflow of the fall-event

The workflow depicted in Fig.2 for the fall detection is proposed: starting with depth data, the person is segmented from the background. Afterwards, a skeleton is fit to the person and the ground plane is estimated. Features are extracted from the skeleton data and a decision whether a fall occurred or not is made based upon a fuzzy logic framework. Pose estimation, Orientation of the body, Spine height, Decision framework based on fuzzy logic are the methods related to visual estimation which will be used. Frequency analysis, height of sound and one class classifier (only class of falls) are the acoustical methods which will be used.

Figure 2. Fall-Detection workflow

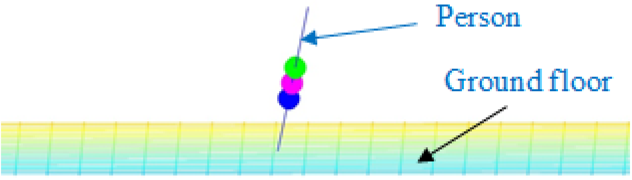

Figure 3. Simplified 3D reconstruction illustrating a person and the ground plane

Using only depth data automatically ensures the anonymity and privacy of elderly, as people and the background cannot be recognized from the depth images. Furthermore, only illustrations representing body coordinates and the ground floor are transmitted to the telematics platform, as illustrated in Fig. 3.

2.1.2 Fire and Smoke Detection

The analysis of images from the Kinect will serve also as input to the fire and smoke detection algorithm. For the fire detection, the following features will be extracted: color analysis (reddish colors to white), fast stochastic changing contour or shape, fast changing lightness (high frequency luminance), color, geometry, and motion of fire region, moving or not moving target. For detection of the smoke, Contour based (grayish), changing or losing sharpness, periodic behavior are the features to be extracted for decision making. This task will be done by the Fraunhofer-IPK.

2.1.3 Detection of Changes in Usual Behavior

The decrease of mobility should be detected and care-takers or relatives should be alerted. Less mobility can for example be caused by diseases, which force elderly to stay in bed. It can be also caused by a change of health condition on the long run or depression. To be able to detect less activity / mobility, different areas within the elderly homes will be (virtually) defined and the frequency and duration of using these areas will be collected. Hence, as the primary end user behavior changes in the long-term, decrease of mobility can be detected easily. Other works [12] have solved the issue dealing with detecting unusual changes in the elderly behavior by placing low-cost sensors at some strategic places in order to detect the use of those places. This way the frequency and time of using these places could be recorded and unusual behavior could be tracked.

2.2 Therapy Plan

Enabling therapy programs within the FEARLESS system is of great importance. Therapy monitoring service will motivate the elderly do some physical exercises at home according to the given plan, since the results will be captured and made available to medical care providers through the system. A target-comparison of treatment will help updating individual plans. This feature will decrease the personal costs which is currently stressing the health system. The Medical University of Vienna will develop therapy programs and define the types of motions for individual patients.

3. RESULTS OF THE CONCEPT

3.1 FEARLESS System Description

In order to reduce the fears of the elderly, FEARLESS ensures that elderly people get help immediately without any intervention. At the same time, the system will not interfere with activities of daily living when no emergency is present. Thus FEARLESS will not be perceived as surveillance system, but as emergency aid that enables an elderly to keep (or re-gain) self-confidence when it comes to dealing with every day challenges.

Figure 4 illustrates the FEARLESS system from the automatic events detection, transfer to the telematics platform via internet and from there the event management and alert forwarding to the concerned players. End users access the fearless system through both web-based or smartphone applications. The sensor system communicates with an intermediate station via USB. The intermediate station processes the data obtained by the sensor and sends alarms either to the base station via WiFi/Bluetooth or directly to the telematics platform. All wireless communication channels use high-security encryption mechanisms.

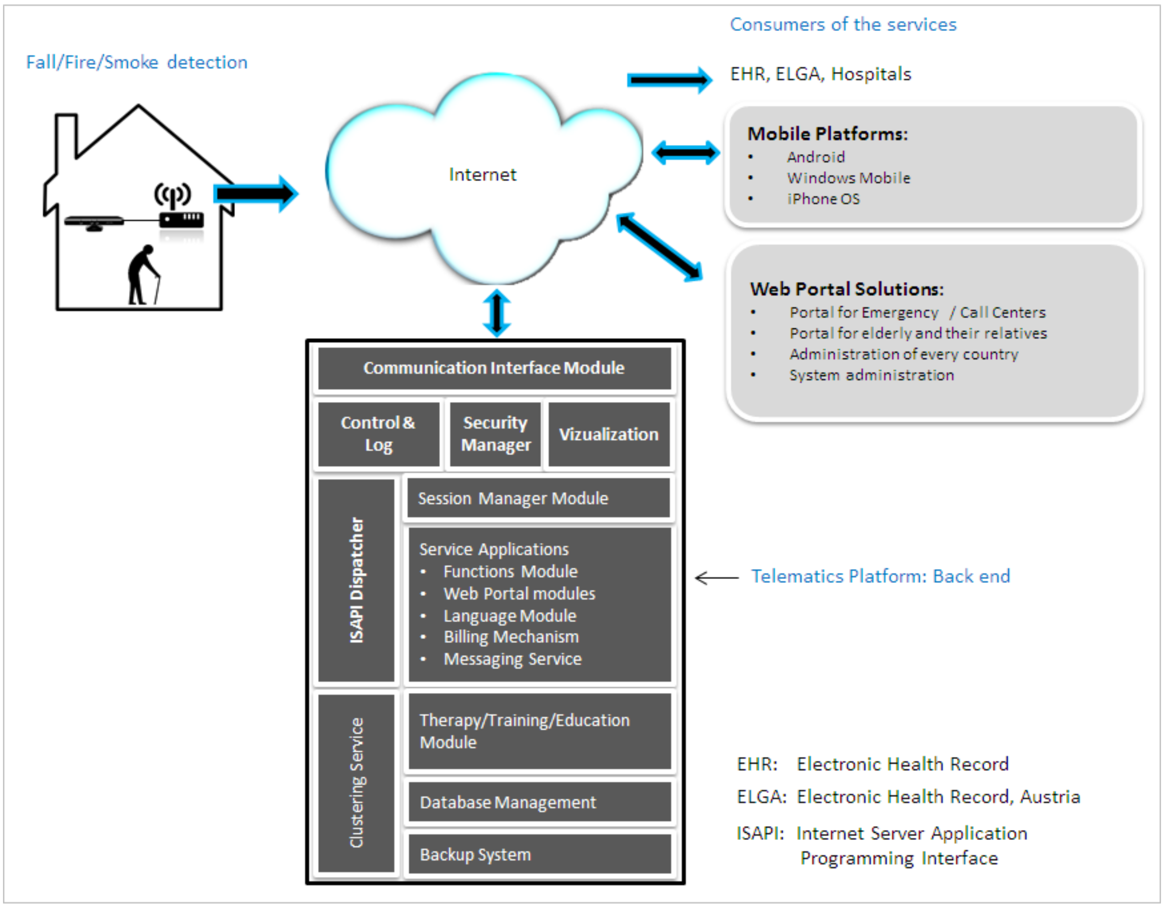

Figure 4. Fearless System

3.1.1 Telematics Platform

The Telematics Platform is a flexible middleware and application server for the hosting of different kinds of telemedical solutions and services. Robust features of this platform as illustrated in Fig.4 enables the hosting of complex systems such as FEARLESS. The telematics platform will receive alarm signals from the sensors after events have been detected from the elderly homes. This information will be forwarded in a structured way to the concerned players such as emergency services and relatives through web portals and messages.

The modularity of the platform is an important factor. The modules enable specific functionalities. These modules can be modeled, pre-installed, updated and configured easily. The modularity enables also a parallelization of the system development.

The communication interface module is responsible for the communication with third party applications. Interoperability and standards are of great importance to avoid isolated applications. Therefore, the Telematics Platform supports standards such as HTTP/HTTPS, SOAP, XML, CDA, HL7, D2D.

The main module is the session manager which is responsible for the login process, session creation and encoding of data session-depended, and access control to the database. The ISAPI Dispatcher module (Fig. 4) is responsible for the communication with the Microsoft Web Server (Internet Information Service-IIS) in order to bring the services to the internet. Portal Modules are set of codes which execute the functionalities covered by web-portals. The platform enables an optimal load sharing through its clustering feature. The basic principle is that individual function modules can be hosted on one or more members of the cluster network.

Data security and confidentiality are fundamental for telematics platforms used for patients oriented services. Therefore, the following features have been implemented into the Telematics Platform in order to address these concerns [18]:

- A separation of the storage of personal from the storage of medical information during data processing is realized.
- Any information stored or transferred through the system is encrypted.
- Medical data are transferred anonymously.
- The services of the Telematics Platform are protected by authentication methods (login and password) and various authorization levels for the different users. This enables a structured control of the data access.
- The services of the Telematics Platform are protected by authentication methods (login and password) and various authorization levels for the different users. This enables a structured control of the data access.

3.1.2 Web Portal Solutions

The web portals will be designed in order to enable every end-user access the set of functions authorized for him, Fig. 4. Figure 5 presents the user hierarchy in FEARLESS. The system administration will have a web-based tool in order to be able to add different countries to the system and the involved emergency services. The administration of each country will access the country admin portal in order to be able to register medical care providers and patients to the system. He will also be responsible for the registration of the devices used at the elderly home side such as wireless stations and their corresponding locations.

Registered care providers will access the FEARLESS emergency Portal and monitor the states of registered elderly. In case of an alarm a popup window launches automatically to keep the attention of the health care providers, this might be accompanied with a sound. Elderly and their families will be able to access the FEARLESS elderly portal in order to check the current situation and the history of events. The updated therapy plan could be accessed through this portal. All the above listed portals are password-protected.

3.1.3 Mobile Solutions

Mobility is perceived as one of the challenging factors in the future of health care. A smartphone application (App) will be developed in order to enable the families of the assisted elderly people access the data and be aware of the elderly state independently from time and location, Fig. 4.

3.2 Fearless User Management

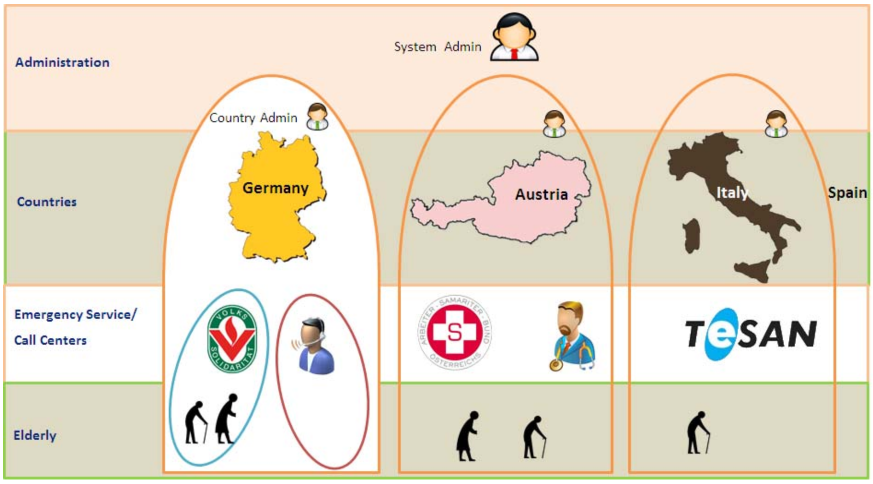

Figure 5. Fearless User Management

The FEARLESS user hierarchy is illustrated in Fig. 5. The system has four levels of user categories. The administration level is for the integration of users and devices to the system. Then follows the country level, where countries with the involved care services are integrated to the system by the system admin. The last two levels Emergency services and Elderly levels are administrated by the country admin. He is as well responsible for the registration of devices used at the elderly home environment

3.3 Iterative Procedure to End Pilot

The technical specification is formulated based on the gathered information from: user requirements, relevant technology methodologies, the market analysis as well as national and international rules and regulations.

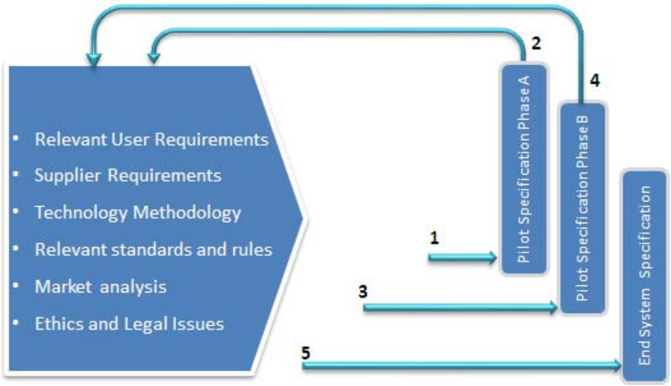

Figure 6. Iterative Procedure to End Pilot

Figure 6 illustrates the iterative procedure to achieve the end system:

- Step 1: Capture and analyze the requirements, set up a specification (version 1) and implement the Phase A prototype
- Step 2 and 3: Evaluate and update specification (version 2) and generate the optimized Phase B prototype
- Step 4 and 5: Evaluate and update specification (spec version 3) and generate the optimized End system

3.4 Fearless Product Distribution

As already mentioned, one of the important reasons for the lack of adoption of AAL technologies is the complexity of the different sensor systems and even more relevant: the lack of expertise at the supplier side. If an enduser is willing to use AAL technology two problems occur: to be aware of existing solutions and to find the right company in order to install it.

Usually elderly people will contact their known and trusted electrician around the corner to get information. The best ambient assisted living technology is worthless, if end users and vendors do not know that this technology exists.

The project FEARLESS is incorporating this aspect and involves via one of its partner (Infokom GmbH) an international network of electricians. This will ensure the usability of the FEARLESS sensor unit and functions as well as the fast adoption by the market. End users will have the realistic opportunity to equip their existing homes with affordable technology. Electricians and electric shops can extend their services and in the long term, care costs will be reduced as elderly people are able to live in their homes longer.

4. CONCLUSION

A smart system for the assistance of the elderly in their home environment has been presented in this paper. Robust event detection suited for the cases of falls, fire and smoke has been presented. Moreover unusual behavior could be detected in order to prevent the worsening of the situation. The system provides a therapy module for the improvement of the elderly health condition.

The telematics platform that covers such tasks as user management, secure data communication, connection of web and mobile platforms, secure interfaces to third party applications and connection of the emergency services and elderly relatives, has been described. Moreover the strategy that will enable the fast adoption of the end product by the market has been presented.

The proposed system will improve the feeling of safety for the elderly, thus reducing their fear. As a result, the elderly will be more active and their wellbeing is directly influenced.

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HELP4MOOD PERSONAL MONITORING SYSTEM: MANAGEMENT OF INTEROPERABILITY IN A WIRELESS HOME FOR MENTAL HEALTH TREATMENT

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ABSTRACT

Help4Mood is a project inside 7th European Framework Programme (FP7) for developing a computational distributed system to support remotely the treatment of patients with major depression at home. Core components are integrated with the ICE framework. One of the main goals of this system is to use the paradigm of a Virtual Agent to support the first symptoms of clinician alert of a patient, to interact with him an to prevent some causes of relapse after monitoring he/she with different sensors. The system processes inputs from different devices for monitoring patient activity at home and how he/she sleeps (also know as the Personal Monitoring System), transmitting this data to a Decision Support System, and defining how a Virtual Agent should interact with the patient before clinical support from hospital is needed if an alert is detected. This data is transmitted by a wireless network designed to improve data communication from sensors in a home environment (easy of installation and maintenance) and implemented using customized protocols and algorithms for reducing power consumption of these sensors. The technical framework is using open source implementations of ICE and HL7-standard-based healthcare integration engines to interact with the different subsystems. Particularly, the use of these standards will contribute to commercialization of the project results and the potential impact through the development, dissemination and use.

KEYWORDS

ICE, mental health, wireless sensor networks, interoperability, unified data processing, communication systems

1. INTRODUCTION

HELP4MOOD [1] proposes to significantly advance the state-of-the-art in computerized support for people with Major Depression by monitoring mood, thoughts, physical activity and voice characteristics, prompting adherence and promoting behaviors in response to monitored inputs. These advances will be delivered through a Virtual Agent (VA), which can interact with the patient through a combination of enriched prompts, dialogue, body movements and facial expressions. Monitoring will combine existing (movement sensor and sleep activity, also called Personal Monitoring System –PMS-) and novel (voice analysis) technologies, as inputs to pattern recognition based Decision Support System (DSS) for treatment management. The main aim of the Help4Mood system is to provide an approach for supporting the control, communication and treatment management of patients with major depression. This approach will be a distributed system with these three main components (the PMS, the VA component and the DSS for Treatment Planning) deployed at patient's site.

The Personal Monitoring System (PMS) allows the detection of specific behaviour patterns in the patient. It collects a relevant set of parameters and data, trying to be as non-obtrusive and non-stigmatising as possible. Following this philosophy, several sensors have been developed and interconnected forming a Wireless Sensor Network (WSN) to obtain actimetry and sleep monitoring data. WSN implementation and developed test platform are described in Sections 4 and 5 respectively.

One of the main technological objectives is to interconnect the different subsystems using standards, mainly using ICE framework (Internet Communications Engine) and HL7 (Health Level 7) in the application layer. For this purpose, i2Cat (http://www.i2cat.net) researchers have tested different engines that could be adapted for this heterogeneous environment. As an interesting comment, we must note that the Evaluation Summary report of the EC commission stated that “In particular the use of standard HL7 will contribute to interest in the project results”, in the “Potential impact through the development, dissemination and use of project results” section.

2. HELP4MOOD PROJECT AND 7TH EUROPEAN FRAMEWORK PROGRAMME

Help4Mood is an initiative funded by the 7th Framework Programme on 2009, in the call FP7-ICT-2009-4.5.1 for Personal Health Systems [2]. Help4Mood is a collaborative initiative of several European institutions, based in United Kingdom, Spain, Romania and Italy.

This project is funded by the objective addressed by FP7-ICT for Mental Health, specifically for ICT based solutions for persons suffering from stress, depression or bipolar disorders, where interdisciplinary research will address the parallel development of technological solutions, as well as new management or treatment models based on closed-loop approaches. Help4Mood emphasises the use of multi-parametric monitoring systems, which monitor various metrics related to behaviour and to bodily functions (e.g. activity, sleep, physiological and biochemical parameters). The proposed system will aim at (i) objective and quantitative assessment of symptoms, patient condition, effectiveness of therapy and use of medication; (ii) decision support for treatment planning; and (iii) provision of warnings and motivating feedback. In the case of depression, the system will also aim at prediction of depressive or manic episodes. The solutions will combine portable or implantable devices, with appropriate platforms and services. They will promote the interaction between patients and doctors and facilitate self-treatment and cognitive behavioural therapy where necessary.

For such project, with different components to be integrated, standardisation is a very important key issue for the European commission as seen in previous paragraphs. ICE and HL7 messages will be used in the communication of this distributed system.

3. METHODOLOGY

In a general perspective, the research group of i2Cat Foundation has tested the ICE platform to reach the desired functionality in such a distributed system. This task implies the evaluation of the solution, in terms of performance and adaptability to fulfil the needs of the project.

What is ICE?

Internet Communication Engine or ICE is an object middleware system that provides a communication solution for heterogeneous distributed systems that span multiple operations systems and programming languages. It also provides a modern object-oriented toolkit that enables you to build distributed application with minimal effort.

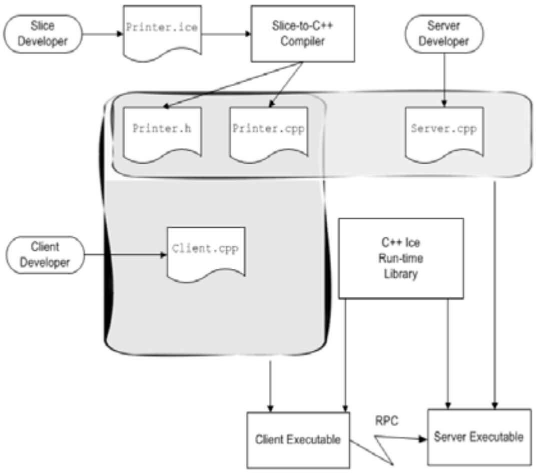
The most similar tools available in the market are RMI (Remote Method Invocation), which is dependent from the programming language Java, and WCF (Windows Communication Foundation), which is dependent from the operating system Windows.

ICE offers a middleware capable to provide a distributed scenario where an object-oriented application can be deployed. The scenario is simple: the “client” (DSS) wants to use the methods that are implemented in the “server” (PMS). That is achieved by giving access to the client to an interface, which contains the methods that are stored in the “server”. This interface has to be independent from any operating system and programming language.

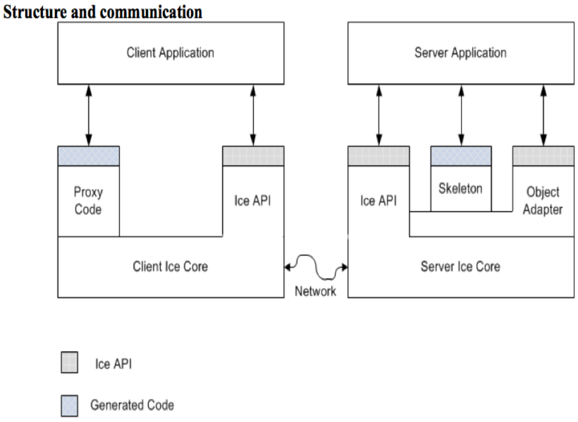
Slice

Each ICE object, which is an entity that can respond to client requests, has an interface with a number of operations. These operations are defined using the Slice language. SLICE (Specification language for ICE) is a fundamental abstraction mechanism for separating object interfaces from their implementations. In other words, is the language that allows you to define the client-server contract in a way that is independent of a specific language, such as C++ or Java.

In the specific scenario (Help4Mood), we have defined one Slice file that contains the methods that the server provides to the client (are visible to the client). The aim of these methods is to obtain information from the server (PMS) that the client (DSS) will use to track the health condition of the patient and take decisions if necessary. This Slice definition is compiled by using one of the available compilers that ICE has, depending on the programming language in which the client and the server are written. That is, Slice has one compiler for each programming language (Slice2Java, Slice2cpp, Slice2php...). The result of the compilation will be the source files that must be combined with the application code to produce client and server executables.



These source files contain, in first place, all the definitions that correspond to the types and methods used in Slice definition, in the second place provides the connection between the networking layer of ICE and the application code. Finally, it provides an API to the client to use all the methods defined. The generated source files belonging to the client-side are the “proxy code”, whereas the generated source files belonging to the server-side are known as “skeleton”.



The structure schema is shown above. The proxy code and the skeleton are the two only parts that are generated and depend on the Slice definition. The other parts are specific to the ICE library: the Client/Server ICE core contains client and server run-time support for remote communication plus a number of libraries that client and server use. The object adapter is a part of the ICE API specific to the server-side, it maps incoming requests from clients to specific methods on programming- language objects.

To establish a communication between the server (PMS) and the client (DSS) by using ICE, it is necessary to follow a set of instructions that are quite similar in both sides. The server has to initialize the ICE run-time and create an object adapter, which as it has been said before is the responsible to map incoming request from clients to specific methods. Next step is to create an instance for our interface and inform the object adapter of this new instance.

On the other side, the client also has to initialize the ICE run-time but at this point the client has to obtain the proxy for the remote interface, that is an artefact that is local to the client's address space. It represents the ICE object for the client. After getting the proxy from the server, the communication client-server has finally been established.

4. WIRELESS SENSOR NETWORK IMPLEMENTATION

Selected devices for the first release of the PMS are shown in Fig.1. Each patient will select the devices with which feels more comfortable from the given set: usually one for actigraphy (wrist watch, waist/belt device, key ring device, smartphone), using either the under-mattress sensor or the watch for sleep monitoring.

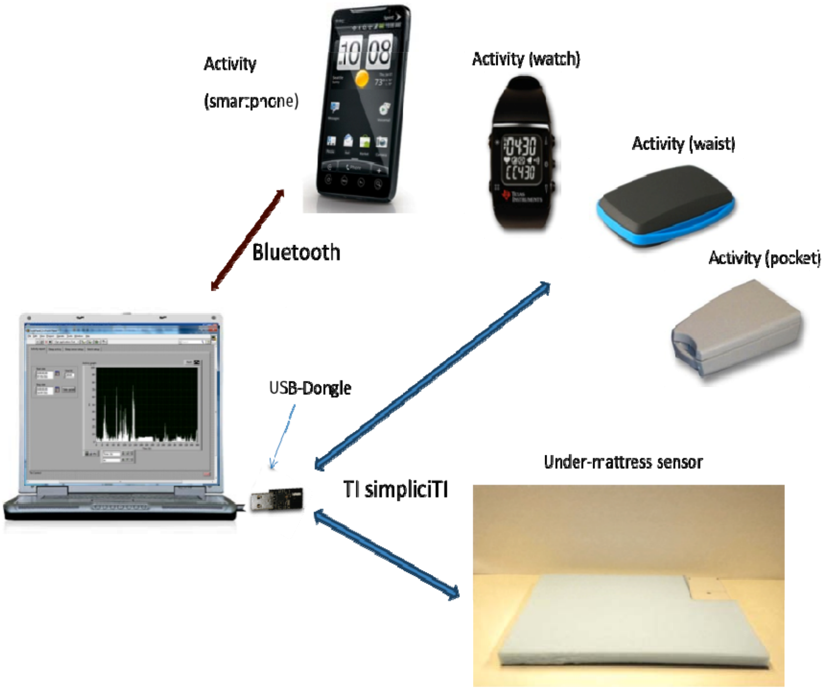


Figure 1. PMS components

The TI eZ430-Chronos Wrist Watch [4] has been selected, and configured so it can store approximately up to four days of data without downloading them to the PC. Every time the application attempts to connect to an access point, turning on the RF transceiver, the data logging process is stopped until the transceiver is turned off. The waist/belt and key ring devices are based in the internal components of the eZ430-Chronos, removing all the non-necessary functionality of the internal software, except for the data log and data transmission procedures, to reduce energy consumption. Only one button is kept to manually start/stop de data transmission.

The under mattress sensor is and electronic system based also on the TI eZ430 watch hardware, and designed to detect presence of the patients in the bed and also their movements during sleeping time [5]. Resulting data will be subject of further analysis using pattern recognition to evaluate the feasibility of using the data as an indicator of the sleep quality.

HTC Wildfire Mobile phone with Android 2.2 has been selected, and a Java software has been developed for it which allows the recording of acceleration. The program starts automatically with system start up registering continuously patient data.

The wireless sensor network is configured to work with two different technologies: Bluetooth for the smartphone chosen instead of wifi due to a reduced consumption and SimpliciTI, used by the other devices.

Patient data (accelerometer) are stored on the SD card of the phone using text files and the name of the file to be transmitted is stored in another text file called “H4Mdata.log”. On a regular basis the PC, using a Perl script, asks, via Bluetooth for the “H4Mdata.log”. When reading this file, if a new filename is found it is requested to the smartphone, and once downloaded, the PC adds and OK next to the filename in the log file indicating a successful download or an OK-LAST (to the last name in the log file) to indicate a successful download but that the file has to be requested again in the next connection. Having the Bluetooth always on at the smartphone (active/sleeping mode) represents less than ten minutes in the duration of the battery with respect turning it off.

SimpliciTI is a proprietary proposal of TI but it is open source and can be easily modified. Sensors (End Devices) are connected to one USB dongle at the PC that acts as the access point of the system. The data transmission algorithm is depicted in Fig. 2, where several loops can be appreciated to introduce different time periods of the protocol: ON_PERIOD (1 min), SHORT_PERIOD (1 hour) and LONG_PERIOD (11 hours) oriented to optimize the consumption achieving a good trade-off between battery lifetime and loss of data. The variable MAX-RETX (equal to 3) limits the number of attempts of transmission to assure that the data logging will be stopped at a maximum of three minutes. This prevents against sensors, that being at the cell edge, try to do continuously the data transfer without success until battery is empty.

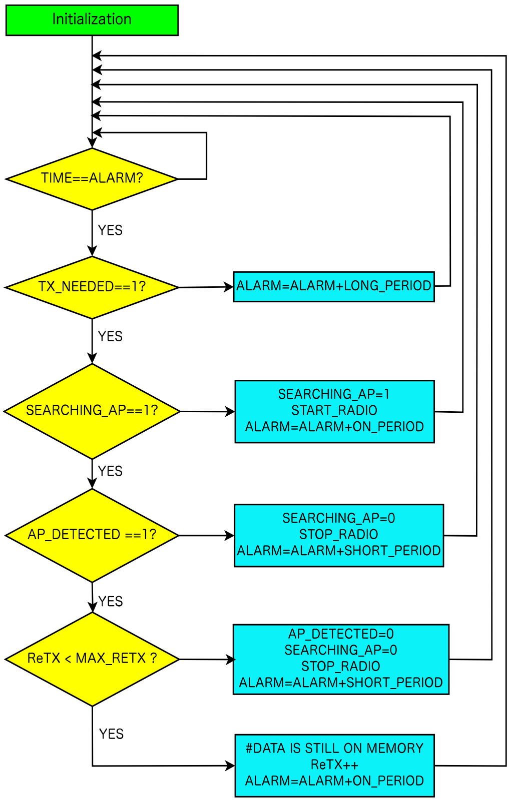


Figure 2. Communications algorithm of the sensors based on SimpliciTI

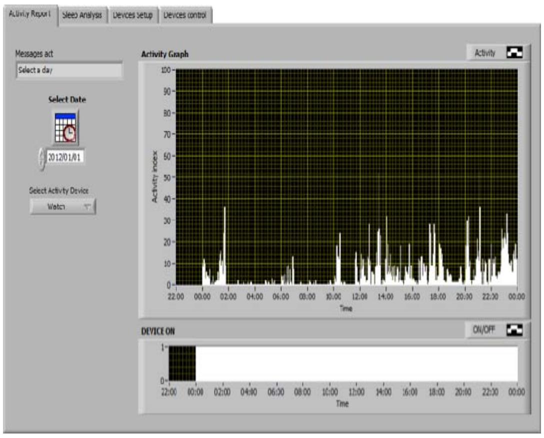
Star Network topology has been chosen for the first implementation of the WSN. The access point located at the PC would be the main node ant the rest of the sensors would connect to it.

5. DEVELOPED TEST PLATFORM AND RESULTS

LabVIEW has been used to manage simplicity connections. While the program is running it will open the USB serial port assigned to the simpliciTI AP and will wait for the different sensors to connect and upload the data. Although this is the main purpose of the software, it offers other functionalities as can be data visualization, initial device setup and device control.

After installing the software, a window for controlling and visualizing the data acquired from the sensors will be opened. It allows retrieving the activity data stored on the PC for a selected period of time. Its purpose is only informative. The data can be downloaded from hard disk or transmitted to the DSS for further analysis. As can be seen in Fig.3(a), after selecting a day and a sensor device the recorded activity is shown at the right. Below it, another graph indicates whether the device was on which allows detecting malfunctions. The tab associated with the sleep reports is slightly different. The lower right graph represents the output of the presence detector. An example is depicted in Fig.3(b). The platform has been tested during several weeks under realistic conditions.

On future versions of the software, which are currently under development, all the communication functionality will be done using Python and LabVIEW will only be used for data representation. The software will be also improved with the introduction of an SQLite database to store the data and other parameters of the communication process. These changes will allow us to use a more efficient communication algorithm and powerful data mining capabilities.

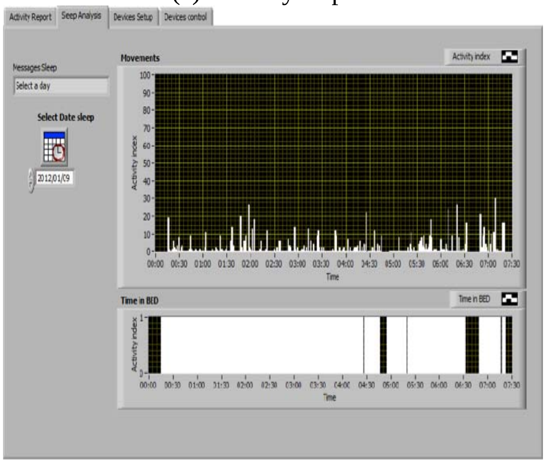


Messages act: Select a day

Select Date: 2012/01/01

Select Activity Device: Watch

(a) Activity Report



Messages Sleep: Select a day

Select Date sleep: 2012/01/09

(b) Sleep Report

Figure 3. Screen captures of the test software

A. Under mattress pad

Measures show that the sensor easily detects not only the presence of a body over the mattress but also to differentiate among several types of breathing. And even more, with a proper noise filtering it could be possible to extract cardiac activity.

B. Smartphone issues

The main issue has been to minimize the power consumption because the phone disconnects the sensors when entering into stand-by mode. This is not an exclusive problem of the selected model but also of the vast majority of the cellular phones based on android in the market. So, in the case where the phone goes to stand-by because the user presses the power button, or when the screen turns off for the system timeout, the accelerometer sensor is turned off. For this reason an alarm is sent, with an interval of 10 seconds that wakes the phone up even if the user puts it on stand-by. In addition, an application is placed in the main activity window of the phone to allow switching between two screen brightness levels to save battery. With this conditions and processing the patient data, saving one measurement of activity per minute, the phone works for 14 hours with the screen brightness equal to 0%, and for 7 hours and 45 minutes with the screen brightness equal to 100%.

C. eZ430-Chronos based sensors

The transmission power of the simpliciTI compliant sensors has been limited to 0dBm in order to reduce the power consumption and rise the battery lifetime to reasonable values. This implies we cannot achieve the theoretic 50 meters distance and low coverage area should be considered.

In free space measures, we obtained a maximum range of 17.5 meters when transmitting at 76.8kbauds. This implies a sensitivity of the receiver of -99dBm. These results can be improved if we change the transmission data rate. For example, if it is drastically reduced to 1.2kbauds the range is increased in 20 meters (37.5 meters) and the sensitivity is then of -108dBm. Nevertheless, indoors, this change is only slightly noticeable. To obtain these measures we used a complete ez430-Chronos watch kit (watch+AP) and another AP with a modified firmware to act as a packet sniffer. To allow the access point firmware reprogramming it is also necessary to do some hardware modifications. This is necessary not only to change the AP behaviour into a packet sniffer but also to change the transmission parameters (transmission power, data rate, etc.). By now with these obtained values is recommended to place the laptop at the same room than the under mattress sensor or in an adjacent room if the environment conditions are favorable. The rest of the sensors are wearable, so generally the data will be transferred without issues when the patients use the PC.

6. CONCLUSION

Today, in medical environments there are different ways to represent medical data in computer world. This is a real problem if we need to share certain data. For instance, patient information needs to be revised by two or more area specialists to perform a diagnosis. To avoid this problem hospitals and medical clinics use HL7 as a standard to represent medical information in computer world.

The first prototype of the PMS has already been presented. It includes a wireless sensor network with several devices as can be a cellular phone, a wristwatch, a key ring or an under mattress sensor. These sensors will provide the activity measures to be transmitted to the clinical site for their interpretation.

Nowadays, the Personal Healthcare Systems (PHS) is one of the emerging fields [3]. In PHS there are several fields where lot of research has to be done and still going on in the future there endless scope to do work in personal healthcare too.

There are future directions of the development of this home health systems, and integration and interoperability of the components that collect, transmit and processes these data, will use standards as ICE and HL7 to maintain the compatibility of the whole system.

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PURCHASE INTENTION OF AMBIENT ASSISTED LIVING TECHNOLOGY- RESULTS FROM A GERMAN PERSPECTIVE

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ABSTRACT

The aim of the study was to analyze older people's attitude toward a product, as well as their trust, and purchase intension, for various scenarios of Ambient Assisted Living (AAL) technology. The eight different scenarios included solutions for each of the four AAL market segments. The 77 participants of the online survey were between 50 and 81 years old and their average age was 63.9 years. The data was collected from September to October 2011. The study revealed a strong significant correlation between attitude toward a product and purchase intention (between 0.640 and 0.793). Furthermore, the attitude toward a product in AAL technology scenarios focusing on security and health prevention, was significantly higher than in scenarios that focused solely on issues of comfort. The variable purchase intention also shows significantly higher values in security and health care scenarios, which implies that the elderly are more likely to pay for these AAL services. Another research finding shows an solid overall level of trust in all scenarios, with no specific scenario being singled out. Moreover, a high correlation between attitude toward the product and trust of AAL technology was detected (between 0.545 and 0.695). Finally, the participants' ages had no influence on the different scenarios across all variables. These results indicate that further research in this innovative technological field is required. Experiments for analyzing the levels of trust in different AAL products, as well as testing these products with older people, will provide a more precise picture of the attitude toward the product, as well as the purchase intention of AAL technology.

KEYWORDS

Ambient Assisted Living, attitude toward a product, elderly persons, purchase intention, technology, trust

1. INTRODUCTION

Does a connection between the three variables attitude toward a product, purchase intention and trust in different scenarios of Ambient Assisted Living (AAL) technology exist? Based on this research question, the study analyzed these variables via an online survey of older persons. The development of AAL products has gained increasing importance in recent years [Costa et al., 2008; Kleinberger et al., 2007; Muñoz et al., 2011]. The German Federal Ministry of Education and Research is subsidizing the development of AAL technology and services with total funding of 45 million Euros [Ambient Assisted Living, 2008; Ambient Assisted Living, 2011; BMBF, 2008; BMBF, 2009]. Despite this, AAL as an area of social research is underrepresented. Thus, this analysis investigates the nexus between the attitude toward a product, as well as the purchase intention and trust in it, in the context of AAL technology.

The connection of the attitude toward a product and the purchase intention has a long tradition in research [van der Heijden et al., 2003; Moon et al., 2008; Broekhuizen, 2006; Grewal et al., 1998]. As illustrated by Grewal et al. (1998), there is a strong significant correlation in the context of perceived value and purchase intention (Grewal et al., 1998). This link was also established by Broekhuizen (2000). However, the purchase intention does not always result in an actual purchase decision (Kotler and Armstrong, 2010). As one of the first authors, Muir (1987) analyzed the research object trust in technology. In the process, users and designers of human-machine systems were examined and "trust as a moderator between the properties of a machine and a human's use of that machine" was highlighted (Muir, 1987, p. 538). Today, the importance of elderly persons' trust in AAL as a multi-faceted technology is still in its early stages. Just a few articles have considered trust in assistive environments, along with its multiple implications [Coughlin et al., 2007; Coughlin et al., 2009; Sanchez et al., 2005; Wälivaara et al., 2009], whereas no research into trust of older people towards AAL exists [Steinke et al., 2012]. Hence, this study will also investigate people's trust in various AAL products and services and show how trust is related to the attitude toward the product as well as the purchase intention.

The article is structured as follows: Within the background section, the intersection of the need for assistive technology due to demographic change and AAL is described. Further, the four AAL market segments are outlined and the nexus between the attitude toward the product, the purchase intention and trust is described in reference to potential AAL products and services. The methodology section is separated into background information, questionnaire development with presentation of the eight scenarios and statistical analysis. In the analysis section, a descriptive scenario analysis as well as a statistical evaluation of the interrelations between the attitude toward a product, the purchase intention, and trust is investigated. Moreover, the influence of participants' ages on the AAL scenarios is explored. The final section contains the discussion of the results and implications for further research in AAL products and services.

2. BACKGROUND

Ambient Assisted Living (AAL) describes a complex, highly dynamic information and communication technology domain designed mainly for the elderly. As a result of demographic ageing, AAL technology has gained importance in recent years (Wichert, 2010; Costa et al., 2008; Kleinberger et al., 2007; Muñoz et al., 2011). Due to the increasing life expectancy and consistently low birth rates, the German population will be one of the oldest in the world in 2035. By the middle of the 21st century, more than half of Germany's inhabitants will be older than 50 years and every seventh will be older than 80 years (Hampicke et al., 2011). Although ageing is not automatically equivalent to the need for care, the majority of the population increasingly relies on assistance, support and medical care with advancing age (Wichert, 2010). In 2009, 2.34 million people in Germany depended on care (Statistisches Bundesamt, 2011). The majority of older persons desire to remain in their accustomed living environment as long as possible (Wichert, 2010; Osl et al., 2010). Today, already 30 per cent of the over-60 year olds live in single households (Statistisches Bundesamt, 2010). However, the likelihood of care dependency increases with age, with 83 per cent of those in care aged 65 and above (Hoffmann and Nachtmann, 2007; Statistisches Bundesamt, 2011). In 2009, 1.07 million people were cared for at home (by relatives and / or mobile nursing services), while 717 000 were cared for in nursing homes (Statistisches Bundesamt, 2011). An age-appropriate design of the living environment, as well as the support and care of relatives or professional care services, make it possible for people to age in their accustomed living environment (Georgieff, 2008). To ensure the future care and support of the elderly, AAL technology will gain importance (de Ruyter et al., 2010). AAL technology refers to technical devices that provide various services to persons with special needs, in order to support them in their daily life.

The German Federal Ministry of Education and Research distinguishes between four market segments for AAL developments. Solutions of the first segment 'Health & Homecare' aim at the adoption of intelligent systems for assistance purposes supporting preventative health care and rehabilitation at home. Examples include reminder functions that support the management of medical treatment. Products of the second segment 'Safety & Privacy' are intended to identify imminent danger without limiting the freedom of movement – or, if possible – to increase the freedom of movement. Examples are floor sensors that identify emergency situations like a fall resulting in injury and then immediately call for help. Solutions of the third segment 'Supply & Household' support everyday household activities. Products of the fourth segment 'Social Environment' aim to support and facilitate participating in social life – particularly for those, who are limited to their accommodation, whether temporarily or long-term. These systems support access to information, learning, and communication with others.

The attitude of a customer towards a product, defined as a 'person's relatively consistent evaluations, feelings and tendencies toward an object or idea' (Armstrong et al., 2009, p. 160) influences their trust and purchase intention. The importance of customer trust is rising for companies since 'trust has become the cornerstone to a continuing relationship' (Armstrong et al., 2009, p. 463).

However, trust in AAL technology is a relatively unexplored research field (Steinke et al., 2012a). In this context, Steinke et al. (2012b) examined older persons' trust in sensors and characteristics of AAL technologies. In order to expect high levels of trust, sensors need to be visible and installed in the home environment and especially has to be reliable and simple to use (Steinke et al., 2012b).

The existence of purchase intention as a predictor of subsequent purchase is well documented in literature (Grewal et al., 1998) but does not always result in an actual purchase decision (Kotler and Armstrong, 2010). Factors, such as the attitude of others or unexpected situational factors like the expected income, expected price and expected product benefits, may change the purchase intention (Kotler and Armstrong, 2010).

3. RESEARCH FRAMEWORK

3.1 Background Information

The survey was based on data collected in an online questionnaire using the software "oFb – der onlineFragebogen" offered by the website www.soscisurvey.de. Personal contacts via email, social networks, forums and XING Groups were used to recruit participants. It was carried out between September 21 and October 23, 2011. In order to reach older people who may potentially use AAL products and services, the analysis was limited to consider only those aged 50 years and above.

In the 33 days period, 339 persons klicked on the questionaire's link, while 108 (32 per cent) completed it. When limited to the target age bracket, this figure fell to 83. After the exclusion of another six questionaires due to inappropriate answers – these participants evaluated each question of every scenario identically – 77 data sets were taken into account for the analysis. As a result of including only the participants aged 50+, the sample did not describe a cross-section of the German population.

Participants were between 50 and 81 years old and their average age was 63.90 years (median of 64.00 years) with a standard deviation of 7.89 years. The majority of 43 respondents (55.8 per cent) were male and a minority of 34 respondents (44.2 per cent) were female. With reference to their current employment situation, 40 persons (52.6 per cent) identified as having retired, with the rest (36 persons, 47.4 per cent) identifying as still being active in the workforce. Regarding housing situation, most participants answered that they lived together with others (61 people or 79.2 per cent), whereas 16 persons (20.8 per cent) lived in single person households. Concerning smartphones, the majority of 64 persons (83.1 per cent) stated that they did not have one, whereas 13 respondents (16.9 per cent) did.

3.2 Questionnaire Development

Eight independent scenarios were formulated relating to different possibilites of everyday life support. The questionnaire was originally drafted in German and translated into English. Each scenario was constructed on the basis of the same pattern: First, an intuitive everyday situation in an elderly person's life was depicted. Second, a solution for support in the specific situation based on the usage of a smartphone was described. Third, the advantages of each solution were highlighted.

The evaluation of the scenarios was conducted by means of classical test theory (Schnell et al., 2005). Participants were asked to envision each described situation and evaluate the solution. Three established scales were applied in each scenario to subsequently compare them. The first, derived from a study by Ziamou and Ratneshwar (2003), measured a consumer's opinion of a product and inclination to use it – meaning the attitude toward a product (hereinafter: PR). The second scale was initially developed by Rodgers (2004) and was used to measure a consumer's likelihood of buying a particular product or service – meaning the purchase intention (hereinafter: PI). The third scale, originally designed by Jian et al. (2000), was intended to measure the trust in a described solution (hereinafter: TR). However, only six out of twelve scale items were applied for the analysis since there was no difference between certain items when they were translated into German . Moreover, each scale was slightly modified and adapted to the specific logic of the scenarios. Each scale's items were measured on a seven-point Likert scale. The eight scenarios are outlined in Table 1.

