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FOREWORD

These proceedings contain the papers of the IADIS International Conference e-Health 2011, which was organised by the International Association for Development of the Information Society in Rome, Italy, 20 – 22 July, 2011. This conference is part of the Multi Conference on Computer Science and Information Systems 2011 20 - 26 July 2011, which had a total of 1402 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) 2011 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 2011 conference received 103 submissions from more than 29 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 19 full papers were approved which means an acceptance rate below 19 %. 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 and posters, the conference also included a keynote presentation from internationally distinguished researchers. We would therefore like to express our gratitude to Dr. Roberto Ascione, Publicis Healthcare Communications Group Company, Italy.
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 Rome, and we invite all participants for the next edition of the IADIS International Conference on e-Health 2012, that will be held in Lisbon, Portugal.

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Instituto Politécnico de Tomar, Portugal
e-Health 2011 Conference Program Chair

Piet Kommers, University of Twente, The Netherlands
Pedro Isaías, Universidade Aberta (Portuguese Open University), Portugal
MCCSIS 2011 General Conference Co-Chairs

Rome, Italy
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KEYNOTE LECTURE

DIGITAL & HEALTHCARE:
TOWARDS AN (E)HEALTHIER FUTURE

Dr. Roberto Ascione
Publicis Healthcare Communications Group Company, Italy

ABSTRACT

The upcoming generation of digital developments will help people manage their health through tailoring information as well as facilitate monitoring via interconnecting objects.

Digital channels are playing an increasingly large part in everyday life. Everyone is connected and able to search, select, rank, generate and exchange content with ease and it should be no surprise that the web is used for health issues, both to find information about them and communicate, not only by consumers, but by all healthcare stakeholders, including physicians.

The web and digital communications in general are evolving rapidly and some of the key trends are relevant to new approaches in healthcare.

New information and communication technologies have facilitated the emergence of rapid, dynamic interactions, driven by the active participation of users who generate content and, more recently, services.

Semantic web and Internet of Things are two of many examples of how digital is co-driving some of the key transformations in health and medicine.

Digital is definitively changing healthcare creating completely new paradigms and the challenge is to embrace the change while evaluating the impact on our society.
Full Papers
DEVELOPING TEMPLATED CLINICAL NOTES
FOR CANCER SURVIVORSHIP CARE

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ABSTRACT

Background: Health Information Technologies (HITs) have the potential to improve clinical care delivery and provide
cost-savings. Synoptic reports have been successfully utilized for pathology and surgical reports, and discharge
summaries. This project explores the role of synoptic reporting in a Cancer Survivorship Program.

Methods: Utilizing the eCancerCare™ model for synoptic reporting, an iterative design approach was utilized for three clinical processes: 1) the internal referral; 2) the survivorship consult and follow-up; and 3) the clinical management of late effects. The system optimizes clinical care, research and patient-provider communication.

Results: eCancer Survivorship Program (ESP) is designed to standardize data collection during the survivorship consult with an easy-to-use, click-box approach. Overall, the effect of EPS on the clinical encounter and on the patient experience was positive. Patients found the tool helpful in planning and strategizing within the consults; however, some patients expressed concerns over the computer not being personal enough. The synoptic reporting system yielded significant cost savings by eliminating the need for transcription services and saving clinical time.

Conclusions: Synoptic reporting structures have important advantages over traditional clinical notes in several different settings and can be an effective means of capturing both clinical and research relevant data.

KEYWORDS

Synoptic, templated notes, cancer survivorship, cost benefit, innovation

1. INTRODUCTION

It is often asserted that adoption and proper implementation of Health Information Technologies (HITs) across care settings can lead to greater efficiency, better access to quality healthcare, and improve overall health care delivery (Chaudhry et al., 2006; Davis, 1993; Esper et al.; Thakkar & Davis, 2006). Although HITs vary widely and incorporate a wide spectrum of clinical functionalities, synoptic or templated reporting of clinical data, in particular, has attracted a great deal of interest over the last several years. Systems that incorporated templated reporting in pathology and surgical settings, for example, have been shown to have important benefits to clinical practice (Amin, Sirintrupan, & Parwani, 2010; Murari & Pandey, 2006; Qu et al., 2007; Srigley et al., 2009; Temple et al.). Nevertheless, there is often resistance to the introduction of
templated reporting in a clinical or counselling setting. Clinicians often have concerns that the technology will slow down the clinical workflow, that they will not be able to see as many patients, or that the patients will have a poorer clinical encounter because the clinician is working on the computer. In addition, concerns are often raised that the clinical notes generated through this process will not adequately capture the specific details of the clinical encounter because the structure of the note does not allow for adequate freedom of expression when reporting the details of the clinical consultation.

At the same time, templated reporting has the potential to be a valuable tool to collect data effectively and efficiently at the point of care. Templated reporting allows for the standardization of data collection and the collection of data in discrete fields. The discrete field collection improves advanced data mining. This type of data collection is designed not only to support clinical practice, but also to support research and administrative uses of the data. Standardized reporting has proven to be a viable method for entering diagnostic information and may be integrated more easily into the clinical workflow. This approach may reduce reporting errors (Qu et al., 2007), improve work efficiency & increase compliance (Qu et al., 2007), allow for easy data viewing and extraction (Murari & Pandey, 2006), improve turnaround time (Mohanty et al., 2007), and potentially reduce the use of transcription services (Mohanty et al., 2007). The ESP templating clinically facilitates continuity of practice, provides a method to explore and discuss oncologic care in a collaborative and structured format with the patient. Successful adoption of HITs will rely on their integration and meaningful use in clinical workflow (Bowens, Frye, & Jones), but cost benefits are important drivers in the decision to implement a new system.

There has not been sufficient attention to the cost benefit equation of different types of HITs, such as templated reporting systems. Studies show that the implementation of HITs have the potential to improve health outcomes and offer substantial cost savings (Alaigh; Bramble et al., 2010; Chaudhry et al., 2006; Cusack, 2008; Hook, Grant, & Samarth, 2010; Hsu et al., 2005). There is a pressing need to demonstrate that the benefits of HIT interventions outweigh their costs. There has not been substantial evidence of economic benefit (Fairman & Curtiss; Sidorov, 2006). The costs of creating and maintaining a HIT is often cited as a barrier to their overall benefit (i.e. installation related costs, maintenance and support costs) (Sidorov, 2006). Net savings from implementation of a HIT may be low at the beginning of a project life-cycle and difficult to detect. This front-end loaded cost is probably attributed to systems-related costs such as installation, maintenance, and support fees (Hillestad et al., 2005). In light of the complex financial implications, there is a need to incorporate the potential economic impact in assessing the long-term benefits of a HIT system.