Table 1. Scenarios for support in everyday life (authors design)

Scenario 1 (addressing the market segment Safety & Privacy): Imagine, you are suddenly unwell and you need medical advice (e.g. in case of an allergic react ion or an intolerance of drugs). In this scenario, you can speak to medically trained personnel using your smartphone – no matter where you are. At the same time, your location will automatically be determined to assist you quickly and comprehensively.

Scenario 2 (addressing the market segment Safety & Privacy): Imagine, you are home alone and a medical emergency (for example a fall resulting in heavy injury) occurs. As a result, you are no longer able to make an emergency call. In this scenario, and with the aid of suitable sensors, your smartphone detects the distress and makes an emergency call automatically. Thus, an ambulance will be notified and could potentially save your life.

Scenario 3 (addressing the market segment Health & Homecare): Imagine, you are suffering from a chronic disease such as diabetes or hypertension, and therefore want to be able to easily monitor your condition. In this scenario, you are able to measure and evaluate blood sugar levels or blood pressure with your smartphone, and the help of suitable sensors in real-time - no matter where you are. If there is a deviation from the control condition, you will be alerted automatically. Thus, you can react quickly in case of an emergency.

Scenario 4 (addressing the market segment Safety & Privacy): Imagine, you leave your accommodation, but you have accidently left open windows or doors, or you have forgotten to switch off electrical devices. In this case, your smartphone automatically reminds you, with the help of appropriate sensors at the front door, to rectify this. Thus, you are able to prevent burglary, fire or flooding.

Scenario 5 (addressing the market segment Supply & Household): Imagine, you would like to perform small tasks (such as cleaning, shopping, mowing lawns), but due to your deteriorating health, you are no longer able. In this case, you can request housekeeping services from both voluntary as well as professional providers with your smartphone. Of course, the choice of provider is yours. Thus, it is ensured that you can continue to live in your home without sacrificing your standard of living.

Scenario 6 (addressing the market segment Social Environment): Imagine you plan activities whose feasibility can be affected by the weather (e.g. going for a walk or riding to visit a friend). In this scenario, your smartphone verifies the feasibility based on current weather forecasts, and subsequently it makes suggestions on which activities are currently best suited to current conditions - no matter where you are. Thus, planning security is ensured and you do not have to cancel activities due to bad weather anymore.

Scenario 7 (addressing the market segment Social Environment): Imagine, you would like to do something, but you do not have any idea what. In this scenario, your smartphone is able to propose appropriate activities (such as a guided walking tour and a museum visit) and events (such as theater or cinema) and subsequently save them automatically - no matter where you are. If you have selected and saved an activity, your smartphone remembers it automatically. Thus, your everyday life is diversified on the one hand and organized on the other.

Scenario 8 (addressing the market segment Social Environment): Imagine you would like to get in contact, and /or make arrangements, with your family or friends - no matter where you are. In this scenario, you are able to simultaneously inform all of them about your current wishes (such as meeting for coffee or going for a walk) with the help of your smartphone. Thus, you are able to increase the probability, and the frequency, to get in contact with others.

Subsequently, numeric values for each scale in every scenario were calculated as latent variables per participant. Therefore, two quality criteria had to be fulfilled: reliability and validity. Assuming that each scale measures a continuous, normally distributed and latent variable, which was measured by indicators with minor measurement errors, numeric values could be calculated by averaging the items (Schnell et al., 2005). Thus, means of all participants' values for each latent variable were calculated to conduct a general evaluation.

3.3 Reliability

Reliabilty is defined as the extent to which repeated measurements of a single object by means of one measuring tool deliver the same values. One popular coefficient to calculate reliability is Cronbach's Alpha. Alpha can take values from 0 to 1, whereas only those close to or above 0.7 are acceptable for empirical evaluations (Schnell et al., 2005). Cronbach's Alpha was calculated for all scales.

3.4 Validity

Validity of a measurement tool is the extent to which it actually measures the value it is supposed to. There exist three differt kinds of validity: content validity, criterion-related validity and construct validity. In this context, only construct validity is relevant, which can be measured by means of a principal component analysis to evaluate the dimensionality of the instrument (Schnell et al., 2005). The residual components' eigenvalues and the percentage variance accounted for by each component were calculated. In accordance with Kaiser's Criterion, only components with an eigenvalue greater than 1 were retained (Kaiser, 1970).

3.5 Statistical Analysis

In order to obtain results for the implemention of products and services mentioned in the eight scenarios, the 24 ascertained latent variables (PR01-PR08, PI01-PI08 and TR01-TR08) were analyzed. For this purpose, descriptive statistics and correlation analyses were conducted using SPSS Statistics version 17.

4. DATA ANALYSIS

4.1 Validation of Reliability

Each scale (PR, PI and TR) could be considered as reliable for each scenario. Values of Cronbach's Alpha lay between 0.848 and 0.933 (for PR), 0.855 and 0.949 (for PI) and 0.712 and 0.847 (for TR) and were thus acceptable for a further empirical evaluation. In order to obtain the highest reliability for the trust scales, one of the six items was excluded.

4.2 Validation of Validity

Content validity was also ensured in each case. Percentage variances in the principal component analysis lay between 0.702 and 0.834 (for PR), 0.775 and 0.908 (for PI) as well as 0.572 and 0.853 (for TR).

4.3 Descriptive Scenario Analysis

As illustrated in Table 2, means of PR01-PR08 in scenarios 1 to 4 were close to five or even above five and thus in the upper range on a seven-point Likert scale. In contrast, scenarios PR05- PR08, produced a clear distinction in participants' evaluations, as their mean scores of 3.32 to 4.18 lay in the scales' medium range. Thus, there is a split in the sample. The first four scenarios – dealing with offers regarding security and health prevention aspects – were generally considered more valuable than the last four which addressed delivering small services, planning activities, or getting in contact with others. These findings were approved by analyzing the purchase intention (PI01-PI08), since participants evaluated analogically to PR. PI01-PI04 featured mean scores of 3.99 to 4.49, whereas PI05-PI08 were only assessed with values between 2.59 and 3.37. This means the elderly were more likely to pay for solutions of the first four scenarios. It is likely this results from the close nexus between the attitude toward a product and the intention to purchase it. However, the intention to purchase a single solution was always ranked below the attitude toward it. This means that the value of a product is assessed higher than the willingness to pay for it. In contrast to PR and PI, mean scores of trust solely lay in the medium range on a seven-point Likert scale. Thus, participants gave consistent scores with values around 4 on a seven-point Likert scale in all described scenarios, but did not highlight specific ones. Hence, no split between the first and last four scenarios could be detected. Although the means of TR01-TR04 were slightly higher than those of TR05-TR08, the gap was closer compared to PR and PI

Table 2. Descriptive Statistics of all calculated latent variables (authors design)

	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08
N	77	77	77	77	76	75	76	77
Mean	4.92	5.31	5.11	5.05	4.18	3.36	3.32	3.60
	PI01	PI02	PI03	PI04	PI05	PI06	PI07	PI08
N	77	77	77	77	76	76	74	77
Mean	4.04	4.49	4.42	3.99	3.37	2.74	2.59	2.78
	TR01	TR02	TR03	TR04	TR05	TR06	TR07	TR08
N	77	77	77	77	75	75	76	76
Mean	4.41	4.60	4.52	4.62	4.33	3.89	4.25	4.22

4.4 Interrelations between the Attitude toward a Product, the Purchase Intention, and Trust

Interrelations of respective pairs of PR and PI (e.g. PR01 and PI01) were observed by means of correlation analyses (see Table 3). Strong significant correlations between 0.640 and 0.793 showed that participants saw a very close link between these variables. However, there were no huge differences between the scenarios. This means that the attitude toward the product determines, to a similar extent, the intention to purchase it in each case. In relation to the nexus between the attitude toward the product and trust, there were also strong correlations (values between 0.545 and 0.695). However, values were slightly below those mentioned before. Nevertheless, PR and TR interact strongly with each other. Conversely, correlation coefficients between trust and the purchase intention were weaker to some extent in comparison with PR and TR across-the- board with one exception.

Table 3. Correlations between the respective pairs of latent variables (authors design)

	PR01* PI01	PR02* PI02	PR03* PI03	PR04* PI04	PR05* PI05	PR06* PI06	PR07* PI07	PR08* PI08
Cor. Coef.	.640**	.771**	.787**	.793**	.745**	.745**	.794**	.723**
Significance	.000	.000	.000	.000	.000	.000	.000	.000
N	77	77	77	77	76	76	74	77
	PR01* TR01	PR02* TR02	PR03* TR03	PR04* TR04	PR05* TR05	PR06* TR06	PR07* TR07	PR08* TR08
Cor. Coef.	.695**	.634**	.604**	.604**	.545**	.642**	.639**	.628**
Significance	.000	.000	.000	.000	.000	.000	.000	.000
N	77	77	77	77	75	75	76	76
	PI01* TR01	PI02* TR02	PI03* TR03	PI04* TR04	PI05* TR05	PI06* TR06	PI07* TR07	PI08* TR08
Cor. Coef.	.497**	.593**	.607**	.583**	.437**	.618**	.561**	.616**
Significance	.000	.000	.000	.000	.000	.000	.000	.000
N	77	77	77	77	75	75	74	76

* correlated with

** Correlation is significant at the 0.01 level (2-tailed)

4.5 Influence of Participants' Ages on the Scenarios

As illustrated in Table 4, a slight negative correlation was observed between participants' ages and PR01-04 as well as PI01-PI04. This resulted in a progressively less favourable attitude toward the product and purchase intention with increasing age. However, only PR03 and PR04 showed significant results. In any case, as already detected, the sample was split. Neither PR05-PR08 nor PI05-PI08 showed clear trends (correlation coefficients close to zero) or significant results. In terms of trust, there was neither a split in the sample nor a general trend with significant results that particpants' ages influenced TR01-08. This was illustrated by correlations with coefficients close to zero. In conclusion, there was no evidence that people of different ages evaluated the scenarios with respect to all variables differently in general.

Table 4. Correlations between age and each calculated latent variable (authors design)

		PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08
AGE	Cor. Coef.	-.148	-.113	-.233*	-.257*	-.031	.039	.005	.149
	Sig. (2-tailed)	.199	.326	.041	.024	.790	.743	.965	.195
	N	77	77	77	77	76	75	76	77
		PI01	PI02	PI03	PI04	PI05	PI06	PI07	PI08
AGE	Cor. Coef.	-.123	-.078	-.178	-.105	.087	.005	.047	.097
	Sig. (2-tailed)	.285	.497	.121	.364	.456	.968	.689	.400
	N	77	77	77	77	76	76	74	77
		TR01	TR02	TR03	TR04	TR05	TR06	TR07	TR08
AGE	Cor. Coef.	-.053	.054	-.085	-.179	.031	.059	.110	.078
	Sig. (2-tailed)	.649	.641	.465	.119	.791	.615	.346	.505
	N	77	77	77	77	75	75	76	76

* Correlation is significant at the 0.05 level (2-tailed)

5. DISCUSSION

The study explored older people's attitude toward a product, trust and purchase intension for various scenarios of Ambient Assisted Living (AAL) technology. The analysis revealed that products and services of scenarios 1 to 4, which referred to the market segments Safety & Privacy and Health & Homecare, were evaluated more favorably with reference to the attitude toward a product and the purchase intention. In relation to these variables, the sample was split. This means that the elderly were more willing to use solutions aimed at security and prevantitive health measures instead of those dealing with delivering small services, planning activities or getting in contact with other persons. When considering AAL technology, older people obviously focused on primary needs essential to ensure a safe life in their accustomed accommodations. Conversely, they generally did not place great emphasis on functions able to connect them with other persons or help them to maintain their house. Although many studies identified the need of older people for social contacts, they obviously seem not to prefer technical support to satisfy this need. At least, they rejected the possibilities offered in the scenarios. This is why prototype developments should concentrate on solutions dealing with Health & Homecare as well as Safety & Privacy issues. In doing so, there is also the advantage for the supplier that customers are willing to pay for these offers. In addition, the possibility to differentiate from competitors is even bigger in offering real products – which is constituted by many offers of the market segments Health & Homecare and Safety & Pricacy – instead of acting as a mediator offering intangible assets – what is very likely when addressing the market segments Supply & Household or Social Environment. As the attitude toward the product and the purchase intention were highly correlated, it is observed that the elderly are willing to pay for solutions to the extent they offer value. This means: The higher the value, the higher the willingness to pay. Thus, AAL solutions are not viewed as diverging from most products and services offered by other industries. Nevertheless, further research has to cope with older people's use of technology in various situations of daily supports by conducting experiments with working prototypes.

In contrast, there was no clear trend with relation to trust. Since trust in the solutions was assessed with scores in the medium range on a seven-point Likert scale, there was no wide difference between scenarios 1 to 4 and 5 to 8 in relation to PR and PI. This means that trust – in contrast to the attitude toward a product and the purchase intention – does not depend on the the market segment a product or service is assigned to. However, further research, e.g. by means of other scales in surveys or experiments including prototypes, is required to verify these results.

In addition, a substantial nexus between trust and the attitude toward a product, as well as the purchase intention was detected. However, correlation coefficients for each variable were slightly below those between PR and PI. Since the connection between PR and TR was somewhat stronger in comparison to the connection between PI and TR, the attitude toward the product mainly influences trust. Vice versa, PR was very likely to have only a small impact on TR. Nevertheless, this finding needs to be verified by means of a regression analysis or other means of multivariate analysis methods.

In any case, this survey did not aim solely at the core target group of people aged 65 and above, but also included those with a minimum age of 50. Since the analysis was based on fictitious scenarios, the opportunity existed to find out if age influences the evaluation of PR, PI or TR. Although slightly negative correlations could be dectected with respect to PR and PI, no general trend was observed that older people evaluate PR or PI less favorably due to potential lower technology affinity. Thus, results acquired on the basis of today's elderly are able to be projected to the next generation of older and very old people. In addition, this offers the possibility to develop AAL products suitable for the mass wihtout addressing a specific age group. However, further studies, including more participants, are needed to validate this.

Further research is also requried with respect to the general outline of AAL technology questionnaires. Since the three scales could potentially influence each other, tailored and standardized scales for the purposes of AAL in form of a validated questionnaire should be developed and applied. Alternatively, experiments on the basis of working prototypes and an appropriate target group need to be conducted. This approach would allow a long-term observation with different target groups or pre-post comparisons with the same target group. On the basis of those results, detailed information on the willingness to pay for certain solutions should be gathered as the next step to develop valid business models for enterprise networks which deliver AAL products and services. Additionally, elderly persons' trust in AAL technology will be underlined by model development and several experiments.

6. LIMITATIONS

In spite of many valid results, there are some limitations in the survey. Since only 77 participants were questioned, some t-tests for unpaired comparisons, as well as correlations, failed to deliver significant results. Since trends without significant results were observed in several cases, further studies must interview more participants to verify differences in the sample. This is why only age was considered to assess differences in the sample. Moreover, the study was conducted online with the result that few very old people were reached due to their low affinity for the Internet. Thus, average age of participants was below those of persons who will eventually use the products and services described in the scenarios. Further, the possibilty only existed to conduct scenarios envisioned for the German market.

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Short Papers

AN ONTOLOGY-ENHANCED SOA-BASED HOME INTEGRATION PLATFORM FOR THE WELL-BEING OF INHABITANTS

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ABSTRACT

Smart homes are expected to provide better services to inhabitants, supporting independence especially to elderly people in living their lives. Home automation system plays an important role in supporting the well-being of inhabitants, reducing necessary human interventions in achieving different tasks. Sensors, actuators, and various devices are required to be installed in smart homes to provision context-aware services. This paper presents a home integration platform architecture based on Service-Oriented Architecture paradigm that can be used to integrate the functionalities of different devices. A proposed ontology to enhance the automated reasoning process is also presented, and several example scenarios related to safety and security at home utilising the Semantic Web Rule Language rules are described as well.

KEYWORDS

eHealth, smart home, SOA, Web Services, integration platform, ontology

1. INTRODUCTION

The role of Information and Communications Technology (ICT) is becoming more crucial in home environments, especially for supporting elderly inhabitants. Home automation system should be able to control various devices installed at home, turning the aforementioned homes to so-called smart homes. Smart homes are also envisaged to enable healthcare providers to provide remote patient monitoring and care, which can potentially reduce the required time for patients to stay at the healthcare premises. From this standpoint, smart homes will provide more independence to elderly people in living their lives with minimum interventions.

Integrating various different devices (including sensors and actuators) in a smart home can be challenging, especially when different vendors are involved in the process. Redundant and overlapping functionalities between different devices may exist with very limited reusability in different services being provided to the inhabitants. To solve this issue, a service-oriented approach is proposed to promote reusability and interoperability, as its loosely coupled nature allows integration of legacy and existing systems in granular way that can easily accommodate changing needs. The adoption of Service-Oriented Architecture (SOA) (Barry, 2003) paradigm in a smart home will provide a unified way of combining and using data from various devices, providing a standard way to develop and compose services.

As automated decision making is of great importance in a smart home environment, a knowledge base containing real-time information and context of different entities in the smart home should be present. This knowledge base has to be updated whenever any condition of the entities is changed, then reasoned upon by the home automation system to make correct decisions. Ontology is an approach for storing and managing knowledge base that can be used in a smart home environment. It can also be used to model and store contexts.

This paper, which is based on an ongoing research project, proposes a SOA-based home integration platform architecture that is enhanced by incorporating an ontology for modelling contexts of different entities in a smart home environment. Some scenarios related to safety and security of inhabitants are also discussed with corresponding rules for automated reasoning.

2. TOWARDS SERVICE-ORIENTED PARADIGM

SOA has been widely adopted until recently, especially using Web Services (Barry, 2003) technology. Web Services technology promotes interoperability between various software applications running on disparate platforms by employing open standards and protocols. In addition, it also enables the reuse of services and components which further increases the speed of service creation. In general there are three different entities in SOA: service provider, service consumer, and service registry. Service provider provides services and publishes their interfaces as well as access information to the service registry. Service consumer locates entries in the service registry and binds to the service provider in order to invoke services.

SOA is envisaged to give a significant impact when applied to eHealth services in smart home context for the well being of inhabitants as it is well suited to tackle interoperability issues by separating implementation logic and interface of a service. Furthermore, since the SOA concept promotes reusability of existing services, new and tailor-made healthcare services can be provisioned in a timely manner.

As eHealth services becoming more pervasive, medical sensors alongside other devices are required to be installed in the smart home to deliver eHealth-related services. These devices may not be owned by the inhabitants, but rather provided by healthcare service providers (e.g. hospitals) with a wider scope of business processes. A device placed by a healthcare service provider in a smart home generally serves a specific purpose. This, however, limits the full potential of the corresponding device as the data produced or captured by the device can potentially be utilised by other services in the smart home. A common interaction platform between devices is necessary to be present in the smart home to tackle this issue.

Point-to-point communication between service provider and service consumer is mainly used in traditional Web Services approach. This may work well when a small number of devices are present. With an increasing number of new devices being installed in the smart home, a centralised management system is beneficial to be deployed. This can be achieved by introducing a logical smart home service bus that supports event-driven SOA. A technology called Enterprise Service Bus (ESB) (Chappell, 2004) existed within the SOA domain that can be used for this purpose. An ESB provides the implementation backbone for an SOA, acting as a hub between service provider and service consumer. It provides a loosely coupled, event-driven SOA with a highly distributed universe of named routing destinations across a multi-protocol message bus. Applications in the ESB are abstractly decoupled from each other, and connected together through the bus as logical endpoints that are exposed as event-driven services. In general an ESB has four major functions: message routing, message transformation, protocol mediation, and event handling.

3. CONTEXT-AWARENESS IN SMART HOME ENVIRONMENT

Context is any information that characterise an entity's situation (Dey, 2001), where an entity can be a person, place, or any object that plays a role in any type of interaction. Although the definition of context within computer science communities rooted in user location, context encompasses many other things of interest including physical surrounding environments (e.g. lighting, noise level, temperature), network connectivity, communication costs, communication bandwidth, and social situation. Context-aware computing is about gathering user information and their environment, where such information is used for adjusting environment settings to suit user needs and preferences. Context-aware applications and services are most suitable to be applied in spaces where humans spend the majority of their time, including homes. Context-awareness is a prerequisite for adaptivity (Schilit et al., 1994), and when applied in a smart home environment, it can potentially release the inhabitants from doing different tasks and support their well being at home.

Acquiring context is a starting point for any context-aware system. Context acquisition is the process where the real situation in the world is captured, the significant features are assessed, and an abstract representation is created, which is then provided to components in the system for further use. In a smart home environment, contextual information is mainly gathered by various sensors. In order to support home automation system, the context-aware system architecture should enable integration of different sensors with other devices. Thus, a home integration platform that is context-aware is required.

4. HOME INTEGRATION PLATFORM ARCHITECTURE

Integration of different devices and services in smart home environment is necessary in order to enable collaboration among them. By utilising the SOA principles, services beyond the basic utilisation of each device or service can be provisioned. To achieve this, a logical home integration platform is needed, acting as a logical central hub for all communications among devices and services. This platform should provide service creation and composition capabilities as well as event-driven message handling functionalities. Additionally, the platform should also follow standard-based interoperability best practices by utilising open standards to further avoid vendor lock-in. Figure 1 shows the proposed architecture of the home integration platform, which is extended from the authors' previous work in (Trinugroho et al., 2011).

Application developers are given the freedom to either use service enablers per se, combined the application with composite services, or rely on the mediation layer's specific functionalities such as the mediation flow for sequencing the invocation of services. By deploying this architecture, it is envisaged that integration of various devices and services will be easier in the smart home, and new services can be created faster to meet the inhabitants' needs.

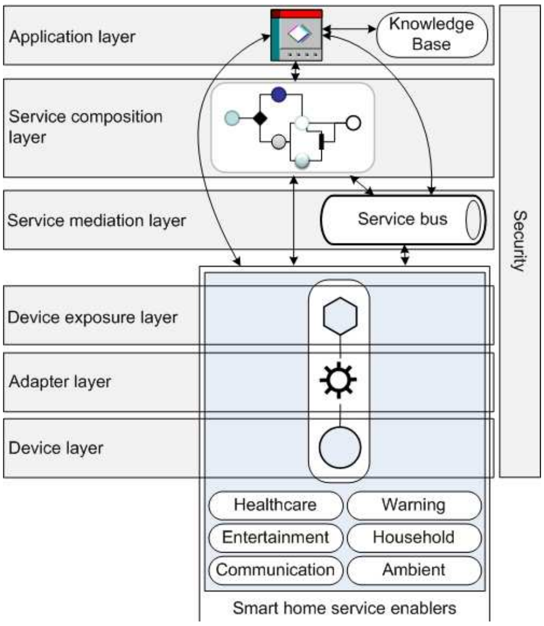
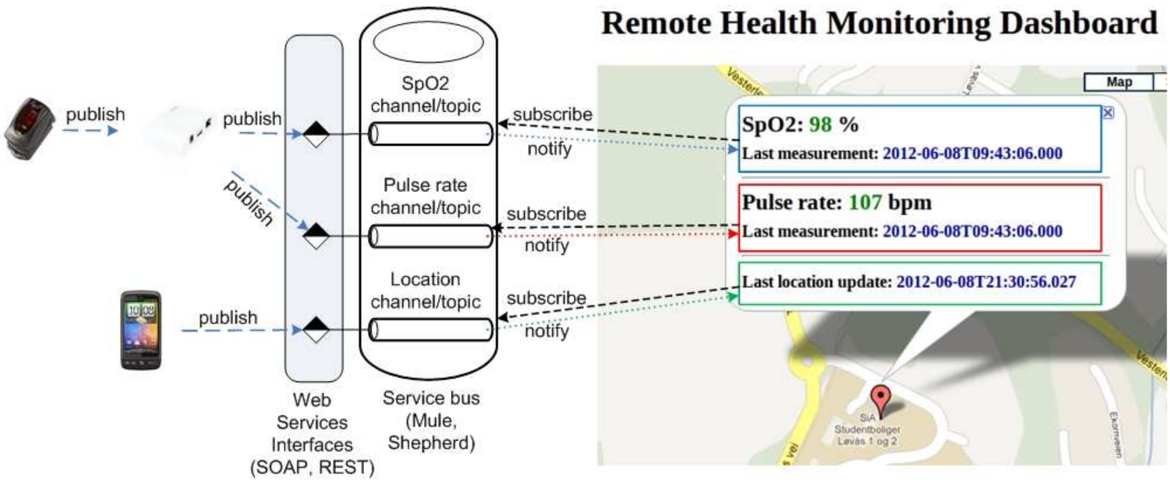


Figure 1. Home integration platform architecture

Initial prototype of the architecture in Figure 1 has been implemented within remote health monitoring application domain. Only three different types of information have currently been integrated: location, SpO2, and pulse rate. SpO2 and pulse rate information are gathered from Nonin Onyx II 9560 device with Bluegiga AP3201 as its gateway. Location information is gathered from an Android phone application deployed on HTC Desire. Mule open source ESB and Telenor Objects' Shepherd Platform are used as the service bus to provide event-driven, publish/subscribe messaging pattern. Web services interfaces (SOAP and REST) are employed for data input interfaces to the service bus. A web-based application based on Ajax and Java servlet technologies has been developed to visualise the remote health monitoring dashboard. The preliminary prototype implementation architecture is shown in Figure 2.



SpO2: 98 %
Last measurement: 2012-06-08T09:43:06.000

Pulse rate: 107 bpm
Last measurement: 2012-06-08T09:43:06.000

Last location update: 2012-06-08T21:30:56.027

Figure 2. Remote health monitoring prototype

5. ONTOLOGY-BASED AUTOMATED REASONING

An ontology has been developed within the Application layer in Figure 1, acting as a knowledge base to describe relationships between different entities in the smart home environment. The ontology itself is developed following the Web Ontology Language (OWL) (McGuinness and Van Harmelen, 2004) standard representation. Semantic Web Rule Language (SWRL) (Horrocks et al., 2004) is used for reasoning on the ontology, where the rules are of the form of an implication between an antecedent and a consequent. The ontology, combined with SWRL rules, is aimed to support context-aware applications and services in the smart home to make correct decisions.

5.1 Smart Home Ontology

The well-being of inhabitants in a smart home setting is dependent on both the inhabitants' personal and surrounding ambient conditions. The developed ontology should cover both person-centric and ambient smart home context modelling. The current contexts being modelled in the ontology include activities of the inhabitants, the personal state of the inhabitants which covers both physical and mental states, location of the inhabitants, and the surrounding ambient smart home states. In addition to modelling contexts, the ontology also provides knowledge base for devices in the smart home. Figure 3 shows several important classes (concepts) of the proposed smart home ontology.

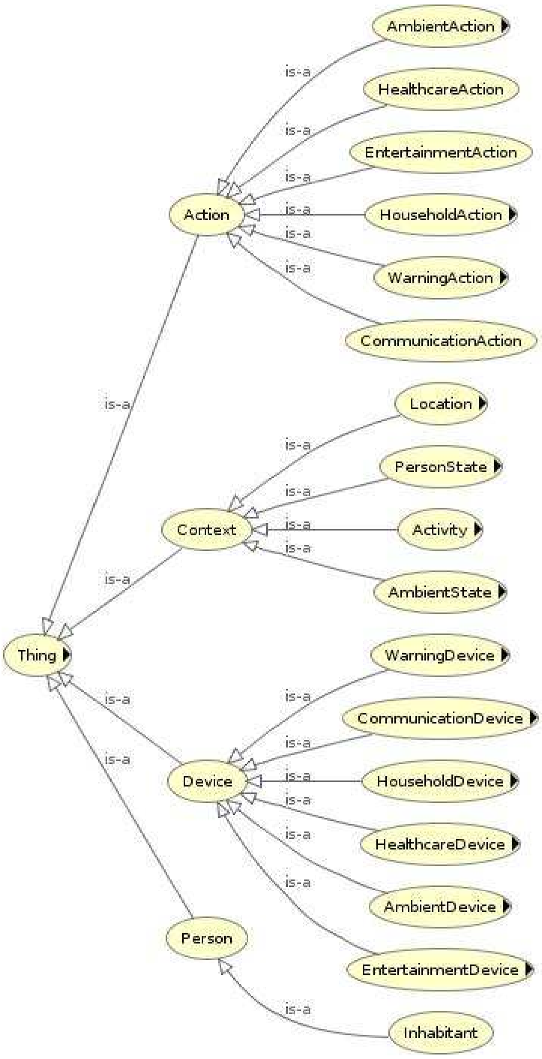


Figure 3. Smart home ontology

The Device class has six subclasses that map one-to-one with the service enablers in the home integration platform architecture (Figure 1). This particular class enables the underlying devices to take part in the reasoning process. The behaviour of the devices is represented by the Action class, which is also mapped one-to-one with the Device class, related by different object properties. Individuals (instances) of the Action class (and its subclasses) represent the possible actions of the underlying devices. The changing values of datatype properties of the Action class (and its subclasses) resulting from the reasoning process indicates that specific actions should be performed on the physical devices. The context-aware application has to be informed about these changes so that service functionalities of the corresponding devices can be invoked. After a successful invocation, the changed value of a datatype property should be reverted. From the SWRL rules' perspective, the value changes of datatype properties of the Action class' individuals act as consequents of the rules, where the antecedent is mainly played by the contextual information provided by various sensors. Several SWRL rules are provided in the scenario examples. Figure 4 shows the general context-aware application architecture. The context-aware application subscribes to all sensor-related information to the service bus, and listens to all notifications coming from the service bus whenever new sensor-related information arrives. It then updates the ontology and runs the SWRL rules. If an action should be carried out, the context-aware application invokes the corresponding service in the action space category. The services within the action space category can be actuators as well as external services such as social media APIs.

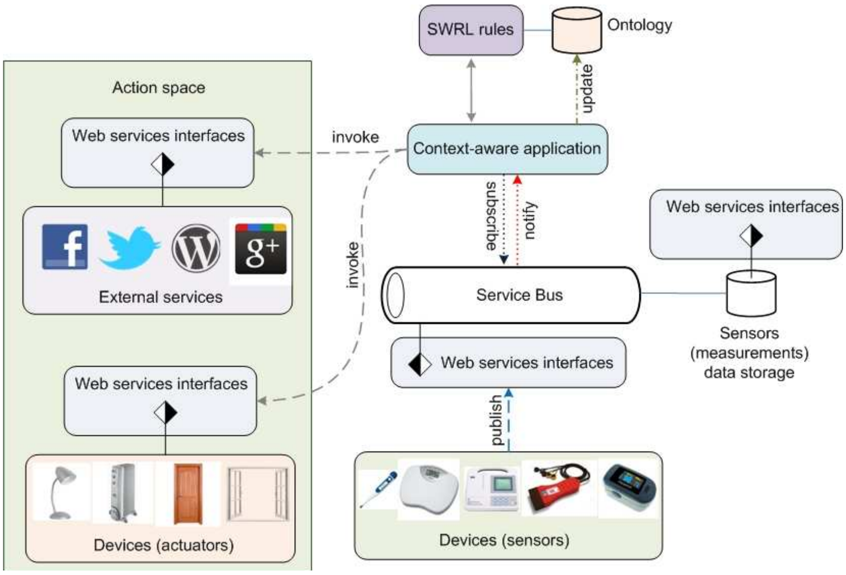


Figure 4. Context-aware application architecture for home automation system

5.2 Example Scenarios

Safety and security of inhabitants in smart home are of great importance. Home automation, which is an intrinsic part of smart home, can strengthen safety and security aspects of smart home. Several simple scenarios have been devised relating to those aspects, described as follows.

- *Automatic Door Locking*

An inhabitant leaves his house, gets on his car, and drives away. However, he forgot to lock the house's main entrance door. The home automation system detects this situation and makes a correct decision (i.e. locking the main entrance door). A rule to simulate this scenario is as follows.

```
Person(?P) ∧ MainEntrance(?E) ∧ SmartHome(?S) ∧ Door(?D) ∧ hasRoom(?S,?E)
∧ hasRoomComponent(?E,?D) ∧ isLocatedAt(?P,?L) ∧ isTransportation(?L,True)
∧ isLocked(?D,False) ∧ hasDoorAction(?D,?A) → lock(?A,True) ∧ unlock(?A,False)
```

- *Automatic Window Opening*

An inhabitant sets in his profile that a comfort temperature for a living room is between 19 and 25 degrees Celcius. A living room is considered to be hot when the temperature is above 25 degrees Celcius. The home automation system detects the temperature of the living room with a thermometer and change the temperature state to hot whenever the thermometer's temperature value exceeds 25 degrees Celcius. A rule to simulate the knowledge base update in the ontology of the changing temperature state is as follows.

```
Room(?R) ∧ hasTemperature(?R,?T) ∧ hasTemperatureSensor(?R,?S)
∧ hasTemperatureValue(?S,?V) ∧ hasMaxComfortTemperature(?R,?C) ∧swrlb:greaterThan(?V,?C)
→ hasTemperatureValue(?T,?V) ∧ hasColdnessState(?T,"Hot")
```

This condition can be further used to control actuators, such as opening the window when the temperature state of the living room is hot. The rule for this task is as follows.

```
Room(?R) ∧ hasTemperature(?R,?T) ∧ hasColdnessState(?T,"Hot") ∧ Window(?W)
∧ hasRoomComponent(?R,?W) ∧ hasWindowAction(?W,?A) ∧ isClosed(?W,True)
→ open(?A,True) ∧ close(?A,False)
```

- *Automatic Electric Stove Turning Off*

An inhabitant sets the standard maximum time for taking a shower in the bathroom in his profile to 60 minutes. Given that each room in the smart home (including the bathroom) is equipped with several infrared sensors for detecting the inhabitant's presence, the home automation system can detect the most current location of the inhabitant as well as the duration of his presence in that particular room. The inhabitant cooked food using an electric stove, then left the kitchen for taking a shower. 60 minutes has passed and he has not left the bathroom yet. The home automation system detects this anomaly, turns off the electric stove, then activates an alarming system in the bathroom for a notification to the inhabitant that he has been taking a shower more than the maximum normal duration and the electric stove has been turned off. A rule to simulate this scenario is as follows.

```
Person(?P) ∧ BathRoom(?B) ∧ SmartHome(?S) ∧ hasRoom(?S,?B) ∧ isLocatedAt(?P,?B)
∧ hasTimeOfStayInAPlaceMinutes(?P,?T) ∧ hasMaxNormalDurationMinutes(?B,?X)
∧ swrlb:greaterThan(?T,?X) ∧ ElectricStove(?V) ∧ isOff(?V,False)
∧ hasElectricStoveAction(?V,?O) ∧ ElectricAlarm(?W) ∧ hasDevice(?B,?W)
∧ hasAlarmAction(?W,?A) → turnOff(?O,True) ∧ turnOn(?O,False) ∧ setVolumeLevel(?A,"Low")
∧ setWarningMessage(?A,"Kitchen stove turned off!") ∧ startWarning(?A,True)
∧ stopWarning(?A,False) ∧ hasAlertState(?P,"Yellow")
```

As previously mentioned, the antecedent of the rules (subsequent to the implication symbol) indicates actions needed to be taken by the home automation system application. Thus, the application should be notified of these changes after a reasoning process takes place. The presented rules have been tested with Jess rule engine (Friedman-Hill, 2003).

6. CONCLUSIONS AND FUTURE WORK

Interoperability, reusability, and modularity are some of the positive traits of SOA that are expected to give positive impacts when applied to home automation systems. In this paper a SOA-based home integration platform to support context aware services was proposed. An ontology which describes the relationships between different entities in the smart home was also presented, and several reasoning scenarios related to safery and security of inhabitants using the SWRL rules were described. The deployment of the proposed home integration platform, combined with the ontology, is foreseen to enable the creation and deployment of sophisticated composite services for well-being of inhabitants in the smart home.

Implementation of context-aware applications utilising the developed ontology and various devices is planned to be carried out in the advancement of this work.

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ON THE USE OF SOCIAL HEALTHCARE NETWORKS IN IRAN ADDRESSING CARDIOVASCULAR DISEASES

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ABSTRACT

Since the demand for healthcare services increasingly surpasses supply, it is important for the industry to increase its efficiency and give people innovative resources to manage their wellness. Information Technology (IT) has become a critical factor in improving operational efficiency, achieving better quality, and providing innovative care solutions. One of these innovations is the application of Social Healthcare Networks (SHNs) which facilitate communication, collaboration, and information sharing in the healthcare sector. This paper explores potential use of SHNs in Iran to address cardiovascular diseases since these are among the main causes of mortality in the country. Properties, characteristics, and different aspects of current SHNs were studied and a survey was conducted among potential users of these networks in Iran. The survey results revealed that 75% of participants have not used any Persian healthcare websites or found them in poor quality. Moreover, 66% of them expressed their interest in sharing and discussing health related issues. This indicates that this area is mostly an untouched and therefore there are excellent opportunities for players to invest in Iranian healthcare networks. In addition, this study classifies, quantifies, and ranks the preferences that Iranian users want to see in sites dealing with cardiovascular diseases. 80% of the participants considered prevention as the most important content. The study also shows that tracking, monitoring, calculating, and recording personal health, as well as sharing, and exchanging facilities which operate in a secure mode and conserve their privacy are the most attractive features they would want in cardiovascular SHNs.

KEYWORDS

Social Healthcare Network (SHN), Cardiovascular Diseases in Iran, Survey of SHNs, SHNs features

1. INTRODUCTION

In the Internet era many projects have been defined in the healthcare domain. Both Information Technology (IT) and healthcare specialists are very keen to use the cutting edge IT tools in the context of healthcare (Yu and Siddiqui, 2009, David K, 2007). Having a virtual place that bridges information technology and healthcare can help in predictive and preventive care by rising education and awareness (Murray et al., 1996).

Cardiovascular diseases are among the main reason of mortality in most developing countries including Iran (Azarpazhooh et al., 2010, Hosseini et al., 2010). Statistics show that in 2005, 41.3 % of deaths in Iran were caused by cardiovascular diseases and based on WHO’s predictions, this will reach to 44.8 % in 2030 (Haghani, 2008). Cardiovascular disease can root in different factors such as: genetic problems, nutrition style, lack of activity, smoking, stress and different environmental factors (Delbari et al., 2010). Rapid growth of cardiovascular diseases in developing countries is highly connected to the increase rate of people living in urban areas and inappropriate life styles. Improving people’s awareness about these factors can enhance prevention of cardiovascular diseases. Application of Social Healthcare Networks (SHN) can be very beneficial to boost this awareness (Gajanayake et al., 2011b). SHNs could help patients to track disease progress, track health improvements and share their progress with others. In addition, SHNs could facilitate to have access to disease information and make better decision on treatment methods and treatment centers, to track health related life style and finally may result in patients feeling less isolated since they can share their issues with other users.

Internet penetration in Iran raised to more than 46.9% in 2011(Internetworldstats, 2011). Despite this increase, the amount of healthcare related contents in Persian on Internet is not very large. In a survey conducted in 2007 (Fathifar et al., 2007) only 75 different healthcare related Persian websites were found. Online Social Networks, allow both individuals and organizations to “construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view and traverse their list of connections.” (Boyd and Ellison, 2007) In recent years, some Online Social Networks emerged which were dedicated to healthcare industry, but they have a slow penetration in both care delivery systems and people. Despite limited use of these sites and unsolved privacy and data accuracy challenges in this area, predictors regard them as a platform for future healthcare systems which facilitate patients and healthcare stakeholders’ interactions (Domingo, 2010, Gajanayake et al., 2011a).

This research was conducted in order to analyze the current status of cardiovascular social healthcare network in Persian language. In this research the potential use of SHN in Iran with focus on cardiovascular disease has been investigated. Furthermore, the most desirable features of these networks by potential users were surveyed. To construct the questionnaire for the survey, the following criteria were considered: (1) Medical Information Content, (2) Medical Information Presentation, (3) Information Providers, (4) Communication Methods, and (5) Recommended Features. After formation of criteria, target groups were identified. After that, the questionnaire was tested and distributed through online forms. In the final step of the research, the data was collected and analyzed based on predefined criteria.

Next section provides an overview of Social Healthcare Networks, their types, usage and key features. Then, the result of the survey are reflected and analyzed. Finally, the conclusion and future work are discussed.

2. SOCIAL HEALTHCARE NETWORKS

SHNs provide an environment where people can share their stories in order to acquire emotional support. Furthermore, medical professionals can meet and share their cases and stories in SHNs. Moreover, researches can participate together with patients in these networks to learn about different side effects which could help in future prescribed therapies (Landro, 2006, Gibbons et al., 2011, Gajanayake et al., 2011a).The exchange of health information and personal stories in this setting can even exceed medical textbooks (Sarasohn-Kahn, 2008).

2.1 Types of Social Healthcare Networks

There are two types of SHNs: physician oriented and patient oriented (Domingo, 2010). Through physician oriented SHNs, professionals share clinical cases, images, educational videos, and different type of knowledge. For patient oriented SHNs, even though physicians can also be involved, concentration is on patients’ support, promoting awareness, and positive behaviors in order to stay healthy. Patients and all caregivers can participate in creating content, connecting with others and collaborating in order to go through and explore treatment options and other issues. This research focuses only on patient oriented SHNs.

2.2 Social Healthcare Networks in practice

As mentioned earlier, SHNs offer a great foundation for disease information exchange; beside emotional support, they provide a broad knowledge about symptoms and treatments; They also help in lowering the anxiety, giving answers where to go for a treatment, giving additional information about drugs side-effects and gain more knowledge about treatment and symptoms during doctor’s appointments (Domingo, 2010, Gibbons et al., 2011). The collective wisdom on SHNs sites can be complementary to the information any single physician can provide(Steininger, 2009). The more people participate in SHNs the bigger contribution is achieved thanks to the collective intelligence (Sarasohn-Kahn, 2008).

Even though SHN provide good infrastructure for providing comfort, discussing about treatments, sharing symptoms and progress, it raises different questions like - What are the advantages and disadvantages of participatory medicine compared to traditional healthcare resources. What about privacy? What happens if inaccurate data are provided? (Domingo, 2010, Gajanayake et al., 2011a) Surprisingly, according to some surveys, patients often trust more in other patients rather than their doctors. Since they often cannot get answers to their questions from their doctors they have to access medical information on Internet (Doherty, 2008).

2.3 Features of Social Healthcare Networks

SHNs are relatively new and quite few of them have been developed. The characteristics of these networks vary from one to another, but the most common features of these networks are:

"*Profile*": Users can create their own profiles; they can add their personal information, topics they are interested in and their medical conditions. User profile can be either public or restricted to specific people.

"*Patient's Status*": Users can complete their profile in a few ways. They can fill out the "questionnaire" and describe the conditions they are dealing with, they can put their medical "measurements" online and "compare" these measurements with others or standard levels. Furthermore, users can open a health "portfolio" which would contain "medical history", "physicians", and "institutions". Users can set their "goals" in their profile (for example losing weight to specific amount) and SHNs can help them by suggesting how to achieve it, or by providing "Features" to track their progress in achieving that goal.

"*Support Groups*": SHNs can have support groups which are commonly organized by topics or problems.

"*Sharing*": In addition to sharing personal experience, users can also share their experience and opinion about medicines, physicians, medical centers, etc. Furthermore, they can rate them based on different criteria.

"*Networking*": After creating profile page, users can participate in groups, discussions, and compare their condition with others. Also, they can make new friends based on their interests and conditions; they can track posts of certain people, topics and groups; they can invite other people and physicians to discussions.

"*Research Participation*": Users can also participate in different medical investigations and contribute with their data in a secure mode. This participation can accelerate the development of new solutions for patients.

3. SURVEY OF SOCIAL HEALTHCARE NETWORKS IN IRAN

An on-line survey was used to estimate the characteristics of SHN addressing cardiovascular issues in Iran. In this survey, the questionnaire was designed with two main purposes: to provide a holistic view of the potential use of SHN in Iran to address cardiovascular diseases and to extract the most desired features for this target group.

355 people mainly coming from the city areas of Tehran and Isfahan participated in this survey. Their age range was between 18 and 75 years. 9% of them had relevant education or occupations to healthcare industry. 49% of them either personally suffered from cardiovascular diseases or had a family member (father, mother, siblings, and grandparents) with this condition. Around 56% of participants spend more than 21 hours online per week.

Based on our investigation, currently there is no SHN in Persian language. Accordingly, users have to resort to use websites mostly in English. Therefore, instead of asking about SHN, we asked people about the quality of Persian healthcare websites. The result shows that about 75% of participants have not used Persian healthcare websites at all or found these websites in poor quality (Figure 1). Around 19% of the participants considered the quality of the websites acceptable and only 6% think that they are good. Despite the absence of SHNs in Persian, 36% of participants search for more than 30% of their healthcare problems on Internet; 66% of them expressed their interest in sharing and discussing health related issues online.