The purpose of this project is to evaluate the design and impact of the electronic platform developed to support the Princess Margaret Survivorship Program (PMSP). The PMSP has developed a model of care for cancer survivors based on the assumption that survivors must be engaged and empowered to be active participants in their own care. A core component of the PMSP is the Survivorship Consult (SC). The SC has been demonstrated to improve the confidence of breast cancer survivors to manage their survivorship care, as seen by the increase in self-efficacy scores (Wiljer et al.). In addition, the PMSP has developed a clinical program designed to promote patient self-management and self-care of a wide range of clinical issues related to cancer and its treatments, including lymphedema, bone health, fatigue and neuro-cognitive issues.

The platform described in this paper was designed not only to support the services delivered by the PMSP, but also to capture data to support research activities and to provide data to support administrative decisions about the program. This paper reports specifically on the electronic component of this initiative. Other aspects are reported in other related papers. This paper demonstrates the important role that templated reporting platforms can have beyond pathology and surgical notes, especially in inter-professionals, psycho-educational and patient-centred settings.

2. THE ECANCER SURVIVORSHIP PROGRAM (ESP)

2.1 Application Description

The eCancer Survivorship Program (ESP) is built on the eCancerCare™ platform for synoptic recording. eCancerCare™ was developed through a collaboration between the University Health Network Princess Margaret Cancer Program, the Hospital for Sick Children, and the Ontario Cancer Institute. The original purpose of eCancerCare™ was to streamline surgical clinical documentation for paediatric retinoblastoma,
testicular cancer, bladder cancer, kidney cancer and gynaecologic cancer. In contrast, the development of ESP focused on developing a real-time data entry application that would support psycho-educational interventions. An iterative design approach was utilized to develop ESP for three clinical processes for the Survivorship Program: 1) the internal referral; 2) the survivorship consult; 3) the clinical management of late effects. The EPS system optimizes clinical care, research and patient-provider communication.

In the initial rollout, the project was designed to provide a robust information architecture for future growth and an internal referral system to streamline the flow of patients into the clinic. The priority component, however, was the design and implementation of clinical notes that would be produced in real-time, during the consultation or clinical encounter. The notes were designed to be collaborative in two ways. First, they were designed to be inter-professional to support the team-based, inter-professional approach to the survivorship program. Secondly, the notes were designed to promote collaboration between the inter-professional care team and the patients themselves. At the end of the clinical visits, the intention is to create a note that respects the perspectives of all members of the care team, including patients and their families.

In the first phase of development, two main types of notes were developed: 1) the survivorship consult note and 2) the lymphedema note. The notes were created from paper-based notes that had been developed over a 2 year period prior to the creation of ESP. The paper-based notes and workflow were optimized prior to and during the creation of ESP. Both notes are synoptic or templated-notes in their structure. As clinicians go through the clinical encounter, ESP is open and clinicians complete the templated note. The majority of the note is constructed by selecting a series of check boxes. Once the box is selected, a template comment appears in a clinical note field. Once the clinical appointment is complete and all of the appropriate boxes on the form have been selected, a complete note has been constructed. The note can be modified easily so that additional comments can be added. At the same time, the majority of the data has been entered into discrete fields, making the data easy to mine for research or administrative purposes.

Two unique versions of each note are created. The first version of the note is written for the needs of the referring physician and is intended to document the clinical visit briefly and succinctly. This note, once complete, is sent through an electronic interface to the Electronic Health Record (EHR) and becomes part of the patient’s medical record. The second version of the note is designed for the patient. It becomes the patient’s record of the conversation after the appointment. More importantly, it is a self-management document for the patient, outlining the patient’s priorities at that point in time: what the patient’s goals are, and what activities the patient might engage in after the appointment to achieve those goals. The notes generated through ESP are, therefore, designed to support not only the documentation of the clinical visit, but also the patient self-management and self-care of their cancer related issues. This dual role is a unique contribution to this area of clinical documentation and supports a collaborative, patient-centred experience for the patient, family members and entire clinical team.

2.1.1 Template 1: Survivorship Consult

The Survivorship Consult (SC) is a 45 minute reflective interview with cancer survivors (Wiljer et al.). The interview is led by either a social worker, a clinical psychologist or a nurse. Through this interview, a comprehensive summary of the survivor experience is developed, exploring their unique needs and the subsequent strategies for managing their cancer experience. The SC is guided by a templated interview that is organized according to the needs of cancer survivors (Wiljer et al.). The initial SC templated interview is divided into seven sections: 1) patient demographics, 2) patient and family history, 3) treatment history; 4) patient support needs and resources, 5) patient perspective, 6) patient goals; and 7) recommendations for the patient to achieve those goals (see Figure 1). A modified version of this note was created for follow up SCs. At the end

![Figure 1. Survivorship Consult Template](image-url)
of the interview, the clinicians and the patient should have a better understanding of how the patient perceives the cancer experience and collaborative goals are established with the patient to improve the quality of that experience. Two documented notes are created at the end of the process, one for the referring physician and one for the patient.

2.1.2 Template 2: Lymphedema Clinic

As an integral part of the Survivorship Program, a series of self-care clinics have been established to assist patients in the management of issues related to the long-term effects of cancer and its treatment. The first of these clinics was developed to promote self-care around secondary lymphedema related issues. The clinic is inter-professional, including physical and occupational therapists, nurses, and manual lymphatic drainage (MLD) therapists. Complex cases are referred to a specialized clinic at the Toronto Rehabilitation Institute. Three types of templated notes were developed to support the clinical intervention: 1) the initial, 2) the follow-up and 3) the annual visit. The structure of the note varies depending on the type of note, but generally the notes have 11 sections: 1) patient demographics; 2) treatment history; 3) lymphedema history; 4) daily living behaviours; 5) limitations due to lymphedema; 6) assessment; 7) measurements; 8) clinical evaluations; 9) required actions; 10) recommendations; 11) self-care activities (see Figure 2). A version of the lymphedema notes are created for both the clinical team and for the patient. The follow-up notes and annual visit notes also have the functionality to trend results and show progress over time, making the management of the disease easier to track.