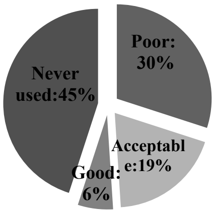
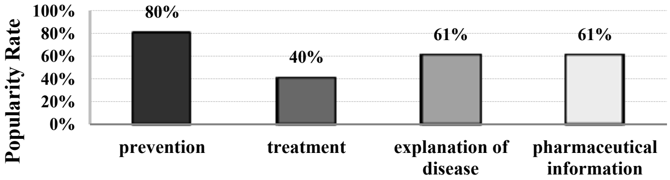


Figure 1. The quality of healthcare related websites in Persian language

3.1 Medical Information Content

The second part of the survey included questions of which medical information content is more important. The selection choices were: *"prevention"*, *"treatment"*, *"explanation of disease"*, and *"pharmaceutical information"*. 80% of participants chose *preventive information* as a beneficial content in SHNs. Moreover, 77% of people with cardiovascular disease concerns rated the prevention as a beneficial content. In comparison, *treatment information* attracted less people and received 40% of total votes and 45% of people with cardiovascular diseases. Around 61% of people showed their interests to the *explanation of disease* and *pharmaceutical information*, which had the same rate of interests among people with cardiovascular disease concerns. (Figure 2)



(Note: Percentages sum to greater than 100% due to multiple responses.)

Figure 2. The rate of popularity of different medical information content

Beside that 68% of participants, who were involved in healthcare industry, believed on *prevention* information, 68% on *explanation of diseases*, 61% on *pharmaceutical information*, and only 32% on *treatment information* as a beneficial content for SHNs.

3.2 Medical Information Presentation

Appropriate presentation of information plays an important role both in ease of use and popularity of SHNs. According to the survey, 67% of people were interested in graphical presentation method, 55% in video presentations, 46% in text pages, and only 8% were interested in vocal information.

3.3 Information Providers

Based on survey results, the level of trust in medical information content is highly dependent on *information providers* rather than *type of information*. In the survey, information providers were classified in three main groups: (1) Online forums which contain patients' experiments, (2) authorized providers such as: physicians, medical universities, and the Ministry of Health, (3) all online sources that covers both online forums and authorized organizations, non-experienced people, non-professionals, medicine companies advertisements, etc. The survey reveals that people trust in authorized providers at the highest level, i.e. more than 92%. The level of trust in online forums was in the range of 28% to 38%, and in all online sources was the lowest level, i.e. less than 9%. Online sources in treatment and pharmaceutical information category held the lowest demands and in prevention with a little difference obtained moderate votes. (Table 1)

Table 1. Level of trust to different medical information content

(Note: Percentages sum to greater than 100% due to multiple responses.)

Provider/ Contents	Online Forum	Authorized Providers	All Online Sources
Prevention	38%	94%	9%
Pharmaceutical	29%	92%	7%
Treatment	28%	93%	4%

3.4 Communication Method

This part emphasizes on the communication capabilities of the social networking for the exchange of cardiovascular diseases information. Based on study of existing SHNs, the communication methods on SHN were classified in *"topic-based"*, "*user-based*" and "*inspiration campaigns*".

"Topic-based" communication refers to the health related topics which are issued and discussed by users of SHNs. Therefore, the participation rate is analyzed in different contents such as: prevention, treatment, and pharmaceutical topics. The participation rate consists of Internet usage amount, users' intention to share personal medical experiences, and their health information. Among people with more than 3 hours/week Internet usage and the ones who intend to unconditionally share their medical experiences on SHN, the tendency to use *"topic-based"* communications with preventive care information was 67%. These statistics were 44% for pharmaceutical information and 22% for treatment information.

"User-based" communication includes sharing personal healthcare problems or medical experiences and discussing about them. Among people who share their healthcare information in websites, 67% were more eager to share and discuss when they have the privacy setting services and when they can define the access level of others to their profile.

"Inspiration campaign" means whether people get inspired by attending in campaigns and events in SHNs. According to the statistics, 60% of people who had cardiovascular disease concern stated that they were inspired through information exchange in SHNs.

3.5 Recommended Features

Participants were asked to vote for different types of features they would prefer to use in a SHN targeting cardiovascular diseases. Table 2 illustrates the popularity of different features that can potentially be used in a SHN.

Table 2. Different features for SHN and level of popularity

(Note: Percentages sum to greater than 100% due to multiple responses.)

Feature	**Votes**
Find and record symptoms	83%
Record and track your blood pressure & heart rate	66%
Set goal and track its accomplishment for exercises, calories burnt, cigarettes smoke, ...	62%
Calculate Body Mass Index(BMI)	61%
Get information about nutritive value of foods	59%
Record and track cholesterol	58%
Send a reminder based on user settings	58%
Get information about calories of foods	57%
Find and record treatments	55%
Record and view patients' lab test results	54%
Track and count calories daily intake	54%
Find and rate doctors, hospitals and medical institutes	52%
Have a graphical representation of your symptoms	49%
Have a graphical representation of your treatments and their influence	39%
Compare patients' health status information with other users	33%

4. DISCUSSION, CONCLUSIONS AND FUTURE WORK

SHNs have great impact on exchange of healthcare related information. By increasing the awareness of people in society, SHNs can play a significant role in prevention and treatment of cardiovascular diseases.

The results of this study indicated that three-fourths (75%) of survey participants were unsatisfied with the quality of Persian healthcare websites or lack of them. Besides, it was found eagerness to search for health related information in more than one-third of participants (36%). In addition, there were strong interest in sharing and discussing about health related issues in two-third (66%), and great concern about cardiovascular disease among half of participants (49%). All indicate a high potential for implementation of a SHN in Persian language that address cardiovascular diseases.

A holistic view on participants' responses reveals different facts: Application of SHNs for prevention ranked first among the other factors (80%), subsequently people showed their interest in using SHNs for acquiring pharmaceutical information and explanation of diseases (61%); and after all they tend to use SHNs even for treatments (40%). This order also applies to the opinion of people who are involved in healthcare industry. In addition, people trust more in authorized sources for acquiring all types of information on SHNs (above 92%). Furthermore, people trust to other users' preventive advices or discussions more than treatment and pharmaceutical talks. Their tendency to participate and share in preventive discussions (67%) and pharmaceutical subjects (44%) is also considerable. In communication methods, approximately two-thirds of participants (67%) tend to exchange preventive care information on "topic-based" communications. The same number of people was interested in "user-based" communications when they could apply privacy setting. Moreover, over half (60%) of respondents with cardiovascular disease concern were in favor of "inspiration campaign". Finally potential users demand a SHN equipped with variety of features (tracking, monitoring, calculating, and recording personal health), as well as sharing, and exchanging facilities which operate in a secure mode and conserve their privacy.

Our results should be validated by a larger sample size and statistical methods in future investigations. Future investigations can also validate and broaden findings of this study by implementing SHNs and examining them in practice. On a wider level, investigations are also needed to be conducted for a comprehensive SHN which simultaneously encompass patients, physicians and various stakeholders in healthcare industry. The application of SHNs in Iran is currently in its infancy stage, therefore creating fantastic opportunities for the healthcare industry and authorities to provide innovative services that can be beneficial to the community.

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FIRST RESULTS IN MODELLING STRESS SITUATIONS BY ANALYSING PHYSIOLOGICAL HUMAN SIGNALS

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ABSTRACT

This work presents preliminary results in seeking a relationship between stress and/or anxiety human feelings, and the corresponding physiological human emotional responses. By analysing the variability of several unintentional physiological signals in stress situations, a first approach of modelling of the human response has been reached. In several critical sectors of our society, such as people with disabilities, the stress processes end up in a blockage situation. The results presented in this work offer a way to implement, in the near future, new non-intrusive devices for predicting the mentioned blockage situations, by processing several human physiological signals. This fact can give a powerful tool to human tutors and relatives, for helping people with special needs, increasing consequently their quality of life.

KEYWORDS

Stress situation modelling, physiological signals.

1. INTRODUCTION

Actually, much of the world population is affected by stress that adversely disturbs in the physical and emotional health of people, reducing the capabilities of conflict solving, task managing, and leading a healthy life. This fact is especially more significant and severe in people with disabilities. People with any kind of disability have fewer resources to face and resolve each labour, social and emotional problem hindering their integration. The fact of being able to identify and resolve the stress situations leads to improve quality of life for all people, especially to those with disabilities. Such situations may be of continued stress due to society demands or a punctual stress situation causing a blockage situation. The development of a device that detects when a person starts to live a stress state would serve as a support to identify the start of a stress situation because there are people who are not even aware of that they are stressed, to identify the stressor or cause that originated it, and to redirect to a situation of stability.

The stress is a psycho-physiological response of alarm, as originally indicated Cannon (1935), that arises when a person needs to react to certain situations or stimuli perceived as threatening, dangerous or uncertain, whether internal or external. During the alert or alarm state, the organism activates a series of defensive devices, both physiological and psychological, in order to overcome and face the possible threat. Stressors are any external or internal stimulus, which initializes the destabilization of homeostasis (in the dynamic equilibrium of the body) (Cannon, 1935). Specifically, it should be noted that in people with disabilities the stress supposes a big problem, called chronic stress, even if it was not a factor maintained in time. In this work, we have studied the possible relationship between stress situations and the human emotional response.

The stress response includes the activation of the central nervous system (CNS), the autonomic nervous system (ANS), the endocrine system, and the immune systems, also with the corresponding neurotransmitters, composing the complexity that characterizes the response (Nelson, 2000). The ANS regulates the heart rate, respiration, circulation, digestion, sweating, metabolism and body temperature via the sympathetic and parasympathetic systems. Besides, it coordinates all these vital functions involuntarily in order to maintain the homeostasis in the body. The activation of the parasympathetic system promotes vegetative effects associated with conservation and energy restoration, promoting a decrease in heart rate, muscle relaxation, etc. On the contrary, in situations where the person integrity can be injured, the sympathetic system responds quickly preparing the organism towards “fight or flight” for preservation (Barash, P.; Stoelting, R.; Cullen. B, 2005). Thus, in any type of stress or blockage, the ANS plays a major role and the study of different physiological variables shows affective states of a person. Through the experiments performed in this work, we can notice the relationship between stress and the changes happened in various physiological variables. Therefore, the study performed in this work is particularly interesting to develop wearable devices based on ICT that in real time were able to measure and identify those situations in order to help people at the beginning of "blockage situation".

In the next section, we present how a human emotion evaluation can be focussed. In section 3, we introduce the designed experiments in which participants had to solve a 3D puzzle in limited time, and we subsequently analyse the obtained results. Finally, some conclusions and future works are presented.

2. HUMAN EMOTIONS EVALUATION

Several authors have selected different methodologies for elicitation of emotions in laboratory, such as hypnosis (Bower, 1983), repetition of phrases (Velten, 1968), facial movements (Ekman et al., 1983), imagination (Lang, 1979), music (Sutherland, Newman and Raciman, 1982), pictures (IAPS, Lang et al., 1999), films (Gross & Levenson, 1995), exposure to real situations (Gilet, 2008; Marci et al., 2008) and even combined methods (Mayer et al., 1995). After analyzing all of them, the exposition of the participant to a real anxiety situation has been considered to cause a stress situation in an experimental environment.

The situations of anxiety, stress and blockage are affective states which could be characterized as a high activation state and negative valence, from the point of view of a dimensional model of emotions. Therefore, the named blockage situations can evoke different emotions. Moreover, it has been not possible to find research references looking for the relationship between the mentioned situations and emotions. This means that a new research line has appeared and new hopeful results can be obtained in the near future. In this work, the selected way to detect stress situations is to associate them to emotional changes. Based on previous works as the one presented by Nasoz et al. (Nasoz y Col, 2003), we have used the relationship between emotional states and physiological variables, in order to detect the beginning of a blockage situation.

In this work we present the set of designed experiments to elicit anxiety and stress situations. In order to study emotional changes, the measure of previously mentioned physiological signals is made in stressful situations. The analysis of these signals provides information related to gradual changes of stress of each induced person. The physiological variables measured are: Galvanic Skin Response (GSR), Electrocardiogram (ECG) and its Variability (HRV), the Respiration (RSP) and the Electromyography, specifically, the Integral Value (IEMG). These signals are regulated by the ANS which is directly modified by emotions (Zhai et al., 2005; Gonzalez et al, 2011; Sloan, 2004).

3. EXPERIMENTAL STAGE DESIGN

3.1 Method

Participants

A total of 49 persons (42 men and 7 women) aged between 19 and 36 years (x= 24.63 and SD = 4.51) participated voluntarily in our experiments. All participants were students in our university (UPV/EHU).

Instruments and Study Materials

Puzzle: 5 different 3D wooden puzzles were used with rules and geometric visual measures. Figure 1 shows one of the used puzzles with its resolution.

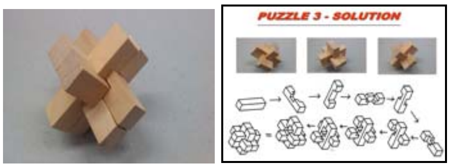

Figure 1. Puzzle and resolution

The puzzles have different difficulties, so we will be able to generate different states of stress.

Questionnaire: After finalizing the experiments, the participants should answer a questionnaire regarding the tranquillity degree felt during the neutral video (bit quiet, quiet or very quiet) and during the puzzle test (little nervous, nervous or very nervous).

Data Acquisition Devices

For the collection of the physiological variables the Biopac Student Lab equipment were used. This system was connected to a computer where data processing was made by the Acqknowledge program. Four physiological signals were measured from each person with corresponding electrodes as shown in figure 2.

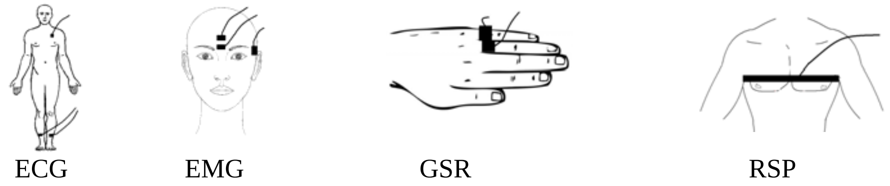

Figure 2. Location of electrodes

Procedure

The phases of the experiment are an important aspect to be taken in mind. Initially, each participant signed a consent form according to the ethical laws (Ezeiza et al., 2008). Before doing the puzzle, a video with relaxing music and nature imagine was projected to bring the participant to a basal emotional status (Gross & Levenson, 1995). In this manner, we obtained the basal measure of the physiological variables. Later on, their values were compared with values obtained in stress emotional status. After the video, participants started with the puzzle trying to solve it during 10 minutes. A warning was made just 2 minutes before finishing. Once the time was over, in order to lead the participant to a tranquillity stage, the relax video was projected again. Finally, the registration of physiological variables stopped and they answer the emotional evaluation questionnaire referred below. In Figure 3 a timing diagram shows the experimental phases.

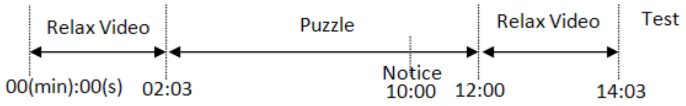

Figure 3. Experimental phases

3.2 Preliminary Results

In this section we present the obtained results in the experiments. We compare the physiological signal behaviour during puzzle solving tests. Figure 4 shows the differences between two possible situations, when the puzzle has been solved (Fig. 4-a) and unresolved (Fig. 4-b).

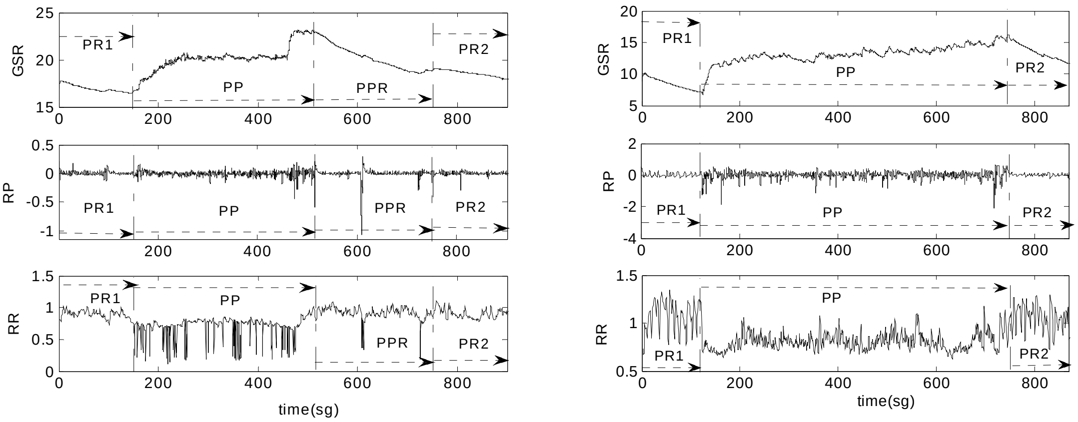

Figure 4. a) Puzzle test solved b) Puzzle test unresolved

In both figures there is a close relationship between the physiological variables. Three phases can be distinguished during the experiment: the first phase includes the relaxing phase (PR1) during the video showing; the second one displays the stress status generated when trying to solve the puzzle (PP): and the third is a new relaxing phase when the video is showed again (PR2). When the puzzled is solved, a new relaxing status (PPR) appears after PP.

Analyzing the physiological signals, heart rate (HR) has lower values in the relaxing phases (PR1, PR2). Hence, distances between R peaks showed in figure 4 are bigger. At the same time, sweating is reduced so decrease the GSR values. Moreover, the RP frequency is wide in these phases. These facts suggest that it is possible to find numerical differences, both timing and frequency, between PR1, PR2, PPR and PP phases.

3.2.1 Statistical Results

The main objective of our work is to find significant differences between the relaxation and stress phases. Hence, the analysis of data has been made from two points of view, the statistical and spectral methods.

Spectral method

The values shown in figure 5 correspond to the average power spectrum of the RR wave of the participants in both phases: relax and stress. During relaxation state, higher medium powers can be observed. While in states of stress, high frequencies are more significant.

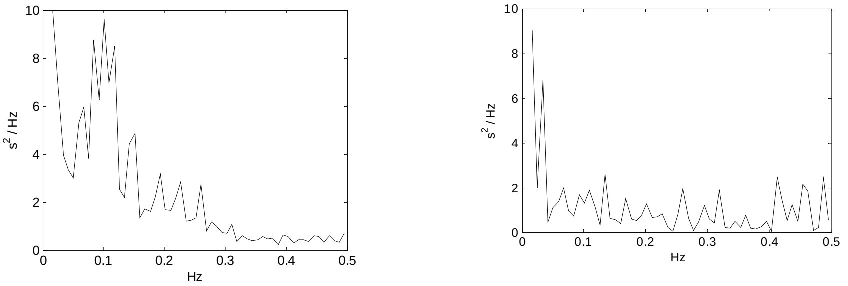

Figure 5. a) Relax state power spectrum b) Stress state power spectrum

Statistical method

The studied statistical variables for the RR wave and normalized GSR have been: mean, median, mode, maximum, minimum, range, mean and standard deviation. Moreover, for analyzing of these variables we have used Machine Learning techniques and classification algorithms as trees J48 and meta Dagging. The classification methods have been applied over the cross validated data sets using WEKA. The results obtained for the RR wave using trees J48 algorithm were a 72.87% of correctly classified instances. For the GSR normalized wave the best results were obtained with the meta Dagging algorithms with a 85.18% of correctly classified instances.

4. CONCLUSION

A first study has been made to analyze the evolution of different physiological variables during human emotional changes. By means of specific designed experiments, participants were led to a stress situation which was performed under laboratory conditions. The chronology of these experiments allowed finding differences between baseline emotional states and elicited stress states. 3D puzzle solving was a satisfactory experimental test for showing human emotional changes in short periods of time.

The selected physiological signal showed relevant changes for an appropriate analysis between emotional states. For this reason, electrocardiogram (ECG) with heart rate variability (HRV), the galvanic skin resistance (GSR), respiration (RSP) and integrated electromyogram (iEMG) are proposed from this work as a useful set of variables.

After the analysis of physiological variables in states, relaxation and stress, different human emotional patters have been found. During the relaxation state, it has been proved that the parasympathetic system takes strength decreased heart rate. Therefore, HRV becomes sinusoidal and predominant in low frequencies. In turn, the galvanic skin resistance decreases showing a signal linear trend. Finally, the general relaxation state involves the relaxation of the musculature producing lower values in the iEMG.

In the emotional change from a relaxation state to a higher level of stress, the GSR undergoes a dramatic increase due to the parasympathetic system which prepares the person for fighting or flying to the problem to encourage. This change also occurs when a person feels close to the puzzle solving. Besides, respiration and HRV become more disharmonious.

Therefore, during a blockage situation, GSR come into a high increase in a small period of time, being maintained until the end of stressors. Simultaneously, an increase in heart rate, HRV and respiration appear, together with a significant increase in muscle activity (IEMG).

Future works will be concentrated on a more extended analysis of the used physiological variables. First results show a hopeful possibility to discriminate between stress and relaxing states. This fact will lead to develop real ICT solutions with wearable and embedded sensors, for analysing human emotional states, and for prediction of blockage situation beginning in people with disabilities.

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A SURVEY ON TASKS PERFORMED IN ELDERCARE

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ABSTRACT

In the Netherlands, a vast increase of the expenses on eldercare is expected for the future. Currently, an IT system is under development that aims to assist care providers with their tasks in providing care services. Before such a system can be used in practice, insight is needed on the current work situation in eldercare. This paper presents interview surveys on tasks currently performed by professionals in two nursing houses. Both the professional population and details on how it spends its time are described. Little room is observed for automating tasks in nursing and/or caring houses.

KEYWORDS

Homecare systems, elderly common problems, service tailoring.

1. INTRODUCTION

In the Netherlands, 19% of the health care budget of 1999 was spent on funding nursing and caring houses (Polder et al, 2006). In 2003, 14% of the Dutch population was over 65 years of age and this number is expected to raise up to 23% in 2040 (Jong, de, 2003). A number of studies from the Dutch planning agency (Dutch: “Sociaal en Cultureel Planbureau”) show that the total expenses on nursing and caring for elderly people will rise from 2% to at least 3% of the Dutch gross national product (GNP).

Within the U-Care project (U-Care project, 2011), research is undertaken to develop a platform that enables tailoring of generic services to specific service consumers. The project aims to reduce the burden placed on (health) care providers when caring for elderly people by automating specific tasks currently performed by care providers, hopefully, helping to stop the increase of expenses on eldercare and cover the shortage of labor force in this domain. The platform consists of atomic services that serve as building blocks that deliver a small, yet distinctive, service to a care consumer. Care providers can tailor these atomic services, resulting in composite services that satisfy individual requirements of care consumers.

Since no assumptions can be made about the care providers affinity with computers, service tailoring has to be very simple. To achieve this, a number of *service blueprints* will be made available to the service provider that can be tailored to the specific needs of a care receiver. For example, the composite service blueprint might be “taking medicine'” consisting of atomic services for enabling a medicine dispenser, generating reminders for taking the medicine and alerting a care provider if the medicine is not taken in time.

To deliver a number of useful *composite service blueprints* to the care providers, it is necessary to discover which common tasks are currently being performed to guide the development of blueprints. The main question that this research answers is: ”*Which common care tasks are provided in nursing and caring houses in the Netherlands and which of them are suited for service blueprinting*”. The following questions break this research question down into smaller questions:

1. Which professions are active in eldercare in the Netherlands? What percentage of the total time spent is performed by each profession?
2. Which common tasks are performed by each profession and how much of the total time spent on elderly care is spent on each type of task?
3. How are these tasks performed?
4. Which of these tasks can be translated in a composite service blueprint?

Answering question 1 will show how much time is spent by each profession in eldercare. This will provide direction in selecting professionals to interview when trying to answer question 2. Answering question 2 will provide a list of tasks currently performed in elder care and will show how much of the total time is spent on a specific task. Answering question 3 provides how each task is performed currently without using an IT-based system. These detailed descriptions can also be used to set up the actual service blueprints. Answering question 4 helps to select those tasks that can be blueprinted.

Throughout this paper, the term *nursing house* is used to refer to a nursing and/or caring house. Both houses researched employ *state-registered carers* that can provide medication that is prescribed by a medical specialist. There are also regular carers that are not allowed to provide medication. The term *carer* is used when no distinction is necessary. The first nursing house that has been studied uses *health care dossiers*. These are detailed dossiers that are maintained about every resident and contain all information on their next of kin, medication and their day-to-day situation. Every resident has a *first responsible carer* that oversees the dossier and defines specific tasks and goals for the resident in the dossier. Residents are helped with activities like getting dressed, cleaning and showering. These activities together are called the *daily routines*.

The remainder of this paper is structured as follows. Section 2 describes how the interviews were conducted. Section 3 summarizes the results of these interviews. The results will be discussed in section 4 and conclusions are drawn in section 5.

2. RESEARCH METHOD

This section describes how the interviews were conducted and the results were gathered. The method followed is close to an approach proposed for a case study (Yin, 2009). This approach is the best in cases where questions about how and why needs to be answered and historical facts are not considered (Yin, 2009).

Eight nursing houses in Overijsel (The Netherlands) have been asked to participate in this research. Of these eight, only two accepted. Most rejections were due to time constraints. At the houses that were willing to participate, interviews were scheduled by the staff of the houses. Unfortunately, it was not possible for the interviewer to select who to interview himself. However, at both locations persons playing the most prominent roles have been interviewed; team leaders and (state-registered) carers.

At both nursing houses, an interview has been conducted with the manager responsible for the care. These interviews were short and focused on gaining the goodwill for more interviews to be conducted and to investigate whom exactly worked at that particular nursing house.

After the interview with the manager at each location, a number of interviews with other personnel have been conducted. The first part of these interviews concentrated on retrieving the tasks that the interviewee performed on a normal day. After gathering a complete list, more details were asked about how much time was spent on each task. First the interviewee was asked to order the tasks on the time they take. Only after this the interviewee was asked to fill in how much time was spent exactly. The second part of the interview concentrated on getting insight in how specific tasks were carried out.

3. RESULTS

3.1 Time Spent on Different Tasks

Table 1 presents the results of the interviews with the managers of the nursing houses. It presents how many hours are spent by each profession on a weekly basis. Furthermore, a short introduction on the philosophy and inner working of both nursing houses was given to the interviewer.

House A is a modern caring house providing (health) care. The staff is organized in three teams, each lead by a team leader. All team leaders report to the “manager care.” Every resident can keep his own physician, so no physician is associated with the nursing house. If needed though the nursing house can obtain a *physician*, *psychotherapist*, *dietitian* etc. from the larger organization the house is a part of. The staff at nursing house A as presented in Table 1 is responsible for 68 residents and 2 short-stay recovery rooms. The care level provided varies from domestic care to full eldercare.

House B applies a concept called small-scale living (Dutch: “kleinschalig wonen”), which tries to shift the focus from providing care to promoting welfare under their clients. Even though they recognize good health care is an aspect of welfare, they try to deliver on other aspects of welfare as well. House B has a flat organizational structure with just one manager. All personnel except for the manager and carers in house B are also provided by a mother organization. In this case, the average hours spent by them are available. House B has two departments, a nursing house and a caring house. The staff for nursing house B as presented in Table 1 is responsible for providing full health care to 12 residents with a somatic condition, 18 residents with a psychogeriatric condition and 12 residents that are entitled to eldercare. As can be seen in Table 1, at both locations the majority of the labor force consists of carers. Even at location A where a bit more time is spend by team leaders, it should be noted they share tasks with the carers for about half of their time. Also, other roles are visible. However, they are often performed by persons who are hired on an as-needed basis.

Table 1. Labor force: Professionals working at nursing houses A and B in hours/week and percentages

Profession	House A	House B
Nurse	24 (3.4%)	n/a
Team leader	50 (7.1%)	0 (0%)
Location manager	18 (2.6%)	0 (0%)
Managing care	15 (2.1%)	20 (1.7%)
Central duties	15 (2.1%)	n/a
Physician	n/a	8 (0.7%)
Psychiatrist	n/a	8 (0.7%)
Psychotherapist	n/a	8 (0.7%)
Welfare worker	n/a	18 (1.6%)
Carer (state-registered)	372 (52.8%)	980 (84.9%)
Carer	210 (29.8%)	112 (9.7%)
Total	704 (100%)	1154 (100%)

Table 2. Time spent on different tasks at houses A and B in hours/week and percentages of the total time spent. (Unmentioned tasks are marked as not available and percentages do not necessarily add up to a 100%)

Profession	Profession	House A	House B
Carers	Daily routines	8h 10m (38.8%)	5h 30m (39.3%)
	Health care dossiers	4h 20m (20.6%)	n/a
	Medication	2h 45m (13.1%)	> 1h (>7.1%)
	Meetings	2h (9.5%)	n/a
	Planning	1h (4.8%)	n/a
	Helping people move around	1h (4.8%)	n/a
	Providing coffee/tea/lunch	n/a	> 1h (>7.1%)
	Housekeeping	n/a	> 1h (>7.1%)
	Personal attention	n/a	> 1h (>7.1%)
Team leaders	Daily routines	6h 30m (40.6%)	
	Project work	3h 15m (20.3%)	
	Dossier evaluations	3h 15m (20.3%)	
	Meetings	1h 30m (9.3%)	
	Administration	1h (6.3%)	
	Personnel / Planning	30m (3.1%)	

All interviews with carers or team leaders started with retrieving common tasks as presented in Table 2. These figures cannot be considered as correct up to each percent, mainly due to the difficulties classifying tasks and finding out how much time is spent on each of them. Also, tasks are often intertwined and team leaders might include activities like providing medication as part of the *daily routines* since they classify their complete morning as helping with *daily routines*. Finally, care providers are often interrupted by residents using the in-house phone system. All this makes estimations less reliable.

The task *administration* involves updating the health care dossiers that are kept in residents rooms in house A. This task involves both regular interaction as interaction as the *first responsible carer*. At house B, a special task *personal attention* was mentioned. They mean taking the time to read a newspaper to a resident that can no longer read or taking a walk with him. This is part of the philosophy of house B and therefore mentioned separately.

In Table 3, these results are extrapolated to all employees of houses A and B. The way hours are spend by regular and state-registered carers are assumed to be the same. The presence of regular carers causes a shift in the duties of any state-registered carers, so this seems a reasonable assumption.

Table 3. Different tasks at houses A and B in percentages of the total time spent. Tasks that were not mentioned in the interviews are marked as not available. The times spent by regular and state-registered cares are assumed to be the same.

Task	House A	House B
Daily routines	32.5%	36.9%
Health care dossiers	17.6%	n/a
Medication	10.8%	> 6.7%
Meetings	7.9%	n/a
Planning	4.0%	n/a
Helping people move around	4.0%	n/a
Coffee / Thee / Lunch	n/a	> 6.7%
Housekeeping	n/a	> 6.7%
Personal attention	n/a	> 6.7%
Rest / Unknown	21.2%	n/a

3.2 Task Execution

For all tasks on which more than 10% of the total time is spent a more detailed description will be given. These are three tasks: Daily routines, health care dossiers and providing medication. The first one is not very interesting for blueprinting, since this task is difficult to shift from people to IT. Interviews also objected to this idea, since if such a thing would be possible, it would introduce robots into very intimate situations for residents. This leaves two tasks to be discussed in detail: health care dossiers and medication dispensing.

In house A, all residents have a health care dossier in their room. When working as a carer at the room of a resident, observations about the condition of the resident can be made by the carer. All these observations have to be written down in the health care dossier. This is the responsibility of every carer and mostly occurs while performing the daily routines. Interacting with the health care dossiers as first responsible carer involves three things: Setting goals for residents that apply to their situation, reflecting on these goals and reports of fellow carers and undertaking appropriate action like calling a physician or inquiring about medication when neccesary. Twice a year, a team leader uses the dossiers to schedule an evaluation with the resident and his physician. In this evaluation, the (health) care provided to the resident is discussed with him, the physician and family. At nursing house B, the interviews mentioned no dossiers or similar approach.

At nursing house A, each patient has a closet at his own room containing his medication. The medication is kept in sealed bags. These closets are generally not locked, except when this is necessary from a safety point of view. Each resident has in his health care dossier a page listing all the medication he has to take and when it has to be taken. A medication round starts at the floor office and all residents that need medication are visited. The carer also consults a special list to see if any temporary medication has been subscribed. After this, the medication is prepared and in most situations carers have to wait until all medication is taken before they can move on. Some residents can take their medication themselves, so their medication for the whole day is put down in advance. One of the examples used to explain service tailoring has been the task of dispensing medicine. After explaining this task to the team leader responsible for medication safety at house A, she stated that out of the current 68 residents, at most ten could take their medication in this way safely.

At house B, there is no centralized list of residents that have to be visited for medication. Each group, consisting of six residents, has only one list containing all the medication for the six residents. Also no personal trays or sealed bags for each resident exist. Here also, all medication is kept in a locked closet. In this house, the carer always has to wait until all the medication is taken before moving on to the next resident.

The manager of house A was glad to see that everyone was spending time on the daily routines, since this is where most of the workload is concentrated. Four out of five employees of house A claimed the task dossiers/administration takes more time than the task daily routines while it was the other way around. Although all of the interviewees were positive about introducing IT, none of them had any concrete ideas on where IT would have added value and all mentioned the work should keep a human touch.

Another IT solution that received positive comments from all interviewees was recording the administration. A system would then automatically translate the recordings to written entries in a health care dossier. A lot of administrative work is done by carers at house A and they believe this kind of solution would have added value for their work by reducing they time spend writing.

A team leader at house A felt that IT-based homecare systems would have more chance in extramural situations. She stated that people only move to a nursing house when they really cannot care for themselves. People still living at home, might even appreciate the technology and the extra independence they gain from such technology. This opposed to people living in a nursing house who, generally, appreciate every visit.

4. DISCUSSION

This research aimed at taking a step away from designing IT solutions before attempting to introduce IT. Its goal is to provide insight in the current time allocation in eldercare and show which tasks are appropriate for automation. This research is limited to the professionals that are directly providing care. Other professionals such as cooks, cleaners and technicians are not considered.

Only two nursing houses were visited during the interviews and at each house only a limited number of interviews could be conducted. However, it seems reasonable to assume that these two nursing houses do not significantly differ from other nursing houses, especially since both nursing houses are part of a bigger organization. The results achieved do show on which tasks most time is spent. However, strong reservations have to be made about the preciseness of the results. For example, based on the results above, it can be stated that roughly one third of time spent, is spent on daily routines. More precise statements are not justified.

Another difficulty when trying to estimate the accuracy of the results is that there are no results to compare with. Surprisingly, almost no research of this kind could be found when trying to compare the results with earlier research. The most comparable research found was on time allocation in meetings between physicians and eldercare receivers (Tai, 2007). They used recordings of visits and could very precisely measure what topics were discussed and how much time was spent on each topic. More research has been done in the domain of non-professionals. A study in Canada by Cranswick and Dosman (2008) also identifies a list of tasks often performed by non-professional caregivers. Other research in this domain mostly concentrates on the consequences of non-professional care giving for people that have a job (Hammer and Thompson, 2009) or their employers (Dembe, 2008; Sherman and Reed, 2008). Most other papers that come up are directly concerned with solutions for automating tasks (Marcelino and Pereira, 2009; Kaluza et al, 2011), but no real research into which tasks currently are performed and how often could be found.

Based on the performed interviews, it is also not possible to make a claim about the generalizability of the results. More research is needed to verify the obtained results and compare them with similar research in other nursing houses. There is also the risk that the interviewees forgot to mention tasks or were inaccurate in there estimations. Other studies might yield more complete or different results. However, brief statements during two of the interviews at house A from employees that worked at other nursing houses as well, suggested that the practice at nursing house A is comparable to other nursing houses in the Netherlands. Therefore, it seems reasonable to assume that similar research at other nursing houses in The Netherlands and maybe even the whole of Western Europe will yield similar results.

Other interesting further research might focus on interviewing care receivers, yielding another view on the automation of care providing. Especially in extramural situations this might provide different results.

5. CONCLUSION

The first two interviews with the managers of both nursing houses provided detailed information on the professions that are working in Dutch health care. Based on Table 1, it can be concluded that over 85% of time is spent by nurses and carers. Only around 2% of time is spent on overhead and/or managers. The remainder of the time is divided between supporting professionals, nurses and more carers.

Further investigation of the tasks performed by all professionals revealed that over 50% of the time is spent on providing care. In nursing house A, a little over 10% is spent on overhead such as planning and meetings and another 18% is spent on administrating delivered care. Since nursing house B does not have this formal approach, little time is spent on administration and is most likely included in the times mentioned on other tasks. It is also visible that personnel at nursing house B have more tasks around the house taking up over 14% of their time. At both nursing houses a small amount of time is spent by supporting professionals.

Tasks descriptions are delivered in section 3.2 for each task taking more than 10% of the total time. The daily routines are ignored based on clear indications of the professionals that this task cannot be automated.

It is difficult to state which tasks can be (partially) automated. The example proposed in section 1 was considered a clear candidate. However, looking at section 3.2, it does not seem likely that this is a good scenario. A new possibility is that of automating administration in health care dossiers.

In conclusion, little possibility has been found in this research for introducing a platform such as the one currently under development in the U-Care project. A number of processes occur around the health care dossiers that are kept on paper currently. Partly automating the storage and retrieval of forms in these dossiers using speech recognition software, might be something that the U-Care platform can do. Other tasks like the daily routines vary too much to be automated or need personal supervision for security reasons (medication). Therefore, very little opportunity for service blueprinting is found.

Note that the negative conclusion stated before, only applies to the domain of intramural care provided by nursing houses. This means that more opportunities might exist in extramural care. Furthermore, benefits here are potentially much higher, since extramural care involves a lot of travelling.

Another potentially positive aspect of introducing a service platform in (health) is improved quality of service. A clear example is non-stop blood pressure registration over once a day. Another unexplored option is that of caring for more residents at the same time using help from the U-Care platform. Future research might show approaches exist in which the U-Care platform can provide the means to care for more elderly without having to increase the number of carers.

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PORTABLE COMMUNICANT SYSTEM TO ASSIST THE PERSON WITH LOSS OF AUTONOMY: “REMINDER" SOLUTIONS

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ABSTRACT

Even if it cannot be cured, intellectual deficiency may be at least assisted or even compensated. The “reminder” solution then appears to be an attractive answer which can be thought by several ways depending on the type and level of desired mobility and on the degree of disorder of the person. From “human-centric” parameters, the proposed solutions, all non-intrusive, are based on the expressed needs of the person from his own life style and life project. The aim is to enable a better location in space and time through an adequate mobile and contextual assistance for daily tasks. The solutions must be implemented according to the history of a person and as a natural extension of his gesture. We propose four possible solutions: a “LED” mirror, a digital photo frame, a touchpad and a smart watch.

KEYWORDS

Cognitive deficiency, reminder, interface, mobility, autonomy, ethics

1. THE LOSS OF AUTONOMY IN THE WORLD TODAY

Loss of autonomy is a term that takes into account many aspects including memory and cognitive disabilities. This deficiency consists of two main groups of diseases, a first one called progressive and a second one from stabilized brain injuries or troubles.

Alzheimer's disease is an evolutionary disease which affects 25 million people in the world. It is a progressive disease, in which nerve cells deteriorate continuously. This is a form of dementia. Today, it is well known that this disease causes a loss of recent memory, troubles of motor skills, troubles of language, disorientation, altered judgments, lost objects, behavioural problems, loss of intellectual concentration. The number of patients worldwide is growing every year and the scientific community thinks that people affected by Alzheimer's will triple by 2050 to reach 120 million people. Other diseases like classical intellectual disability (IQ <69 affecting about 1-3% of the population), trisomy 21, the fragile X syndrome and accidents of life (head injury) result in a number of troubles of related type with equivalent consequences. The patients concerned can then be indifferently young children, injured adults or elderly.

2. NEEDS OF PEOPLE WITH LOSS OF AUTONOMY

The goal is to find a comprehensive solution designed to be responsive and adaptable to the greatest number of cases. To compensate for the entire set of identified deficiencies, the functionalities of the communicant reminder must meet the following requirements: help to locate in time, help to locate and navigate in space, and remember daily tasks. Table 1 lists the different types of disorders associated with different types of diseases or neurological disability.

People with loss of autonomy because of Alzheimer's disease, developmental disabilities or after head trauma have difficulty to identify in time. Regarding children, it is often difficult to tell time on an analogue clock, so that the reminder should rather offer a digital display. In a same way, people with Alzheimer's disease do not recognize the seasons, or times during the day and the ICT (Information & Communication Technology) object will have to take into account these two main parameters to address this need.

Table 1. Review of deficiencies.

	Progressive diseases	Diseases from brain injuries or troubles	
	Alzheimer's disease	Intellectual disability	Accident of life
Learning abilities		X	X
Increased latency	X	X	X
Memory disorders	X	X	X
Disorder in identification in time	X	X	
Disorder in identification in space	X	X	
Integration into society	X	X	
Behavioural disorder	X	X	X
Language disorder	X	X	
Disorders in performing daily tasks	X		
Reduced handling abilities	X	X	X
Loss of interest and concentration	X		X

All cognitive impairment causes problems of location in space. People with Alzheimer's or even victims of head trauma sometimes struggle to remember where their kitchen and bathroom are. It is sometimes difficult for them to understand where they are. So there is a significant need to remind them where they are but also where they can and must go.

A reminder process of daily tasks will simultaneously allow ensuring a “normal pattern” of life mode, also ensuring a certain degree of safety.

To be more easily appropriated by the user, the system must be both playful and intuitive but also mobile and transportable, autonomous in terms of time and functionality. Children who are identified with intellectual disabilities, particularly through integration problems in society, are at their age still able to learn and no one can say whether these children will experience or not mental problems in the future. Thus, in order to offer the greatest potential, our communicant interface has to provide a playful aspect so that the child can remember just by learning what functionalities are offered. But it is also important for people who suffered a head injury, in whom the re-learning, is part of rehabilitation.

The « mobile and transportable » aspect is particularly important to ensure an adequate assistance, for example for children going to school.

The communicant object must be able to actively help the person to perform tasks and then be able to provide an autonomous intelligence itself. In particular the elderly with memory troubles can show some difficulties in using technology and keep in mind the process of operation of the device.

3. APPROPRIATE FUNCTIONALITIES TO IMPLEMENT

A person with troubles or disabilities is above all a person who has difficulty to integrate best to her surrounding environment. Although the immediate technical solutions are many, not all of them however respect the integrity the needs really expressed and the life choices of the person. Our "reminder" must be:

- an object close to an everyday object in daily use,
- non intrusive in the life of the person and his entourage,
- not an assistant, but rather a guide,
- editable and readable at any time in a concerted and collaborative way by a relative or caregiver.

To respond effectively, we also considered the term "mobility" from different angles. While maintaining the aspect non-intrusive, the notion of mobility can have different meanings depending on whether one considers mobility within the home or outside (indoor or outdoor). This reflection has led to propose four solutions, one integrated within the housing, fixed, two others mixed but with the same type, to help move inside or outside of the house, and finally to ensure an assistance outdoor. These four solutions can be managed by the same central system or be completely independent, but will appear to the user in ways very similar at both the features of graphic design or usability of the interface. The goal is to find a comprehensive solution designed to be responsive and adaptable to the greatest number of cases. To compensate for the entire set of identified deficiencies, the functionalities of the communicant reminder must meet the following requirements: help to locate in time, help to locate and navigate in space, and remember daily tasks. Table 1 lists the different types of disorders associated with different types of diseases or neurological disability.

3.1 The “LED Mirror”

The mirror is an accessory of everyday life that allows the individual to perceive an image of himself and which is used several times a day. It is non-intrusive just because the person makes a voluntary act of standing in front to receive an image of himself. The question is then to take benefit of these moments of indirect interactions to provide an “augmented” version of contextual temporal or environmental information. In addition, it is extremely easy to integrate such an accessory (now become a communicating interface) in the habitat of the person. A simplified example of this type of mirror, just indicating the hour of the day, is shown in Figure 1.

The primary role of the mirror will be to compensate for a disorder in locating in time and to help with daily tasks. It will remember the hour, the current date and what the person is supposed to be normally doing at that time (eating, bathing, shopping, the arrival of caregivers, etc.).

The display can be done through LEDs of different colours, which will display logos and pictograms associated with the moments and phases of the day. Significance of colours has been discussed in [1]. Figure 1 also shows an example of a very simplified logo that can indicate the time of lunch.

One can also imagine that the mirror can broadcast a beep to warn the person of an event that has to be validated. A touch-sensitive area may then be provided in addition for the validation process.