2.1.3 Visual Timeline

In addition to the template tools, ESP also includes a visual timeline tool to track a patient’s progress through the Survivorship Program. This timeline displays the type of interventions and activities that an individual patient has received and participated in over a specified period of time. As appointments are recorded in EPS, a pathway is created and coded according to the type of intervention and/or activity. This map or patient timeline allows patients and their clinical team to quickly see the clinical pathway or journey that a patient has undergone (see Figure 3). The timeline is designed to facilitate communication between patients and the clinical team. In addition, it is designed to assist the clinical team in quickly understanding the management history of a particular...
patient. The view of the timeline can be modified if the patient has received a large number of interventions or if they received these interventions over a long period of time.

2.2 Application Development

The application was developed iteratively over a 1 year period. The development occurred in five stages: 1) Collection; 2) Design; 3) Feedback; 4) Specification; 5) Prototype Review.

2.2.1 Stage 1: Collection

In the first stage, the development team worked with a designated clinical liaison who understood the specific clinical parameters and requirements. There was one liaison for the lymphedema note and one for the SC note. For each of the clinics, an event-based workflow diagram was created and all of the relevant materials were collected and analyzed. These materials included transcription templates from dictated notes, existing paper and electronic forms as well as potential database schemas. Initial schemas were designed exclusively for clinical documentation, but they were redesigned throughout the process to include clinical case management tools to support the patients and the clinical team. These tools included the trending of results for the lymphedema clinic.

2.2.2 Stage 2: Design

Once the paper-based clinical documentation and workflow were analyzed, an initial specification outline was drafted. The specifications identified overlapping data points between clinical notes as well as EHR documentation. Overlapping data included demographic and contact information. In addition, a workflow-based approach was utilized to walk through event diagrams and capture missing inputs. Paper-based templates were merged into a master-note template. The clinical liaisons reviewed the master note for comprehensiveness and redundancies.

2.2.3 Stage 3: Feedback

The master note template was then sent to clinicians for feedback from the entire team. Team buy-in for the master note, in particular, was critical and feedback at an early stage enhanced the potential for widespread adoption across the team. In addition, the written documentation and record of feedback was essential to inform later changes and avoid multiple, repetitive changes.

2.2.4 Stage 4: Specifications Finalized

Once the master note template was finalized, the clinical liaisons met with developers to review specifications and incorporate feedback from the clinical consultations. The “majority” changes from team members, or the ones that everyone agreed upon, were generally included in the design of the ESP. “Minority” changes were included based on scope and resources available. “Conflicting” changes were resolved as best as possible by clinical liaisons to expedite prototype development. In several instances, “conflicting” changes continued to be problematic areas in the note and had to be resolved through consensus building amongst the team before, during and after initial pilot testing.

2.2.5 Stage 5: Prototype Review

After the specifications were finalized, a working prototype was presented to clinicians and tested. A series of scenario based tests were utilized to expedite the review and training process. A simulated clinical encounter scenario was also utilized to improve the comfort level of the clinicians in utilizing the new systems. Members of the project role-played, simulating the SC in an environment that was safe for the clinicians to learn the system and try different approaches to certain scenarios. This stage was vital in the preparation for clinical deployment since clinicians became very comfortable with the system and were not afraid that they would be perceived as “unprofessional” as they were learning how best to integrate it into the clinical encounter.
2.3 Application Implementation

After testing a number of hardware configurations, the clinical spaces were equipped with hard-wired workstations as well as wireless tablets with portable and adjustable carts to integrate easily with various clinical workflow scenarios. The EPS was then introduced into the clinical environment over a 2 month time period. A phased approach was utilized so that changes could be addressed as soon as possible to avoid clinical interruptions. The current implementation has now been deployed in 2 clinics since August of 2008. The notes that are generated are sent directly to the EHR as well as provided directly to the patient in the format of a professional summary and recommendations letter.

Although initial adjustments to the hardware and software were made, the clinicians reported minimal negative impact on their workflow. In the first two months, an additional half an hour was added to the clinical appointment times, but this additional time was eliminated once the confidence of the clinicians in the EPS began to grow. This varied amongst the clinicians, but the current clinical time per patient is equivalent to that prior to the implementation of the EPS. Post implementation, the clinicians did not have to book dictation time since the document was completed during the clinical encounter. This also allowed for additional patients to be seen within the allotted clinic time.

2.3.1 Impact on Patient Experience

As part of a larger study on the SC, qualitative interviews were conducted on 8 participants to determine the effect of ESP on the clinical encounter and on the patient experience. The ESP was perceived by participants as useful in capturing pertinent information from the consult. Participants appreciated the fact that they could receive a print out of the consultation, which allowed them to look back at the information that was documented and review the questions and the answers immediately. This made the information easy to follow. A participant stated, “[It] was very helpful because I’m a visual person so it was good to see everything…you just see it and you can check up on more than one, so it was the fact that we were working off one screen was very helpful”. Another participant indicated that the computer facilitated easy planning and strategizing within the consults, “yeah, basically we were working off her computer and we were working off the calendar showing all the programs and…over the month, and because I was curious about programs it was very easy to plan and strategize.” However patients reported some drawbacks to the computer as being not personal enough and following a rigid structure due to the checkboxes.

2.3.2 Financial Impact

The cost of developing this application was approximately $75,000 in development costs, with an ongoing maintenance cost of $7,000 per annum. In addition, clinical expertise was required in developing the design for the system and the templates for the notes. Post implementation, time spent on documentation and the costs associated with transcription were calculated. Adoption of synoptic reporting in the clinic resulted in time-saving benefits, the combined clinical time spent on breast cancer and lymphedema consults (initial, follow-up, and annual) over the course of the period from 2008-2010 was estimated to be 1,132 hours (Table 1). Based on an average work year of 1820 for one full time equivalent (FTE) clinician, the time saved translates into approximately .25 of
an FTE over the course of a year, or more than 1 extra day of clinic time per week. The cost savings from transcription fees at a rate of $3/min was estimated to be a total of $102,969 over the course of 29 months from 2008-2010. (Table 2). The calculations were based on an average dictation time of 15 minutes for initial and annual visits and 7 minutes for follow-up visits. After less than three years, EPS has saved enough money to pay for itself and cover the ongoing maintenance costs.