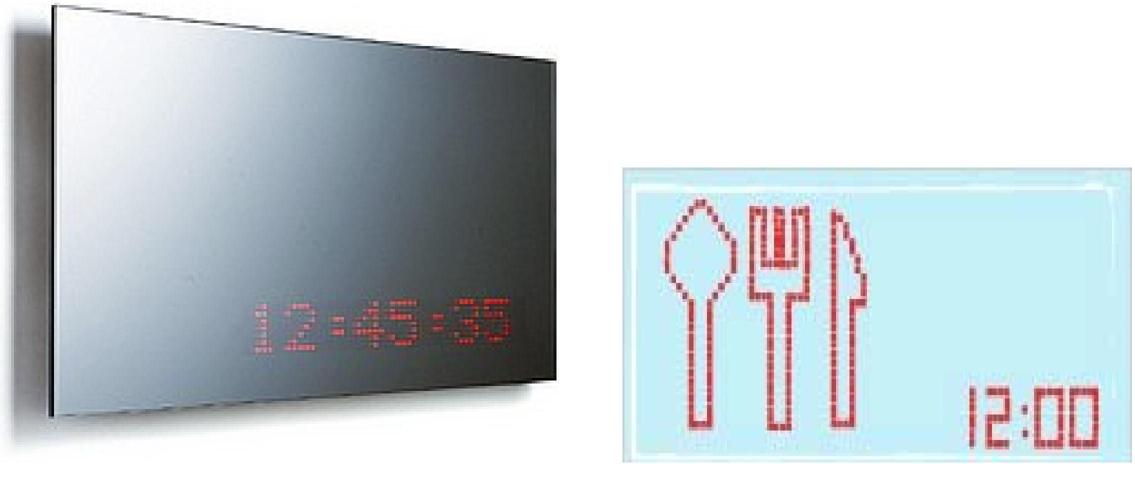

Figure 1. A “LED mirror” augmented with the time display. Example of a contextual help provided by the mirror at lunch time

3.2 Intelligent use of a Digital Photo Frame

Halfway between the fixed solution integrated with the housing and a mobile communication solution for outdoor activities, a digital frame, provided with the adequate information to display with the proper timing can be very effective in meeting the most part of the objective functionalities.

It has the advantage of being small, non-intrusive, generally aesthetic, but also placed at locations desired by the person based on strong emotional processes (especially when it shows family pictures) so at visible locations. Compared to the mirror, its role will be to distil information, accessed by the person or not, in the adequate format and quantity, but displayed according to a precise temporal scheme. There will be no validation of this information. This solution is therefore in support of the mirror. In particular, it can be moved from place to place based depending on changes in mood of the person but also of her troubles, anxieties or pathologies.

In detail, the intrinsic, aesthetic or technical characteristics of this communicating object should be discreet and pleasant to watch, simple design, display of the date and time, customizable slideshow (time, number), ability to play videos, storage capacity of a hundred photos, battery operation or mains, ease of update on PC, screen size sufficient to clearly distinguish the image and its details (8 inches) regardless of its location and the degree of disorder of the person, alarm (audio and video).

In addition, for indoor and outdoor uses, a digital key chain based on the same operation can also "accompany" the person as a sort of guide. The displayed information will of course be adapted to the display format, in terms of graphics used and the density of the information provided.

3.3 The Touchpad Solution

The touch pad is a form of portable computer terminal running with an operating system which is controlled in an extremely intuitive manner. The product is compact, lightweight, standalone for several hours and therefore obviously promotes mobility. For the elderly in particular, an adapted graphical user interface enable to suggest the interface as a natural extension of the gesture, promoting better learning and appropriation processes of the ICT communicating and assisting object as discussed in [2].

A touch pad does most of the functions and features which are those of a conventional computer. Therefore, even with purposes very close to those of a digital photo frame, the touch pad provide a certain degree of interactive intelligence that can enable to set up a natural collaborative dialogue with the user. Its main features of mobility and portability make it a solution for as much role in and outside the home.

With the ability to be permanently connected to the Internet, one of its associated key functions is the ability to communicate, including visually via the integrated webcam, with any contextual contact.

Then, the features which must be provided with a touch pad for this real-time kind of mobile assistance are: task planning, video playback, pictures and images display, beeping, Internet connectivity, possibility of visual communication from point to point connection or Internet video communication application, automatic standby, potential for customization.

An approach of this style has been discussed in a slightly different form by [3] and [4].

In addition to communication applications (for social link or emergency situations), it will mainly consist in using the task planning functionality to schedule at specified time and date the appearance of a picture, a pictogram or a video associated with an appropriate tone. The touch interface then provides the ability and security to ensure a voluntary acknowledgment and validation, in time by the person.

Moreover, the touch pad seen as a playful and intuitive computer interface stimulates the intellect of the user, for example with games, but also with the more common computer tasks as office tasks or internet browsing.

3.4 The « Smart » Watch

If we try to push to the extreme the ultra-portability criteria, a solution may lie in an item worn on a daily basis as a watch or a pendant. Depending on the degree of functionality that is seeking to fill the object, the complexity and cost may vary. That can go for the simplest solution to a simple key chain displaying information in a time-programmed manner, to a tactile watch, connected to the internet and communicating in the same way and with the same features as a touch pad.

An example is shown with the "Wrist-PDA" watch [5] developed by the Texan manufacturer Fossil and which provide the same functions as a PDA (Figure 2). This watch can of course display the time as well as other information such as contacts, notes or reminders of events. It is described by Fossil as a mini-computer bracelet and is compatible with the Palm OS. Before Fossil, the Timex Company had already presented connected watch model which can read e-mails.

The alarm is an important point. It sounds at a precise moment with a relevant photo or personalized message well chosen and focused.

It is also important to think about putting in pictures of the relatives of the person (family, neighbours or caregivers), on the one hand to stimulate the desire for a social link, and also to familiarize the person with some faces and thus avoid any fearful or aggressive behaviour to these persons in every day phases.

Figure 2. The «Wrist-PDA» from Fossil

4. CONCLUSION

This is now admitted that, even if it cannot be cured, intellectual disability may be assisted or at least compensated. This deficiency creates difficulties in accessing social life, especially due to disorientation, memory loss, behavioural or concentration problems. The reminder appears then be an attractive solution, which, as we have shown, answer which can be thought by several ways depending on the type and level of desired mobility and on the degree of disorder of the person. The proposed solutions, all non-intrusive, are adaptable at different levels (ethical, technological...) and are based on the expressed needs of the person from her own life style and life project. They allow a better location in space and time for adequate, mobile and contextual assistance for tasks of daily life. They must be thought and implemented according to the "history" of a person and as a natural extension of her gesture and way of acting. Clearly indicate advantages, limitations and possible applications.

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HOW A PATIENT MIGHT ADJUST HIS COCHLEAR IMPLANT BY USING A SMARTPHONE?

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ABSTRACT

A new generation of medical implants, more autonomous and totally implanted, are designed and rated for the near future. Experts on this domain are thus interested in new possibilities to provide implanted patients with better assistance and support. In this paper, we present challenges in the Human Computer Interaction area that are raised by such advances, especially concerning cochlear implants. These challenges result from a study conducted as part of an academic and industry project aiming at designing and developing medical User Interfaces. Such UIs are dedicated to assist patients in adjusting their cochlear implant.

KEYWORDS

Human Computer Interaction, Personalized Medicine, IT and Patient Care, Medical Data Visualization

1. INTRODUCTION

The continuous development of Information and Communication Technologies (ICT) increasingly support medical applications. Technologies as wireless and mobile devices, interactive interfaces, web services, for example, help to provide and improve the quality of healthcare and support medical practitioners and organizations (Cavaro-Ménard et al, 2010 ; Andry et al, 2008). This fact motivates many medical application domains as medical diagnosis, or patients monitoring to evolve and discover new ways to interact with patients.

This is the case of medical implants domain, where several industrial teams currently put their expertise and research to design and conceive new cochlear implants. A new generation of such implants, more autonomous and totally implanted, are designed and rated for the near future. Experts on this domain are thus interested in new possibilities to provide implanted patients with better assistance and support.

At present, adjusting a cochlear implant system is possible through audiologist fitting software (on PC) and resulting settings are then available to the patient on the prosthesis (outer part connected to the implant) by directly acting on their listening level. With the new generation of cochlear implants, profound deafness patients and totally implanted, must be provided with a practical manner to adjust their implant remotely. Adjusting devices considered for this type of implant are the Smatphones.

In this paper, we aim to identify and propose solutions to the HCI (Human Computer Interaction) challenges resulting from the specificities of new generation of cochlear implants. After a brief description of cochlear implant features in Section 2, we introduce our study and prototype in Section 3. In Section 4, we conclude and provide our future work.

2. COCHLEAR IMPLANT

Currently, cochlear implants are intended for “profound deafness” people. An implant is mainly composed of two parts: an inner part (implanted) and an outer part (prosthesis). The inner part is implanted by a surgical procedure. The prosthesis requires a battery and a processor to correctly process and store patient data. These two parts are connected by magnetization and a transceiver system through the skin. The energy transmitted by the prosthesis feeds the subcutaneous implant (NIH, 2011).

A cochlear implant is set by an audiologist with fitting software (on PC). With this software, audiologists can create and set programs matching four different listening situations for a given patient (2 profiles in the previous generation). These programs enable the patient to dynamically adjust the settings of the implant (i.e. transition from silent to noisy environment or vice-versa, microphone's sensitivity). They are accessible via few buttons placed on the prosthesis. Actions performed over these buttons, involve an immediate adaptation of the implant's profile acting on the quality of the patient's listening (NIH, 2011).

The new generation of cochlear implants deals with issues related to the disappearance of the prosthesis and the possibility of adjusting the implant via a Smartphone. Our challenge is thus to provide patient-oriented HCI ensuring the application requirements: safety of adjusting operations, ease of use and confidence in the application.

3. ADJUSTING COCHLEAR IMPLANTS: A PROTOTYPE ON SMARTPHONE

Recent medical services as adjusting cochlear implants are based on scheduled visits at clinics where the implant settings are verified and adjusted if required. This procedure has two major drawbacks. First, it only provides temporary information of the patients' state, and second it fails to acquire contextual information that only can be acquired in a natural environment (e.g. home, workplace…) where important events or symptoms may manifest (Shih,2010). Current research studies confirm that mobile devices, as a Smartphone, contribute to solve this problem even if sometimes such use comes with considerable costs of managing, upgrading and maintaining (Burdette, S.D. et al, 2008). In fact, medical professionals can now obtain better information about patients and motivate them to be more responsible of their care and continue a regular life (Focosi, D., 2008). Providing patients and their family with useful tools, we get best results, both in patients' health condition, as in the clinic services (Stroetman, K.A. et al, 2003)

Unlike current research work in this domain (i.e. UTD, 2011) and in order to guarantee the reliability of our proposal, we have adopted the main specificities of a medical application, especially to ensure safe operations. More precisely, in any case, an adjusting action should not cause pain or endanger the patient. The privacy of patient data and the quality of healthcare must be respected. Maintaining safe operations for the patients involves also an implicit control of the patients' adjustments by the practitioners. Improper adjusting can potentially cause irreversible damage. Applications dedicated to cochlear implant adjustments require as well a secure connection to authenticate them.

3.1 Patients adjusting their Cochlear Implant: Requirements

To design the prototype, we have taken into account two kinds of specificities: user and usage requirements and device specificities.

User and usage requirements:

(a) Safety of adjusting operations is ensured by the specialist that establishes listening profiles. These profiles correspond to patient activities and are adjusted according to a range determined by the audiologist. On the current generation of implants, four buttons are present: number ergonomically compatible with the hardware constraints (implant size and surface area accessible by the patient). It is however possible to change profiles placed on the processor when visiting the specialist. These aspects can be restrictive for an active patient (continuously modifying listening profiles) because it limits the number of available programs and requires him to make an appointment.

(b) The analysis of patient needs has stressed the importance of facilitating access to the selection tasks in the profile settings. In the case of an active user, it is important to provide a profile shifting facility so the user's listening can easily be adapted several times a day. There is also a need for quick access to volume and noise adjustment. Access to the buttons on the prosthesis is not very discreet and not always easy. Any change of prosthesis requires new learning (recent upgrade from 2 to 4 profiles for example).

(c) Data security is guaranteed naturally by the fact that the prosthesis is worn by the patient and is the only one who can set it.

Device specificities:

(a) The migration to Smartphone for implant setting broadens the possibilities. The adjustment from a mobile device removes the limit of the number of embedded profiles. Thus, this number can be established according to the real needs of patients and their activity.

(b) Access to settings is also easier and more discreet. To ensure fast access to the main tasks, it is important to analyze the level of navigation according to Android and iOS systems capabilities.

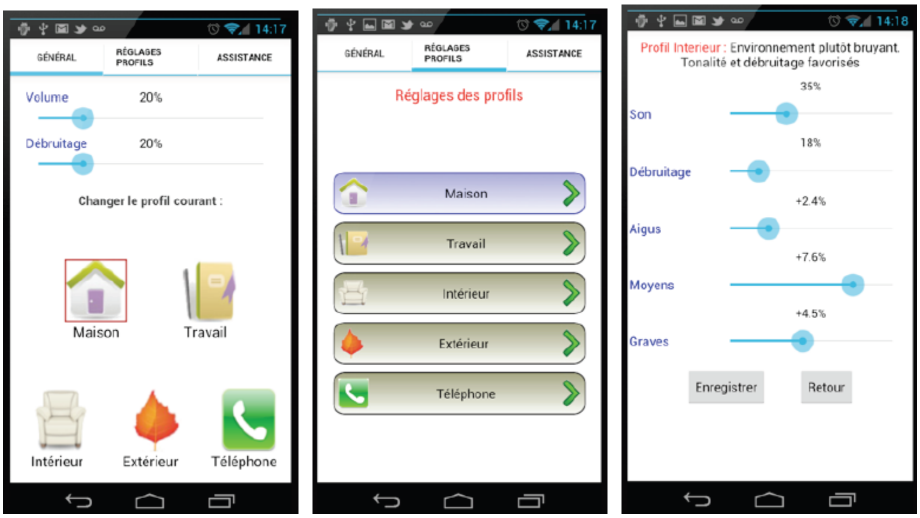
(c) To make application faster, it is also possible to adapt a profile depending on the context of use. Smartphones have a GPS that can help automating profile change: automatically switching to stealth mode at work or enabling WiFi on the way home for example. Time is also an element that can influence: disabling connectivity at night, for instance. However, practitioners worry that the use of an automatic profile setting be risky for patient safety. They argued for providing suggestions like: *"It may be that you are in a noisy place. Remember to activate your profile outside if necessary".*

An important and associated factor is the "distrust" towards the information displayed in the interface of a medical application (Fishman, P.A. et al, 2011; Hû, O. et al, 2011; Stoicu-Tivard, L., 2006) For example, an inappropriate choice of color, a zoom or a wealth of information can lead to a misperception of information. This could bring incorrect information processing or irrelevant decision making. In our solution, confidence in the data received from the implant is gained by the fact that adjusting procedures been used for many years and meet the medical standards. Currently, none of the current systems either Android or iOS are certified for medical applications in terms of security. Security and privacy manners are not the subject of this paper.

3.2 Prototype

The prototype proposed in this paper has been developed following a user-centered approach and it is related to a cochlear implantation context. A cochlear implantation applies to all kinds of people, from infants to the elderly. In case of dependent patients, family members are often required to assist in tasks such as profile adjusting, program change, make an appointment with the specialist, etc.

As we introduce in Section 2, our prototype is based on specific requirements and successive cooperative evaluations developed as part of an academic and industrial research project. In order to ensure the medical feasibility of the proposal, our prototype is evaluated by both patients and medical specialists.



Volume 20%

Débruitage 20%

Profil Interieur : Environnement plutôt bruyant. Tonalité et débruitage favorisés

Son 35%

Débruitage 18%

Aigus +2.4%

Moyens +7.6%

Graves +4.5%

(a) (b) (c)

Figure 1. Interface Patient Adjusting

Two different models of application have been proposed to the users: one based on an Android-like navigation and another on iOS-like. Based on these propositions, our final choice privileges a task appending interface, based on a "dashboard" composed of icons, and an adapted sequence of screens considering the task use rate. More particularly, the application opens directly to the "General" tab located on the left side of the screen (Figure 1a). The dashboard allows selecting a listening profile thanks to the icons. The current profile is indicated with a red border and the patient may, at any time, change its current profile among those that have been configured with the audiologist (Figure 1b). Adjusting the volume and/or reducing the noise according to the allowed values are also possible (Figure 1c). The variation percentages to fine-tune listening profiles (i.e. highs, mids and bass) are only allowed for the values determined by the audiologist. Similarly, the use of "*sliders*" enables setting volume and denoising levels using a scale from 0 to 100%. New settings are applied in a controlled and safe manner and directly perceived by the user (patient). The confidence level of the patient and his entourage is also based on the capability to customize implant's settings, already defined by an audiologist especially for his profile (i.e. allowed framing and limits). Moreover, an option enables patient to call a specialist if any doubt or problem arises.

The evaluation of our prototype was cooperative and focused on users' satisfaction with respect to visualization selection and tasks. They were conducted with four patients all older than 60 years old, where 50% of them had already used a Smartphone. This application has been implemented for a Smartphone equipped with the Android platform. In order to validate the reliability and relevance of our prototype, the evaluation was also conducted with two medical experts, main actors of the cochlear implant improvement and specialists on implant adjusting.

In a general way, participants have appreciated the clarity of the proposed interface. They considered it easy to handle and they stressed the importance of having clear and representative task icons. The distribution of information on several screens was also considered as relevant together with the adequate size and readable text. In order to be sure of the manipulation and resulting effects, users reported the need to incorporate a textual explanation about the impact of profile adjusting. Users have also responded very positively to being able to *save* and *undo* any changes in the profiles. These aspects have greatly reassured users during application handling. Finally, users also noted that adjusting the implant through a Smartphone becomes more unnoticeable; they would probably be led to use it more often and benefit from better listening conditions. The results of these evaluations enable us to highlight the strengths of the application, particularly about the interface navigation and the remaining improvements; no comment was made about a lack of confidence or about the execution time. We already planned to evaluate this prototype by young patients, more familiar with Smartphones.

4. CONCLUSION AND FUTURE WORK

Finding new ways of improving monitoring and medical care is a challenge and remains a very important topic. In this paper, we have highlighted the UI challenges related to the specificities of the future generation of cochlear implants and their setting by the patient. We have proposed a prototype designed to facilitate and assist the setting process.

For this fist prototype, we made design choices concerning visualization and task organizations accordingly. Such design has been evaluated and validated by potential users. The current proposal still needs further validation steps before it can be completely accepted. We continue our study by for example, adding an interaction modality based on the "*plus*" and "*minus*" physical buttons founded on mobile devices (commonly used to adjust the volume) (Rekimoto, J., 1996) for setting hearing parameters of the implant. We also perform a parallel survey and proposal considering audiologists requirements and the integration of other mobile devices as Tablets.

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ADOPTING ELECTRONIC HEALTH RECORDS IN HEALTH CARE PRACTICES: A MULTIPLE CASE STUDY OF THE PORTUGUESE HEALTHCARE SYSTEM

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ABSTRACT

Recently, we are witnessing the effort of healthcare providers to move from paper-based records to electronic records, in order to reduce data access times and also to share clinical information. However, many of these electronic records projects have failed, as they are not well fitted to the healthcare professionals' practices. This paper presents a study on the impact of Information Technology in the daily routine of healthcare providers, to support the development of Electronic Health Records that are well adapted to these organizations' operational processes and are successfully adopted.

KEYWORDS

Information Systems, Electronic Health Records, Medical Records Systems, Systems Understanding

1. INTRODUCTION

Electronic health records (EHR) have been one of the major topics in health informatics in recent years. The concept evolved from a local scope (within the healthcare provider) to national or even international inter-institutional information sharing scopes. Hence, in order to build an EHR system, one needs to deal with four main types of problems (Rindfleisch, 1997; Shortliffe, 1999):

- Data privacy, confidentiality and security;
- Need for standardized clinical practice and terminology;
- Data input issues by the healthcare professionals;
- Integration of the information provided by electronic records from different institutions.

The success of the implementation of an EHR has been defined by the quality of the information provided to the healthcare professionals for clinical decision-making and the quality of the communication between professionals during patient care (Hayrinen et al., 2008). Recent studies made a balance between the possible benefits, savings and costs of the implementation of EHR systems (Hillestad, 2005). The results point that despite the high implementation costs, an effective usage of EHRs reduces other costs by a much larger margin. Thus, several countries like Canada (Canada Health Infoway, 2005), Sweden (Affairs, M.o.H.a.S. et al., 2009) or the UK (Swindells, 2010) have been starting to implement EHR systems. However, many electronic records projects have failed, as they are not well fitted to the healthcare professionals' practices or are too ambitious right from the start of the project.

This paper presents the results of a multiple case study within the Portuguese EHR initiative. The study allowed for assessing the current Information Technology (IT) impact in the operational processes of the Portuguese healthcare institutions and identifying the impact of the introduction of an EHR system in the Portuguese National Healthcare System (NHS). These results have provided support to the implementation of the Portuguese EHR and to propose a set of recommendations to smooth the impact of its introduction in the NHS.

2. METHODOLOGY

Given the exploratory nature of this work, we adopted a multiple-case study methodology (Yin, 2009), driven by the following research questions:

- How do Information Systems impact the daily routine of healthcare professionals?
- How do inter-institutional IS affect the institutions functioning?
- How will an EHR system impact current organization processes?

The selection of the case studies took into account the heterogeneity of the Portuguese healthcare institutions. The criteria included the type of care, the size and the type of management. In order to address this diverse set of characteristics, we collaborated mainly with five institutions:

- The Regional Health Administration of the north of Portugal (ARS Norte). ARS Norte provided us a holistic view of the organization of the healthcare sector (mainly the primary care), including the most common Information Systems (IS) in use;
- ACES Gondomar, which is a primary care institution;
- Hospital da Prelada is a relatively small hospital with strong surgical and physical rehabilitation valences;
- Centro Hospitalar de Vila Nova de Gaia e Espinho (CHVNG/E) is one of the biggest hospitals in the north of Portugal. It has about 600 beds and provides an extensive list of medical services.
- The National Institute of Medical Emergency (INEM) provides emergency care and patient transportation to hospitals, if necessary.

Case studies involved multiple methods for data collection. Direct observation of the daily routine of healthcare professionals was our main method. These observations involved visiting the institutions, to follow up the professionals routines, taking notes and asking questions whenever necessary. We spent on average 7 days on each institution and the study involved a total of 28 days of observation, interacting with around 60 healthcare practitioners (excluding administrative staff). Direct observation was complemented with in-depth semi-structured interviews with key healthcare practitioners and administrative staff (2 doctors, 2 nurses and 2 administrative staff) to consolidate the data gathered with the observations. The interviews were conducted with open-ended questions. We also leveraged these two methods to identify and gather documents of interest that were analyzed. The notes taken during observation and interviews were qualitatively analyzed to characterize patterns of usage of the IS and the impact on the daily routines.

3. CASE STUDIES

The analysis of the case studies allowed us to understand the daily activities of the healthcare professionals, the IS they use and their information needs. By studying different types of healthcare institutions, this work allowed us to understand impacts of the IS and identify similarities and differences across the different institutions.

3.1 Primary Care

The medical consultation is based on a direct interaction between the doctor and the patient. The doctors use a medical support system to visualize the patient's clinical record and update it with information provided by the patient (whether it is new symptoms, exams results, a letter with speciality consultation notes, etc). It is also possible to access SAPE (nursing practice support system) to obtain information collected by nurses, appoint a speciality consultation at the referral hospital or use other means of communication (e.g. telephone) to schedule exams. As it is not common to have information sharing between the medical support systems from the primary care institutions and hospitals, it is often necessary that the patient carries letters from the hospital with relevant information for the general practitioner (GP).

The nursing consultation can have different types: vaccine administration, maternal health, family planning, home visits, etc. During the consultation, the nurses record the collected information (contacts, weight, height, blood pressure, temperature, vaccines, etc) in SAPE. At the moment there is no information sharing between the primary care and hospital nursing medical systems.

The core applications used are usually quite old (10+ years). Despite a hard transition from paper to electronic records, the electronic system is now preferred to paper records. We can observe performance and reliability problems in the applications used in primary care units, especially the speciality outpatient consultation referral application (which was created recently).

3.2 Hospital Care

Outpatient consultation in a hospital is similar to the medical consultation in a primary care institution. The main differences are that the doctor is a medical specialist and the information systems used (sometimes even paper records). If it is the first consultation with the doctor, the doctor can see the information provided by the GP during the referral request. During this first consultation, it is very important for the doctor to know the patient's clinical history and register it in the patient's hospital clinical record (electronic or in paper).

Hospitalization typically starts with an admission interview, in order to collect patient's relevant data (health indicators, clinical history, current medication, etc) from scratch (assuming this is the patient's first hospitalization in the hospital). There is considerable duplication of data if paper forms are used and these are not shared among the different hospital services. The social assistance professionals work closely with the nurses. When the nurses detect potential risks, the social assistance evaluates the situation. The nurses take monitoring notes (vital signs, baths, physical exercises, etc) and the doctors make regular visits to check the patient's progress (analyzing the patient records, exams results, etc). Finally, the discharge letter contains the hospitalization motive and summary, summary of surgery (if applicable), things the patient should keep in mind (medication, physiotherapy, etc) and an appointment of a follow up consultation (if applicable).

The psychology service receives requests from other services (e.g. psychiatry, neurology) to perform psychology assessments on the patients. The hospital IS doesn't support direct appointments, so it is necessary to ask the administrative staff to schedule these requests. The psychology assessments are consultations, which consist in direct interaction between the psychologist and the patient. The psychologist takes notes and, afterwards, prepares a report on this assessment. These reports are made on the computer, however, they are confidential and the psychologist must decide what parts of the report are more relevant to share with the doctors.

3.3 Emergency Care

Emergency care professionals are transitioning from paper based records to electronic records. However, despite having passed five months since the new computer system introduction, this system is still not very reliable (has considerable down times) and many professionals are not using it yet.

The emergency team receives the information provided after calling the emergency telephone number and travels to the victim's (name given to the person needing assistance) location. Here, while health indicators (blood pressure, temperature, etc) can be measured, other very important information can't - clinical history, allergies, medication and when was his last meal (for hypothetical surgery reasons). After assessing the victim's current condition, it is decided if it is necessary to transport the victim to a nearby hospital's emergency unit.

3.4 EHR Impact

Different types of care require different types of information. However, in a nutshell, the most relevant types of information to get from an EHR system are:

- Basic citizen personal data (identification, height, weight, gender, etc);
- Clinical history;
- Past exams and respective results;
- Past and present medication.

We can divide the usage of an EHR in two moments: access information and write information (see figure 1). On one hand, the main usage of the EHR's source of information is done at the beginning of an episode of patient care, while the health care professionals are getting to know the clinical history of the patient. On the other hand, the most relevant information to share about a health care episode is only available at the end of the episode - usually the episode's summary (e.g. hospital discharge letter).

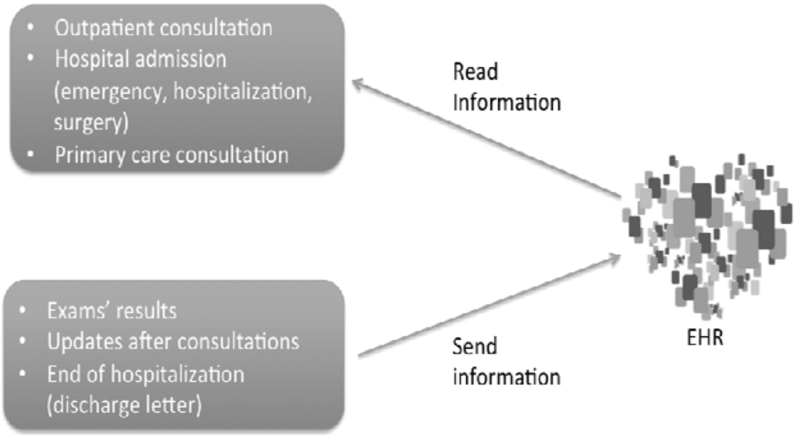

Figure 1. Examples of read and send information processes.

4. CONCLUSION

This work had a strong exploratory nature: to better understand the healthcare professionals, their activities and their needs.

Our first research question was *How do Information Systems impact the daily routine of healthcare professionals?* We found that the healthcare institutions have been investing in transitioning from paper-based records to electronic records and this trend will continue in the next few years. However, there are several issues that are delaying or sometimes even blocking this process. Users dissatisfaction with current IT infrastructures (old applications, poor reliability, bad usability and performance) strengthens their resistance to change to newer computer applications and many professionals still prefer to register information in paper-based records (despite admitting that electronic records facilitate information sharing and data portability). This resistance is more notorious in older age groups, which claim that they waste too much time writing their records in a computer.

Our second research question was *How do inter-institutional IS affect the institutions functioning?* Generally speaking, there is little to no inter-institutional information sharing (the exceptions being the outpatient consultation referral and some regional experiences linking a hospital and some primary care institutions). In most healthcare institutions there is even a lack of internal information sharing between different services, where they use different custom-made applications, which don't communicate with each other. The implementation of an EHR system could be a driver to promote internal and inter-institutional interoperability.

Our last research question was *How will an EHR system impact current organization processes?* The implementation of EHR systems usually require long projects that face many challenges that need to be addressed since the early stages of the projects. As seen in the answers to the previous questions, there are many internal challenges that healthcare institutions need to address before thinking in inter-institutional interoperability. These challenges can have different dimensions: technical (e.g. information systems integration), infrastructural (e.g. network broadband, performance) or change management (change of current operational processes).

Further research is needed to find the best ways to redesign current organizational processes, in order to reduce the impact of the introduction of an EHR system to the minimum possible.

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ADDRESSING OBESITY USING A MOBILE APPLICATION: AN EXPERIMENT DESIGN

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ABSTRACT

Obesity is becoming a worldwide epidemic and can significantly reduce life expectancy and increase the likelihood of developing other diseases. Patients can achieve weight loss through traditional obesity management programs, but have difficulty maintaining it. Promoting self-awareness and control can have significant positive results on weight loss maintenance. In this paper, we describe a newly designed mobile application for sustainable weight loss based on established behavior change theories. We expect that using a mobile application to reinforce behavior change is more likely to trigger weight loss than non-technology based methods. In this paper, we discuss three strategies for sustained weight loss and the corresponding mechanisms within a mobile application, a messaging system for sending frequently personalized reminders, a goal management system for visualizing progress toward dieting goals, and a social support facilitation system for impacting dieters attitudes toward a healthy life-style.

KEYWORDS

Healthcare information systems, weight management, mobile application, behavior change theories.

1. INTRODUCTION

The increasing prevalence of Obesity is a serious concern. A wealth of studies on diet and physical plans exist. Algazy (2010) evaluated contributions of interventions in the past ten years and concluded that only modest weight loss is achieved through single intervention programs and that multiple simultaneous interventions achieve better results. Such interventions include physical activity, healthy balanced diet, behavior modifications, and social or community support. It was also noted that completing programs and maintaining sustainable weight loss are important challenges difficult to overcome (Ross et al., 2006).

We propose a mobile application to address sustainable weight loss (Limam Mansar and Kekre, 2011). The application implements three levels of support for changing dieters' knowledge, attitude, and motivation to achieve a healthy weight and a healthy life-style.

1. Providing frequent, in-time *reminders* for increasing awareness of dieting aims
2. Providing a *goal management system* for fostering motivation and self-efficacy
3. Providing *social support* for impacting dieters' attitudes

2. THEORETICAL BACKGROUND

With regards to the efficiency of diverse interventions for obesity management, dieting has several dimensions that have to be addressed when trying to establish a healthy life-style and achieving a healthy weight. These dimensions include cognitive, motivational, and social aspects.

Based on evidence, we have applied Stroebe and colleagues' theory on behavior change (Stroebe, 2008; Stroebe et al., 2008) for designing obesity management support technology. They explain dieters' challenges during comparably short-term time intervals. When starting a diet, dieters maintain several, partially conflicting goals. One of these is a novel dieting goal for loosing weight. An already established conflicting goal is enjoying-good-food. For a given food-related situation, these goals compete for execution. Two factors determine which goal is chosen for execution, the *activation strength* based on earlier experience and the *utility* based on how rewarding the outcome of the action is and how likely that strategy will result in success. Therefore each time, dieters are confronted with food cues in their environment, the established enjoying-good-food goal is activated and competes with the dieting goal. Once, the enjoying-good-food goal has gathered sufficient activation, it will be chosen and might result in overeating. Correspondingly, challenges during dieting are associated with factors supporting the enjoying-good-food goals: salience of food cues (Mischel et al., 1992), sensory cues while eating (Herman & Polivy, 2008), overall stress level (Slochower, 1983), and cognitive load (Higgs & Woodward, 2009). To support the food-restriction goal, obesity management supporting technology should provide cues associated with that goal and / or provide reward for achieving that goal (see strategy 1 and 2 below).

Associated with the utility of the novel dieting goal, there is evidence that constantly present challenges can deplete the self-regulatory strength of the dieter (Hofman, Rach, & Grawronski, 2007; Kahan, Polivy, & Herman, 2003; Vohs & Heaterton, 2000). In addition, delay of gratification associated with long-term goals of loosing weight and with seeing the dietician only once a week may jeopardize the dieting attempts (Herman & Polivy, 1993, 2008; Mischel et al., 1992). This implies the reward for enjoying good food comes immediately, while the reward for achieving the food-restriction goal comes earliest after one week when reporting to the dietician. Again, this shifts the odds for activating the dieting goal in a given situation towards the enjoying-good food goal. Therefore it is crucial that obesity management support technology provides immediate and in-time rewards for achieving goals. This will strengthen the dieters' food-restriction goal and enhance their experienced self-efficacy (see strategy 2 below).

Finally, after dieters have established food-restriction goals and have integrated those in their mental reward system, they still face the challenge to integrate new eating and exercise habits in their social context (e.g., Cohen, 2008; Hekler et al., 2010). There is evidence that eating and exercise behavior is modulated by a dieter's friends and relatives (e.g., Christakis & Folwer, 2007). This is especially true in the Middle East where high temperatures during summer and social norms for females limit the opportunities for exercise and many social gatherings are associated with eating together. Therefore, our obesity management support technology will also foster social support for dieters.

2.1 Proposed Strategies for Obesity Management Support Technology

A necessary precondition for implementing the supposed strategies is that the dieter has set concrete and detailed goals that can be achieved in a given period of time between two appointments with the dietician. For example, 'using the stairs three times the day' is a better goal than 'using the elevator less often or not at all'. For these goals, it is possible to provide in-time reminders and to accredit rewards for achievement. In contrast, what if the dieter has used the elevator twice a day, but also used the stairs once, for the less specific goal? After these goals have been defined by the dieter, we will implement 3 different support options as a mobile phone application that can help the dieter to achieve these goals.

First, we will provide cues or *reminders* for agreed upon goals several times a day based on an agreed upon schedule. For example, the dieter with the 'stairs' goal might be reminded when entering the office building, before going to lunch, and before leaving the office. This should make the goal more salient and therefore more likely to be implemented, and not forgotten. As a side effect, dieters will experience that they actually can achieve their goals enhancing their self-efficacy.

Second, we will implement a *goal management system* that visualizes progress toward set goals. This provides rewards for achieving dieting goals and motivates to complete the self-set assignment. For the 'stairs' goal, seeing a progress bar with a 66% achievement score motivates to add the remaining 34%. At the same time, this system makes it easier to track achievements and to assign utility to a dieting goal. Again, this should modify the likelihood of dieting goals to be activated and to be chosen. At the same time, self-efficacy should be enhanced.

Third, we will implement a *social support facilitation system* that allows dieters to network and to achieve dieting goals together. On one side, social support adds a novel kind of reward for achieving goals that might replace rewarding themselves with food-related treats. On the other side, being part of a team can help to change attitudes toward a healthy life-style. Taking the stairs with a colleague makes it harder to opt out and take the elevator, it rewards with social interaction, and it gives a double-score for the same achievement.

These three strategies are being implemented in traditional weight loss programs as well. Our novel approach is that in this research, we include them through mobile phone technologies as a mean of creating reinforcement. We choose mobile applications as the medium for technology support for the advantages mobile phones provide: we can plan interventions at virtually any time because mobile phones have a persistent presence; we can push data to participants rather than wait for them to pull data (call us, visit us or visit a website). Mobile applications are likely to be better accepted: from a usability perspective, the small screens on mobile phones push technology designers to minimize information and design to the essentials, interfaces are usually simple and rarely overloaded with information (as website tend to do). They are, hence, easier to use for users with lower information technology literacy. In Qatar, there is a high saturation of mobile technology and openness for technical progress. Mobile phones subscription rate in Qatar is high and reaches 120.8% (IctQatar Landscape, 2009). We can assume that this technology will be accepted (but will have to be tested).

3. IMPLEMENTATION

How can we implement the three behavior strategies we have described using a mobile phone? We propose an intervention that uses the mobile application for:

(1) Strategy 1 (reminders): We will remind dieters of their set dieting goals by sending them tailored text messages. Based on Stroebe and colleagues' theory, we expect that text messages will result in improved dieting behavior and indirectly result in weight loss, but not necessarily in changed eating attitudes or body image.

(2) Strategy 2 (goal management system): We will provide support with sub-goals and visualizing progress by displaying sub-goals and current state of achievement. For the 'stairs' goal, dieters might press a button each time they use the stairs and the corresponding goal would automatically update. Given the current stage of technology, it is easy to implement motion related measures. At the same time, it is still challenging to automatically track calorie intake. For that reason, currently 'eating an apple a day' is a goal that is easier to track than tracking the corresponding nutrition values, or 'saved' calories for not eating chocolate. Based on Stroebe and colleagues theory, we expect visual sub-goals tracking will contribute to changing motivation to achieve the final goal and indirectly contribute to weight loss, but not necessarily foster changed eating attitudes or body image.

(3) Strategy 3 (social support facilitation system): We will provide means for social support through technology. One aspect of that support are the tailored text messages from the dietician implemented for strategy one. As another aspect, we will incorporate social networks (group discussion boards, chatting) and restrict access to appropriate participants (dieters with similar goals and caregivers). We hypothesize it will contribute to changing motivation to achieve the final goal.

Mobile technologies have been demonstrated to be effective for supporting dieting behavior. For example, there is evidence that tailored health information delivered via mobile technology or via web can be effective for improving health behavior and/or reducing weight ((Huang et al., 2006), (Peterson et al., 2010), (Frenn et al., 2005), (Webb et al., 2010), (Patrick et al., 2009), (Gold et al., 2007), (Donaldson, 2011), (Burnett et al., 1985), and (Mattila et al., 2010).

Other studies indicate that focusing on specific sub-goals supported by mobile technology can foster dieters' weight loss: Transmitting blood pressure, weight, and responses to goal achievement questions via phone resulted in marginally significant BMI changes compared to control (Goulis et al., 2004), (Block et al., 2004), (Woolford et al., 2010).

Mobile technology has the potential to impact dieters' health behavior by using social influence, or more specifically, mechanisms of social support from the nutritionist's side or social referencing from the dieter's side. SMS from experts being more effective for weight loss than a commercial website (Gold et al., 2007). This might be at least partially explained by social impact. Other studies show that social referencing impacted overweight children's eating and exercise patterns (Salvy et al., 2007, 2008).

4. MOBILE APPLICATION DESIGN

To implement the three strategies, three interfaces have been designed: A messaging system, a personal goal management system, and a social support facilitation system. The following describe a sample implementation walk-through for the three interfaces:

Figure 1 shows the first part of the mobile application (Messaging: SMS exchange).

Figure 2 shows the second and third set of interfaces. The left and center images reflect the 'personal goal achievement setting'. The right side image on Figure 2 shows the home interface for group progress, what we called the 'group achievement setting' through a virtual social support network.

Figure 1. A sample of the messaging mobile application interface

Personal goal setting	Personal sub goals setting	Group progress

Figure 2. A sample of the personal and group 'goal achievement setting' mobile application interface

5. CONCLUSION

In this paper, we introduced a mobile application that applies established behavior change theories to sustain weight loss. The mobile application makes a clear separation between various strategies for weight loss, allowing for a staged assessment of impact. Such an application can be used to complete a traditional weight loss program.

In order to increase the appeal of the mobile application to its potential users, the design and the look and feel of the application can be further enhanced. Another extension for the application could be to connect it to a web portal, accessible by the caregivers as well as the users. The web portal can reflect the data collected through the mobile application (such as frequency of messaging, charts and statistics around goals attainment and caregiver's follow up strategies with the patients).

The application is currently being tested for cultural appropriateness and efficiency with weight management.

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MOBILE APPLICATION FOR PEOPLE WITH VERBAL COMMUNICATION DISORDERS

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ABSTRACT

This paper deals with an Android-based application which was first designed to give mute people the ability to make calls. The operation is performed using the smartphone keyboard, the message is directly transmitted to the interlocutor within the call through the speaker. This allows for real-time communication. Word/message libraries can be prior set to ease the communication.

KEYWORDS

Mobile communication, nonverbal language, speech synthesis, android-based application, vocal system, handicapped aids

1. INTRODUCTION

For the last few years, mobile phones have known a real revolution with the marketing of smartphones. The introduction of smartphones, allowing the user to do much more than just making calls and sending texts, has modified the way people interact with these devices.

In spite of this technological evolution, the telephony remains hardly accessible for people with a handicap although they represent 15% of the world population. Indeed, there are approximately one million people suffering from aphasia just in the USA [1]. People without verbal language are a good example. Although the sign language exists, the communication is very limited since only 0.2% of the European population knows it [2]. Moreover, a normal phone conversation is simply unthinkable. As many people worldwide, we are aware of problems of people without verbal language and, we have been working to improve the communication of these people. This is the reason why we have worked to offer an application for Android smartphones which allows people without verbal language to have a conversation thanks to a speech-synthesis.

In this paper, we will present in a first part the existing solutions and why our solution is innovative. In a second one, we will describe our application (Android OS, features, design and user-oriented description), and finally we will focus on its future (Released on Google Play Store, new features and ideas for the development).

2. INNOVATION

Some technologies in the field of nonverbal communication disorders already exist, but only a few concern smartphones. Moreover, most of these products require external devices, such as the “Echo200” [3]. This application made us believe that it might be possible to do something for mute people and led us to our current innovation (to provide an application for smartphones). This device has a speech synthesis, but the user cannot make a phone call with it. The price is also an obstacle, because most applications proposed to disabled people are very expensive since they are not profitable for major companies. We wanted to use the “Echo200” as an inspiration, and designed new features as the possibility to make phone calls, to manage emergency numbers, to instantly start the application in case of an incoming call and the possibility to create and to manage sentences libraries. We also wanted to provide these features on an everyday life device: a smartphone.

By adapting existing technologies, we have created new features which enrich the application. The main technology is clearly the speech synthesis, which allows the user to transcribe his text into a voice. On Android, Google provides an application programming interface (API), named **T**ext-**T**o-**S**peech (**TTS**). TTS offers some tools we need to develop our application.

As the Android SDK does not allow modifying the voice stream during a call, we have decided to try the use of the built-in speaker output instead, and transmit it to a built-in microphone. The sound generated by the loudspeaker is “listened” by the microphone which enables the interlocutor to hear it. Then, we performed a few tests. The results were quite satisfactory in many cases. Indeed, we have carried out the tests with 4 different devices. We noticed that we have better results with smartphones when the speaker is next to the microphone. On the other hand, if the speaker is far away from the microphone, we get poor results. To make this work properly with our Android application, we automatically switch the loudspeaker on during the communication, once a call is started. We also added a volume bar so the user can easily set the appropriate volume of the synthesis voice and therefore the speaker volume.

3. DESCRIPTION OF THE APPLICATION

Android is a Linux-based mobile Operating System (OS) owned by Google Inc. Google purchased the startup that created this OS in 2005 [4], and the first public version (1.5, dubbed Cupcake) was released in April 2009 on the market.

In 2011, 60.490 smartphones were Android-based, which represented 52.5% of the sold smartphones [5]. Android is also the first mobile OS, before iOS (Apple) or BlackBerry OS (RIM) [6]. An Android application is written in JAVA programming language. It is composed of many different activities (each one represents a single screen view on a user interface).

Voice SmartAccess enables concerned people to have a proper conversation with anyone, thanks to a written message which is read by a synthesis voice.

This application has been developed for either mute people or any people affected by communication disorders, which includes all kinds of learning disabilities and speech disorders. In other words, the developed application (namely Voice SmartAccess) gives a voice for those in need. We really want the solution to be mobile, intuitive and economical. Also, Voice SmartAccess is very user friendly.

We have designed our application source code such as all activities are implemented as a subclass of a same activity and therefore they can share the same functions required in every activity. Regarding the implementation of our code we made it as structured as possible using design patterns. Most of the code is reusable and adaptable. The code is divided into 2 parts: AndroidTools, an “external library”, reusable in any kind of Application, and the code only usable in Voice SmartAccess.

On the communication screen, the user just writes a message. Once the button “Read” is touched, the message is read by a synthesis voice. Moreover, the application contains various functions which allow the user to spare time. The application provides word/sentence libraries accessible during a conversation. The user can personalize these libraries. As soon as the call is started the application runs automatically and an automatic introduction message can be set. Also to prevent any surprises for the interlocutor, it informs that the user is mute and that he is using a synthesis voice to talk. The application uses a speech synthesis engine available on every smartphone and it is possible to download other voices directly from online stores and, to use them in the application.

Finally, it is possible for the user to call someone directly from the application. The user can either choose a contact from his phone book or enter a phone number. The application starts the call and redirects the users towards the application communication screen. To perform a call with the application, it is just necessary to switch on the loudspeaker during the call. The interlocutor does not require any extra installation or application on his phone. For him, it is a normal call. For the user almost too, he hears the synthesis voice which replaces his voice during the call. The synthesis voice goes through the smartphone microphone. To be able to contact people quickly (in case of emergency for instance), the application allows storing directly one’s favorite contacts.

As we have already said, a database is used to manage many data:

- Favorite contacts: we store phone numbers and names (from the phone repertory) so as to allow the user to retrieve them. A contact will be ranked by priority and then by the number of times it has been called.
- Message: They are managed by the user in the application. A message can be a single word or many sentences. As favorites, a message will be ranked by the number of uses.
- Group: They can be either a conversation or a category (daily use), and they are managed by the user too. As favorites and messages, those most used will be better ranked.

4. FUTURE DEVELOPMENTS

4.1 Expected Impact

To validate our solution, we have met teenagers who have nonverbal language, we also met their speech therapists and ergo therapists. They were very enthusiastic about the proposed application and helped us to improve it.

The expected impact is that the application would be useful and would give voice to people who do not have one. The late version application is available on the Google Play Store in order to reach as many people as possible. Thus, we are able to monitor the numbers of downloads and the ratings of the app. Besides, the “Association des Paralysés de France” (APF) is releasing the application within its organization for their members who need it. They will then, provide us with a return of experience, which will be very useful for future improvements and for a better understanding of their needs. We have completed the first version of the development phase, which has already been awarded during an innovation contest in Paris, and has been a finalist in another one. Finally, we hope that this application could be an example because few applications exist to help the minority communities such as handicapped people. Indeed, it is not financially profitable for companies because such applications would only be used by a limited community. Nevertheless we do have today a technology which is able to improve life conditions of some of these people.

4.2 The Future

Now we are focusing on new features such as internationalization, extra word/sentence libraries and we are also working on the communication around our application. Our project is driven by the motivation of entrepreneurship and thus, the setting up of a social enterprise. We are thinking at the moment about a possible adaptation of our application to the general public for two reasons; first, the general public version may help us financing future developments of the version intended to people without verbal language. And the second reason is that the general public would speak to their circle about our application and it would be a good publicity, especially if there are mute people in their circle.

In the future version, we would like to integrate the possibility to use a contactor to navigate in the application. A contactor is a device which enables motor disabled people to interact with an electronic device. The application could be used by people without verbal language and/or with mobility problems. We wish the contactor to connect either by USB or Bluetooth, with a Printed Circuit Board (PCB) designed by us. We already have a first version of its diagram (Figure 1).

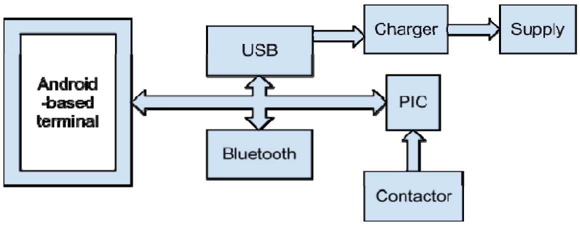

Figure 1. Block diagram of the PCB

This application could also be adapted to be used as part of a speech therapy. The speech therapist would, for instance, provide some pronunciation exercises to be done at home by the patient. The application would pronounce different words or sounds the patient has to repeat until he says them properly. For a better use, the application should be run on an Android tablet device.

Today, we have a functional application in French and English. Now, we hope that it is just the beginning of a beautiful adventure which is, in our opinion, a great experience both as a professional development and in human terms. With all our ideas about the future and our application, this may lead to the setting up of a startup, which will allow focusing even more on the development and the communication about the project.

5. CONCLUSION

To conclude, Voice SmartAccess is an innovative project that will help people with non verbal communication. They will be able to perform a call with anyone, and without any external device, but it is not limited to that, it is also possible to use the application in order to communicate face to face with someone who does not know the sign language for example. The limitations at the moment are that you need an Android phone, and it is better to be within a quiet environment. Moreover people with dexterity disorder of the upper-front members would not be able to use our solution. On the other hand, this application could be also used in other contexts; for instance it could serve as translation support while travelling abroad or be used as a homework support for speech therapy.

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BALTIC HEART STUDY – AS INTERNATIONAL ACTIVITIES IN TELEMEDICINE AND TELEEDUCATION OF PATIENTS WITH CHRONIC HEART FAILURE

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ABSTRACT

CHF patients do not successfully manage their disease; thus, rehospitalisation and high mortality rates prevail. Intensive tele-education programs, and home health monitoring can help reduce hospitalizations and mortality rates. The aim of this study is to test the hypothesis that standard care supplemented with telemedicine and distance learning applications in patients with NYHA II-III chronic heart failure is superior to the only standard care model after hospital discharge.

This study designed as a prospective, non randomized concurrent control, multi-center design study. Study involves patients who have had diagnosed CHF (II-III NYHA). The telemedicine set includes a telemetric scale and telemetric blood pressure monitor with possibility to transmit clinical data to the telemedicine center via sms and phone line.

With this study it is expected to evaluate the feasibility of telemedicine and distance learning applications for CHF patients after hospital discharge. Also to evaluate the efficacy of telemedicine and distance learning applications on mortality, morbidity, symptoms and quality of life compared to standard care and to evaluate safety and patient satisfaction on selected telemedicine and distance learning applications used for patient home care model.

KEYWORDS

Telemedicine; Tele-education; Chronic heart failure; International study

1. INTRODUCTION

Chronic heart failure (CHF) is a major public health problem characterized by significant mortality, frequent hospitalization, and poor quality of life, with an overall prevalence that is increasing throughout the world. Unfortunately, many CHF patients do not successfully manage their disease; thus, rehospitalisation and high mortality rates prevail. Frequent communication between the patient and health care professionals, intensive education programs, and home health monitoring can help reduce hospitalizations and mortality rates. Despite the dismal prognosis, there are several examples of CHF patients living beyond the years normally expected. These successes are usually attributed to patients taking an active role in disease management, facilitated by appropriate diet, exercise, daily self-measurement (e.g., weight scales and blood pressure devices), medication compliance, smoking and other behaviour control, education, recognition of disease-related symptoms (1;3).

Basic technological solutions for better integration of medical professionals and patients in health care processes are available in many cases (2;4). However the deployment of information and communication technologies in the regional health systems has been severely lagging behind compared to other sectors of European economies. Although there are many reasons to cooperate transnationally in health care, the use of eHealth is not very exploited yet.

The BALTIC HEART study designed as international eHealth initiative in “ICT for Health” project part-financed by European Union Interreg program. Study aims to assess effects of telemedicine and distance learning applications in the prevention of further hospitalisations in patients with chronic heart failure. Transnational cooperation in this study opens the mind for innovative ways of eHealth deployment in different health conditions and for sharing knowledge and resources across borders.

2. OBJECTIVES

Primary objective of the BALTIC HEART study is to test the hypothesis that standard care supplemented with telemedicine and distance learning applications in patients with NYHA II-III chronic heart failure is superior to the only standard care model after hospital discharge.

Secondary objectives are:

- to evaluate the feasibility of telemedicine and distance learning applications for CHF patients after hospital discharge.
- to evaluate the efficacy of telemedicine and distance learning applications on mortality, morbidity, symptoms and quality of life compared to standard care.
- to evaluate safety and patient satisfaction on selected telemedicine and distance learning applications used for patient home care model.

3. METHODS

This study designed as a prospective, non randomized concurrent control, multi-center design study. Total follow – up period in this study is 12 month.

Study participants: Study involves patients from Lithuania, Germany, Sweden, Finland, Norway and Poland who have had diagnosed CHF (II-III NYHA) and had at least one hospitalisation before involvement to the study.

Setting: International study performed in Lithuania, Germany, Norway, Sweden, Finland and Poland.

Key criteria for inclusion:

1. Written informed consent obtained.
2. Male and female patients over 18 years of age.
3. Chronic heart failure diagnosed at least before study involvement. Treated with relevant long-term oral treatment.
4. Relevant NYHA II-III symptoms at screening.

Key criteria for exclusion:

1. NYHA I or IV at screening
2. Therapeutic education impossible
3. Severe renal insufficiency (serum creatinine >450 μmol/l [5.0 mg/dl]) or on dialysis
4. Severe anaemia (blood haemoglobin <10 g/dl) at screening
5. Other serious diseases limiting life expectancy considerably (e.g. end-stage cancer)

This study investigates the superiority and effectiveness in 3 arms (figure 1):

1 arm: SC + TM + TE: the standard home care program plus a 6 month telemedicine program and plus 6 month tele-education program

2 arm: SC + TE: the standard home care program plus plus 6 month tele-education program

3 arm: SC only (Comparator): only standard home care.

Patient allocation to groups will be based on patient possibilities to use telemedicine applications, availability and competence for internet use. Those who do not have internet connection or are incompetent users are assigned for the standard care.

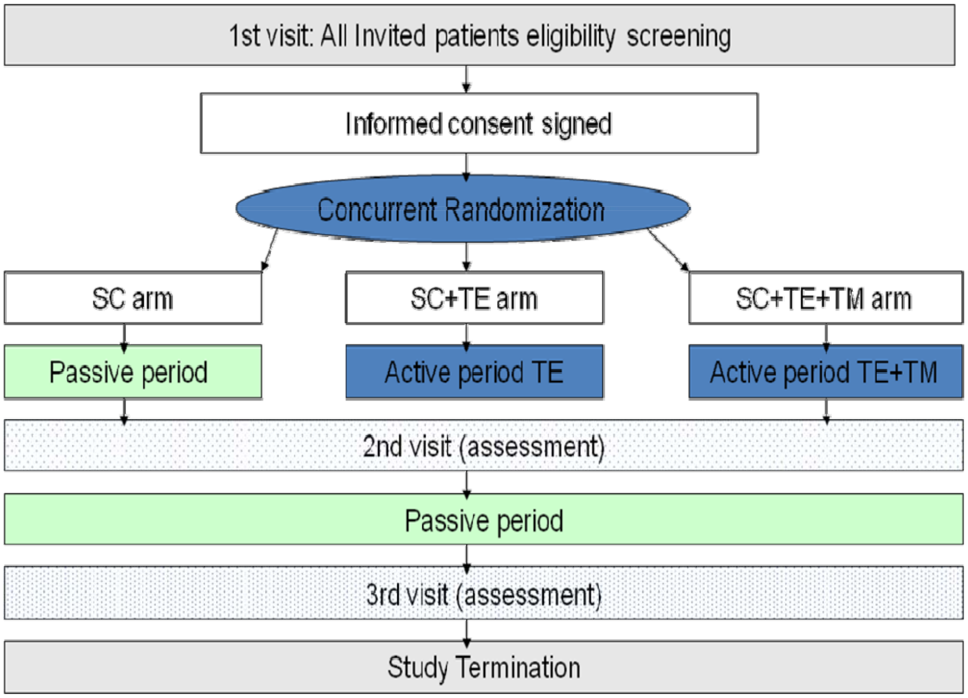

Figure 1. Study management scheme.

Key baseline characteristics have to be balanced between arms: age, gender, educational level, LVEF, NYHA class at baseline, hypertension (documented by medical records), overweight (KMI > 30).

3.1 Telemedicine and Tele-Education Technology in use

The telemedicine set includes a telemetric scale and telemetric blood pressure monitor with possibility to transmit clinical data to the telemedicine center via sms and phone line.

Telemetric BP measurement device. The Communication BP monitor - Stabil-O-Graph will be used in the active implementation period (0-6 month). The communication BP measurement device is equipped with a Bluetooth interface, which enables the transfer of measured data to an online database.

Telemetric scale. The Communication Scale - Libr-O-Graph will be used in the active implementation period (0-6 month). The intended use is measurement the body weight of a user at home. The communication scale is equipped with a Bluetooth interface, which enables the transfer of measured data to an online database.

Tele-education content. Distance learning program will be used for CHF patient basic distance learning on disease. Patients on tele-education beside tele-education program will receive short educative messages on individual risk factors at the regular basis (every 2-3 weeks).

3.2 Investigations and Data Analysis

SC + TM + TE group. The patients at the SC + TM + TE group will receive local standard of care supplemented by telemedicine and tele-education.

During the active implementation phase the patient starts the Web based training. The patients continue self measurements and reporting with his allocated telemedicine devices during all telemedicine period. The patient will be also advised for behaviour change according to individual risk factors.

SC + TE group: The patients at the SC + TE group will receive local standard of care supplemented by tele-education program.

This group of patients during active implementation phase the patient starts the Web based training.

SC group: The patients at the SC group will receive local standard of care. The patient adviced for self measurements and behaviour change according to individual risk factors.

The PP (per-protocol) population will be used for supportive analyses. The analysis will be presented, by treatment group, to summarize the primary, secondary and all other variables. Additionally, multifactor analyses will be performed for each of the components of the all events and risk factor profile changes.

4. CONCLUSIONS

With this study it is expected to evaluate the feasibility of telemedicine and distance learning applications for CHF patients after hospital discharge. Also to evaluate the efficacy of telemedicine and distance learning applications on mortality, morbidity, symptoms and quality of life compared to standard care and to evaluate safety and patient satisfaction on selected telemedicine and distance learning applications used for patient home care model.

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ELDERLY AND HOMECARE TASKS: A LITERATUE REVIEW ON PROBLEMS

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ABSTRACT

Personalization of IT-based homecare services is one of the essential requirements for their successful introduction. A service tailoring process assist a person responsible for deciding on the care activities (the ‘care-giver’) to create a personalized composite service for an elderly (the ‘care-receiver’) based on the care-givers professional knowledge and with minimal assumptions on their technical knowledge and skills. The outcome of the service tailoring process is called a service plan, which represents a composite service tailored to the specific needs of a care-receiver. Designing such a service plan from scratch is a difficult and time consuming task. The use of patterns can simplify the process of creating a service plan. A service plan pattern, as a starting point for the tailoring process, is a treatment pattern which is an activity structure for handling a generic homecare task. To define the treatment patterns the understanding of problems related to such homecare tasks is necessary. This paper, by means of a literature survey, studies characteristics of common problems faced by elderly and current existing solutions for these problems. We believe that identifying such problems helps IT experts to develop a better understanding of requirements and to define correct and complete treatment patterns.

KEYWORDS

Homecare systems, elderly common problems, service tailoring.

1. INTRODUCTION

The increasing percentage of elderly people puts health care systems in developed countries under great pressure (Ghorbel, Arab & Mokhtari 2008). Providing IT-based care services at home to elderly (the ‘care-receivers’) is one of the means for tackling this problem (Zarghami et al. 2011; Betge-Brezetz 2009). However, these services need to be tailored based on care-receivers personal needs (Zarifi Eslami et al. 2010). The outcome of such a service tailoring process is called a service plan, which represents a composite service tailored to the needs of a specific care-receiver as understood by his/her care-giver.

Designing such a service plan from scratch is a difficult and time consuming task. The use of patterns is believed to simplify the creation of a service plan. A service plan pattern is a treatment pattern for a specific generic homecare task (Zarifi Eslami et al. 2011). In this way, the tailoring system proposes a pattern to a care-giver, whenever she selects a homecare task from a menu with a list of common homecare tasks. Therefore, she does not have to create a service plan from scratch, and instead can configure and modify an already provided plan by the tailoring system.

To be able to provide appropriate treatment patterns to the care-givers in the service tailoring process, there is a need for identifying common homecare tasks and their corresponding treatment patterns. Zarifi and his colleagues (2011) have already identified the common homecare tasks through couple of interviews. To develop a better understanding of these common homecare tasks and their existing (IT-based) solutions, this paper contributes in studying these common tasks and identifying their characteristics. For this investigation a literature study has been carried out. We believe that, the result of this work can help IT provider to define appropriate treatment patterns for the homecare tasks.

The rest of the paper is structured as follows. In Section 2, we have discussed identified common homecare tasks (i.e., common problems faced by elderly) and in Section 3, we have discussed our findings and show how it can help IT providers to define treatment patterns and finally, in Section 4, we conclude our paper.

2. COMMON HOMECARE TASKS

Among the homecare tasks, medicine taking is the most common problem. Poor medication adherence is one of the biggest problems being faced by many industrialized countries (Lee et al. 2009). This poor medication adherence causes death and also account for increase in medication cost. For example, in United States, non-adherence of medication causes over 100,000 deaths yearly (Boquete et al. 2009; Lee et al. 2009) and account for incurrence of cost $177 billion (Lee et al. 2009). In addition to medicine taking, measuring blood pressure, weight and oxygen saturation level at home, having social activities and interaction, maintaining daily routine and physical training plan are some other examples of common problems faced by elderly. In this section, we discuss our findings regarding characteristics of the common homecare tasks. These common tasks identified through interviewing the care-givers (in a care institute in the Netherlands) in the work (Zarifi Eslami et al. 2011).

2.1 Medicine Taking

Elderly face problems in medication consumption as well as in medication logistics. Based on Lee and his colleagues work (2009) we identify following problems faced by elderly in taking medicine.

i. Elderly forget to take their medicine on time. Forgetfulness or dementia is one of the common challenges faced by elderly. However, Lee and his colleagues' study identified different reasons behind such forgetfulness. Most common cited reasons include tiredness or distraction at the time of medication intake. Distraction may be caused by being busy with some other thing at the time of medication.

ii. Difficulty to handle complex regime (complicated prescriptions) is also common problem to elderly people. Elder people found facing difficulty to remember taking pill that is prescribed to be taken in middle of the day, every other day, weekly or in association with meals. Also elderly found difficulty to take medication when they are needed to be taken away from home such as middle of work or while taking meal in a restaurant.

iii. Coping up with the changes in lifestyle is another problem faced by elderly related to medicine taking task. Any change in life style causes elderly to miss medications. Different routines for weekends, shifting meal times, or travel/vacations are the reasons to affect the ability to maintain medication schedule.

2.2 Social Activity and Interaction

An elderly requires participating regularly in social activities and requires interacting with their family members and/or friends. In the following, we list the characteristics of this problem.

i. Elderly with vision and/or hear impairment, lacks enough confidence to participate in social activities or perform a social interaction (Crews & Campbell 2004). Thus elderly with any of these two problems may found confused and impatient while interacting with other people.

ii. For performing social activities and interactions with friends and family, elderly require making prior appointment. But due to dementia elderly may forget to make appointment on time and thus, their social activity and interaction is limited.

2.3 Daily Routine Activities

Although care-related tasks such as medicine taking and measuring blood pressure, oxygen saturation and pulse are part of daily routine activities, however, by daily routine work/activities, we mean general tasks of daily life such as walking, going to/out of bed, eating, bathing, toileting etc.

i. Crews and Campbell (2004) argued elderly with vision and hearing impairment having difficulty to perform their daily living activities. According to them elderly with such impairments found to have difficulty with walking, getting outside of their house, getting in or out of bed or chair and preparing meal.

ii. Elderly with more frail condition have more problems to perform their activity like bathing and toileting which requires involvement of a care-giver (England & Dyck 2011).

iii. Many elderly require performing a minimum level of daily physical activities. For example, the guidelines of the Centers for Disease Control (CDC) and the American College of Sports Medicine (ACSM)

1995’s guidelines suggest that an adult should perform daily minimum 30 minutes of physical activity with medium intensity (Pate et al. 1995). Identification of problem related to this task is difficult. Proper monitoring of an individual elderly’s daily activities can only reveal problems.

2.4 Training Plan

While talking about problem of elderly related to perform daily routine activities, we referred to Pitta and his colleagues’ (2005) work, which is based on CDC and ACSM’s guidelines from 1995. An updated recommendation of that guideline is done by ACSM and American Heart Association (AHA) (Nelson et al. 2007). This guideline provides required training plan for enabling an elderly to meet the guidelines of daily physical activities.

i. ACSM and AHA guidelines suggest different level of physical activity for various persons. A physical activity plan incorporates physical activities required for a specific person and routines for the person to adopt that plan. Thus it requires a tailorable training plan. Such a training plan for an elderly people can be complex. Nelson and his coworkers also argued that activity plans for many elderly people require to be integrated with preventive and therapeutic recommendation. They suggest such an activity plan should be tailored according to an elderly person’s chronic conditions, activity limitations and risk of falls. For example, physical activity recommendation for a diabetes patient suggest performing at least 3 days of physical activity with no more than 2 consecutive days without activity, while for a patient with Coronary artery disease recommendation is at least 3 days of physical activities per week (Nelson et al. 2007). This means that activity plan for patient with diabetes must be different from an activity plan for a patient with coronary artery disease. Thus a training plan for such physical activity becomes more complex for an elderly. Adoption of such a complex regime of training plan is a problem for elderly people.

2.5 Blood Pressure Measuring

Although home blood pressure measuring is considered cheaper and available 24/7 and therefore, easier to predict high/low blood pressure values (Green et al. 2008; Pickering et al. 2008), its accuracy depends on following its recommendation and guideline of measuring. The problems related to this task are as follows:

i. Accuracy of blood pressure measurement depends on the reliability of the machine and the way it is used. For example, it is recommended that to ensure the accuracy of the machine, reading should be taken same time of the day, such as every morning, while taking the measurement subject should be resting in seated position (Pickering et al. 2008; Wong et al. 2005). Correct home blood pressure measuring technique is more critical; recommendation suggests three readings should be repeated after 5 minutes or more. Although home blood pressure monitoring tends to show accuracy (Pickering et al. 2008) and its usage found more common to elderly, it is a complicated procedure and elderly people may not be able to use those complex devices properly. Thus practice of such complicated procedure is a problem for elderly.

ii. Due to elderly people’s inability to handle such complex devices properly, they need to be trained before using such a device (Pickering et al. 2008). Adoption of such training is an additional problem for elderly.

2.6 Oxygen Saturation and Pulse Measuring

Like blood pressure measuring, blood oxygen saturation and pulse monitoring system handling is complicated for elderly people. However, for measuring the pulse rate and oxygen saturation various kinds of devices exist, such as classical handheld pulse oximeter, wearable ring device (Anliker et al. 2004; Asada et al. 2003; Leonhardt 2006) which can enhance the measuring those values.

i. Lin and coworkers designed a ubiquitous monitoring system in living space of elderly, using biosensor and RFID technology (Lin et al. 2007). Along with providing continues tracking of elderly, this system is capable of measuring pulse rate, blood oxygen saturation and temperature. The problem with such a system is that it needs to turn on by elderly when care-giver is not around them. Since dementia is common to elderly (Bekkelund, Kujala & Rosenvinge 2001), bearing in mind to switch on such a device may be a potential problem for elderly.

ii. Elderly need to maintain a routine to attach the measurable device by them. Maintaining such a routine base work can be a problem for them. However, more modern devices such as wearable ring devices may reduce the complexity of such a routine.

iii. Many automatic monitoring systems exist for above mentioned two problems, which introduces problem related to battery as argued by Lin and his colleagues. Those systems do continues measurement which may result in quick power consumption. As a result elderly may require changing the battery. So requirement of changing regularly the battery of these measuring devices is a problem for elderly.

iv. Like in blood pressure measuring, elderly have difficulty to handle different devices to measure oxygen saturation and pulse. Because measuring oxygen saturation and pulse at home requires handling many more complex devices.

3. DISCUSSION

Surprisingly we have discovered no in depth research has been done in identifying problems of elderly faced with performing homecare tasks. Few researches we found addressing problems from the perspective of providing a specific solution. For example, Lee and his colleagues' work (2009) only talk about elderly people's poor medication adherence. Some of those researches have broader view on problems, for example, Crews & Campbell's work (2004) doesn't have a different view for 'social activity' and 'daily activities'. But in our opinion a distinguishing view would help to develop a better understanding of these problems.

Table 1. Homecare problems, characteristics and tailorable parameters

Problems C	**haracteristics**	**Tailorable parameters**
Dementia	Requires different level of reminder.	Reminder schedule (Time), Reminder priority
Problems with complex regime	Requires different level of reminder, determination of patient specific threshold value for task (e.g. training plan).	Reminder schedule (Time), Reminder priority, Threshold value for a training/ physical activity.
Vision & hear impairments	Requires different level and type of reminder (e.g reminder by text or voice message).	Reminder schedule (Time), Reminder priority, Modality.
Problems with measuring devices	Requires different level of reminder, correct measuring technique and determination patient specific threshold value for alert (for measuring BP/ oxygen saturation task).	Reminder schedule (Time), Reminder priority, Threshold value for vital signs.

In section 2, we identified four major categories of problems of elderly with homecare tasks. These are dementia, problems with complex regime, vision & hear impairments and problems with measuring devices.

Table 1, summarizes our findings regarding these problems and it can help IT providers in designing It-based services. The first column of the Table 1 incorporates the problems we identified for elderly related to homecare tasks. The second column shows the characteristics that require incorporating in the service pattern to handle the corresponding problem. While in the third column we have included corresponding tailorable parameters. In our opinion each of those parameters are required for corresponding service pattern to be tailorable for an individual.

For all of the problems elderly requires reminder and reminders need to have different level and different priority depending on the patient's frail condition. Thus, a service plan to handle any of those problems needs to tailor parameters – *Reminder schedule (time)* and *Reminder priority*. A reminder schedule will be based on required service patterns for an elderly such as reminder time schedule for medicine taking, reminder time schedule for blood pressure measuring, etc. Also different reminders may have different level of priority. Further, if an elderly has hear and/or vision problem, then appropriate reminder is required. Thus reminder with appropriate interface (*modality*) needs to be considered. We identify the need for two other parameters *threshold values* for *a training/physical activity* and *threshold values* for *vital signs*. By setting threshold values for a training/physical activity, an alert can generate and send to the care-giver if an elderly does too excessive physical activity. Likewise in blood pressure, oxygen saturation and pulse measurement tasks, patient specific threshold values need to be set and exceeding such a value will generate an alert as well. We also identified that there are problems that require direct care-giver intervention which should have especial consideration in service tailoring process. For example, many elderly with vision and hearing impairment or with frail condition may not be able to perform their daily routine activities like walking, getting into or out of bed, preparing meal etc. by themselves.

4. CONCLUSION

In this paper, we identified that due to forgetfulness, elderly face problem to remember taking medicine. This poor medication adherence is also caused by their change in life style or due to their inability to handle complex regime (complicated prescription). Vision and hear impairments are found to be the problems that make elderly people reluctant to perform their social activities and interactions. We also found these two impairments inhibiting elderly peoples' daily routine activities. It is also found that elderly with frail condition require care-givers' involvement to perform daily works. Many elderly with COPD fail to perform required physical activities, which are risky for such patients. Elderly with various diseases require performing different level of physical activities. To adapt those physical activities, elderly need to go through complicated training process. To measure blood pressure, oxygen saturation and pulse, elderly faces problems due to their inability to handle complex devices. To be able to use those complex devices, elderly may require training on the procedure of their measurement. Both handling complex devices and go-through the training process are challenging for elderly. Moreover, we found that due to dementia, elderly forget to remember switching on/off those device and take the measurement.

Our work is not free from limitations. One can argue that the list of homecare tasks is not complete as it is based on only one scholarship. We admit that limitation and we argue that a more extensive work to identify homecare tasks is required. Furthermore, some of the problems we have identified are not directly mentioned as problems by the scholarships. However, based on corresponding scholars' argument and our assumption, we inferred some of those. The reason behind such action was lack of scholarships. It was very surprising that there is a little number of works which study problems of elderly in homecare domain. We argue that researchers should look into this aspect and do extensive research to identify problems of elderly in the homecare domain.

Despite the argument regarding completeness of the homecare task or related problem list, we have shown how the identification of problems related to homecare tasks can be help in service tailoring process. If all the potential problems related to a homecare task is known to IT service providers, they will be able to define all the required service plan patterns. This will eventually help creating individual service plans for any care-receiver. Besides, we also have shown how identification of problems can lead to identification of required tailorable parameters.

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PATIENTS AND PHYSICIANS SATISFACTION USING TRANS-TELEPHONIC 24/7 ECG SERVICE

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ABSTRACT

Empowering patients to record him-/herself ECG and to transmit it via a regular telephone line allow us to follow up our patients' health status at their homes. Trans-telephonic health care services contribute to higher accessibility of health care services and make possibilities to get acceptance and safety to our patients. The aim was to assess patients and physicians satisfaction with application of international trans-telephonic ECG (TTECG) system.
Follow up study design was used. Basic medical and personal patient data, including reference ECG, disease severity, and quality of life were collected during the initial hospital stay and follow - ups. After completed follow – up period each patient filled in questionnaires to assess compliance, quality of life, acceptability and satisfaction within the TT ECG system.
Our data showed high acceptance and expectations to clinical tele-cardiology services we provided. It can be regarded as such service meets expectations and shows high value to users with such application. System was was highly accepted by patients but less accepted by physicians as it had higher number of unneeded consultations by phone.

KEYWORDS

Satisfaction; Telecardiology; Telemedicine; Patients; Physicians

1. INTRODUCTION

The effectiveness of hospital services use and safety to patients' health can be improved, the pre- and in hospital stay periods could be shortened using modern trans-telephonic technologies and consultations by phone to follow up ECG changes of our patients in a waiting list. Empowering patients to record him-/herself ECG and to transmit it via a regular telephone line allow us to follow up our patients' health status at their homes (5;6), emergency ECGs compared with a reference ECGs stored in database and in combination with verbal communication by phone could help us to select right patients who have pathologic ECG changes and transfer them for urgent surgery or examination in emergency unit (1; 3). Trans-telephonic health care services should also contribute to higher accessibility of health care services and get acceptance and safety to our patient (6;7).

2. OBJECTIVES

Aim was to assess patients and physicians satisfaction with application of international trans-telephonic ECG (TTECG) system.

3. METHODS

Follow up study design was used. Basic medical and personal patient data, including reference ECG, disease severity, and quality of life were collected during the initial hospital stay and follow - ups. After completed follow – up period each patient filled in questionnaires to assess compliance, quality of life, acceptability and satisfaction within the TT ECG system.

Participants were all patients and physicians in the hospital who contributed to clinical tele – ECG system application and patient management in the pilot were asked to fill in the satisfaction with the working model questionnaires.

3.1 Device and Application Description

One day before discharge from hospital patients were equipped with a personal 12 lead event recorder (model CG 7100G manufactured by Card Guard AG). This device has easy lead placement. Only three wires are used to record the modified bipolar leads (4; 5). The device should be placed on three different chest locations in order to record V1-V2, V3-V4, and V5-V6. The first recording phase records lead I, II, III, aVR, aVL, aVF, V1 and V2. The recording time of first phase is 20 seconds. Phase two records V3 and V4 for 7 seconds, while in phase three V5 and V6 for 7 seconds are recorded. The total recording time is 41 second.

Patients were trained by nurse to use the device, to place the electrodes correctly and to send the ECG via toll- free line and regular phone to the Telemedicine Centre in Germany from which ECG's are retransmitted to referral 24h Call Center (Figure 1).

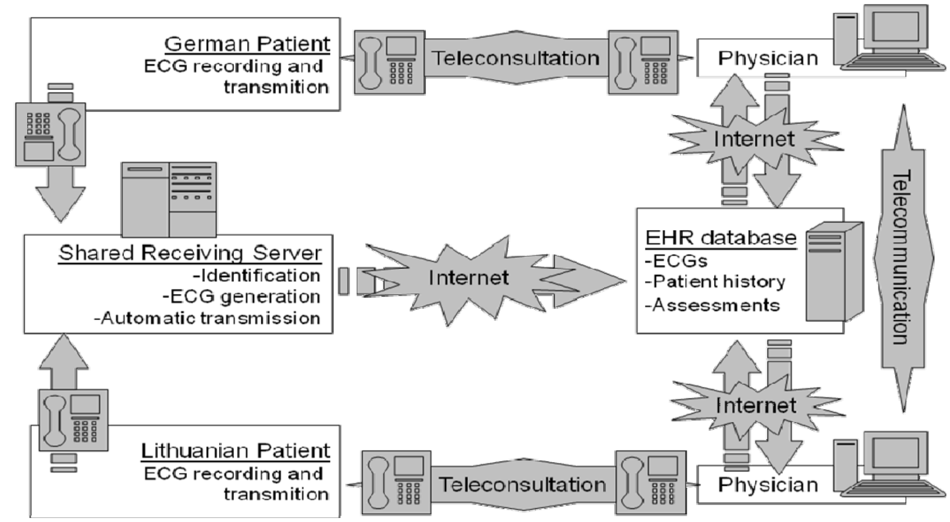

Figure 1. Telemedicine service management.

3.2 Data Collection and Analysis

Baseline data is documented within database forms at initial hospital stay and within the questionnaires during follow-up period. A detailed descriptive analysis of collected data was made.

We evaluated physician satisfaction and acceptability of trans-telephonic ECG system by validated MSSQ questionnaire, consisting of five domain aspects of telemedicine system use:

- general functionality and acceptability;
- technical quality;
- acceptance to current health status;
- data trustiness and security;
- satisfaction with care.

4. RESULTS

According to our study inclusion exclusion criteria we have done trans-telephonic ECG system application to high risk for future IHD events patients group. During follow-up period until 1 May, 2007 34 patients were recruited and we have received 14 ECG with changes, from overall 329 ECG‘s sent by the patients. There were 86 telephone consultations performed following the ECG transmission. In the management of those patients has participated 17 physicians.

4.1 Patients Satisfactions and Acceptance of Trans-Telephonic ECG System

Analysis of patients satisfactions and acceptance of trans-telephonic ECG system pilot application in cardiology clinical practice showed, that there‘s very high acceptance of such system from our patients. In average 97 % of our patients were very satisfied or satisfied with telemedicine services their have received. Highest satisfaction according to our inventory from patients received general functionality of the system and data trustiness and security domains. Lower acceptance and satisfaction was within technical quality and preparedness domain as there were highest number (5 %) of dissatisfied patients, in all other domains there were from 2% to 3.3 % patients who were dissatisfied with such application of clinical telemedicine services.

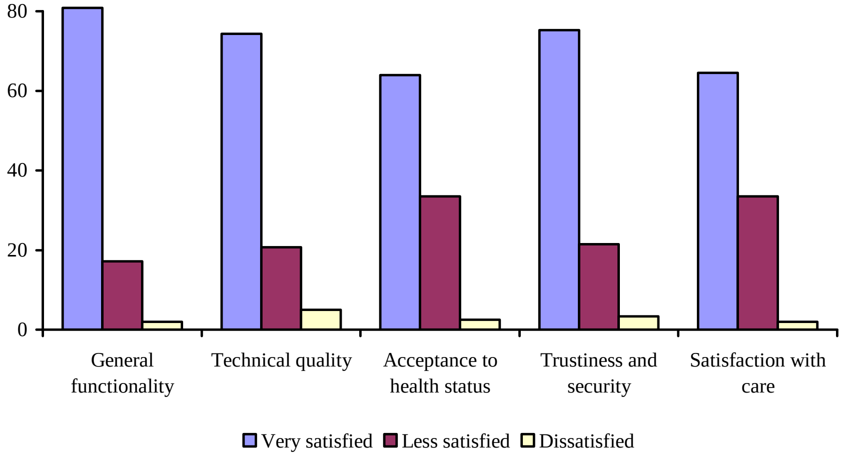

Figure 2. Acceptance and satisfaction of patients with telemedicine services

4.2 Physicians Satisfactions and Acceptance of Trans-Telephonic ECG System

Analysis of physicians satisfaction and acceptance of work in telemedicine service in cardiology clinical practice showed, that such system in current its application has high acceptance. In average 77.6 % of our physicians see the high value in clinical practice for such system application. Highest satisfaction according to our inventory from physicians received general functionality of the system domain. Lowest acceptance and satisfaction was within technical quality, acceptance to care, trustiness and security domains as there were highest number (26.2 – 37.5 %) of dissatisfied physicians.

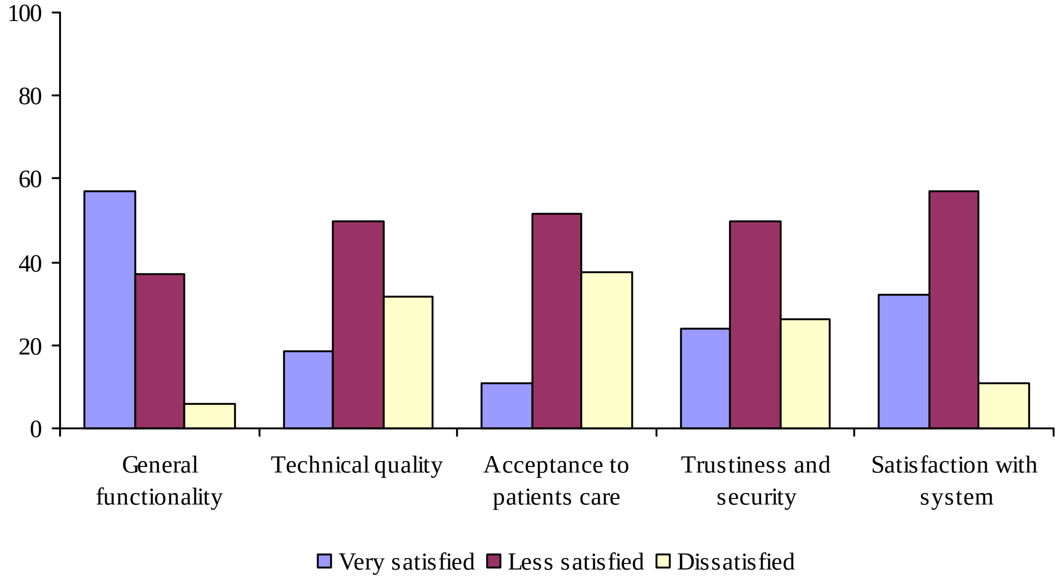

Figure 3. Acceptance and satisfaction of physicians with telemedicine services

Main weaknesses that was mentioned by physicians using tele-ECG system first was that application of this system rarely has positive impact on job demands in practice and to effective use of working time, second was mentioned communication process by phone with patient rarely is effective and constructive as half of the calls was not associated to heart attack or emergency and third weakness is because of quality of received ECG's as up to 23% of ECG's was unreadable and not applicable to clinical analysis.

Main strengths of the system mentioned by physicians was that it is easy to learn how to use the system, second - it is seen as the progress in medicine, third – it can help to identify patients with heart attack symptoms and forth – that consultation by phone to physician is same comfortable as consultations done in the department.

5. DISCUSSION

Cardiovascular diseases remains the leading cause of morbidity and mortality in developed and developing countries, while health services in these countries are experiencing a number of conflicting influences. Developments of technology and imaging techniques have greatly increased diagnostic powers. These developments have been well publicized, creating widespread awareness of them among both the general public and patients. This has increased public expectations, not only for high-technology health care but also for rapid, unimpeded access to health care services. On the other hand, hospital diagnostic facilities have expanded slowly while the debate regarding the future funding and provision of health services continues (4). According to our experience for cardiovascular patients would be more favourable to use technologies based on automatic ECG registration and transmission, which are already available in the market. On the other hand, such system has employed rapid, unimpeded access to health care services for the study participants and further technological adaptation of the system and telemedicine has ability to overcome the problems that will make the technique so potentially useful (2;4; 6;8).

6. CONCLUSIONS

Current our research data showed high acceptance and expectations to clinical tele-cardiology services we provided. It can be regarded as such service meets expectations and shows high value to users with such application. System was was highly accepted by patients but less accepted by physicians as it had grooving up numbers of unneeded consultations by phone but it is expected to be reduced unneeded hospital visits.

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THE OPPORTUNITY AND CHALLENGES FOR DELIVERING GROUP-BASED REHABILITATION SERVICES TO THE HOME VIA DIGITAL TELEVISION

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ABSTRACT

Rehabilitation programs improve wellbeing and quality of life in a number of conditions, but travel demands or poor health mean that many patients cannot participate in hospital or clinic-based programs. Previously, we reported a successful feasibility study to deliver pulmonary rehabilitation to a group of patients with chronic lung disease in their own homes, involving videoconferencing on a mini computer connected to the Internet with the television as the video display. This paper reflects on the opportunity and challenges for delivering group-based rehabilitation services to the home via digital television. The popularity of television and the digital switchover, the drive for universal access to superfast broadband and the shift in health care policy to delivering services closer to home, all point to the emergence of digital television as an important platform for widening access to care and rehabilitation services.

KEYWORDS

Digital television, health care, rehabilitation, videoconferencing.

1. INTRODUCTION

The delivery of health and social care is changing in response to an ageing population, the growth in long-term conditions, and the rising trend in emergency admissions to hospital among older people. Health care has been hospital centered and reactive. The evolving model of care emphasizes care in the community and preventive care [1] and policymakers see Information and Communication Technology (ICT) as a potential solution. In particular, there is significant interest in the opportunity offered by digital television to provide new ways for the public to access health and social care services.

Rehabilitation has become increasingly important as a strategy to improve wellbeing and quality of life in a number of conditions, such as Chronic Obstructive Pulmonary Disease (COPD), Ischemic Heart Disease, Stroke, and following trauma. In some cases, rehabilitation will be tailored for an individual patient and will be delivered on a one to one basis. However, for other conditions, such as COPD and Ischemic Heart Disease, rehabilitation programs are delivered in a group setting and there is evidence that participation in the group is an important determinant of the outcome of the program [2]. Conventionally, COPD rehabilitation groups will meet on a regular basis at a defined location, usually a hospital, or other clinical facility, and will be directly supervised by a physiotherapist. At each class, in addition to a supervised exercise program, the patients will be offered a series of educational talks about issues such as smoking cessation or inhaler technique [3], and in many cases there will also be a social element to the class, sharing refreshments and informal chat at the end of the session. The effectiveness of conventional pulmonary rehabilitation is established [4]. However, patients who are unable to attend a central hospital or clinic facility by virtue of geography, lack of transport or poor health are denied both the clinical and social benefits of participation.

In two previous papers [5, 6], we reported a feasibility study to deliver pulmonary rehabilitation to a group of patients in their own homes, which involved videoconferencing on a mini computer connected to the Internet with the television as the video display (figure 1). The findings demonstrated the feasibility of delivering such a program, with clinical outcomes comparable to a conventional program. Reference [5] described the design of our videoconferencing system and reported findings from the first trial. Reference [6] contributed findings from the second trial with a discussion of the main challenges encountered and opportunities for future development of such systems. Across both papers, we presented related work on the remote management of COPD at or close to home, using ICT. This paper contributes a discussion of the opportunity and challenges for delivering group-based rehabilitation services to the home directly via digital television; that is without the need for a separate, dedicated computer.

Figure 1. Group pulmonary rehabilitation delivered to the home via videoconferencing on a mini computer connected to the Internet with the television as the video display.

1.1 Related Work Overview

Over the past decade, there have been a number of digital television initiatives involving a range of public service providers. In 2001, the UK Department of Health took first steps in exploring the feasibility and effectiveness of the medium for delivering health information and advice to the public [7]. The results demonstrated that a market for digital health existed and that digital television could prove effective at reaching groups that may be reluctant or unable to access services via personal computers, such as older people. The research culminated in the launch of "NHS Direct Interactive" in 2004, available to digital satellite viewers; despite the use of the word "interactive" the channel was launched as an information only service. NHS 24, who provide health information and self care advice for people in Scotland, recently launched a comparable digital television service called "NHS Scotland" to digital satellite and cable viewers.

However, the market may still be in its infancy. A recent systematic review of digital television systems that communicated information to or from an individual's home with either a health or social care application, concluded that digital television has the potential to deliver health and social care to people in their own homes [8]. However, only seven of the 25 systems identified were commercially available. Eleven of the systems (44%) facilitated some form of direct consultation with health and social care professionals via voice, text and/or video. Seven of the systems (28%) facilitated social interaction in some form, mainly through video communication with other users.

2. OPPORTUNITY AND CHALLENGES

The popularity of television and the digital switchover, the drive for universal access to superfast broadband and the shift in health care policy to delivering services closer to home, all point to the emergence of digital television as an important platform for widening access to care and rehabilitation services.

2.1 Digital Television: A Popular and Social Medium

Television is one of the most pervasive technologies in the home. In the UK, an estimated 97% of households own a television [9] and watching television is the most popular media activity; in particular, older people watch more television compared to all adults [10]. Although many older people have difficulty with the physical handling of standard television remote control devices [8], Industry is taking steps to improve product design. Over the last few years, there has been a dramatic rise in sales in the UK of televisions with screens 40inch or bigger [11]. A large screen size is well suited for displaying all the patients and the physiotherapist in a remote rehabilitation program, which is important to allow people to feel part of a group despite being geographically distant.