3. CONCLUSION

The ESP and its templated reporting system have important advantages over traditional clinical notes for the Princess Margaret Survivorship Program. In implementing a templated reporting system, clinician engagement is critical and must be iterative throughout the process. ESP provides a structured and preformatted method for entering clinically relevant details and provides benefits beyond the obvious functions of efficient and less labor-intensive archiving, retrieving, and printing of patient care information. The template ensures all important areas of care are documented and shared with the patient, including genetic and medical risk, knowledge of their cancer treatment, symptom assessment, surveillance and disease management. It provides uniform and standardized data elements through checklists that enable clinicians to make notes of findings in the consults. This encourages clinicians to enter information by themselves, averting the need for transcription services and thereby reducing turnaround time and costs. Impact assessment research is being conducted to determine the effect of ESP on the clinical encounter and quality of data collection. The ESP template will also allow for the collection of data over years and decades providing a more comprehensive longitudinal examination of the needs of cancer survivors and their clinical care needs.

ACKNOWLEDGEMENT

We would like to thank the Princess Margaret Hospital Foundation for their ongoing support of our program and research. We would also like to thank the clinical teams that implemented the program and the patients who graciously donated their time and their thoughtful comments to improve the project.

REFERENCES


ABSTRACT

If used holistically, information technology and management systems in healthcare can increase the effectiveness, safety and quality of patient care. Ideal pharmacy systems should integrate pharmaceutical, clinical and administrative information providing a critical contribution to quality of care and efficiency of health resources utilization. The need to have a versatile and complete pharmacy system is now vastly recognized, but even more so is the role of integrating this system with other clinical systems within hospitals. Such integration means providing a tool which empowers the pharmacist by allowing him/her to write, edit and change critical aspects of care. Most vendors’ applications, however, lack the capacity to profoundly integrate Electronic Health Record and the respective Computerized Prescription Order Entry suit Pharmacy Systems geared towards dispensing and stock management. This leads to a break in the medication use cycle, increased pharmacists’ workload and fails to provide a holistic solution to patient safety and efficiency initiatives.

Our project, involving mostly pharmacists and IT managers, aims to design and implement a Pharmacy Decision Support and Validation System with an effective bidirectional communication capability. Such communication entails not only with Pharmacy Automation Systems but also Electronic Health Record (with Computerized Prescription Order Entry) systems.

This Pharmacy Decision Support and Validation System will be an important tool to increase the effectiveness, safety and quality of patient care. Additionally, such enterprise wide system provides new tools for an old but increasingly relevant profession.

KEYWORDS

Healthcare, information, quality, pharmacy systems, EHR

1. INTRODUCTION

Patient safety has been an issue since ancient times although the concept was only related to protect patients from accidental harm from human sources. It has increasingly been recognized that system failures account for a majority of incidents in healthcare settings like large hospitals (11).

Leaderships in health care institutions can make patient safety a priority by developing a reliable culture of safety, incorporate such culture in workplace and an effective way to achieve this is vis-à-vis the use of Information Technology (11).

Information systems can be extremely important tools to create safe systems through improving access to all the information required, increasing vigilance, contributing to standardization of processes and enforcing practice protocols. In brief, they arbor the potential to reduce human error. This potential has been vastly demonstrated in several areas of patient safety. (4-6,9)

Medication management is one of the most frequently computerized processes in clinical care. Since adverse drug events represent one of the best documented causes of lack of safety (1-3,6,12), the medication use process appears to be a critical issue where several applications may have an important and positive impact.
Pharmacy systems often integrate pharmaceutical, clinical and administrative information which give an important and crucial contribution to the quality of care and efficiency of health resources. There is a need, however, not only for versatile and complete pharmacy system, but also, for its integration with other clinical systems that coexist within the hospital.

Most vendors’ applications lack in integrating the Electronic Health Record (EHR)/Computerized Prescription Order Entry (CPOE) with dispensing and management Pharmacy Systems which leads to a discontinuity in the so called medication cycle, especially because the pharmacist intervention in the pharmacotherapeutical validation of the medication order is not fully documented and available in the EHR.

Hospitals usually have several information systems but many lack effective communication between them, lack a clear clinical IT strategy – with applications proliferating in many clinical settings – and enact diverse medication prescription – dispensing-administering-checking practices, being them paper-based, computer-based or mixed paper-computer.

With this project we aim to create a Pharmacy Decision Support and Validation System (PDSS) with communication facilities with Pharmacy Automation Systems and to EHR /CPOE systems, in which the pharmacist plays an important and crucial role in the development of Clinical Decision Support tools and in the maintenance of Medication Masterfile, Order Sets and Formulary and Related Drug Information. Also, and what we consider the major innovation, the pharmacist relevant information about the medication of that specific patient, that is to say the pharmacist pharmacotherapeutical validation, becomes available in the EHR to all the health care professionals, and not only in the Pharmacy Database.

PDSS provide patient monitoring tools that help pharmacists, and other health professionals, impact health outcomes and provide more consistent monitoring in specialized areas of pharmacy practice such as verification of orders, therapeutic drug monitoring, pharmacokinetic monitoring and onco-pharmacy requisites.

2. PHARMACY DECISION SUPPORT AND VALIDATION SYSTEM CONCEPT

Only a few years ago Portuguese hospitals introduced computerization of their pharmacies aiming to monitor medication use, but mostly for economic/financial reasons. Soon after it became relatively common to evolve for using Automated Dispensing Systems in order to facilitate dispensing. This increased patient safety, since the dispensing errors were substantially reduced, but the problem was that neither the prescription nor the administration records were electronic. By remaining, on paper they mean that the transcription of the medical order as to be done in the PDSS by the pharmacists.

Hospital Fernando Fonseca is a 700 hospital bed, where in 2007 a CPOE using a specific platform, HOSIX by SIVSA, was introduced. This system allows computerized administration records by nursing staff but for many reasons this remained paper-based. The prescription system was integrated with the PDSS and pharmacists stopped transcribing medical orders of medication. The physicians also had access to the Formulary Drug Database with important clinical information and some Clinical Decision Support (CDS) tools. Since this application was not considered a full EHR the hospital adopted another application allowing physicians and nurses to record more extensively, access information and record administration of drugs.