Socialization and companionship are important components of group-based rehabilitation programs. People usually find that taking part with others who have similar problems helps them to carry out the exercises and increases their confidence and enjoyment. Television has always been a social form of media that can also provide a source of companionship for older people [12], particularly those who are housebound or infirm. However, technological advances are changing the experience into a two-way social viewing experience and providing people with new opportunities to socialize. For example, the "Skype" video calling service is now available on a limited range of televisions; the service requires a fast broadband Internet connection and a television compatible webcam [13]. Such systems remove a major barrier to remotely delivering short-term home-based rehabilitation services, namely resource allocation and cost to install and remove audio-visual equipment.

2.2 The Digital Switchover

Later this year, all television in the UK will switch to a digital signal and the existing analogue television signal will be switched off. In preparation, UK households have been switching to a digital signal, region by region, since 2008: the number of homes with digital television reached 93.1% by Q1 2011 [14]. Across Europe, the majority of countries will also have completed digital switchover by end 2012. Digital television uses less broadcast space than analogue broadcast, allowing for more channels and features than traditional analogue television. The range of features depends on the type of platform – digital terrestrial television, digital satellite, digital cable, Internet protocol television (IPTV) – but the main benefits are better quality pictures and varying levels of interactivity. The availability of more channels, and more specialist channels and programs, has potential to cater to smaller but better-defined audiences, such as rehabilitation groups.

2.3 Superfast Broadband

Digital television platforms have varying levels of availability across the UK and differing levels of interactivity for the viewer, depending on the available bandwidth and whether or not the platform has a return path to allow the user's equipment to communicate with the service provider. Delivering a home-based rehabilitation program by means of videoconferencing requires a platform with a high-speed return path, which digital cable and IPTV have but digital terrestrial and digital satellite do not. However, digital cable and IPTV are currently only available to 49% and 39% of UK homes respectively – although IPTV is gaining popularity – compared to digital terrestrial and digital satellite that have near-universal coverage [15]. Most of the systems (72%) reviewed in reference [8] were designed for use with a broadband Internet connection to enable the two-way communication, including most (67%) that incorporated videoconferencing. The authors identified the requirement for a high-bandwidth communications infrastructure as a barrier that will need to be addressed for digital television to deliver health and social care effectively on a large scale.

At end 2009, less than one in fifty households in the UK, France, Germany, Italy and Spain had a superfast broadband connection – take-up has been much higher in the US, Japan and Sweden [16]. However, there is an emerging consensus among policy makers about the importance of superfast broadband and investment in extending access is gathering pace. In the UK, Government has pledged to spend £530m of public funds to help upgrade rural areas as a step to providing superfast broadband to all by 2015. Speeds up to 40Mbps are expected, with a better balance between download and upload speeds.

3. CONCLUSION

Rehabilitation services have become increasingly important as a strategy to improve wellbeing and quality of life in a number of conditions, including COPD, Ischemic Heart Disease and Stroke. However, travel demands or poor health mean that many patients cannot participate in hospital or clinic-based programs.

Television is popular, convenient and one of the most pervasive technologies in the home. By end 2012, the majority of European countries including the UK will have completed digital switchover, providing the potential for health care providers to reach virtually the whole population. Combined with continuing improvements in broadband take-up, speeds and availability, digital television offers an opportunity to deliver group-based rehabilitation services directly into patients' homes, widening access in both rural and urban areas. The preliminary results of our home-based pulmonary rehabilitation program demonstrate the feasibility and acceptability of delivering a group-based service via the Internet using the patients' home television as the video display [5, 6]. In future, rehabilitation services could potentially be delivered on digital television platforms with a high-speed return path.

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COLLABORATIVE LEARNING PLATFORM IN THE FIELD OF TELEMEDICINE

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ABSTRACT

The proposal of this research tries to stimulate online discussions about clinical cases and offer a knowledge management resource for data related to disciplines focused in undergraduate disciplines in medicine. Beyond offering tools for communications that promote the dialog and interactivity between teachers and students, the solution should become a source of references. This exclusive database benefits students, teachers, doctors and groups of interest. The model searches an open dialog that should allow an exchange of medical knowledge, in the sense of reaching a better solution for specific problems within each group.

KEYWORDS

eHealth, collaboration, learning, usability.

1. INTRODUCTION

One of the fundamental characteristics of distance learning is its versatility. Regarding to pre defined pedagogy premises, it is possible to elaborate educational programs for any type of theme. The learning strategies are appropriated to specific issues of each area, this way personalized solutions are proposed to different approaches and situations.

An area that has being influenced by the possibilities offered by distance learning is health. There are already many ongoing projects dedicated to the teaching of health practice and concepts of health. Projects related to the offering of information and knowledge dedicated to the prevention of diseases (for example) through the Internet, gain relevance in the health area.

Once technology is explored in the concept of telemedicine, especially in environments that interaction is privileged, distance learning techniques are applied to fulfill the needs of learning regarding health. The intersection of education and health, inside the telemedicine field, happens in the moment that technology is used to mediate distance learning initiatives.

2. TELEMEDICINE IN BRAZILIAN UNIVERSITIES

The dissemination of telemedicine in Brazil occurred after the advance of the Academic Telemedicine Network (Rede RUTE). This initiative was developed by the National Network of Learning and Research (RNP) that started operating in 1991. The RNP connects today more than 400 learning and researching institutions, a estimated public of over one million people, connecting al the academic Brazilian networks. The RUTE network is an initiative that aims to support the infrastructure for telemedicine in universities and hospitals.

Figure 1. Telemedicine laboratory in a Brazilian university

2.1 Telemedicine in UNIRIO

In 2007 the RUTE Network (Rede RUTE) had only nine telemedicine laboratories installed in Brazilian universities. According to an expansion plan in hospitals and universities, in 2008 seminars where given in many renamed health institutions all over Brazil in order to leverage new interest in the project. Along one of the seminars, held in the university of UNIRO (Rio de Janeiro), the theme became a priority both for the Dean of the university and professor Leonardo Frahjof, who developed the submission program in order to incorporate the activities of telemedicine in the university. After the proposal was accepted, it was given to the university the right and a financial incentive to build a laboratory dedicated to telemedicine practice.

In august 2009, the laboratory of telemedicine of UNIRIO was established and structured inside the university with equipment able to support distance communication between institutions related to the RUTE network. Professor Frajhof became the head of the telemedicine laboratory and rapidly involved UNIRIO in the circuit of participating in videoconferences with institutions inside and outside Brazil.

Asked about his vision of the future of telemedicine in Brazil, Frajhof states:

"The medical practice is collaborative. Especially in the reality of the clinical doctor, who can choose in what area he is going to evolve. In some cases, the clinical doctor understands more than one subject and treats the patient superficially. If the case is more specific, than the patient is oriented to another specialist. This way it is always important to learn with the technical and special staff to understand how to diagnose and help the patient for the right specialist. Technologies help collaboration. The future of telemedicine goes through the integration of different technologies and the exploration of its possibilities. Monitoring, education, diagnosis and treatment."

3. PROPOSAL OF AN ONLINE COLLABORATE LEARNING ENVIRONMENT IN THE FIELD OF TELEMEDICINE

From 2009 to 2010 the activities in the UNIRIO Telemedicine laboratory mainly explored the potentiality of videoconferencing. The university got the opportunity to get involved in many special interest groups topic discussions, interacting with institutions inside and outside Brazil. By the year of 2011, professor Frajhof reached out for researching opportunities (maintaining Telemedicine as the main topic) in the university of PUC-Rio, that already had involvements with the research topic at the laboratory of software engineering (LES) and the laboratory of ergonomics, usability and human-computer interaction (LEUI). With the intention of leveraging the possibilities of the Telemedicine project inside UNIRIO, professor Frajhof started a partnership, interdisciplinary researching project with both laboratories in PUC-Rio. Trying to involve in the future the participation of teachers and students in UNIRIO to collaborate with the program, the project pointed out for a learning perspective.

The objectives of the project are the following:

. Develop a Telemedicine system for teachers and students in the university of UNIRIO, focused on collaborative learning activities;

. Enable the learning resources to be reached over the internet, in multiple platforms (desktop computers, tablets, smartphones);
. Stimulate learning through interactive collaboration;
. Enable knowledge regarding case studies, clinical statistics and treatment conditions;
. Connect students and teachers to health institutes, university hospitals and groups of interests;
. Create new interest groups, encouraging new points of discussion;
. Provide new tools to spread knowledge for the medical community.

3.1 Users Involved

The research focuses primarily on the development of a solution for teachers and students engaged on the 5th period of the undergraduate course of Medicine, in the university of (BLIND REVIEW). All the participants are enrolled in the discipline Medical Clinic, discipline that defines the students entrance in the hospital routine.

The discipline takes place in nurseries and clinics inside the universities hospital and students follow clinic cases along with doctors and specialists. Classes are composed, in general by 60 students, divided into 3 groups of 20 people. Each group is supported by one teacher that guides the students in their activities. The student of the 5th period in the medicine course in UNIRIO has, in average, 24 years old. Nowadays, due to the strong competition to enroll in medicine universities, most of the students take several exams before being able to join one institution.

The student characterized under this profile has the ability to adopt very fast new technologies and new approaches to learning. It is possible to acknowledge that if this student is faced with new interesting challenges, the interaction will be instant. However, students and lecturers have a tendency to follow whatever is already stipulated in terms of traditional methods of teaching and learning. Traditional teaching practice in medicine where the teacher holds all the useful information is still very common to be found.

According to professor Frajhof's vision, the undergraduate medicine student needs to understand that medicine is a collaborative activity. He mentions "Collecting different opinions and perspectives in a case only brings advantages for the treatment of the patient. Nowadays the exams are done by specialists and therefore to understand what is truly going on in a case, the doctors need to collaborate with each other. It is important to transfer this notion for the students." For the first step of this project two students where selected to collaborate with the activities that where proposed.

The tool selected to work as a collaborative learning platform was the software Youknow, designed by the Brazilian educational company Affero. The company was founded by ex-students from PUC-Rio and has a research agreement with the university, therefore the platform was dedicated for the project. This platform is based on the web and accessed via computer browsers. The project happened during four months (August/November 2011) in which professor Frajhof updated the platform overtime with relevant information (videos, texts, articles, images) related to a patient analysis. During that time, the students involved where stimulated to research for similar cases and to collaborate with the current case, trying to identify the right diagnose.

3.2 The Platform

In accordance to the possibilities of the tool, it was created a community dedicated to the exploration of the discipline Medical Clinic 1. In this community, it was possible to relate all the items that where inserted by the teacher and the students to each other. This way it became possible to relate relevant content and media to the case being discussed over time.

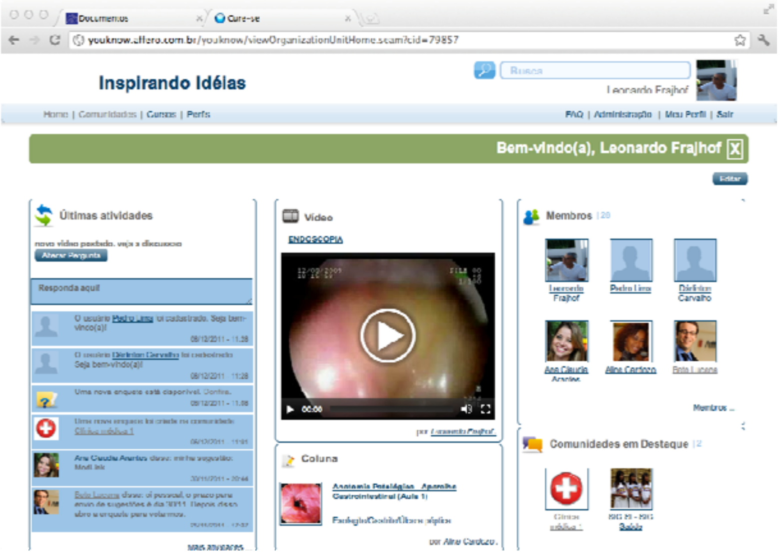

Figure 2. Example of screen capture of the collaborative learning environment

Another interesting issue brought up by the students along this experiment was the possibility of a cross over between disciplines during their studies in the under graduation course. By the time that the content were uploaded in the platform, they had the chance to show it to other teachers to get different opinions.

During the period that this stage of the project occurred, the students took the initiative of adding the forum tool into the platform. They used it to open a channel of discussion between themselves and the teacher in order to clear questions about the case.

With the first step of interaction concluded, there where applied interviews with the participants to understand the positive and negative issues involved with this collaborative learning format. The results of this analysis will become the foundation of the development of major adjustments and the following steps of the project, involving mobile solutions.

4. ENVIRONMENT’S CONCEPTUAL EVALUATION

The overall objective of the first set of interviews focused on the opinions about the method of learning and the dynamics applied by the teacher. The interviews where held among the students and the teacher involved in the process. The questions basically tried to capture the perception of the interaction from the participants and the platform. After the interviews, a workshop complemented the information brought up along the interviews. The workshop took place in (BLIND REVIEW) and counted with presentations with different perspectives of the use of the prototype by all the laboratories involved. The title of the workshop was “Usability of the platform Youknow as a learning tool for medicine students”. The presentations can be reached at the link:

http://hosting.desire2learncapture.com/pucrio/1/watch/79.aspx

Overall, the students had no difficulties using the platform and tried to use the most of it. They understood the platform and the content delivered as a complimentary effort to class studies. Other interesting issue brought up was the ability to upload relevant content by themselves to the platform.

The students reveal that “The platform Youknow makes it possible to exchange information through the real engagement of the students. It is a place that everyone can collaborate, regardless if you are a student or a teacher”.

A similar perspective was revealed by the teacher involved, which observed that he didn’t have to force the participation of the students. He mentioned that his participation only happened when it was really necessary. In other cases, the students figured out a way to search for relevant information, regarding the actual case.

5. FURTHER WORK

The next step of the research will focus on mobility issues. Due to the profile of the students involved and their participation in class during the time taken on the discipline in the hospital, it is possible to believe that the access of the content and the collaboration with the platform should be useful as well if done in real time, in a mobile way.

Therefore, conclusions about this first step taken are already being incorporated in the following of the research. Mobile platforms are being studied and the main tools of the learning collaborative platform are being elected to become the first interactions available in the new solution. Along with the development of these functionalities based on mobile applications, an architecture information study is being developed involving the future users. In order to supply solutions for an engaging learning experience, the project will move on for the next couple of years.

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PROFILING REMOTELY MONITORED PATIENTS WITH ADHERENCE PARAMETERS

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ABSTRACT

Remote patient monitoring systems provide plenty of structured information about the monitored health variables. We propose a set of parameters that exploits the remotely monitored data to describe patient's monitoring adherence from different viewpoints. The parameters were applied in self-monitored weight and blood pressure data sets of 30 heart failure patients inherited from a clinical trial setting. With the help of the extracted adherence parameters the thirty heart failure patients were clustered into two subgroups with different monitoring profiles: a group of well-performing subjects (n=22) and a group of low-performing subjects (n=8). Beneficial effects of active monitoring were reflected as positive changes in clinical health outcomes and lowered burdening of health care providers among the group of well-performing subjects.

KEYWORDS

Remote patient monitoring, telehealth, adherence, clustering

1. INTRODUCTION

Heart failure is a complex syndrome associated with a high rate of hospitalization and short-term mortality that can be up to 50% during first year [1]. The majority of the costs (70%) result from frequent and lengthy hospitalizations [1] that makes the prevention highly valued from economical viewpoint. It is shown that hospitalizations in heart failure are associated with a lack of knowledge about the disease (nonadherence to diet or failure to detect the signs of deterioration) [2, 3] as well as a lack of medical compliance [4]. This highlights the importance of self-observation in the management of the heart failure disease.

Along with the recent advances in technology, remote patient monitoring (RPM) has become a high-potential treatment approach for people suffering from chronic diseases [5]. Self-monitoring increases the awareness of the current health status and, thus, improves skills to control the disease and enhances efficacy. Inducing RPM to treatment plan moves professional-centered care to patient-centered care where patient him/herself is encouraged to take more responsibility of his/her own health. The underlying idea is to decrease the demand of health care services with the potential effect of lowering the associated costs for society [6].

In several studies where RPM systems are utilised, patient's engagement to self-monitoring is reported through adherence that measures how patient's behaviour matches the prescriber's recommendations. Typically the evaluation is based on the home monitored data [7] or self-assessed questionnaires. In this study we propose a set of parameters that utilizes home monitored data to describe patients' monitoring adherence from different viewpoints. We test the relevance of these parameters by applying them to the data from a clinical trial setting where heart failure patients have monitored their blood pressure and weight a period of six to seven months. This study has two objectives. Firstly, we develop measures of monitoring adherence that do not depend on patient's own assessment but provide objective information about the monitoring activity. The parameters are intended to be universal in sense that they can be applied in the context of different diseases and RPM settings. Secondly, we aim to extract different monitoring profiles to gain information on what kind of patients are expected to benefit RPM most and how certain profiles are associated with health outcomes and resources usage.

2. MATERIALS AND METHODS

2.1 Self-Care Model for Heart Failure Patients

This sub-study on monitoring adherence is a part of the randomized controlled trial of 93 heart failure patients at the Cardiology Clinic of Helsinki University Central Hospital. Until now, information exchange between heart failure patients and care personnel has taken place during patients' visits at the clinic and by telephone. A new care process, in which a patient regularly reports the most important health parameters (blood pressure, weight, symptoms) to the nurse through a mobile phone application, is introduced to improve the reliability of the measures and to shorten the time for care personnel's interventions when needed. Based on the reported measurements the care team may invite the patient to a control visit for example to change the medication. The overall architecture used in the self-care process is depicted in Fig. 1.

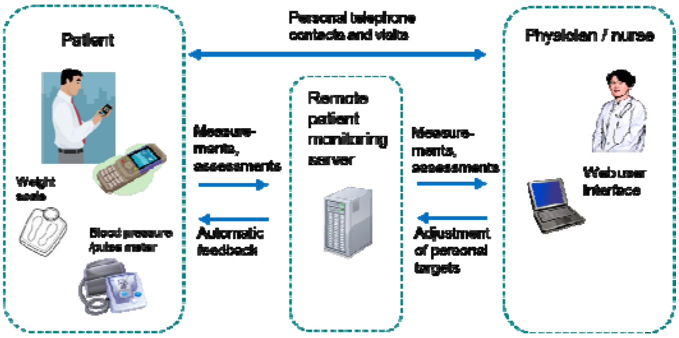

Figure 1. The overall architecture for the remote patient monitoring

Patients participating in the self-care programme are given a home-care package including a weight scale, a blood pressure meter, a mobile phone and self-care instructions. A pre-installed software application in the mobile phone supports uploading of measurements and self-assessment of symptoms. The home-made measurements to be uploaded are: diastolic and systolic blood pressure, heart rate, and body weight. The self-assessment concerns the patient's feeling of dizziness, weakness, dyspnea and symptoms of arrhythmia. The patients are asked to carry out and report the measurements together with the self-assessment once a week. In the context of each submission of information, the patient gets automatic feedback according to his/her personal targets set by a health care professional. The measurements and self-assessment parameters are stored in a server database where the information can be accessed by the care team. The care team uses the information together with other patient information as appropriate in the patient's care process. Ethical approval was given by the Ethical Committee of the Hospital District of Helsinki and Uusimaa.

2.2 Target Group

In the sub-study reported in this paper, we analyse self-monitored weight and blood pressure data of the first group of 30 intervention subjects who have completed the trial at the Cardiologic Clinic. There are 24 males and 6 females in the group. The average age of the patients is 57.7 varying with 11.5 standard deviation. New York Heart Association (NYHA) functional classification is used to measure the extent of the heart failure. According to the NYHA classification, 8 patients (27%) are categorized in class II, 'Slight limitation of physical activity', 21 subjects (70%) belonged to class III, 'marked limitation of physical activity', and 1 (3%) belonged to class IV 'Unable to carry out any physical activity'. Utilization of health care resources is recorded over the study.

2.3 Adherence Parameters

The patients are advised to measure their weight and blood pressure and report their symptoms once a week during the self-care period. Using these data, we have generated an algorithm that calculates four descriptive parameters characterizing the patients' adherence in self-care:

Termination - Indicates the patient ending the monitoring period earlier than planned. Measured as a number of days by which the monitoring period was shortened caused by the earlier ending. *Discontinuity* - Indicates the patient having breaks during the monitoring period. Measured as a number of non-monitoring intervals that are longer than 20 days. *Commitment* - Indicates dedication to the predefined reporting plan. Measured as a proportion of weeks that include at least one measurement. *Activity* - Indicates monitoring frequency during the intervention. Measured as the ratio of the total number of reportings and the individual length of the monitoring period that is counted in days.

2.4 Classification - K-Means Cluster Analysis

To identify subjects with similar monitoring patterns, k-means cluster analysis [8] is used. The method is used to assign subjects to fixed number of groups whose characteristics are not yet known but are based on the set of the extracted adherence parameters. Subjects' assignment to certain clusters is based on their Euclidean distance from the cluster location that is the mean value of cases in each cluster. Cluster locations are updated iteratively until cluster means do not change or until maximum number of iterations is reached. The goal is to minimize variability within the clusters and to maximize variability between the clusters. The method allows the number of clusters to be determined in advance which is necessary for this sub-study. The number of groups is limited to prevent obtaining too small clusters. The optimal number of clusters is not known a priori but need to be estimated. Exploiting *cascadeKM* function in R, Calinski-Harabaz (C-H) criterion [9] is used to determine the optimal value for the number of clusters. The C-H criterion measures the variation of the data points within clusters (SSW) and between clusters (SSB). The highest value of the criterion shows the optimal number of clusters.

2.5 Application

The adherence algorithm is applied to weight and blood pressure data sets of 30 heart failure patients producing four parameters for the two types of readings. With the help of these parameters, k-means clustering is implemented with number of clusters set to two and three. Higher amount of clusters would result small group sizes that does not serve intentions of this study to profile generalizable monitoring patterns. Variables are standardised by subtracting the mean and dividing by its standard deviation to scale the parameters to the same level. That is required to ensure that each variable has equal effect on the cluster formulation. The clustering algorithm is sensitive to outliers since they strongly affect cluster's center locations. Five outlying observations (standardised value > 2.6 or < -2.6 that theoretically covered 1% from all values) were detected and were removed from the clustering implementation procedure. The outliers were distributed to four patients. After finding the final cluster locations, the missing classification of these subjects are backfitted based on the minimum Euclidian distance from cluster centroids of other variables but the one with outlying observation. For the analysis computations, R 2.13 software is used. In conjunction of classification results, F-value of each variable in each cluster solution is reported. The magnitude of the F value on each variable is an indication of how well the respective variable discriminates between the clusters. The cluster effect on patient characteristics and health outcomes is tested using two sample t-test for normally distributed variables and Mann-Whitney U- test in the presence of non-normality. The level of alpha is 0.05 for significance tests.

3. RESULTS

Table 1 presents clustering results of the 2-means and 3-means clustering. The Calinski-Harabaz criterion for the 2-cluster solution is 21.6 and for the 3-cluster solution 19.5. Therefore, 2-cluster solution is preferred and explored further. Variables were standardised that prevents from the direct interpretation of cluster centers but gives an indication of the direction of the cluster effect. Positive values indicate higher values than observed on average and, correspondingly, negative values indicate lower observed values. According to all other variables but activity, the difference between clusters goes in a similar manner. In cluster 1(referred as ‘well-performing cluster’) there are patients who were committed to the weekly reporting recommendation, had fewer discontinuities, and continued with reportings close to the official trial termination. Cluster 2 (referred as ‘low-performing cluster’) comprises subjects who have irregular reporting times, who terminated the monitoring in advance and who had more non-monitoring intervals during the intervention. Contrary to other parameters, activity is higher on average in cluster 2 than in cluster 1. This indicates that there are patients with high number of reportings but relatively low commitment to the treatment plan to carry out reportings on each week. Also there are patients with lower number of reportings, but carefully following the self-care plan. F-values show that continuity and commitment variables provide the greatest separation between the clusters. The activity variables show hardly any differences.

Table 1. Clustering results for adherence parameters

2-cluster solution	F value	cluster1, n=22	cluster2, n=8	
Termination_weight	5.5	-0.25	0.02	
Termination_bloodpressure	2.8	-0.21	0.07	
Commitment_weight	27.4	0.44	-0.52	
Commitment_bloodpressure	24.9	0.40	-0.53	
Activity_weight	0.86	-0.13	0.09	
Activity_bloodpressure	0.08	-0.20	0.13	
Discontinuity_weight	144.8	-0.54	1.46	
Discontinuity_bloodpressure	73.3	-0.50	1.64	
3-cluster solution	F value	cluster1, n=16	cluster2, n=5	cluster3, n=9
Termination_weight	7.0	-0.35	-0.36	0.32
Termination_bloodpressure	5.0	-0.32	-0.32	0.37
Commitment_weight	14.4	0.65	-0.31	-0.55
Commitment_bloodpressure	13.5	0.60	-0.27	-0.59
Activity_weight	2.6	-0.04	0.47	-0.45
Activity_bloodpressure	0.85	-0.17	0.36	-0.38
Discontinuity_weight	19.3	-0.60	1.98	0.04
Discontinuity_bloodpressure	19.4	-0.50	2.02	0.00

The upper panel of Table 2 characterises demographic features of cluster members. According to the NYHA classification, patients in cluster 1 are in better condition. Almost one third of the patients belong to class II in cluster 1 whereas one out of eight patients in cluster 2 belongs to the corresponding class. Statistically significant differences between clusters were not detected in either of the demographic variables. The lower panel of Table 2 describes changes in clinical health outcomes and in the usage of health care resources. High levels of proBNP in the blood is related to the severity of heart failure. Thus, lowered values in the proBNP levels are denoted as positive change. Increased ejection fraction is desirable. In cluster 1 the patients have achieved more positive changes in clinical values although the difference from cluster 2 is not statistically significant. Also the burdening of the health care personnel is lower in cluster 1, especially regarding nurse’s workload. The number of telephone contacts and the number of visits at nurse as significantly lower is cluster 1 than in cluster 2.

Table 2. Cluster descriptions, means or medians and standard deviations or inter quartiles subject to clusters' baseline characteristics and health outcomes

Background characteristics			
	cluster1, n=22	cluster2, n=8	p-value
Sex	18 males / 4 females	6 males / 2 females	1.0
Age (years)	57.1 (11.6)	59.6 (12.0)	0.603
BMI (kg/m^2)	29.8 (5.9)	28.9 (6.6)	0.715
NYHA	class II : n=7 class III: n=14 class IV: n=1	class II : n=1 class III: n=7 class IV: n=0	0.546
Health outcomes			
	cluster1, n=22	cluster2, n=8	p-value
Change in proBNP (ng/l)[a]	-926 [-2220, 62]	90 [-2235, 5216]	0.682
Change in ejection fraction (% units)	6.0 (11.8)	5.1 (11.5)	0.865
Change in blood pressure (sys/dia mmHg)	2.6/0.2	4.8/2.5	0.670/0.687
Number of unplanned visits at nurse [a]	2 [1, 5]	4 [3, 7]	0.417
Number of unplanned visits at doctor	0.09 (0.29)	0.13 (0.35)	0.729
Number of planned visits at nurse	4.6 (1.9)	6.5 (2.9)	0.043
Number of planned visits at doctor	2.0 (1.0)	1.9 (0.8)	0.760
Used nurse time (minutes)	133 (43)	162 (40)	0.101
Used doctor time (minutes)	81 (31)	85 (44)	0.762
Number of telephone contacts with nurse	4.3 (2.7)	8.5 (3.6)	0.002
Number of hospital days	0.45 (1.7)	2.1 (4.9)	0.375

[a] Medians and 25th and 75th centiles in case of a non-normally distributed variable.

4. DISCUSSION

Studies that include remote patient monitoring systems provide plenty of structured information about monitored health variables. Typically the change from baseline values to end-point values are the primary interest remaining remarkable amount of data unanalysed. In this study we proposed an algorithm that exploits data over the whole monitoring interval and summed them up in four parameters that measured patients' adherence. The extracted parameters provide an objective tool to evaluate patients' engagement to the treatment plan to be used in parallel with subjective tools such as self-assessment questionnaires. The method relies on several adherence parameters measured from different viewpoints to provide a deeper insight into the data. In addition, parameters are not study-dependent but can be applied widely to different types of RPM measurements and target groups.

K-means cluster analysis showed that the group of 30 heart failure patients can be optimally divided into two subgroups according to the four adherence parameters calculated from the two types of readings. There was a division of patients to subgroups of well-performing and low-performing subjects. In the low-performing group, subjects didn't perform reportings on each week, they terminated the monitoring in advance and they had more non-monitoring intervals during the trial. The interpretation of the well-performing group is the opposite. It was discovered that the discontinuity parameter, that reveals if a patient has stopped the monitoring for longer than three weeks, and the commitment parameter that measures if patient made reporting on each week, had the strongest influence on the separation of subjects. On contrary, activity parameters made no clear separation.

Finally, we explored characteristics of the groups of well-performing and low-performing subjects. The underlying idea was to gain knowledge about factors that correlate with active usage of the technology or which are potential barriers for the usage. No statistically significant differences were detected in patients' backgrounds. The results suggest that RPM interventions are feasible for wide range of patients with different backgrounds. However, wider range of background variables, with the emphasis of psychological factors, would be recommendable. Concerning the outcome variables, the changes in clinical health parameters in the group of well-performing patients were more positive and the well-performers utilized nurse resources less showing signs of cost effectiveness of RPM which is in line with the findings in [6].

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ALTERNATIVE METHODS FOR SUSTAINABLE SURVIVORSHIP CARE

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ABSTRACT

The growing population of cancer survivors with long-term supportive care needs presents an enormous challenge to the health care system. This paper examines thyroid cancer patients' preferences for email and videoconferencing alternatives to face-to-face follow-up visits, the estimated travel costs, as well as health system and environmental implications. This study is a component of a cross-sectional self-report survey involving thyroid, prostate and breast cancer patients receiving follow-up care at Princess Margaret Hospital (PMH) in Toronto, Canada. The findings suggest that there are substantial estimated savings that can be obtained in terms of time, cost, and greenhouse gas (GHG) emissions avoided associated with vehicle travel to access follow-up care among a sample of thyroid cancer survivors. On average, the 113 patients who participated in the survey spent an estimated 2 hours travelling more than 120 kilometres to and from PMH for their follow-up appointment. This was associated with an estimated total of $5822.42 CAD in vehicle costs and an estimated 6945.6 kg of carbon dioxide equivalents ($CO_{2\text{-eq}}$.). Nearly one-third of participants (30%) agreed or strongly agreed to videoconferencing based follow-up care and 18% agreed or strongly agreed to email-based follow-up care (18%). The potential for savings in personal time, travel time/distance, cost and environmental savings associated with using technology as an option for thyroid cancer follow-up provides further incentives for their adoption. Videoconferencing appears to be a more preferred form of technology to access follow-up care than email especially when patients experience geographic or mobility barriers to access care that may be otherwise unavailable. Future research should examine patient and provider requirements for participation in technology assisted cancer follow-up care, the extent to which it could complement or replace traditional follow-up care, as well as the feasibility of using freely available web-based video-conferencing software solutions.

KEYWORDS

Thyroid Cancer, Telemedicine, Videoconference, Email, Cost, Greenhouse gas emission, Travel distance

1. INTRODUCTION

It is estimated that there are almost 1 million cancer survivors living in Canada (CCS, 2008) and 12 million in the United States (CDC, 2007). The increasing number of cancer survivors, the complexity of their supportive care needs and the limited number of cancer specialists combined limit the sustainability of the current model of specialist-based follow-up care in Canada. Alternatives to specialist-based follow-up care have emerged including a shared-care model that integrates oncology with primary care follow-up, a nurse-led model of care, and specialized multidisciplinary survivorship follow-up clinics (Hewitt & Stovall, 2005).

Follow-up cancer care provided in the community by primary care practitioners has been demonstrated to be as effective as specialized care from a cancer centre (Grunfeld et al, 2006). However, not all patients are willing to participate in shared-care models. In an Ontario-based retrospective longitudinal study of women diagnosed with breast cancer, 66% of participants were still seeing both their oncologist and family physician 5 years after initial diagnosis (Grunfeld et al, 2010).

Tele–consults have been promoted as a method of providing access to specialized cancer care in the community for thyroid cancer survivors (Gibelli et al, 2008). However, relatively little is known regarding thyroid cancer survivors' views on technology assisted follow-up care. Results from a pilot feasibility of specialist tele-follow-up in India involving 34 post-operative thyroid cancer survivors revealed good to excellent patient satisfaction and substantial time and cost savings per visit (Mishra et al, 2009). Technology-assisted follow-up care has the potential to provide significant long-term cost savings for this population.

Previous studies have demonstrated that videoconferencing can support the work of multi-disciplinary teams to improve health services, and substantially reduces the distance traveled to attend medical consultations and related vehicle emissions. A study from Wales illustrated that in a single month over 20,800km of travel and 2590 kg of carbon dioxide (CO_2) could be avoided (Lewis et al, 2009). A study from Ontario demonstrated that 757,234 km of travel and 185, 159 kg of CO_{2eq} could be avoided by 840 telemedicine consultations over a 6 month period (Masino et al, 2010).

This paper reports on a preliminary sample of thyroid cancer patients in an attempt to understand their preferences for technology assisted survivorship care and the potential benefits from financial and environmental perspectives.

2.1 Methods

Eligible patients were those who 1) had been diagnosed with well differentiated thyroid cancer, 2) had completed treatment, 3) were receiving follow-up care at PMH and 4) could read and speak English. Patients who gave their consent completed a questionnaire that asked about whether or not they would be willing to conduct follow-up visits through email or videoconferencing. In addition, a chart review of the participants was conducted and clinically relevant information and postal code were recorded.

2.1.1 Travel Calculations

An average travel distance in kilometres (km) from patients' homes to the Princess Margaret Hospital and an average journey time in minutes (min) were calculated based on postal code data with the Google Maps^{TM} Web mapping software and the Google Maps travel calculator [1].

2.1.2 Environmental and Financial Calculations

Green House Gas (GHG) emissions were based on the methodology described by Masino et al (2010). Vehicle costs were based on $0.41 per kilometre, which is the travel reimbursement rate offered by the Northern Health Travel Grant (NHTG) program funded by the Ontario Ministry of Health and Long-Term Care[2]. This rate includes insurance, fuel and depreciation of the vehicle. Northern Ontario residents who must travel at least 100 kilometre one-way to access medical specialists or designated health care facilities that are not locally available are eligible for travel assistance through this program. In addition, the NHTG program provides an accommodation allowance of $100 per eligible trip to patients whose one-way road distance to the closest specialist or designated medical facility is at least 200 kilometer.

2.1.3 Preferences for Alternative Models of Follow-up Care

Patients were asked to respond on a 5-point Likert scale (1= strongly disagree, 5= strongly agree) whether they would be satisfied if their follow-up appointments with their thyroid cancer specialist were conducted through secure videoconference or email.

The University Health Network Research Ethics Board approved this study.

2.2 Results

One-hundred and forty-six eligible patients were invited to participate in the survey, 113 completed a questionnaire resulting in a response rate of 77.4%.

2.2.1 Distance Travelled

The participants lived on average 63.4km from the cancer treatment centre. The total distance travelled by the sample of participants including return trip was 14,208.8 km. Figure 1 shows the one-way distance traveled.

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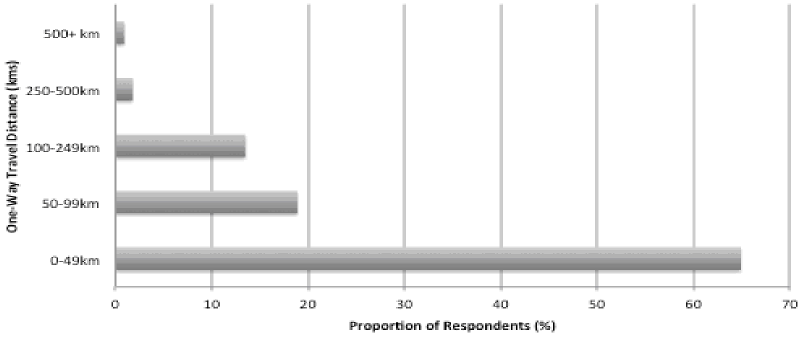


Figure 1. One-way distance traveled (km)

2.2.2 Personal Costs

The costs associated with a one-way road trip from the patients' residence to the cancer treatment site are reported in Table 1. In total, this sample of 113 participants spent 217.8 hours and $5822.42 CAD in vehicle costs on their road travel to their follow-up consultation including return trip.

2.2.3 GHG Emissions

The participants' vehicle use was associated with a total of 6946 kg (6,945,634 grams) of greenhouse gas emissions or 6945.6 kg or 6.9 metric tonnes of $CO_{2\text{-eq}}$.This amount of CO_2 would require 496 mature trees to absorb these emissions in a single year.

Table 1. Costs associated with one-way road travel to a follow-up appointment

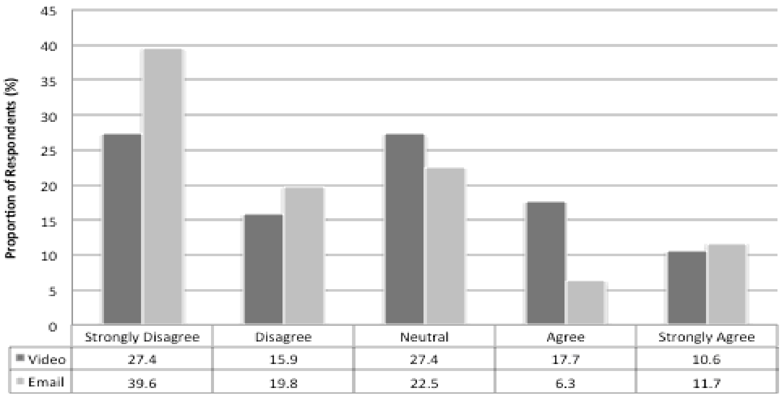
Range		Mean	SD	Sum
Time (min)	4.7 - 542	58.35	70.04	6535.3
Vehicle (CAD$)	0.72 - 279.21	25.99	37.97	2911.21
GHG (g)	880 - 33036	31007.3	45292.6	3472817

2.2.4 NHGT Program

In the present sample, 18 participants travelled more than 100km one-way to the cancer centre, and thus would have been eligible or travel assistance. The NHTG travel allowance has a deductible for the first $100 km of road distance traveled. Therefore the total chargeable travel distance for the 18 participants was 5,831 km, which amounts to a travel cost of $2,390.71. Five participants would have been eligible for the accommodation allowance, which amounts to a total travel reimbursement cost of $2,890.71.

2.2.5 Views of Alternative Modes of Follow-Up Care

Figure 2 shows the proportion of respondents who disagreed, were undecided or agreed with video- or email-based follow-up care. The participants had more positive views of video- than email-based follow-up care. Nearly thirty percent agreed that they would be satisfied with video-based follow-up care, while 18% reported that they would be satisfied with email-based follow-up care.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
■ Video	27.4	15.9	27.4	17.7	10.6
■ Email	39.6	19.8	22.5	6.3	11.7

Figure 2. Views on alternative modes of follow-up care

2.3 Discussion

This study found substantial potential savings in terms of time, cost and greenhouse gas emissions associated with road travel for follow-up care among a sample of thyroid cancer survivors. On average, participants traveled 2 hours to come to and from the cancer centre. This equates to an average estimated total travel distance, including return trip of more than 120km. At least one-quarter of participants in the study traveled between 200 and 500 km one-way for a follow-up appointment visit. In addition, study participants are spending an estimated $50 CAD per visit to travel to and from the cancer centre. This estimated cost does not include lost wages for those participants who had to take time off work to attend the appointment. As has been found in other telemedicine studies, the potential cost and time savings to individuals due to travel costs is significant (Lewis et al, 2009; Masino et al, 2010). The majority of these follow up activities could easily be managed remotely (Hewitt & Stovall, 2006).

This study suggests that a significant proportion of thyroid patients in Ontario are willing to consider technology assisted means of follow-up care for thyroid cancer. Participants were not particularly interested in email as a means of follow up care and in fact only 18% reported agreed to email based follow-up and almost 60% were opposed to the idea. However, videoconferencing appears to be a much more viable option for many participants. While about 40% were opposed to follow-up through videoconferencing, 28% of participants strongly supported the idea and a further 27% of participants indicated that they may consider it as an option. The requirements for patient participation in videoconferencing follow-up were not investigated as part of this study but the visual contact appears to be an important element for patients. Further investigation is also needed to determine the feasibility of using freely available web-based videoconferencing software applications such as Skype, versus the tradition telemedicine videoconferencing units offered by a private secure network (Ontario Telemedicine Network) for hospitals across the province of Ontario.

The environment impact of using eHealth solutions for providing care is potentially substantial. If all of the participants were willing to participate in technology assisted follow up, almost 7000 kg of GHG emissions could be avoided in a 4 month period. Over the course of an entire year, if 50% of the follow up consults in this thyroid cancer clinic could be conducted using technology based approaches, approximately 10,500 kg of GHG emissions could potentially be avoided. In addition, there could potentially be over $7,500 in cost savings to the health system through a government assistance program (NHTG).

There are a number of factors that could influence a cancer survivor's views toward technology assisted follow-up appointments. It is likely that those who are farther from diagnosis, have fewer side effects and health care concerns, and are comfortable using technology including the Internet would be more inclined to adopt technology-assisted follow-up care. In addition, most patients are not aware of the enormous financial and environmental costs of travelling to the cancer center for follow up visits for thyroid cancer. We are in the process of examining these and other potential factors that could influence adoption of technology assisted follow up approaches.

These findings are an underestimation of the total personal costs associated with attending a follow-up consultation. They do not account for appointment wait time, parking costs, and potential loss in income. They also assume normal driving conditions.

3. CONCLUSION

The potential personal time, cost and environmental savings of using technology assisted approaches for thyroid cancer follow-up are significant. Video-conferencing appears to be a more viable option for follow-up care than email. Future research should examine patient and provide requirements for participation in technology assisted cancer follow-up care, as well as the feasibility of using freely available web-based videoconferencing software solutions.

ACKNOWLEDGEMENT

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A SCENARIO-BASED APPROACH FOR DESIGNING A STROKE CLINICAL DECISION SUPPORT SYSTEM

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ABSTRACT

Decision-making is central to the activities of clinical professionals in their dealings with patients. A large body of evidence over many years suggests that clinical decision support systems (CDSSs) can be helpful in improving both clinical outcomes and adherence to evidence based guidelines. Developing a treatment plan for stroke patients and their families requires an understanding of the interactions and dependencies between procedures, and their possible outcomes for an individual patient. This is difficult even for experienced physicians, because it is necessary to keep track of this information as the proposed plan evolves. Therefore, we develop a CDSS which is designed to ameliorate the cognitive load imposed by the planning and communication elements of such medical tasks. In this study, we utilized a scenario-based approach and developed a four-phase model for developing CDSS architectures that focus on: knowledge capture, modeling, storage, and representation. Finally, we conducted usability testing to evaluate the system and improve the system effectiveness. The analysis process and proposed artifact have the potential to benefit physicians. The impacts of CDSS and the effects on the patient outcome remain to be fully understood. Future implementation should build on effective approaches, including the use of system-initiated advice to address safety issues and improve the monitoring of stroke therapy.

KEYWORDS

Stroke, Scenario-Based, Cognitive Fit Theory, Clinical Decision Support Systems, Knowledge Creation

1. INTRODUCTION

Decision-making is central to the activities of clinical professionals in their dealings with patients. Decisions need to be made when diagnosing the state of the patient, planning and adjusting therapy, and monitoring the evolving patient state. Over recent decades, a range of computational methods and tools have been developed to support the clinician in these tasks. In general, their purpose is not to replace or substitute for human abilities or skills, but rather to provide support and assistance. Given the increasing importance of information and communications technologies in the infrastructure of health care organization and delivery, it is important that physicians, allied with health care professionals, and others associated with health care be aware of such computational methods and techniques that can support decision making processes. Delivering outstanding medical services requires providing both high quality and safety care (Bates et al. 2001). The reasons for using real-time clinical decision support systems (CDSSs) are numerous. The integration of computers into critical care is by no means a new concept. CDSSs are information systems designed to improve clinical decision-making. Such systems have been used to prevent errors, improve quality, reduce costs, and save time. Recent reviews have suggested that decision support can improve performance, although it has not always been effective (Garg et al. 2005). Therefore, the objective of this study is to construct the stroke knowledge of CDSSs in targeting specific aspects of the diagnosis, assessment, and treatment plan. Furthermore, we utilized system development method to create knowledge for stroke diagnoses, which would be qualified in the future by neurology specialists in CDSSs interventions.

2. THEORETICAL FOUNDATION

The general procedures of clinical decision making were followed and recorded with SOAP note. The four components of a SOAP note include Subjective, Objective, Assessment, and Plan. These standardized processes guide a physician's mental process to solve the patient's problem(s). The whole process of clinical decision making is one of the progresses of knowledge creation. While performing knowledge creation, a physician constructs a mental representation using internal cognitive processes selected from a structurally similar problem. Recent Reviews enhanced the cognitive fit model by regarding the problem-solving tool as a predictor of the problem solving performance (Sinha & Vessey, 1992; Shaft & Vessey, 2006; Hevner et al., 2004). Cognitive fit theory considers a problem solution to be the consequence of the relationship between a problem representation and its problem-solving task. This theory provided a sound theoretical foundation in this study. Based on cognitive fit theory, the perceptual inference pattern of knowledge creation with a CDSSs for knowledge workers, where the knowledge creation task (problem-solving task) and required relevant knowledge representation (problem representation) use a CDSS (problem-solving tool) to determine the knowledge creation performance. In this study, we assume the diagnosis process to be a problem solving task. A physician needs to gather information of problem presentation (e.g. S and O), then produce a mental representation (e.g. A and P). Essentially, physicians engaged in knowledge creation are attempting to solve a problem so that a course of action can be recommended, resulting in increased knowledge creation efficiency and effectiveness.

3. METHODOLOGY

This study utilized a system design approach to gain an in-depth and holistic understanding of knowledge creation for stroke (Hevner et al., 2004). It consisted of four steps, included knowledge acquisition, modeling, storage and representation. We described these steps in detail to build their procedure and rules as shown in the following sections:

3.1 Processing Procedure of the CDSS for Stroke

In the actual application, the knowledge management process includes some stages: Knowledge definition and acquisition, knowledge modeling and storage, and knowledge representation (see Fig. 1). At the Knowledge definition and acquisition stage, the user chooses a stroke scenario and then defines objective and subjective information to build criterions from the requirement. Second, at the knowledge modeling and storage stage, the user generates the related factors and rules which stored in the database. Finally, at the knowledge representation stage, user may be gathered to meet the exact information needs, if necessary. The system generates queries to retrieve relevant information from the database and then fill in the assessment and plan properly for information presentation. The next section will describe the procedures for CDSS development in this research.

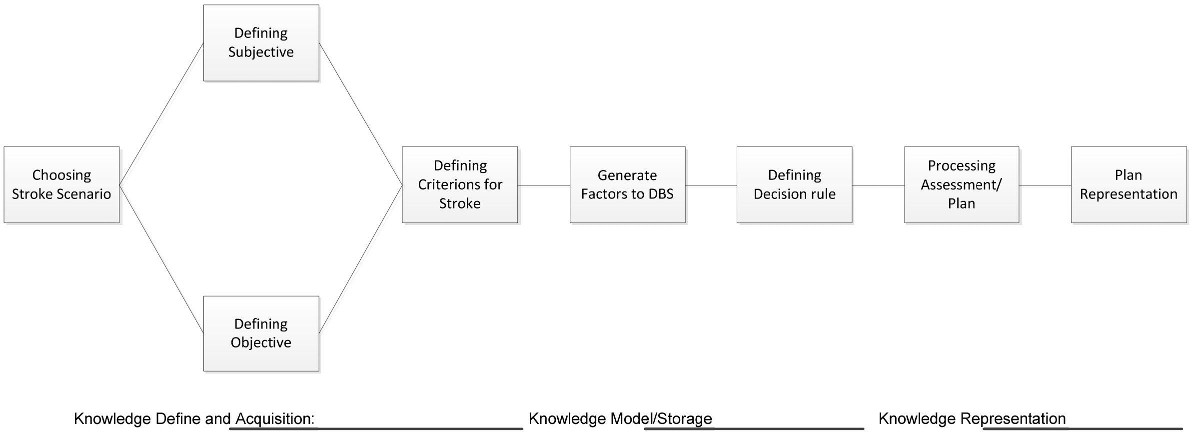


Figure 1. Processing procedure of the CDSS

3.2 Knowledge Acquisition

The objective of this stage is to acquire and model the physician's knowledge activities (i.e., the work flow) and its associated knowledge. The steps included knowledge acquisition and classification. Carroll (1995) argued that the scenario-based approach can be a tool to acquire knowledge. Therefore, we utilized the scenario-based approach to capture and organize domain knowledge via interview with physicians. Finally, the knowledge of stroke was generalized from two approaches: diagnosis assessment knowledge and treatment plan knowledge.

3.3 Knowledge Modeling

The objective of this stage is to conduct an activity diagram in knowledge modeling. According to the well-organized stroke diagnosis assessment (e.g. Rule form of imaging studies) and scenario descriptions, we can get the priority and assessment standards for these factors. Activity diagram from unified modeling language (UML) is commonly used in modeling business process flow (Wu et al., 2004, 2007).

3.4 Knowledge Storage

The objective of this stage is to structure knowledge of stroke diagnosis assessment after the procedure of knowledge modeling. The study was conducted using eXtensible Markup Language (XML) to store the knowledge from previous stages, including the organized form of the diagnosis assessment, treatment plan, and diagnosis assessment activity diagram. We introduced the rules and methods as the XML transformation of diagnosis assessment criterion, the form of a treatment plan, and the XML transformation of diagnosis assessment activity diagram.

3.5 Knowledge Representation

After following the previous mentioned steps to acquire, model, and store knowledge about stroke diagnosis. This study conducted concept map to present the necessary information in the fourth stage. Wu et al (2009) proposed the concept map which utilized the nodes and connections to present the relationships among knowledge. Furthermore, we conducted rules and steps for constructing knowledge concept map for stroke CDSS. This focuses on how to structure knowledge concept map using a three-step approach, which represented the concept map.

4. RESULTS

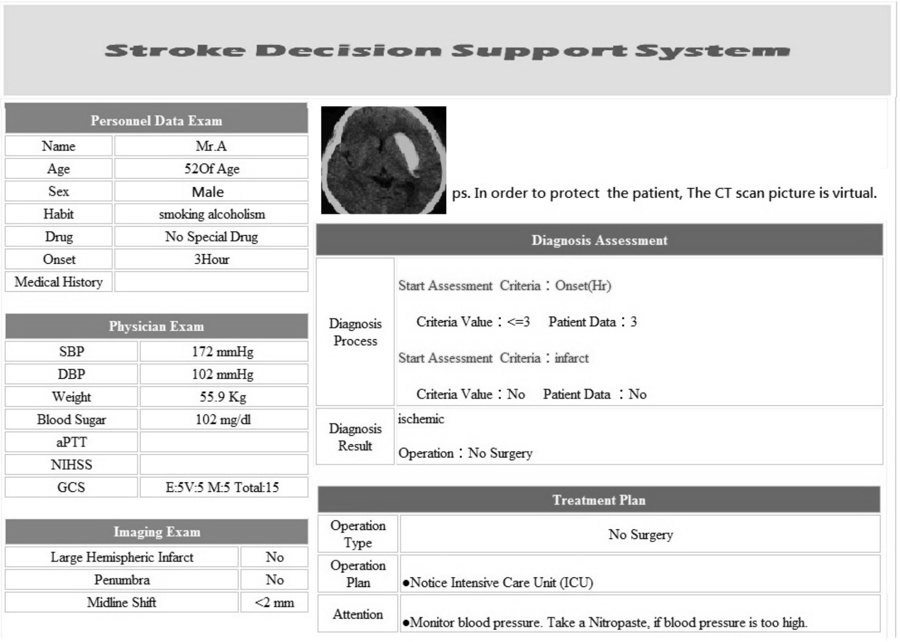
We invited ten neurosurgical and neurological specialists to join the system testing progress of this study. Firstly, we introduced the objectives of this CDSS. Secondly, we introduced the information and operation processes presented within the CDSS. Thirdly, we prepared real patient data for the usability testing; the test included completeness, correctness, and usefulness. Finally, we conducted the survey to collect the testing results. Questions were answered using a scale from 1 to 7 (1 – Strongly Disagree to 7 – Strongly Agree).

4.1 Stroke CDSS Presentation and Testing Cases

We prepared 10 medical records of test cases who provided by a hospital. Each test case captured the necessary information for testing CDSS, including personal data, physician and imaging examination data. One sample data is described as follows:

"Patient name: Mr.Wang, Age: 52-year-old, Sex: male, Hobbits: drinking and smoking for 10 years, Duration time: three hours, Drug: NA, Disease history: none. The physician examination data: BP: 172/102 mmHg, Weight: 55.9 Kg, BS: 102 mg/dl, GCS: E5V5M5 Total score: 15. The imaging examination data: the brain imaging exam of this patient without bleeding, large-scale infarction, and penumbra, which is less than 2mm offset line."

The testing processes were executed and captured the snapshots from CDSS as shown in Figures 2. It represented the test steps of CDSS, which followed the physician visit procedures as SOAP and began from the personal data entry to the results of diagnosis and recommended treatment plan. Furthermore, the system summarized and provided the suggest diagnosis and treatment plan to physician as shown in figure 4e. Physician can refer the suggestions to help decision making.



Stroke Decision Support System

Personnel Data Exam	
Name	Mr.A
Age	52Of Age
Sex	Male
Habit	smoking alcoholism
Drug	No Special Drug
Onset	3Hour
Medical History	

Physician Exam	
SBP	172 mmHg
DBP	102 mmHg
Weight	55.9 Kg
Blood Sugar	102 mg/dl
aPTT	
NIHSS	
GCS	E:5V:5 M:5 Total:15

Imaging Exam	
Large Hemispheric Infarct	No
Penumbra	No
Midline Shift	<2 mm

ps. In order to protect the patient, The CT scan picture is virtual.

Diagnosis Assessment	
Diagnosis Process	Start Assessment Criteria：Onset(Hr) Criteria Value：<=3 Patient Data：3 Start Assessment Criteria：infarct Criteria Value：No Patient Data ：No
Diagnosis Result	ischemic Operation：No Surgery

Treatment Plan	
Operation Type	No Surgery
Operation Plan	●Notice Intensive Care Unit (ICU)
Attention	●Monitor blood pressure. Take a Nitropaste, if blood pressure is too high.

Figure 2. The sample information for Diagnosis and Treatment Plan

4.2 Usability Testing

We conducted the usability testing to collect the feedback from participated physicians. According to international standards, usability refers to effectiveness and efficiency to achieve specified goals and user satisfaction. Usability testing is typically conducted as a standard method for usefulness. Nielsen proposes five attributes of usability: easy to learn, efficient to use, easy to remember, minimal errors, and pleasant to use. In this study, we use completeness, correctness (i.e., effectiveness), and usefulness as the testing criteria. The results indicate that participating specialists slightly agreed (over 3.5) with the performance with CDSS, such as completeness (5.0±0.65), correctness (4.2±0.57), and usefulness (4.4±0.72). These result provide evidence to support the usability of the study proposed stroke CDSS.

5. CONCLUSIONS

As more physicians seek to the clinical support through a decision support system, the need to have a methodology for designing a CDSS to promote heightened levels of implementation success is crucial. Drawing upon cognitive fit theory, we developed a methodology for stroke SOAP analysis and a CDSS prototype to support the stroke SOAP for a physician. With this support, a physician can more easily and systematically review the subjective and objective descriptions, diagnose the symptom and prepare the care plan. The stroke CDSS provides an interactive interface that allows physicians the ability to switch between different information types within the SOAP, between different evidences with previous cases.

These features help physicians verify their internal representation and construct a mental model of the diagnosis analysis. This process results in improved diagnosis performance. The validity of the proposed method is supported via usability testing. The contribution is two-fold: Firstly, the method can alleviate the difficulty in knowledge modelling, analysis and storage. It integrates several concepts and methods into the design process and artifact. Additionally, it provides a better fit for diagnosis assessment that allows physicians to create their own knowledge forms and facilitate knowledge creation. Secondly, the method allows a skeleton of knowledge creation and its associated knowledge objects to be managed separately. This provides flexibility for knowledge modelling, analysis and helps the construction of scenario-based approach to be effective in using existing knowledge. The physician may specify different templates and fill them with the knowledge object in the knowledge storage.

ACKNOWLEDGEMENT

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PHYSICAL ACTIVITY MONITORING FOR THE AGING POPULATION

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ABSTRACT

A significant aspect of the modern, holistic and decentralized health care is the provision of out-of-hospital physical rehabilitation and physical activity monitoring services to frail and aged people. Physical activity monitoring is also meaningful for healthy subjects, as it contributes to the assessment of their wellbeing and enhances their interaction with trainees and teammates. The PAMAP system monitors and analyses physical activity and provides its users and their supervisors with valuable feedback. It helps the subjects to perform rehabilitation related activities and monitor the level of their activity. It also provides them with personal health record service, via interactive TV and smart phone interfaces.

KEYWORDS

Activity monitoring; home-based rehabilitation; electronic and personal health record; interactive TV

1. INTRODUCTION

Monitoring of physical activities is a growing field with many diverse applications in the area of Ambient Assisted Living, ranging from medical screening, disorder diagnosis, rehabilitation, to well-being. A balanced physical activity is essential for “well aging”, and represents a fundamental indicator of good health and life quality [8]. It is well known that physical activity plays a positive role against chronic conditions, and more precisely, stimulates the immune system [1], reduces muscle loosening [7], and reduces the risk of cardiovascular diseases [9]. Moreover, it is an excellent factor for the functional rehabilitation process [5]: in advanced clinical cases, physical activity becomes vital, and patients must, for example, walk or change their posture in bed at regular time intervals.

Current monitoring systems are rather costly, require wires or special infrastructure, and are rather dedicated to motion analysis than to capturing musculoskeletal efforts and activities. As a consequence of their complexity, it is not easy for the end users to undergo unattended sessions. For example the Philips Orthopaedic [3], a product for self-training of patients with video instructions and feedback is approved for use under medical supervision only. Moreover, most of those systems (e.g. ActiGraph [4]) are isolated from other relevant applications, for example personal health records and care management applications and therefore cannot support an integrated approach for physical rehabilitation.

The aim of PAMAP project is to address the identified gaps, by delivering an integrated system for physical rehabilitation and care plan management. The system is designed in a way that makes it particularly user friendly for the elders and capable to address different use cases: unattended physical rehabilitation sessions in out-hospital environments; and supervised strength exercise sessions in clinical environments.

In the subsequent paragraphs, the overall PAMAP architecture (Section 2) and the details about the constituting components (care plan management, in Section 3, physical & strength exercise monitoring, in Section 4, and interactive TV based personal health record, in Section 5) are presented. The conclusions and some early evaluation results are being presented in Section 6.

2. PAMAP ARCHITECTURE

PAMAP project aims at delivering an ICT solution that supports physical rehabilitation and physical activity monitoring in clinical settings and out-hospital environments. Such a system enables accurate monitoring of the physical activities of the monitored subject; provides visualization, guidance and feedback during the execution of a set of exercises; and facilitates healthcare professionals in the establishment and follow up of personalized care plans for their patients. To accomplish these objectives, the project delivers a modular ICT solution, composed of self-contained system components: (i) sensory equipment and associated control unit; (ii) algorithms for physical activity analysis & classification; (iii) physical activity visualization and patient feedback software; (iv) electronic / personal health record and care management application with web and interactive TV interfaces.

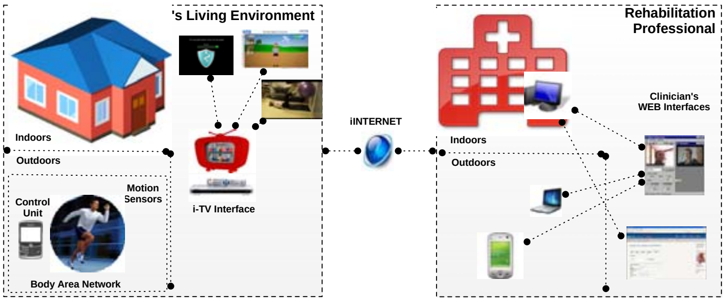

Figure 1. PAMAP system architecture

A graphic presentation of the PAMAP architecture is depicted in Figure 1. The Body Area Network consists of the sensor network and the Control Unit worn by the monitored individual in order to collect data and deduce different types and parameters of physical activity. The patient gets feedback related to her physical activity using her TV monitor. An interactive TV interface provides also access to the personal health record and the details of the care plan to be followed by the patient. The content presented there is synchronized with the content that is presented to the clinician, via her web interface. Using this interface, the clinician sets up the care plan of her patient and reviews the measurement results.

3. WEB BASED EHR & CARE PLAN MANAGEMENT

The web based EHR and care plan management application is built around the needs of the clinicians who curate patients undergoing physical rehabilitation. The application enables them to create, edit, and review the electronic health record of their patients, to set up their care plan and review reports that summarize the accomplished physical activity, the daily vital signs measurements and patient's feedback to quality of life questionnaires (Figure 2). Patients also have access to the web EHR, and can use this interface to acquire an overview of their health information.

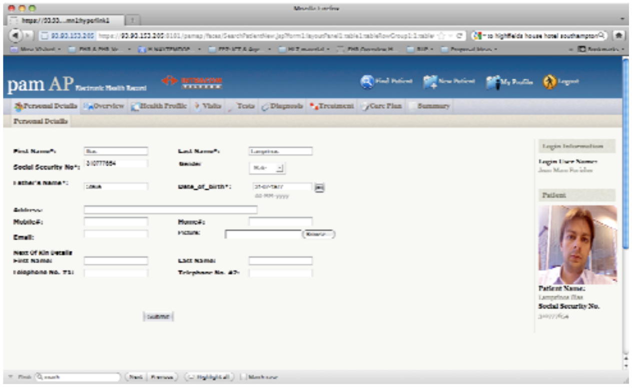

Figure 2. Web-based care plan management

As for the general EHR information, the following fields are available for editing: general health profile; family health history, habits & social history, allergies, vaccinations, hospital visits' details, laboratory test orders and associated results, diagnoses and associated treatment and medication.

With regards to the care plan, each entry consists of prescriptions related to physical and strength exercises, vital signs measurements, educational multimedia sessions, and quality of life questionnaires. Once the plan is set up by the clinician, the information is also fed to the interactive TV application for presentation to the TV monitor and to the Control Unit, for guidance and feedback during the exercises' execution.

4. PHYSICAL ACTIVITY & STRENGHT EXERCISE MONITORING

Figure 3. Elderly user performing strength exercises using a TV and a remote control

This section explains the data presentation component, i.e. the part of the PAMAP system that the user interacts with and presents the information provided by the other system components. The focus is on introducing a user interface concept designed for older adults. The aim of the personalized exercise trainer is to help users follow individually tailored training programs when exercising alone at home. In particular, this means to guide the user through the different phases of the program including preparation, warm-up, work, and cool-down phase; to control the exercise load by suggesting the weights, number of sets and repetitions, and breaks according to the training plan; to function as a virtual memory by counting the number of sets and repetitions; and to control the exercise technique by providing valuable feedback on the way the exercises are performed, based on the information provided by the data processing component.

One of the most difficult problems in adopting technology is the usage of interfaces that are often not well-suited for elderly users. Particularly the aspect of technology acceptance needs to be addressed. The elderly users should be unaware of the complexity of the underlying software and hardware details. The technology should aim at being less noticeable than traditional hardware and better integrated with the elderly's lifestyle [2]. Moreover, the interface should be developed for elderly people with little or no computer experience. The core philosophy is therefore a minimalistic design and simplicity. In PAMAP, the set-up for the elderly makes use of a TV monitor. The patients are able to enter information interactively via a remote control (Figure 3). Being a primary focal point in elderly's lifestyle, television is an ideal candidate for a technological aid by embedding intelligence into it [6]. Using a television the need to learn a new interface is negligible, as the user utilizes an already familiar interface. Furthermore, the user is unaware of any underlying software or hardware details within the system, as the monitor visually and behaviorally represents a television with the remote control still being the primary input device.

Besides the wearable sensor network, the graphical user interface is the main component with which the user gets into contact. Modern interface design requires the use of memory and sight; all faculties that decrease with age [10]. As people age, their abilities change. This process includes a decline over time in the cognitive and physical functions at different rates relative to each other. Visual changes among aging adults include problems with reading speed, seeing in dim light, reading small print, and locating objects.

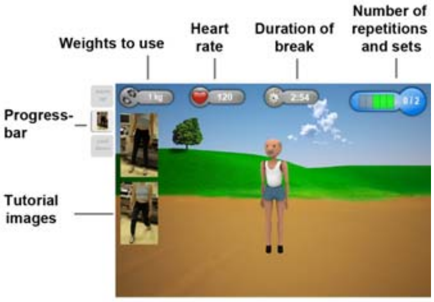

Figure 4. Overview of the UI design elements during an exercise

For the current system the symbols were designed to be simple and large. A large and clear font was also used in the application and only the most necessary information for use is displayed on the screen. To support the presented text information a speech output has been introduced for limited vision users. An overview of the user interface design elements is shown in **Figure 4**. These are the main UI elements to help guiding the user through various types of strength exercise. The progress bar indicates the current phase of the exercise session including the warm-up and cool-down phase for. The remaining UI elements are dedicated to the current exercise: tutorial images, the weights to use, heart rate, the duration of a break, and the number of repetitions and sets to do / performed support the user while executing his exercise.

5. INTERACTIVE TV BASED PERSONAL HEALTH RECORD

As already mentioned, a major objective of the PAMAP project is to exploit the TV set available in almost any residence as e means to provide home based rehabilitation services. Towards this direction an interactive

TV application provides access to the patient's personal health record (Figure 5); this application is hosted by a set-top-box connected to the TV monitor, that gets access to the Internet either via DSL or 3G networks.

The interactive TV application enables the patient to obtain an overview of a subset of her health record, to manually enter data not automatically collected by the PAMAP control unit (e.g. blood pressure as measured with her personal device), to answer to quality of life questionnaires, to obtain an overview of the prescribed rehabilitation plan, to get access to multimedia files related to physical activity practice and tutorials about each particular exercise she should execute, to record personal notes, and receive automatic reminders related to forthcoming care plan related activities. Navigation to the pages presented in the TV monitor is done using the TV remote control.

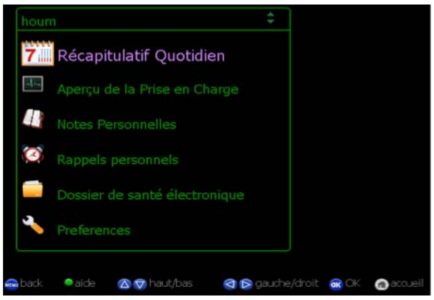

Figure 5. Interactive TV interface

6. CONCLUSION

In this paper an integrated system for physical rehabilitation monitoring, care plan management and personal health information storage and presentation was presented. The system was piloted by Centre Hospitalier Universitaire de Rennes with the participation of 30 individuals between the ages of 60 and 86. The early evaluation outcomes focus on the usage of the digital fitness trainer and indicate that users really benefit from guided training sessions. The participants appreciate the easy user interface, the automatic counting of their executions, and the feedback if they are not performing their exercise correctly. The oldest participant stated in his questionnaire: "the system is easy to learn and use, thus he would use it again on a daily basis".

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Reflection Papers

DESIGN AND DEVELOPMENT OF A MULTILINGUAL MULTIMEDIA BASED PRESURGICAL INFORMATION AND CLARIFICATION SYSTEM FOR TABLET COMPUTERS

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ABSTRACT

Every medical intervention affects a physical injury and therefore requires the consent of the patient to avoid liability. Therefore presurgical information and clarification to the patients is an important condition for any medical treatment and, in Austria, an obligation for the doctor. In the case of a lawsuit, judges depend on the information from the patients. In this instance, justice has a sensible patient in mind, but nevertheless, admits “that also on the part of the patient a joint responsibility“ can be required. However, the doctor has to consider the common knowledge and general education level, as well as concrete life situation, of the patient in the clarification conversation. This proves to be difficult, but is of essential meaning, especially with non-German-speaking patients. In addition, the recollection of the patient is another hurdle on the way to the sensible patient. The recollection is tied together with the patient's understanding and has not been considered, up to now, by justice. In general it is well known that it is nearly impossible to remember such information in detail for a long time. However, studies show that multimedia contents, before the personal information and clarification conversation with patients take place, have a high acceptance and substantially improve the recollection. Many empirical studies have identified the quality and communication of patient information as a major weak point in the treatment process. While in the USA for already a good 20 years, and with great success, films and other multimedia contents are used for the patient's information and clarification, it has been used very seldom in Austria. Hence, a multimedia based multilingual system for tablet computers will be developed for the patient's clarification at the University of Vienna, the medical University of Vienna and the upper secondary technical and vocational college for IT, organisation and health informatics in Grieskirchen.

KEYWORDS

Multilingual, multimedia, presurgical clarification, tablet computer, liability

1. INTRODUCTION

The medical clarification encompasses the self-determination clarification with explanation of the procedure, risks, and possible complications as well as alternative procedures, and the protection clarification with tips for the presurgical behaviour of the patient. The objective burden of proof about the contents of the self-determination clarification lies with the doctor. The protection clarification is a therapeutic duty. That means that if it is missing or unclear for the patient it is a coarse error of treatment [1]. In addition, a clarification must take place on time and must be patient-centred.

A basic human feeling is the fear which can work in either actual or only seemingly dangerous situations not only consciously, but also subconsciously. Many patients are afraid of doctors, medical interventions and anaesthesia [2]. This encompasses fear of loss of consciousness, complications, powerlessness, fear of death, and other object-related fear [3]. Causes are bad experiences, complications, lack of trust or missing / incorrect information [4]. Fear may be decreased by different factors such as pleasant surroundings, good personal care as well as special drugs. The treating doctor may help with fear reduction by reassurance, information and the construction of a bond of trust [5, 6, 7, 8].

1.1 Health and Language

In Austria and Germany the step clarification has asserted itself in general, i.e. the combination of written clarification, in the form of leaflets, and verbal clarification by the doctor. The clarification conversation takes place as early as possible, at the latest the day before of the operation by a doctor who knows the intervention and the possible risks.

2 patient groups have been shown to have problems with the present paper-supported clarification questionnaires:

- People with limited reading and writing abilities
- People with limited knowledge of the German or English language

The faculty for educational science, psychology and movement science at the University of Hamburg published the “leo” study (level one study) which grasps the magnitude of the limited reading and writing abilities of employed German citizens [9] for the first time in Germany. It is to be assumed that these values can be also transferred to Austria.

More than 4% of the working population (situation on alpha level 1-2, 18-64 years) have limited reading and writing abilities. That means a person can understand some single words but not a whole sentence. As well, the affected people must also compose common words letter by letter. The study showed that men are affected more often than women (about 3:2).

Indeed, this evaluation is rather conservative if one thinks that only people were included in this study who can speak the German language, at least, orally.

The second group included people with limited knowledge of the German or English language. The increasing number of migrants increases this group more and more. Above all, with a nevertheless very stressful situation such as a treatment in the hospital, the common argument “They must learn to speak the German language” is not long-lasting. Activities of the Austrian health ministry or the platform to patient security show that this subject is currently more topically than ever. The annual conference of the institute for ethics and law in medicine of the University of Vienna between 10th and 11th of November 2011 devoted itself to this subject under the title: “How much German does one need to be healthy? Migration, translation, and health“.

Most members of this group are migrants, but also vacationers or business travellers. There are no interpreter services for doctors’ informational talks in Austria. In the meantime, in Switzerland there is a 24-hour accessible telephone interpreter's service.

The presurgical clarification should explain the planned intervention to the patient, consider unnecessary fears and involve them in the therapy decision. So the main questions are: Do the patients profit from the information which is offered by a multilingual, multimedia based clarification system? Are the patients satisfied by using a computer based clarification system?

1.2 Fear of the Treatment

In Dijon 80 women were taken up before a surgical intervention in a randomised study. With all patients, an aesthetic breast or stomach operation should be carried out. All women received a printed leaflet of information to read. Moreover, the fear of the operation was evaluated with a questionnaire. In addition, a 10-minute CD-ROM with the same information was played to half of the patients. One day before the operation it was examined, with the help of a questionnaire, how well the single women were informed about the intervention. Here the fear of the operation was measured once more. In the statistical evaluation it appeared that the patients who additionally received the information on the CD-ROM clearly had less fear of the operation. They were also much better informed about the operation, although the remaining patients had read the same information in the printed leaflet. [10]

1.3 Working with Computers

A study at the clinic and outpatient clinic for orthopaedics and physical medicine at the Martin Luther University of Halle-Wittenberg with regard to patient satisfaction [11] showed that the contact with multimedia contents for most patients was pleasant as well as easy to use. Family members could be present and discuss potential problems with the patient afterwards. This form of the clarification ran without pressure of time, the patient could often repeat single passages or the whole process again and again. Also for the medical staff the usage of the multimedia patient's clarification brought an essential saving of time. In the doctor's personal conversation the patients were perceptibly better prepared than at times before the use of the clarification program.

2. FUNCTIONALITY OF THE PROGRAM

The multilingual, multimedia based program combines multimedia contents such as films and pictures, as well as animation, textual information and questions to the forthcoming therapy. The questions are general questions regarding the topical state of health as well as special therapy-related questions including questions regarding the medical prehistory of the patient, and, if essential, of members of the family. To be without barriers the issue of the texts is presented by voice output and the input may be done by means of keyboard, pencil or orally.

After filling in the questionnaire the program allows the printing of this protocol in text form (including pictures and diagrams) as a base for the following verbal clarification conversation. Because of the standardised questions this protocol can also be printed out into several languages. The German version may be for the treating doctor, with different language versions for the patient or consulted interpreter. This interpreter could also become available, as is already possible in Switzerland. and discussed in Austria, via phone or videophone.

2.1 The Different Phases of the Production Process

1. Development of a generic program on the basis of Android based Tablet PCs from 7” to 10“ screen diagonals.
2. Project development and research: The research encompasses the capture of "state of the art" content for suitable therapies, as well as the evaluation of the available patient's materials. In addition, patients are interviewed in the approach to check whether the main elective focuses and containments are properly selected. Furthermore the frame of the multimedia contents (texts, films, pictures, diagrams, animations) is fixed.
3. General preparations: According to the epidemiology of the illness a profile production of possible protagonists occurs. The experts are named in arrangement with the University of Vienna, and the medical university of Vienna, as well as the Austrian medical association. The textually outlined contents are worked out during the work by specific question in a new form.
4. Realisation of the graphics: In addition to the experts’ and patients’ statements, graphic animations are provided. Additionally, texts are written and storyboards are provided which are tuned with the help of experts in the particular fields.

3. CONCLUSION

The patient is well prepared by a clear multimedia presentation on the treatment, a great satisfaction is achieved, and the conversation is simplified for the doctor. All studies show that such multimedia systems may positively influence the length of the conversation between patients and doctors and the presurgical fear of the patients. The patients feel comfortable, safe and well informed.

With this system the authors expect an improvement for all partners: better and longer lasting information for the patients and a bigger safety for the doctors that their clarification was understood. For the hospitals the authors expect economic advantages by shorter, more intensive, conversations between doctor and patient and a higher legal security. Hence, it should bring for the purposes of the patient's safety and the quality in the health service an essential improvement.

So the “informed and therefore mature patient” may become reality in the world of health care.

The presentation covers the design process, the development of the program and the research for the content.

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MULTIFUNCTIONAL WEB BASED TELEMEDICINE SOLUTION FOR THE PROVINCE OF BENGUELA - ANGOLA

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ABSTRACT

Poor and developing countries can consider a broad range of telemedicine solutions. Angola presents a considerable number of public health problems. This paper presents a fully designed and implemented telemedicine solution for the Province of Benguela based on a low cost open source software, the Joomla Content Management System (CMS). Several different functionalities were added and successfully configured in the selected system such as a multimedia center, forms and reports creation and management (medical staff, patients and examinations), historical and epidemiologic data management, a virtual market and others. Important technical background applications are also provided such as an automated backup and restore tool with user level management and a forensic and anti-attack integrated tool. The system prototype was fully implemented and tested at the University Lusiada of Angola but a real installation is planed to the Regional Maternity Hospital at the city of Lobito, Benguela during the second semester of 2012.

KEYWORDS

Telemedicine, Telehealth, Content Management System (CMS), Open Source.

1. INTRODUCTION

Angola is one of the most developing of African countries with several public health problems registering a considerable number of deaths caused by the deficit of medical staffs, qualification and lack of infrastructure for a good diagnosis. A very expensive practice is to send people to other countries such as Portugal, Brazil or South Africa looking for better health care conditions. Nevertheless the most part of the population is poor and cannot afford these expensive treatments and in the country side hospitals and health care conditions are even worse.

Some demographic and health data could be presented (estimated) about Angola [1]:

- Urban population: 57%
- Annual Demographic Growing Rate: (2005 - 2010): 2,81%
- Born Rate (2002): 46/1000
- Mortality Rate (2002): 25,8/1000
- Live Expectance: 42,7 years old
  - Men: 41,2 years old
  - Women: 44,3 years old
- Age classification (2002):
  - Less than 15 years old: 47,7%
  - 16 - 59 years old: 47,9%
  - Over 60 years old: 4,4%

A Telemedicine solution allows the removal of the physical distance between medical staffs and patients usually with a low cost infrastructure based on the internet (3G, Wimax, Satellite, etc).

The basis of a good medical service is the efficient and reliable exchange of information about the patient health status. To create this reliability, all the telemedicine project organizations and members must be part of the process, such as physicians, nurses, psychologists, clinical laboratory staff, etc [2].

The technology nowadays can assist the medical staff with good management tools to control these information and telemedicine solutions are being widely used or considered in the most part of health institution as a reality to improve medical assistance.

This work presents the design and implementation of a web-based internet portal with a large set of embedded solutions to achieve many levels of telemedicine solutions, such as virtual education, remote patient examination diagnosis, e-health and many others, built over a low cost open-source software platform, to improve health conditions in Angola, Africa.

2. MATERIALS AND METHODS

A Content Management System – CMS is a complex and integrated tool for the creation and management of websites, intranets and portals without the need of a single line of code programming. This allows a simple and fast way to make the information public and available.

The CMS are characterized for a large amount of embedded functions (for both presentation and management) and also the possibility of including (addition) of new features classified as components, modules and add-ons. The website design and colors can be easily managed as well with templates that can be changed and downloaded from a huge set of free options in the internet.

2.1 Software Platform

There are many open-source software solutions for content management such as Wordpress, Drupal and Joomla. They are based in many different programming languages or frameworks like Perl, PHP and Python and use several different database management systems, with MySQL and PostgreSQL.

After the comparison of many different CMS systems, this projected selected the Joomla CMS based on a LAMP – Linux / Apache / MySQL / Apache platform as presented in details in Table 1.

Table 1. Complete software solution consisting of only open source software solutions, with operating system (Linux), web server (Apache), database (MySQL) and programming language (PHP).

Software	Version	Description
Linux	OpenSuse version 11	Operating System
Joomla	1.5	Content Management System
Apache	2.0.24	Web server
MySQL	5.0	Database Management System
PHP	5	Programming Environment

3. RESULTS AND DISCUSSION

The provided Telemedicine solution consists of several different embedded software, components, modules and add-ons for the Joomla CMS. Multiple templates were evaluated and the environment can easily be changed as desired.

During the project specification, four different modules were designed with different but complementary purposes:

3.1 Content Center Module

The content management is a key part of the whole project. Articles, audio and video streaming capabilities are the three main selected media. The main idea of this Center was to allow the diffusion of medical information among the medical staffs in the Province and in the country as a whole and also benefit the population with high quality information about diseases, government actions, distance learning capabilities, polls, a photo slide show known as Gavik and other solutions.

Figure 1. The Content Center presents articles, polls and multimedia tools.

3.2 Forms and Reports Module

This area intends to create a medical staff, patients and exams digital database. These data are still manually controlled in Benguela where the low reliability and the loss of information are very usual problems. An important result of this module is the proposal of the development of a Historical and Epidemiologic Data System. This is a proposed solution that is going to be tested in practice after the use at the Regional Maternity Hospital.

Codigo	Nome	Data de Nascimento	Hospital onde trabalha	Data de contratação
004	Alexandre	04/10/2010	HOSPITAL DO LOBITO	19/10/2010
006	[illegible]	07/10/1992	nana	05/10/2010
012	Ednar	02/07/1987	santa	04/11/2010

TELECONSULTA

Faça uma consulta online

Obrigatório *

Nome *

codigo

Diabetico * ○ S ○ N

Nivel de diabetes * ○ A ○ B

Alergias * ○ N ○ Pó ○ Animais ○ Lactose ○ Fumo ○ Remedios

Descreva suas alergias

Sintomas *

Insira seus sintomas

Desenvolvido por by CK Forms

Figure 2. Forms and Reports module to allow the creation of a medical digital database.

3.3 Virtual Market Module

An ecommerce solution was also adopted in the system considering the future possibility of remote monitoring payments and a virtual store for health accessories and home medical equipments. The system already present product catalogs divided in classes, prices, promotions and the possibility of integration with the most common payment gateways (such as credit cards and online payment services)

Quantidade: 12

Figure 3. Virtual market module with different products, shopping basket support and payment module.

3.4 Security Management

Security is an important issue and many different tools were used to enhance the system security as a whole. First, the Joomla user management was considered to filter editing and back-end authentications. An automated backup and restore tool with user level management was installed and a forensic and anti-attack tool was also implemented. Besides, attacks against Joomla web sites are performed regularly and the portal administration must be updated with the latest versions and external protecting tools shall be carefully considered actions when using the Joomla CMS.

4. CONCLUSION

A Telemedicine solution exclusively based on a free software platform and common internet infrastructure can be a viable solution for remote patient monitoring, diagnosis support, virtual education and e-health for poor and developing countries. The solution presented in this work was designed and implemented to integrate different tools for patient, medical and government use. The Joomla CMS was very easy to install, configure and use, has a significant free database of modules and components and its performance is good when compared with some other CMS´s available. Security must be checked regularly as it is a common target of crackers attacks.

The proposed solution was tested in the University Lusiada of Angola (ULA) and the user's feedback was very positive about the site usability and simplicity. Nevertheless, the full installation in a medical institution is going to happen during the second semester of 2012, with training and supporting provided by the ULA research group and more accurate results about the project results could be achieved.

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MICRO HEALTH CENTRE (µHC) CLOUD ENABLED HEALTHCARE INFRASTRUCTURE

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ABSTRACT

India's achievements in the field of health have been less than satisfactory and the healthcare delivery at the village level is constrained by lack of healthcare infrastructure, lack of doctors, lack of supply-chain and lack of appropriate monitoring of the existing healthcare infrastructure. This paper describes an innovative and visionary low cost health care infrastructure solution that can be rapidly rolled out to provide basic healthcare services along with tele-video medical consultation. It consists of a standard shipping container converted to a Micro Health Centre, that is connected to medical personnel through health cloud, to bring much needed preliminary healthcare to those in need.

The objective is to equip the Micro Health Centre with basic diagnostic equipments that can be operated by paramedics or interns, along with specialist medical personnel providing expert interventions through remote medical consultation. It can have a network connectivity varying from 256 KBPA (via satellite) to 2 MBPS (via leased line). Furthermore it can be easily transported to remote rural areas as all supply-chains such as trucks, trains, roadways etc are aligned to handling shipping containers. The Micro Health Centre has been designed to provide healthcare, health education as well as medicines, thereby aiming at providing the basic health facilities to inaccessible areas.

KEYWORDS

Healthcare, Telemedicine, health care infrastructure, health centre, Primary Health Care

1. INTRODUCTION

There is an increasing consensus that stronger health systems are essential for achieving improved health outcomes. The studies done in relation to this suggest that dysfunctional health systems are failing to meet the healthcare needs in the developing nations and the health care delivery at village level is constrained by lack of healthcare infrastructure, lack of doctors, lack of supply-chain and lack of appropriate monitoring of the existing healthcare infrastructure.

The aim of the Micro health centre is to mitigate the ground-level issues of healthcare delivery in remote areas in India and in other economies that are challenged by the inadequacy of health infrastructure. The µHC aims to provide primary, preventive and promotive care and to act as a referral unit. It is able to deliver the above by providing a cloud-enabled health infrastructure. This infrastructure can enable rural citizens to access specialist medical consultation and provide support for disease surveillance by tracking disease patterns and risk factors. Given that µHC is a rapidly deployable infrastructure, it is also appropriate to support disaster relief operations.

The cloud connected µHC can act as a means of performing efficient collection, storage and analysis of patient data, to provide accurate reporting of health indicators and assessing unmet health care needs of the community, thereby ensuring delivery of quality health services and also acting as a tool for creating public awareness. The µHC can be managed by two medical personnel or paramedics for providing care as well as health education and performing simple diagnostic tests.

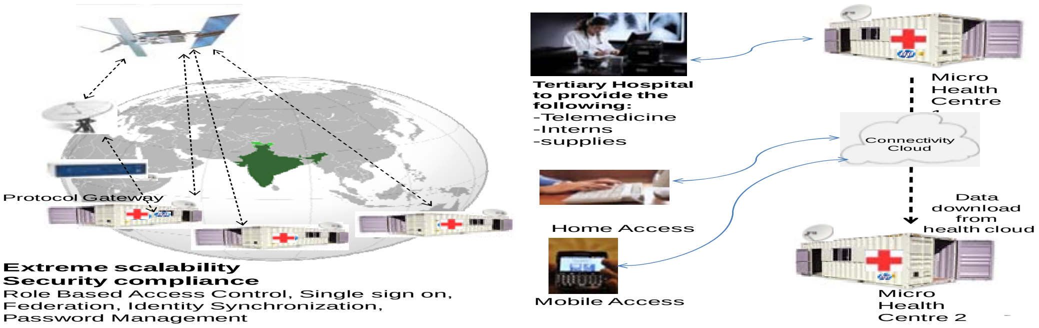

Figure 1. The Cloud connected Micro Health Centre

2. METHODOLOGY

A careful review was done of the published literature on the issues and challenges faced by the healthcare delivery system in India. Primary health care and its role and the importance of informatics in healthcare delivery in resource constrained settings were studied. The literature search was done to generate peer-reviewed academic articles. For this purpose, several databases such as SpringerLink, PubMed and Sage journals online were utilized. The review was supplemented by other e-journal search engines including 'Medline' and 'Google Scholar'. The literature review done is qualitative and based on performing iterations and revisions of the material, until a consensus interpretation was achieved. This research has facilitated the conceptualization of an innovative solution addressing the key challenges of Indian healthcare delivery system in the form of the Micro Health Centre. This solution is based on the application of information technology for improving healthcare delivery. The solution aims to overcome the challenges of Indian healthcare by providing primary healthcare and tele-health services, thereby strengthening the Indian healthcare delivery system. The conceptual framework presented below has been utilized for this purpose. The solution is in the early stages of development and will be deployed very soon in rural settings in India.

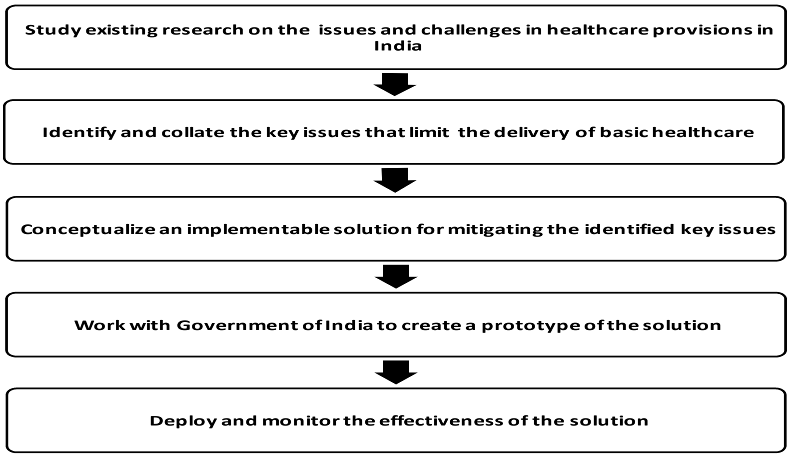

Figure 2. Conceptual framework for Micro Health Centre solution

3. KEY ISSUES THAT LIMIT THE DELIVERY OF BASIC HEALTHCARE IN INDIA

The research done on the existing published literature regarding the issues and challenges in healthcare delivery in India reveals that although a well defined system of public healthcare provision exists in India still there is some shortfalls, as identified in this paper such as:

a. Physical infrastructure deficit in rural areas and lack of monitoring of available healthcare infrastructure
b. Lack of adequately trained staff as well as lack of monitoring of the staff
c. Lack of adequate access to the existing facilities
d. Lack of medicine and other basic supplies and inadequately functioning equipment
e. Poor maternal and child health services, poor disease management services for both communicable and non communicable diseases
f. Manual data collection leading to inefficient data management

4. MICRO HEALTH CENTRE - SOLUTION FOR MITIGATING THE IDENTIFIED KEY ISSUES

It has been increasingly realized that “Cloud technology” has the potential to provide quality healthcare especially in remote, underserved areas of the population. There are a number of studies reporting the potential benefits of using cloud computing in healthcare and also propose different models and frameworks. According to a literature review done in relation to the role of ICTs (Information Communication Technology) in the health sector in developing countries it has been suggested that for implementing ehealth as a digital strategy to non-digital people, an integrated, pragmatic and visionary approach is highly important. Keeping the above in mind, a rapidly deployable self sustainable infrastructure, backed by the robust healthcare services accessible from anywhere, at any time, to the common man has been conceptualized. The objective is to equip a health centre with basic diagnostic equipment that can be operated by paramedics or interns, with specialist medical personnel providing expert interventions through telemedicine. It is based upon the finding that in resource constrained settings Telemedicine applications may serve as the only means to reliably obtain healthcare.