This EHR, Soarian Clinicals by Siemens, has, however, a big disadvantage since it doesn’t have a PDSS component, which led us to the mandatory need of integration with our actual system. This was the main driver for us to decide to design and implement a new PDSS in order to close the medication circuit and allow pharmacists to document automatically and systematically their clinical activities mainly related with the verification of medical orders and drug therapeutic monitoring. The pharmacist interventions were being documented in an Excel database, being only available to those professionals. These new system will allow the pharmacist to document all the interventions directly in the EHR, becoming another full active user of the EHR.

This system, which is now being developed and tested, will allow the pharmacists to validate medical orders, being able to access relevant clinical information contained in the EHR, to document that verification, to give online and on-time information, about that specific patient, to physicians and nurses, or other healthcare professionals, to implement CDS tools and to adequate prescriptions for the dispensing stage.
3. REQUIREMENTS

This new PDSS is based on medical order validation through the perspective of best drug use. Pharmaceutical validation is performed daily by clinical pharmacists on weekdays, but since physical presence cannot be guaranteed for 24 hours every day, lack of validation cannot be impeditive of therapeutic administration by nurses.

Pharmacotherapeutical validation should be made through the initial field "requirements to validate" where a list of patients is displayed with new prescriptions or changes in therapy. In this screen search uses patient name (or identification number), ward, department or floor, and also by validation state. It is also possible to visualize all patients even if they are in a "complete validation" state (Figure 1).

In the start menu every patient has associated a colored symbol according to the validation state:

- Red: all medication needs validation
- Yellow: at least one medication to validate and / or drug eliminated
- Green: all medication validated
- Orange: not validated but reviewed by the pharmacist; provides information to the Pharmacy Technician
- Grey: not validated because it was not yet assessed by the pharmacist

By selecting a patient the following information should be displayed:

Table 1. PDSS information structure

<table>
<thead>
<tr>
<th>Validation Status</th>
<th>Green: validated after examined by pharmacists</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yellow: examined by pharmacists but pharmaceutical validation is pending, waiting for some clarification</td>
</tr>
<tr>
<td></td>
<td>Orange: not validated but reviewed by the pharmacist; provides information to the Pharmacy Technician</td>
</tr>
<tr>
<td></td>
<td>Red: not validated but reviewed by the pharmacist; doesn’t provide information to the Pharmacy Technician</td>
</tr>
<tr>
<td></td>
<td>Grey: not validated because it was not yet assessed by the pharmacist</td>
</tr>
<tr>
<td>Date and time</td>
<td>Date and time of the validation status</td>
</tr>
<tr>
<td>Drug</td>
<td>Name of the drug</td>
</tr>
<tr>
<td>Route</td>
<td>Route of administration</td>
</tr>
<tr>
<td>Dosage</td>
<td>Prescribed dose</td>
</tr>
<tr>
<td>Dosage Unit</td>
<td>Unit of the prescribed dose</td>
</tr>
<tr>
<td>SOS</td>
<td>Symbol indicating if the drug was prescribed in SOS</td>
</tr>
<tr>
<td>Date and time of order</td>
<td>Date and time of the prescription</td>
</tr>
<tr>
<td>Medical observations</td>
<td>May not be visible but accessible</td>
</tr>
</tbody>
</table>

Validation state should be available to physicians and nurses as well as comments or requests for clarification/suggestions. The physician and/or nurse comments should be also promptly accessible to the pharmacist.

This validation may generate pharmacist intervention, if needed, towards the physician and/or nurse which implies an answer. This answer will be the intervention result so we can have two different scenarios: intervention accepted and intervention not accepted the last one with the respective justification. All these scenarios are fully documented in the EHR allowing the pharmacist to become a visible intervenient in the history of that patient in the hospital.

By integrating with EHR, reminders and messages to the prescribing physician can be launched into the system.
The drugs should be classified as or have set the following parameters:

### Table 2. PDSS Drug Classification

<table>
<thead>
<tr>
<th>Category</th>
<th>Example Drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drugs with clinical justification</td>
<td></td>
</tr>
<tr>
<td>Non-Formulary Drugs</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td></td>
</tr>
<tr>
<td>Plasma Derivatives Drugs</td>
<td></td>
</tr>
<tr>
<td>Narcotic and Psychotropic Drugs</td>
<td></td>
</tr>
<tr>
<td>High-risk Drugs</td>
<td></td>
</tr>
<tr>
<td>Drugs prepared in the Pharmaceutical Services</td>
<td></td>
</tr>
<tr>
<td>Pharmacotherapeutic Group</td>
<td></td>
</tr>
<tr>
<td>Pharmacological Group</td>
<td></td>
</tr>
<tr>
<td>Minimum and maximum dose per serving and per day</td>
<td></td>
</tr>
<tr>
<td>Divisible or not divisible Drugs</td>
<td></td>
</tr>
<tr>
<td>Dispensed or not dispensed via automation systems</td>
<td></td>
</tr>
</tbody>
</table>

### 4. VALIDATION OPERATION

By selecting the drug for validation, a screen will appear with all the presentations of this active substance being one automatically associated with the prescription and the number of units required for the prescribed dose. This value should have 2 decimal places so one can validate ¼ tablets.

Drugs not dispensable by the automated dispensing system (previously defined), with zero pre-set amounts, might also be dispensable when requested, by changing to the quantity required.

It may be necessary to replace a drug, eg tablets for oral solution, which generates the need for the “Replace” functionality. This replacement may be necessary as well for different active substances by oral prescription of the physician. The replacement, and the pharmacist who performed it, should be clearly indicated to the physician and nurse.

Clinical data should be promptly available for consultation by assessing the EHR directly. The most relevant data for the pharmacist daily work is Clinical Pathology requests and results, requested MCDT and
results, diagnoses and allergies. The other records from the EHR (eg. reviews) will also be available for consultation.

5. ASSUMPTIONS / GENERAL NEEDS

The next table presents a summary of some of the requisites that such system needs to entail. These have been accounted for in its conception.

<table>
<thead>
<tr>
<th>Requisite</th>
<th>Reason/advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration with EHR/CPOE software, stock management software</td>
<td>Ability to “close” the circuit, integrating the prescription software with the dispensing one</td>
</tr>
<tr>
<td>and others</td>
<td></td>
</tr>
<tr>
<td>Information regarding the type of dosage prescription</td>
<td>Ability to recognize both and make the necessary conversion to allow proper communication between applications. In Soarian, the medical order is done in mg, ml, while in HOSIX is done in tablets, capsules, for example</td>
</tr>
<tr>
<td>Medication Masterfile and Order Sets.</td>
<td>Ability to manage the Hospital Medication Masterfile and sync that with EHR, as well as Order Sets</td>
</tr>
<tr>
<td>Pharmacokinetics</td>
<td>Ability to document, electronically, drug therapeutic monitoring, establishing communication with physicians and nurses</td>
</tr>
<tr>
<td>Drug justifications</td>
<td>Ability to justify a prescription electronically, linked to the drug, with information shown in report form on request</td>
</tr>
<tr>
<td>Creatinine Clearance</td>
<td>Ability to calculate Creatinine Clearance receiving the Clinical Pathology information and the necessary data: age, sex, weight and serum creatinine</td>
</tr>
<tr>
<td>Medication reconciliation</td>
<td>Ability to perform medication reconciliation at hospital admission, in-hospital transference and hospital discharge</td>
</tr>
<tr>
<td>Alerts/reminders</td>
<td>Ability to generate alerts/reminders, for instance in therapeutical duplication (same drug or same pharmacological group)</td>
</tr>
<tr>
<td>Interactions</td>
<td>Ability to introduce drug-drug, drug-allergy, drug-disease, drug-pregnancy, drug-laboratory parameters interactions</td>
</tr>
<tr>
<td>Settings</td>
<td>Ability to define different settings for different clinical wards or specialties</td>
</tr>
<tr>
<td>Narcotics/psychotropic substances and plasma derivative</td>
<td>Ability to control and monitor narcotics/psychotropic substances and plasma derivative drugs utilization based on the nursing records of drug administration</td>
</tr>
</tbody>
</table>
6. VIABILITY OF REPORTS:

The need to produce reports is critical to ensure PDSS not only helps with individual patient care needs but provides basis for healthcare management decisions. The following are examples of the most relevant reports that the system will be able to generate automatically and periodically.

- Pharmaceutical interventions: report issue by time range for clinical wards and also by type of assistance and intervention results (accepted or not accepted) and other parameters
- Utilization of Antibiotics by antibiotic, clinical ward, type of infection and other parameters
- Prescribed medication/diets: for clinical ward and time range
- Medication/diets administered: by service, and time range
- Utilization of medication/diets by article, article type (according to parameterization), clinical ward and time range
- Number of pharmacokinetic monitoring for clinical ward, drug and time range
- Utilization of non-Formulary drugs by clinical ward, time range and disease
- Business/production management of the database
- Report with the actual therapy and diagnoses organized by patient, including not only pharmacological therapy but also diets. This report is crucial to attend clinical rounds.

7. UNFINISHED ISSUES:

Prescription of non-Formulary drugs that the Pharmacy has to acquire:

When necessary to prescribe a medication that doesn’t belong to the formulary, the system must present an electronically form of justification and, if approved, this prescription would be transcribed by the pharmacist.

The physician would later confirm the pharmacist drug transcription, which has to be done in a specific time range previously defined.

Prescription of non-Formulary drugs that the patient brings from home:

This is intimately connected with Medication Reconciliation that necessarily has to be made at patient admission in the hospital. Medical Reconciliation is provided by the pharmacist in many European countries (eg. UK) in which all the patient ambulatory medication is collected, recorded, evaluated and based on this the physician will decide which medication the patient has to maintain in the hospital. In case of maintenance of that medication it will be transcribed by the pharmacist as the process described above.

“Replace” concept:

This concept has two different applications: the replacement of a pharmaceutical form of the same active ingredient and replacement of the active substance within the same pharmacological class.

The replacement will generate information to the physician and nursing staff in case of a mismatch in the pharmaceutical form necessary to a specific administration route and in other situations the replacement should be made after an oral prescription, clearly identified in the system. The physician would later confirm the pharmacist drug substitution, which has to be done in a specific time range previously defined.

8. CONCLUSION

Hospital Pharmacy Information Systems are now an unquestionable reality alongside other applications, however, these are sometimes incomplete if they do not close the medication management cycle.

As advantages of this new PDSS we stress the following:

- Most effective and timeliness interaction between physician-pharmacist-nurse, savings in time used by pharmacists in this management leaving them more available to other clinical and relevant activities
- Provides on-time, and EHR documented information to help clinical decision
- Easier access to clinical and pharmacotherapeutical data
- More accuracy in the medication dispensing process
- Improvement in quality care.
This implementation and improvements, as expected, has however some limitations that are mostly related with the capability of updating the information and monitoring, in a systematic basis, all the processes involved. The strategy will be “less is more” as we need to prioritize the needs of the pharmacists framed in the hospital ones and go forward as our work capability allows.

In brief, with this system we hope to contribute to improve quality and performance although we are aware that in the implementation of new information systems there is always potential for new sources of errors that our team hopes to prevent with exhaustive testing before and during the implementation and close monitoring of all the processes and information.

ACKNOWLEDGEMENT

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REFERENCES

ANALYSIS OF EATING HABITS USING SOUND INFORMATION FROM A BONE-CONDUCTION SENSOR

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ABSTRACT
In recent years, an increasing number of people have been suffering from lifestyle-related diseases such as metabolic syndrome. Although it is important to monitor eating habits to prevent lifestyle-related diseases, no objective sensing or analysis systems have been established yet. Thus, we have been developing an analysis method to differentiate activities at meal times using wearable sensors. The sensing hardware consists of a bone-conduction microphone connected to a portable IC recorder that collects vibration signals from internal body sounds. In the differentiation process, we adopted a wavelet function to extract features that may be relevant to characterize activities at meal times, to produce 70 features from the coefficients after discrete wavelet transformation. Then, we selected an optimal features set using the minimal-redundancy-maximal-relevance (mRMR) criterion, and we finally used a probabilistic neural network (PNN) to classify activities at meal times. Experiments were first carried out on small data set collected from six people. Then, we did further evaluation. The classification of activities at meal time using our proposed differentiation process, resulted in an accuracy of 87% with the larger database including data from 10 food types of 15 participants in the evaluation, and the selected features set was independent of individual differences. Additional analysis was carried out applying principal component analysis (PCA) on extracted features, and we succeeded in obtaining information on food hardness.