The solution is equipped with built in electricity through power generator, built in connectivity, telemedicine services and requires minimal training to operate.

There are three components of this healthcare solution:

1.) The Cloud enabled Physical Intelligent Healthcare Infrastructure: A standard shipping container is converted into an intelligent Telemedicine Health Centre, designed to meet the local needs and conditions without any infrastructural constraints. It is designed to provide following services: OPD services, mother and child healthcare services, health education, diagnostic lab test facilities, disease screening and record of vital events and reporting.

2.) The remote Health Studio at a medical college or hospital: The Micro Health Centre can provide telemedicine consultation to patients in remote rural areas and also referral services to patients requiring specialist medical care. It can provide easy access to consultation from expert doctors through telemedicine facility at the affordable cost of primary healthcare. It provides availability of enhanced quality and timely medical services and can avoid unnecessary travel for health care needs.

3.) The Health Cloud: Cloud computing for Healthcare is advantageous for tele-video medical consultations; it can save the time and money spent by the patient. Real-time devices like tele-ECG at the µHC can transmit data to remote locations for instant analysis. Data can be stored and forwarded to several sites at once or accumulated for further analysis at a later time.

5. CONCLUSION AND FUTURE PERSPECTIVES

The µHC presents an innovative healthcare infrastructural solution. It ensures delivery of high quality health care. It aims to provide essential health care services with Health Cloud connectivity, thus providing invaluable data for research and health policy planning. The advantage of the µHC is that existing shipping containers are used as base, enabling ease of deployment at any location any time, as a result it can be transported easily to remote inaccessible areas.

The solution is also valuable for urban areas where the concept of family physician is fast disappearing. Very often, the first point of healthcare services in urban areas is now the hospital infrastructure, which not only makes basic healthcare expensive, but also puts pressure on an already overloaded healthcare system. This solution also has the potential to provide healthcare to the poor in developed countries leveraging the low cost health infrastructure of developing countries. The µHC has the potential to make a difference in the lives of many people as it can rapidly become functional. The healthcare delivery at the Micro Health Centre can be monitored through the health cloud connectivity, thereby providing highly efficient and quality healthcare. Thus it can dramatically increase the reach of healthcare, bridging the Indian healthcare need gap.

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Posters

ORCON-BASED ELECTRONIC HEALTH RECORD ACCESS CONTROL

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ABSTRACT

Electronic Health Record is a virtual container for documents related to one patient. One of the main security problems is a question how to design and implement an efficient, flexible and secure access control mechanism for nationwide EHR systems. The paper presents an access control model based on the ORCON model. The model is patient-centric, i.e. a patient has a full control of his EHR and grants or remove read rights to physicians. The Policy Decision Point (PDP) and Policy Enforcement Point (PEP) are located inside a secure hardware at physician workstation. It is technically not possible to create a digital copy of the EHR or its part on the physician workstation.

KEYWORDS

EHR, access control, ORCON

1. INTRODUCTION

Electronic Health Records (EHR) are used to store health related documentation. Each EHR is a virtual container for documents related to one patient. EHR systems are usually nation or region wide systems. They must be designed to manage millions of EHR and each EHR can store hundreds of documents. Health related data is very sensitive and unauthorized disclosure can cause economic and personal losses. Personally Controlled Health Record (PCHR) is an EHR with access rights controlled by patient (Chen, 2012). Not all types of documents should be visible for all physicians (e.g. a psychic evaluation) and only physicians who have been authorized by the patient should have access to the patient' EHR (Win, 2007) or its part (see (Bergh, 2009) for advantages of PCHR approach). Also, physicians should have access to documents, which they have created. Additionally, the EHR should be accessible in emergency situations, when patient is unconscious.

This paper presents an EHR access control model based on ORCON (Originator Control) access control model, for ORCON details see e.g. (Park, 2002). In ORCON, in contrast to other access control models like MAC, DAC, RBAC, an owner of a document decides who can have access to the document and, what is more important, a person who was granted read right to the document cannot disseminate it further. It is necessary to use some kind of a secure hardware (e.g. a smart card, a cryptographic token, a dedicated processor) in users workstations to fulfill non-dissemination requirement.

2. ORCON-BASED APPROACH

Nowadays, EHR systems use access control mechanisms, which are combinations of MAC, DAC and RBAC models e.g. (Alhaqbani, 2008), (Baldas, 2010), (Blobel, 2004), (Katt, 2009), (Jin, 2009) and (Sucurovic, 2010). Emergency situations are usually handled by some kind of an audit based access control (someone, e.g. a patient, confirms after treatment that the physician accessed EHR in an emergency situation) (Dekker, 2007). Solutions mentioned above use an access control model in which the access policy is enforced in the EHR system by the service responsible for EHR delivery, i.e. Policy Decision Point (PDP) and Policy Enforcement Point (PEP), which are located inside the EHR system. In a such approach, EHR system does not have technical means to stop further documents' dissemination after the healthcare data is sent to users (e.g. healthcare specialists).

Fig. 1 presents the proposed model of the ORCON-based access control mechanism. The EHR system contains one trusted element, i.e. a long-term service, which is responsible for EHR management. Documents stored in a data storage system are encrypted and can be stored in an untrusted zone. Healthcare specialists have to use a workstation with a secure hardware module (e.g. a secure USB token) to access EHRs. The secure hardware module is a PDP and PEP enforcing access to the EHR and cannot be tampered or modified without authorization. The module is secure because of its internal structure (e.g. smart cards are designed in way that is impossible to copy them or read their content without the proper PIN code). The module provides the protection of encryption keys. Therefore, it is impossible to create a digital copy of the EHR without authorization.

In the model two entities are involved in the access control – a patient and a secure dispatcher. The patient is an owner who can grant or remove access rights to a healthcare specialist to a part or whole of his EHR. Secure dispatcher is a system responsible for verification, if access rights granted to a physician by the patient are compliant with a general access policy. The policy states if a physician having a specific role is allowed to see specific types of healthcare documentation. The dispatcher cannot override the patient and grant wider access than access rights assigned by the patient. Dispatcher can only restrict access rights. The patient can access his EHR through the EHR Website using similar security measures as in e-banking. The EHR owners (patients) are an exception, only EHR owner can access the EHR without the secure device, because it is assumed that the owner can export and copy his medical data outside the system under his responsibility.

The patient using the EHR Website can grant or removes rights to the part or whole EHR. The access rights are granted at the level of documents (compositions in terminology of CEN/ISO 13606). The EHR consists of documents grouped by an archetype id (archetypes specify the type of the documents e.g. a blood test or a prescription). Documents are created by patients (e.g. weight observations) and mostly by healthcare professionals. Healthcare professionals are documents' creators. However, when they upload a document to the EHR system the document ownership is transferred to the patient. The creators have always access to documents they have created, but they cannot disseminate the document or rights to it further (optionally the system can be configured, so that the owner (the patient) will be able to remove the creator permissions).

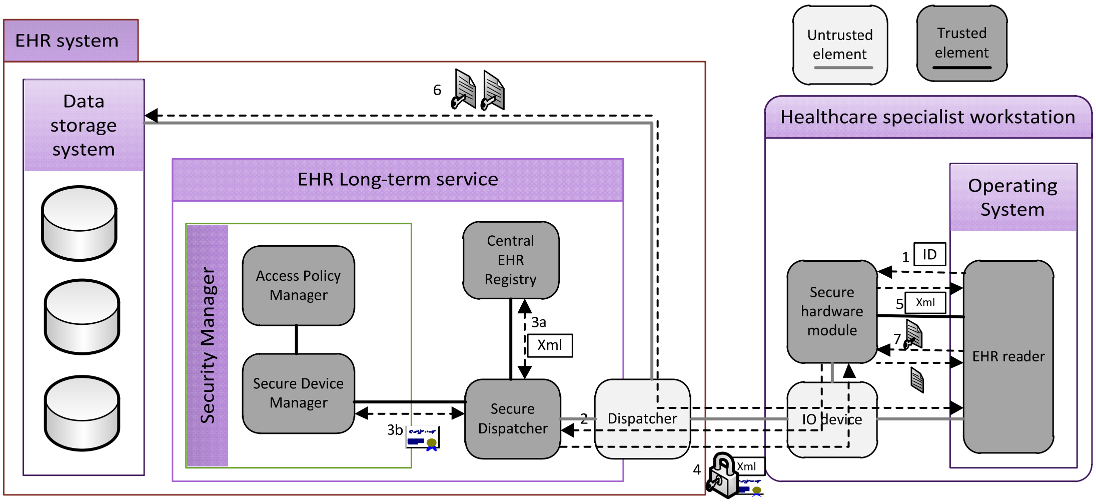

Figure 1. The ORCON-based EHR access control model

The access scenario to the EHR by a healthcare specialist is as follows (compare with numbers in Fig.1). User logs into the system and enters credentials to the EHR reader (the EHR reader is a trusted secure application using the Secure Hardware Module - SHM). The specialist chooses ID of a patient (of an EHR) and the reader sends a request to the SHM. The SHM, using secure SSL/TLS connection, connects to Secure Dispatcher (2). Secure Dispatcher using Central EHR Registry and Access Policy Manager (3a and 3b) prepares a XML file with an access policy and with links to the documents in the data storage system, which are a part of the chosen EHR. The XML file also contains documents' decryption keys. Next, using the Secure Device Manager, Secure Dispatcher encrypts documents with the SHM secret key and transfers them to the SHM (4). The XML file never leaves SHM. The SHM compares user credentials with the access policy in the XML file. The links to the encrypted documents are transferred to the EHR reader (5). The reader using Dispatcher retrieves the encrypted documents from the data storage system (6). In final step EHR reader sends decryption request to the SHM. If credentials match (7), SHM decrypts the documents. The EHR reader is a trusted application not allowing to make copy or to export the documents.

The model uses two types of encryption keys - device keys and documents' keys. The dispatcher and each SHM have one asymmetric key pair. The keys never leaves devices and are used to establish a secure communication path. In the Security Manager database are stored symmetric documents' keys. Documents' keys are send to SHM upon request (step 4) using a secure communication path.

3. CONCLUSION

The ORCON-based model can be used to implement a flexible and secure EHR access control mechanism. The model does not require designing complicated roles like in RBAC approach and does not need the additional entity managing access rights. The user can grant or remove access to his EHR using EHR Website or in the physician office by inserting a healthcare smart card to the reader. The physician application displays the parts of the EHR to which he wants to have access and the patient confirms by entering a PIN code. The secure dispatcher verifies if permissions granted to the physician are compliant with the general access policy. The main drawback of the model is the need to develop the SHM, which is more difficult to implement than in systems with a central trust point. However, similar solution exists (e.g. see SPA architecture (Chen, 2009)).

Future works will include the implementation of the model. The implementation will be used to examine the effectiveness of possible policy formats. Primary analysis has shown that assigning access rights at the level of documents should be manageable by current IT systems. The policy will be written in XML format (most likely in XACML) and transferred to the SHM every time a physician will log on to the system and request EHR.

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A HTML5-BASED SYSTEM FOR VISUALIZING AND FORECASTING THE SPREAD OF INFECTIOUS DISEASE IN JAPAN

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ABSTRACT

Risk management for preventing infectious disease outbreaks requires spatiotemporal surveys of disease incidents and providing forecasts supports risk management and effective intervention against outbreaks. The purpose of this article is to introduce a web-based computer system designed to help medical personnel monitor and predict the spread of infectious disease in Japan. The main feature of this system is that it automatically creates animation or graphic images for visualizing spatiotemporal patterns of infectious diseases using Rich Internet Application (RIA) and Hypertext Markup Language Version 5 (HTML5) according to the user's requirements. Moreover, the system has the function of predicting up to four weeks after common infectious diseases based on a suitable statistical forecasting model. We believe the system will be a useful tool for risk management of infectious disease outbreaks.

KEYWORDS

Infectious disease, Surveillance, Data visualization, HTML5

1. INTRODUCTION

Risk management for preventing infectious disease outbreaks requires spatiotemporal surveys of disease incidents. Having forecasts for outbreaks can support risk management and effective intervention against outbreaks. Under the Japanese infectious disease surveillance scheme, weekly reports of infectious diseases are collected from participating hospitals [1]. However, because current surveillance reports are presented as numerical data and simple charts, it is difficult to grasp any trend of infectious disease morbidity all over the country and/or transmission between neighboring areas. Recently, Web-based geographic information system (GIS) technology has been recognized as a useful tool for disease studies [2]. Disease studies have revealed strong spatial characteristics for case location and disease diffusion. GIS enable medical personnel to visually ascertain disease distribution. We have developed a Web-based data visualization system that makes surveillance data more comprehensible for medical personnel. The system can present several types of visualization based on GIS technology. The main feature of this system is that it automatically creates animation or graphic images for visualizing spatiotemporal patterns of infectious diseases by using Rich Internet Application (RIA) and Hypertext Markup Language Version 5 (HTML5) according to a user's requirements. Moreover, we evaluated the possibility to forecast the future incidence of influenza using time series analysis based on data from the surveillance. A nearest neighbor method was selected as the most suitable model for forecasting incident of influenza and was implemented in the system for predictions of four week after the last incident.

2. FORECASTING MODEL

We applied three forecasting models [3]: an exponential smoothing method (ESM), an autoregressive integrated moving average (ARIMA) and a nearest neighbor method (NNM), to make predictions of morbidity of influenza. Statistical analysis for the ESM and the ARIMA models were carried out using SPSS Ver.19. The NNM was executed using a computer program made by us based on its' algorithm. Retrospective data of Japanese infectious diseases for the period of 2000-2011 were extracted from the surveillance data. These incidences were reported weekly. Prior to the statistical analysis, we combined 4 weeks data into one and presented one year as 13 weeks. These data were separated into two groups: one (from first week 2000 up to week 13 2007) was designated the "training" set and the other (from first week 2008 up to week 4 2011), the "validation" set. Each prediction of incidence was obtained by using the data from first week on 2000 to previous week of the reference. For example, a prediction value for 13 week on 2008 was calculated by using the data from first week on 2000 to 12 week on 2008. We used the mean absolute percentage error (MAPE) to measure and quantify how well the data matched or "fit". For example, a lower MAPE value would indicate a better fit of the data. Figure 1 show the comparison between actual and predictions obtained by ESM, ARIMA and NNM for validation set of influenza. All models seemed to forecast annual outbreaks. A considerable differences between actual and predictions were found in 2009. Novel influenza caused by a new flu virus was spreading in that season. It seemed to make the differences. The best-fit model for influenza was the NNM, where the MAPE was 70%.

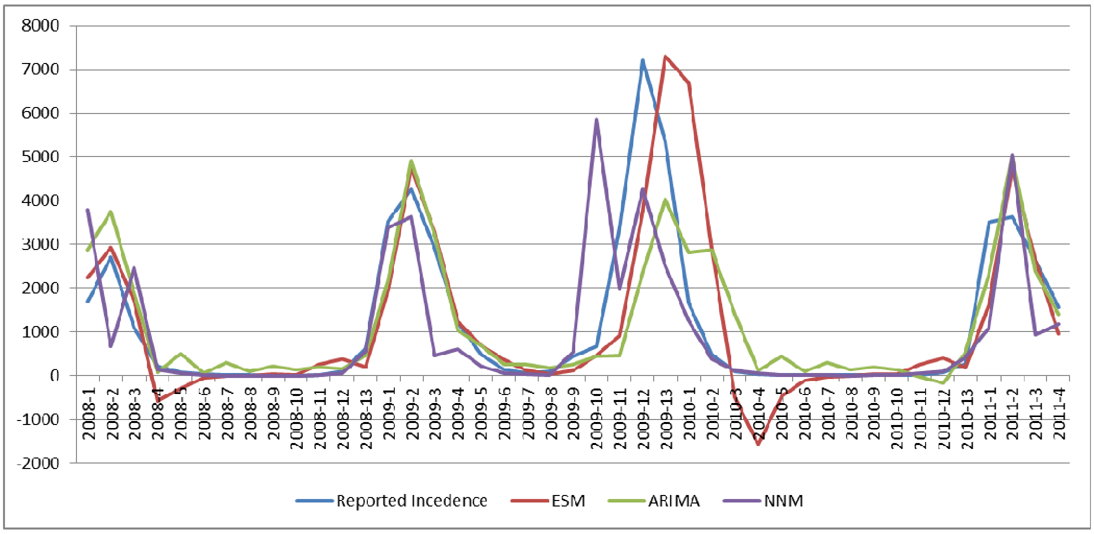
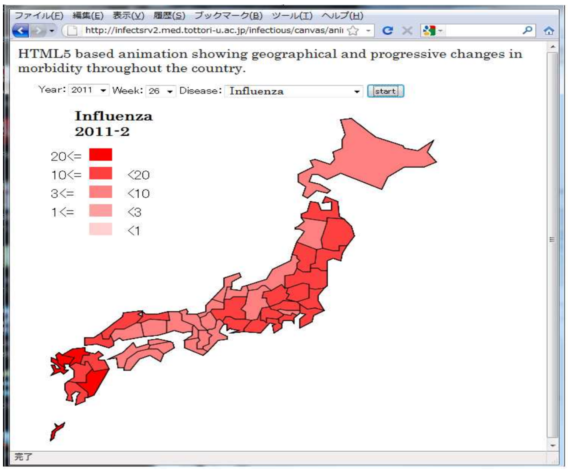


Figure 1. Comparison between actual and predictions obtained by ESM, ARIMA and NNM for validation set of influenza

3. WEB-BASED DATA VISUALIZATION SYSTEM

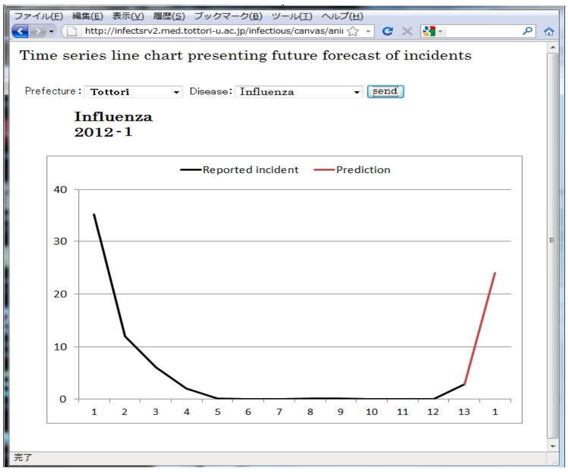
The system was developed on a computer running the Windows 2003 Server with the Apache 2.2 and the MySQL 5.5. PHP 5.3 and JavaScript were used for implementing Web-based applications and Ajax techniques. The system's database currently stores weekly reports of influenza and 11 pediatric infectious diseases from 2000 in the 47 Japanese prefectures, a total of approximately 300,000 cases. This system presents some types of visualization in a sophisticated manner. Figure 2 shows an example of animation. When the user inputs the query key, the system retrieves corresponding data from the database and then creates animations automatically using HTML5 canvas elements. As soon as the start button is clicked, the animation begins and each prefecture is classified into five colors, showing the changes in epidemic intensity over time. Figure 3 shows a time series line chart presenting future forecast of incidents. Black and red lines reveal past-reported incidents and predictions of four week after the last incident respectively.



HTML5 based animation showing geographical and progressive changes in morbidity throughout the country.

Year: 2011 Week: 26 Disease: Influenza

Figure 2. An HTML5-based animation showing geographical and progressive changes in morbidity throughout the country



Time series line chart presenting future forecast of incidents

Prefecture : Tottori Disease: Influenza

Figure 3. A time series line chart presenting future forecast of incidents.

4. DISCUSSION AND CONCLUSION

Monitoring a trend of disease morbidity and sharing these information could be useful for disease control and prevention. To make the Japanese surveillance scheme function well, it is important to provide a good representation and sharing of the data collected in compliance with users' requests. Many Japanese medical personnel working on problems related to infectious disease need more easily intelligible information about nationwide trends in infectious disease morbidity [4]. HTML5 Web pages can provide a powerful and flexible user interface for handling sophisticated data and applications. Use of HTML5 therefore seems to be most practical for medical applications. Forecasting future incidence is also important for risk management against infectious diseases. We found that the ARIMA and NNM provide a useful way of making predictions of disease. The models could well be used in planning for the risk management. We believe the system can help medical personnel quickly ascertain trends in infectious disease morbidity and warn the general population of impending outbreaks of disease.

ACKNOWLEDGEMENT

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DETECTING DISSONANCE IN CLINICAL AND RESEARCH WORKFLOWS FOR TRANSLATIONAL PSYCHIATRIC REGISTRIES

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ABSTRACT

Data capture process is an important step in health care research, but it often receives little attention on research design and, therefore, can present a number of flaws. To the best of our knowledge, no previous studies have developed standards that would allow for the comparison of workflow models of clinical and research activities and the improvement of the data collection process. In the present study we developed workflow models for a translational research study in psychiatry and for the clinic where it was implemented. Models were used for workflow comparison and identification of dissonances between both, qualitative standards and a corresponding taxonomy arose and workflow re-engineering was proposed and implemented.

KEYWORDS

Workflow, UML, Clinical Research, Direct Observations, Standards

1. INTRODUCTION

Data capture process is an important step in health care research, but it often receives little attention on research design and can present a number of flaws (Gurland, Alves-Ferreira et al. 2010; Carvalho, Batilana et al. 2011).

Workflow modeling has been used in clinical research with the objective of improving research capacity (Khan, Payne et al. 2006). Clinical trial workflow modeling in community practice has been used to determine the workflow of clinical research coordinators, the tools used to perform the activities of those workflows, and their ultimate outcome settings (Khan, Payne et al. 2006; Khan, Kukafka et al. 2008).

Current literature, however, has pointed that there are important differences between clinical and clinical research workflow that can generate error and rework (Khan, Payne et al. 2006; de Carvalho, Jayanti et al. 2010). In previous work by our group (Carvalho, Batilana et al. 2011), we have demonstrated that trial sites that have significant discrepancies between clinical and research workflow may present potential data quality problems.

To the best of our knowledge, no previous studies have compared clinical and research activities workflow models. Therefore, the objective of the present study was to develop workflow models for a translational research study in psychiatry, the workflow for the clinic where it was implemented, and then generate qualitative standards and a corresponding taxonomy allowing for the comparison between these models. Also, after the evaluation of these models a workflow remodeling was proposed, implemented and evaluated.

2. METHODS

Initially, ethnographic evaluations were carried out to investigate both research and clinical workflows. Based on these observations, and interviews with all the staff involved in both research and patient care a list of the tasks identified in both workflows and corresponding workflow models were elaborated. Qualitative standards and a corresponding taxonomy emerged from the comparisons of these models. After the evaluation and comparison of the models, workflow re-engineering was proposed and implemented. Re-evaluation of the clinical and research workflow was carried out before and after workflow re-engineering. The study was approved by the local Institutional Review Board at the Hospital das Clínicas form the Medical School at the University of São Paulo, Brazil (Comissão de Ética para Análise de Projetos de Pesquisa do HCFMUSP).

3. RESULTS

Factors observed across tasks that impaired workflow included:

(1) Lack of actors to perform specific tasks, classified as “actor availability dissonance”; (2) use of lengthy instruments for data collection, defined as “time dissonance”; 3) poor communication between actors, “communication dissonance”; (3) difficulties to access patient information in the paper-based medical record, “Information availability dissonance”; (6) Use of inadequate tools in clinical and research activities, “Artifact dissonance”; (8) Inapropriate physical space for research activities, “Space dissonance”.

The new workflow proposed aimed at eliminating the dissonances identified. Main changes included: transfer of tasks to actors with more time avaliable; the use the patient time in the waiting room to carry out the screening tests; implementation of an electronic data capture Dados Prospective (Nguyen, Shah et al. 2006).

In the month before workflow re-engineering, it was observed that a small number of patients was approached (n=2) and enrolled (n=2) to participate in the research protocols under development at the clinic. However, after workflow re-engineering, a marked increase both in the number of patients enrolled (n=8) and approached (n=12) was observed.

4. DISCUSSION

Our main findings included the identification of dissonances among the main activities in the workflows. Once these dissonances were eliminated or minimized through workflows remodeling, a significant increase in the number of patients approached and enrolled for the clinical studies developed in the clinic was observed.

Careful analysis of workflow has been employed in previous studies to model organization of cognitive work and the information flow in clinical and research environments, aiming at discovering latent systemic flaws that potentially result in workflow problems and raising efficacy of patient management. However, understanding the purpose and findings of workflow research can be challenging due to the lack of accuracy in language when discussing workflow research.

In the present study, a significant increase in the number of patients enrolled in the research protocols was observed after workflow re-engineering. Holzinger and colleagues predicted financial and time related efficiency benefits resulting from workflow adjustment (Holzinger, Kosec et al. 2011). Another benefit resulting from our intervention comes from the research data capture implementation, for allowing information to be shared with all professionals involved in research and patient care, and also for facilitating the execution of some tasks.

The reduced number of actors interviewed during data collection is a study limitation.

We have shown that workflow re-engineering can have a positive impact on research efficiency. The methodology developed in this study can be applied to increase research efficiency.

ACKNOLODGEMENTS

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SYSTEM DESIGN OF MEDICAL DECISION SUPPORT FOR INTENSIVE CARE

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ABSTRACT

In Intensive Care Units, physicians and nurses are still performing time-consuming manual data analysis for making the most optimal medical decisions for each individual patient. Moreover, current ICU platforms are not offering an infrastructure for infection surveillance, decision support, data-driven guidance and modeling of critical illness. Due to the lack of an integrated medical management platform detecting infections at an early stage or following the daily patient's evolution is complex. The focus of our work is on the system design of medical decision support services for the ICU and on service optimization through modeling and prediction of the performance of services.

KEYWORDS

Information Technology, System Design, Service Orientation, Intensive Care, Medical Decision Support.

1. INTRODUCTION

Information technology has been slowly adopted in hospitals, although medical informatics has evolved to an important discipline that has the enormous potential to improve the process of care by providing health services to reduce medical costs and to improve the quality of care (Fitzmaurice, 2002). It is a challenge to conduct ICT based research to support the decision making process of physicians and nurses by offering tools that increase the productivity and efficiency in making diagnoses and therapy decisions. The focus of our research is on the design, development and optimization of hospital information systems and services. This includes the automatic recording of patient data, the creation of an integrated view on the patients' electronic records originating from different clinical sources, and providing alerting and advice. The contributions are threefold. First, it is our aim to design a service platform, able to combine and integrate patient data. Second, we investigate the decision support service which encapsulates the logic as a decision plan or guideline. Third, we model and optimize performance changes in the data provisioning in order to ensure robustness and stability of the system and services. The research is applied to a real-life hospital environment, allowing a direct evaluation of the services and an estimation of the clinical benefits as result of the automated collection, processing and presentation of clinical data. Infection control (Eggimann, 2001) and antibiotic management (Charani, 2010) are viewed as priority to improve quality of care in the ICU.

2. SYSTEM DESIGN

Figure 1 gives an overview of the different levels where we applied information technology in the context of the Intensive Care Unit. Specific functionalities are constructed as services in a service-oriented architecture (Koumaditis, 2009). The architecture offers interesting benefits such as reuse in service compositions. The design is constructed as interacting services, able to reduce the complexity of the complete system in smaller pieces. These services are implemented as web services. The data flow of our platform starts with the collection and registration of patient data on the bedside. During the data processing and integration several medical departments are involved. Today, data is fragmented in data silos, not interacting with each other. It makes the access to a complete view on the patient's conditions, results, history and evolution very difficult and time-consuming. By integrating and linking data with each other new insights can be established (Steurbaut, 2012). Specific clinical decision support services may request data from the platform in order to process automatically a computerized clinical guideline. Examples of these services include antibiotics dosage or switch service, organ failure service, kidney alerts. Moreover, the collected data and new generated information can be further analyzed for clinical research.

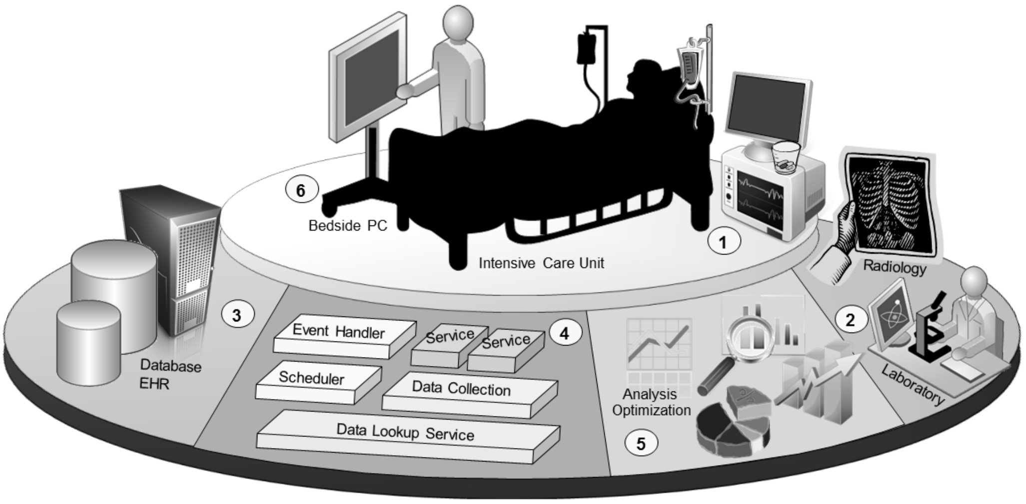

Figure 1. Overview of the computer-based services in the Intensive Care Unit.

The main application levels of our system and the services for ICU, as shown on Figure 1, are:

1. *Monitoring and registration of patient data on the bedside.* This data includes measurements, vital signs, clinical observations and pharmacy registrations of the patient. Manual paper-based processes can be automated by introducing electronic patient records in an information system. With the presence of these records, we were able to replace existing administrative processes in the hospital. For example, the tracking of medical procedures for billing could be automated.

2. Integration of data with the radiology department (for the thorax images) and with the laboratory department (for the blood results and microbiology). Applications and databases are spread across hospital departments and are often not integrated with each other. For infection surveillance and antibiotic management, it is important to have a complete view on the patients' current and historical conditions. Therefore we integrated the relevant data of the clinical information system with data from the laboratory and radiology.

3. Storage of electronic records in the database of the hospital system.

By aggregating data, new views and interpretations of data are possible. Since a linking between infections, antibiotics and microbiology had been missing in other systems, we stored the records in our database. By building a database, later data mining can be applied for clinical research. Many advantages (Haug, 2003) are seen such as the evaluation of past, unaided medical decisions to determine if a need for decision support exists, projection of potential benefits of decision support, accumulate a baseline to evaluate the success of interventions and construct decision support algorithms in order to derive new knowledge and insights from the archived data.

4. *Services for data retrieval, synchronization, decision support and services encapsulating clinical guidelines with advice and alerts of patients' conditions or alarming values.* The data is compared and checked against clinical rules. Output is delivered at the point of care: to the screen, mail client or smartphone of the physician. Services can track the adherence to medical guidelines and alert or remind of changes in the therapy. Alerting can be applied in different scenarios: offering feedback on physicians' actions, giving a critical alert of alarming values, suggesting other therapies, analyse retrospectively the patients' evolution and physicians' decisions. We designed and developed services for infection disease management, antibiotic management, kidney dysfunction (Colpaert, 2012) and organ failure.

5. *Modeling of clinical and management services for optimization of the service execution platform.* The system has been deployed in the real-life setting of an academic hospital's ICU. To minimize downtimes in case of failures, monitoring of the platform is crucial. Therefore we studied optimizations to guarantee optimal quality of service. In extensions of our original platform design we proposed concepts of autonomic computing to create self-managing components, limiting the human maintenance.
6. *Presentation of a real-time complete view of the patient's conditions on the bedside.* The presented information consists of an extended graphical representation of infections, antibiotics consumption and microbiology results which augments the current information offered by commercial systems.

3. IMPLEMENTATION DETAILS

The service platform has been implemented using the Java Enterprise framework. The platform has been deployed on the Java Glassfish Application Server. The service oriented architecture was chosen because of its benefits related to reusability, interoperability. The client modules are implemented as OSGi bundles and are running as a Java client on the bedside PCs. The bundles can be remotely installed, started, stopped and updated without requiring a reboot of the system. We used web services to build the server-side functional building blocks.

We deployed the services platform in the Intensive Care department of Ghent University Hospital in Belgium, a 56-bed ICU consisting of a surgical, medical and burns unit. Annually there are around 4,000 admissions. The application is used to follow-up antibiotic therapies and for infection surveillance.

4. CONCLUSIONS

The multidisciplinary approach of the team of software engineers and physicians has led to the successful design and development of a system with clinical decision support capabilities. The platform contributes to a better infection control and antibiotic management in the Intensive Care Unit.

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Doctoral Consortia

EHR AND HEALTH E–DATA: PRIVACY PROTECTION ISSUES IN ITALY

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ABSTRACT

Mobility of patients and health professionals as well as cross–border healthcare are strongly connected with the increasing use of Information and Communication Technologies in Healthcare Services. Currently, new methodologies and applications are contributing to improve the quality of patient care and to reduce clinical risks. In this scenario, Electronic Health Records represent an important tool empowering health consumers and reducing healthcare spending waste. Health standards and interoperability are as important as legal and regulatory privacy issues. Mandatory acts on the protection of individuals with regard to the processing of health e–Data are still missing at all levels (national, European and international), therefore it's urgent to introduce specific legal instruments to manage the current state of healthcare. Italy is adopting binding and non–binding legal documents to tackle the problem. Are they enough?

KEYWORDS

E-Health, Electronic Health Record, Semantic Web, Privacy, Patient rights

1. INTRODUCTION

Health, proclaimed as a universal human right by international, European and national charters, has been defined by the World Health Organization Constitution (1946) as "a state of complete physical, mental, social well-being and not merely absence of disease or infirmity." According to this definition, all stakeholders involved in healthcare processes (as medical doctors, nurses, patients, administrative officers, and also governments and lawmakers) have to collaborate to achieve the individual right to a "high level of protection of human health".

Mobility of patients and health professionals as well as cross-border healthcare are relevant aspects of globalized societies. Ensuring fundamental rights in destination countries is also essential in order to guarantee a real and effective protection of foreign citizens "without distinction of sex, race, language, religion, political opinion, personal and social conditions" (art. 3, Italian Constitution).

The last decade has been characterized by a new phenomenon: developments regarding Information and Communication Technologies (ICTs). This important evolution has also influenced the health care sector, which is gradually transforming into e-Health, "an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology" [Eysenbach, 2001]. New methodologies and applications are contributing to improve the quality of patient care and to reduce clinical risks; in fact, health information networks, Electronic Health Records, telemedicine services, other software-based tools help disease prevention, diagnosis, treatment health monitoring and lifestyle management [Kelly, 2011].

However, technical aspects reveal only one side of this multidisciplinary thematic area; legal and ethical issues related to e-Health are also important to be considered, especially because personal health data are currently used by these new applications. Citizens' rights to access to information is a key concept for e-Health. Improving ICTs tools in Healthcare Services, such as EHRs, is a strategic vision for public administration, especially considering that mobility of patients and health professionals as well as cross-border healthcare are increasing. So often efficiency and effectiveness are damaged by a muddled and heavy bureaucracy. Instead, primary gaining accessibility and patient empowerment [Wallerstein, 2006], two essential rights for achieving a “state of complete physical, mental and social well-being” and for realizing the wide-spread use of ICTs in public administration, should be the focus. As considerable as the “right to information”, a consumer’s/patient’s right to receive information about health facilities, services and procedures: physicians must provide full and comprehensible information on diagnosis, prognosis, prospects and potential diagnostic and therapeutic alternatives and consequences of decisions made by patients. It will also allow patients to express a well informed “*consensus*” before undergoing diagnostic and therapeutic interventions, also covering possible risks or discomforts resulting from treatments. The right to privacy is particularly significant in the health environment. Generally, each citizen who comes into contact with doctors and health care facilities, medical services, purchase of drugs and administrative acts has to be absolutely guaranteed confidentiality and dignity. Last but not least, it’s important to discuss the right of everyone to data security and their protection in cases of abuse, recalled by article 8 of the Charter of Fundamental Rights of the European Union: “1. Everyone has the right to the protection of personal data concerning him or her. 2. Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified. […]”.

The mentioned patients’ rights are regulated both at the European and national level. During the past few years different European legal instrument related to health and e-Health have been taken into account, as the “Data Protection Directive”, the “E-commerce Directive”, “Medical Device Directives”, the “Directive on Distance Contracting”, the “Directive on Electronic Signatures”, the “Competition Law”. The “Data Protection Directive” and the “Working document on the processing of personal data relating to health in electronic records”, adopted by the Article 29 Data Protection Working Party, represent essential references to analyze the Italian state of the art on EHR and Health e-Data protection issues.

2. EHR, SEMANTIC WEB AND PRIVACY ISSUES IN ITALY

One of the goals of this PhD project is providing an overview of the current state of the field of EHRs with a particular focus on Semantic Web and privacy issues in Italy. Many important results have been obtained from a technical prospective by current European and national projects and initiatives reviewed, but more should be done from a legal point of view.

As it is known, specialized literature distinguishes among Electronic Medical Record, Electronic Health Record and Patient Health Record; all these tools are different from Patient Summaries or e-Prescriptions. Unfortunately, especially in the past, many national projects and actions misunderstand characteristics and differences, naming EHR the instrument that de facto were Patient Summaries or e-Prescriptions. Developing concrete actions to train all participants involved in project drafting is an essential strategy to reduce these errors; the Italian Government’s decision to convene e-Health experts in order to realize a national Electronic Health Record follows this plan. Serious and profound reflections need to be considered for a suitable EHR architecture, based on interoperability standards and legal protection issues, to be implemented.

As the “eGov Italy 2010” report reveals, there are still differences in the state of implementation of individual components and their integration: in 5 regions, a minimum EHR infrastructure is already operational for at least 1% of the population; in 11 regions, EHR trials are already underway, albeit in different forms and with a degree of non-homogeneous distribution; in 3 regions, EHR experiments are under activation; in the others, zero initiatives have been undertaken.

Several technical and technological problems still remain, but EHR national implementation has a central importance in the domain of e-Health. It will ensure a harmonic, consistent and sustainable development of information systems in the country to support patient care and governance of SSN [National Healthcare System], with increasing levels of interoperability [The National e-Health Information Strategy, 2011].

Although many study groups have been established to probe into the various components of this field - including infrastructure and privacy - much remains to be explored. Access to various software companies should be guaranteed, not only in terms of privacy, but also security and reliability. It’s also necessary to define requirements of an expanding infrastructure, and not only in terms of document management; it’s essential to create a method for the definition of standard documents, it’s indispensable to assume an EHR second-generation etc.

Another central theme related to the Electronic Health Record is the use of standards. According to the [final version of the e-Health interoperability report, 2009], twelve types of barriers to interoperability of standards have been determined. They may be the result of gaps and/or overlaps between standards or a combination of other standards than those required by Standard Development Organizations; they may be the result of ambitious architectural choices that require too long of an implementation time, not reconciled with the rapid development of information technology; and sometimes they may be inadequate with a specific domain, such as health. To conclude: the industry needs to continue working on the field of standards in order to achieve solid results and increase the interoperability of systems.

In this debate, it's also extremely important to consider that talking about e-Health and digitalization processes doesn't only mean "translating" what was on paper into a digitalized format; this process requires a structural reflection on new e-Health systems and their roles. Focusing on existing projects, the following conclusions are obtained: at the European level, implemented initiatives - in particular the epSOS project - promoted interoperability of systems and standards, enforcing the EC Recommendation on cross-border interoperability of Electronic Health Records systems (2008).

It stands to reason that more should be done to realize a comprehensive and reliable interoperability (the ability of two systems to operate through the use of the same communication protocol) between different national systems. As the White Paper "Achieving technical interoperability" suggests, there are four categories of interoperability: technical, syntactic, semantic and organizational [Kubicek H. et al, 2009]. Even if the topic is complex, it is urgent to harmonize policies and projects to obtain a real and growing technical and architectural synergy, especially in a historical context where globalization and mobility impose new frontiers of citizenship and access to services.

To conclude on this point, both European and national initiatives are valuable in terms of implementing Electronic Health Records, however, much can still be done in terms of quality and quantity. And interoperability?

Focusing on legal aspects, firstly it's important to mention the absence of legal mandatory and binding provisions on the subject of Electronic Health Records at all levels: international, European, and national. Of course, the leading reason is that it is a recent and evolving phenomenon, especially because of its inseparable connection with the world of ICTs. Secondly, soft law is produced by the European Union (EC Recommendation on cross-border interoperability of electronic health records systems, 2008), the Italian Privacy Authority (Linee guida del Garante per la protezione dei dati personali in tema di Fascicolo sanitario elettronico e dossier sanitario, 2009) and the Italian Ministry of Health (Linee guida nazionali sul Fascicolo Sanitario Elettronico del Ministro della Salute, 2010). Despite *vacuum legis*, they are a vital framework to continue with drafting of binding rules. In fact, it's urgent to provide cogent and articulate law, and if necessary, penalty provisions, for the e-Health field, where fundamental rights are involved.

As seen from architectural and technical aspects, legal profiles also require a homogeneous *corpus iuris*, considering that currently, they are excessively fragmented. The "Privacy Code" regulating "personal data protection" has expressly dedicated special attention to health data, introducing an article on medical records. However, inadequacy of the above mentioned legislation with respect to the e-Health and Electronic Health Record field is evident. If it is true that digitization is not merely a material transposition into a digital support of what previously existed on paper, it is equally clear that an analogous application of privacy rules to an ICT environment has evident limits. It is also why, in their "Guidelines", both the Italian Privacy Authority and the Italian Ministry of Health are favorable for the prediction of an ad hoc discipline when processing health sensitive data. An age-old question related to the right to privacy concerns "*consensus*". The "Privacy Code" makes a distinction with respect to holders of data treatment; it requires us to consider the purposes for which data are collected and, above all, it puts a precise light on the consent or non-consent that patients have to give. In some cases, specifically identified, the Privacy Authority and/or the "Istituto Superiore di Sanità" may be involved. On this specific rule, the European legislations aren't homogeneous; in fact, there are States in which consent is expressly required from patients and others where such consent is absent.

Another legislative problem which health professionals often wonder about concerns minimum security measures: are they suitable with new technological infrastructures?

The mentioned EU legal instruments confirm the European Commission attention on implementing a strategic common framework on e-Health; nevertheless, the existing European legal rules are not complete and are too vague. There are still important issues that have to be clarified at the EU level in order to ensure that e-Health will play a central role in health care system. Going back over the national level, the "Data Protection Directive" has been almost acknowledged by Italy, that, according to the Commission general rule on the security, has their own security requirements for data at rest or in transit. This is similar to the Article

29 Data Protection Working Party observations on the “Data Protection Directive”, article 8, “better and more specific provisions in the Directive for the further use of health data are needed”; in fact, the globalization “requires more harmonized rules for health data processing, particularly as the exchange of data between European e-Health actors will not be limited to the treatment of patients” [Callens, 2010].

3. CONCLUSION

First of all, it’s extremely important to underline that the following reflections are a result of an ongoing maturation.

From a technological point of view, RFID adoption is functional to the implementation of EHRs. A health care organization, which uses RFID technology infrastructure properly integrated with its Health Information System, is able to automate patients’ recognition as well as EHR implementation.

Particularly interesting for this PhD project is that RFID technology is supported by appropriate management level applications, which allows receipting, processing, transferring and direct printing of sensitive data (Hunt, 2009). Equally remarkable is a semantic issue: assigning the same meaning as well as establishing that different terms are semantically equivalent, is a key factor to ensure proper management of care pathways and administrative procedures. The adoption of shared coding systems (eg. LOINC, ICD, SNOMED) and the standardization of terminology are the main actions to ensure semantic interoperability in multiple application contexts. Finally, the implementation of the HL7 standard-CDA2 also provides semantic interoperability of clinical documents.

From a legal prospective it is essential at all levels - international, European and national - to draft ad hoc regulations governing the handling and security of health data, with particular attention to real protection of citizens’/patients’ rights. In the e-Health field, personal data protection cannot be seen only in terms of confidentiality, but also of integrity and availability. The implications of these reflections are multifaceted; digitization and implementation of specific technologies require a patient’s privacy impact assessment. Critical legal issues are also of concern in the misuse of an individual’s health information, and how this may affect the patient’s future medical care or health insurance. Furthermore, inaccurate information about patients’ health may have secondary consequences on public health research or public interest. Cross-border international healthcare as well as national legal systems need a stronger EU legal framework on data protection, specifically modeled on e-Health and EHR issues. It would also be useful to draft strong European rules avoiding a too large acknowledgement? at the national level, where types of processing so often differ.

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AUTHOR INDEX