KEYWORDS
Monitoring of eating habits, wearable sensing system, wavelet features, mRMR, PNN.

1. INTRODUCTION
An increasing number of people have been suffering from lifestyle-related diseases in recent years, such as obesity and metabolic syndrome (MS). Thus, the Japanese government has been promoting healthier daily lifestyles, focusing on exercise, rest, meals, moderate alcohol consumption, and abstinence from smoking. It is already currently possible to monitor daily sleep quality [1] and calorie consumption [2] with wearable sensors. However, no objective ways of monitoring eating habits have yet been established. Healthcare specialists identify the regularity of meal times, number of masticatory cycles, and types of foods eaten as essential factors in evaluating eating habits. Modifications to lifestyles such as improving one's eating habits can significantly prevent obesity [3], which is related to many other diseases such as hypertension [4], heart diseases [5], and diabetes [5].

Current sensing systems for monitoring eating habits are usually not very convenient. For instance, some devices measure the myoelectric potential from the masseter muscle to count the number of bites [6] [7]. The attention of researchers has recently started to focus on analyzing eating habits using internal body sounds, from which it has been demonstrated that it is possible to count the number of masticatory cycles [8] and differentiate speaking from meal-related activities [9]. Also, there is a great deal of research related to classification using sound [10] [11].

However, the accuracy of classification is greatly influenced by an individual's manner of eating. In our previous paper [9], although high accuracy was achieved by using an individual database, accuracy drop down when using a unique database independent of individuals, which means the system has to be calibrated to each individual. Indeed, eating sound signal is very different from person to person because of specific chewing behavior, so that we cannot extract general features from only frequency domain.

In this paper, we propose a method of classification that is less influenced by individual differences. Moreover, we explored food texture properties. An important finding is that from extracted features, we can
then use principal component analysis (PCA) [12] to analyze the textures of foods and output can be used to estimate food hardness, the dynamic state of the food texture can be visualized instead of static analysis.

We present our proposed data analysis system in Section 2 of this paper. Then, in Section 3 we describe the experimental conditions and protocol for data collection. In Section 4 we describe our method for features extraction and optimal features set selection. The experimental results are presented in Sections 5 and 6. We present our results for classification of activities at meal times in Section 6, and food-texture analysis is introduced in Section 6. Finally we conclude on the results obtained in the last section.

2. EATING HABITS MONITORING SYSTEM

2.1 System for Data Analysis

The system for data analysis produces two main outputs, i.e., the first for classification of activities at meal times and the second for food-texture analysis as outlined in Figure 1. The reasons we propose this system are given in the remainder of this section.

![Figure 1. Structure of system for data analysis](image)

2.2 Classification of Meal-related Activities

2.2.1 Feature Selection

To extract features relevant for meal-related activities, we considered the physical mastication process during eating, so that we chose a three seconds window, which corresponds to one to three chewing strokes.

Wavelets are a mathematical tool that can be used to extract information from many kinds of data, such as those from audio and images. As wavelet transform contains information on both time and frequency domains, it represents a powerful tool to analyze and observe details on non-periodic signals. This technology has also been proved to be powerful when applied to the field of classification [13] [14]. In this study we used a discrete wavelet transform (DWT) [14] whose definition is

\[
T_{m,n} = \int_{-\infty}^{\infty} f(t) \psi_{m,n}(t) dt
\]

\[
\psi_{m,n}(t) = a_0^{-m/2} \psi(a_0^{-m} t - n b_0),
\]

where \( \psi(\cdot) \) is a wavelet function, and the integer \( m \) controls wavelet dilation and \( n \) controls translation. Here, \( a_0 \) is a specified fixed dilation step parameter used to change the scale set at a value greater than one, and \( b_0 \) is the location parameter, which must be greater than zero. \( T_{m,n} \) are the discrete wavelet values given on a scale-location grid of index \( m, n \). The \( T_{m,n} \) are known as wavelet coefficients or detail coefficients.

The coefficients of wavelet decomposition were adopted in this research. Several statistical quantities of detail coefficients were adopted as features in this research. Features were extracted for each sound sample from ten levels of wavelet decomposition, using Daubechies basis 5 (db5). Db5 is an orthogonal basis wavelet with no information loss. Also, as it has a high number of vanishing moments and is asymmetric, so
it is suitable to model complex asymmetric signals such as eating sounds. Seven statistic properties of detailed coefficients issued from wavelet decomposition were used to finally extract 70-dimensional vector of features for each sound samples. The seven statistical properties are summarized in Table 1.

Table 1. Statistical parameters for extracting features

<table>
<thead>
<tr>
<th>Serial numbers</th>
<th>Statistic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean value of coefficients</td>
</tr>
<tr>
<td>2</td>
<td>Standard deviation of coefficients</td>
</tr>
<tr>
<td>3</td>
<td>Ratio of mean values of adjacent sub-band</td>
</tr>
<tr>
<td>4</td>
<td>Power of wavelet coefficients</td>
</tr>
<tr>
<td>5</td>
<td>Max. value of coefficients</td>
</tr>
<tr>
<td>6</td>
<td>Min. value of coefficients</td>
</tr>
<tr>
<td>7</td>
<td>Range of coefficients</td>
</tr>
</tbody>
</table>

Feature selection would be helpful to reduce the dimensions of features since there are redundancies in extracted features [16]. mRMR [17] was adopted in this research to select features to enable all wavelet-extracted features to be ranked regarding their relevance and information redundancy. The features were selected by using leave-one-out cross validation combined with a Probabilistic Neural Network (PNN).

2.2.2 Classification and Food Texture Analysis Schemes

Eating sounds have characteristics of being kinds of non-linear signals that contain a great deal of noise and are more prone to individual differences. Artificial neural networks are suitable to handle these because they are very robust in dealing with all non-linear and complex signals. Moreover, the fault tolerance of neural networks is necessary to reduce the influence of noise. Among them, PNN [18] is a kind of artificial neural network that has been proven by many researchers to be suitable for classification tasks [19] [20]. For a univariate case, the probability density function for each data class can be estimated by Parzen’s estimation [21]. And Cacoullos [22] expanded Parzen’s nonparametric estimator for the multivariate case.

The food texture was analyzed using a PCA on extracted features. We found that the first principal component of the extracted wavelet features could be a good index for the hardness of the food. PCA [12] is a mathematical method that reduces the dimensionality of data by analyzing the covariance between factors. Its general objectives are to reduce and interpret data. Technically, a principal component can be defined as a linear combination of optimally weighted observed variables.

3. EXPERIMENTS

3.1 Sensing Devices

A prototype of a wearable sensing system (Figure 2) to analyze eating habits using bone-conduction microphone (Vibraudio EM20 from TEMCO Corp.) with an IC recorder (LS-10 from Olympus Corp.) was developed in our previous work [9] to record internal body sounds signal.

![Figure 2. System for sensing eating habits](image)
3.2 Details on Experiments

The experiments were designed to have two parts. The first was used to obtain a dataset to extract and select features and the second part was used to obtain a validation dataset.

The experiments were carried out on 6 participants. Concrete information is listed in Table 2. We obtained 330 samples from the experiments after preprocessing the collected data. Half of them were used to extract and select features to classify meal-related activities and the other half was used to evaluate the results. These examples involved participants eating three types of food, drinking, and speaking.

Large-scale experiments were conducted to evaluate the selected features as well as classify meal-related activities and assess the system for analyzing food textures. We increased the number of participants from 6 to 15, and also food types. The other parameters were the same as those in previous experiments. The food types in the experiments are listed in Table 3. Following four more natural eating processes were included in the experiment protocol to evaluate feature selection results.

- Participants ate and drank continuously during the recording procedure.
- The sound of teeth hitting when participants ate very soft food was retained as noise.
- The amount of food and drink as well as the speed at which participants ate and drank were not regulated in the experiments to enable the results to be evaluated.
- The number of samples varied in labels of eating hard food, eating soft food, drinking, and speaking.

By using the preprocessing method we previously described, 9000 samples were obtained for evaluation.

Table 2. Experiments’ food types to obtain dataset for feature extraction and selection

<table>
<thead>
<tr>
<th>Soft foods</th>
<th>Hard foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice ball</td>
<td>Pickles</td>
</tr>
<tr>
<td>Bread</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Experimental food types for validation dataset

<table>
<thead>
<tr>
<th>Soft foods</th>
<th>Hard foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream puffs</td>
<td>Sugar candies</td>
</tr>
<tr>
<td>Lemon bread</td>
<td>Peanuts</td>
</tr>
<tr>
<td>Cream filled bread</td>
<td>Rice crackers</td>
</tr>
<tr>
<td>Bananas</td>
<td>Potato chips</td>
</tr>
</tbody>
</table>

4. RESULTS OF MEAL-RELATED ACTIVITIES CLASSIFICATION

This section discusses feature extraction and selection methods for the meal-related activities classification and how we classified these activities using the methods we propose.

4.1 Feature Extraction and Selection

Feature extraction and selection in this research were based on 165 samples. The features were selected by cross validation combined with a PNN classifier. Figure 3 presents the overall error rate recognized for our four labels of eating hard food, eating soft food, drinking, and speaking using PNN with the control groups such as linear classifier (LC) and support vector machine (SVM) using LIBLINEAR [23] and LIBSVM [24], depending on the number of features ranked by mRMR.

We selected feature sets from these results. We called the selected one "proposed features", which contained features ranked by mRMR to achieve the lowest error rate for specific classifiers. Detailed information on these features is given in Table 4. The proposed features were derived in the following format.

\[ F(num1),(num2) \]

where num1 is the decomposition number and num2 is the serial number of the statistic parameters for extracting the features in Table 1. Concrete information on the proposed features is listed in Table 4. The numbers of best case features using LC, SVM, PNN were fixed by using the results shown in Figure 3, those are 70, 18, 21 accordingly.
Table 4. Information on proposed features using PNN

<table>
<thead>
<tr>
<th>Categories</th>
<th>Features</th>
</tr>
</thead>
</table>

Figure 3. Error rate in classification using specific classifier depending on number of features ranked by mRMR

4.2 Results of Classification

In this section, validation for proposed wavelet-based features as well as the classification method using 9000 samples was conducted and the detailed explanation for the validation results was illustrated in the discussion part.

Table 6 summarizes the results of classification based on the 9000 samples and Table 7 provides results on classification including eating hard food (EH), eating soft food (ES), drinking (DR), and speaking (SP).

Table 6. Results of classification experiments in Table 3

<table>
<thead>
<tr>
<th>Feature set</th>
<th>Classification score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC</td>
</tr>
<tr>
<td>FFT-based features</td>
<td>61</td>
</tr>
<tr>
<td>Wavelet-based features</td>
<td>70</td>
</tr>
</tbody>
</table>

Table 7. Detailed results of classification experiments in Table 3

<table>
<thead>
<tr>
<th>Feature set</th>
<th>Classification score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC</td>
</tr>
<tr>
<td></td>
<td>EH</td>
</tr>
<tr>
<td>FFT-based features</td>
<td>39</td>
</tr>
<tr>
<td>Wavelet-based features</td>
<td>65</td>
</tr>
</tbody>
</table>

4.3 Discussion

According to the results of classification in Table 6, accuracy is low by using a Linear Classifier (LC) and a support vector machine (SVM). We can tell that classification results by using these classifiers are greatly affected by more natural eating processes, which are more influenced by varieties of noises. The results also
reveal that PNN is more robust face to more natural situations. Proposed wavelet features works better than the FFT based features according to the classification results.

We need to refer to Table 7 for a more detailed discussion. We can identify the eating activities very well from the data in this table. Mistaken classifications were approximately well distributed to three other labels for the activities of drinking and speaking, as we can see from the data. The false-classification results for the activities of eating soft foods were more mistakenly classified as eating hard foods, and eating hard foods were more mistakenly classified as eating soft foods, except for the previous reasons. One more reason that clarifies why these two activities were classified mistakenly is because the texture of food changes during the eating process. As hard foods become increasingly soft, there is a point where these two eating activities merge, as we will argue in the next section. And the recognition ability for drinking is low because the drinking sound is very similar with the swallowing sound during eating.

5. FOOD-TEXTURE ANALYSIS

5.1 Hypotheses

5.1.1 Food-hardness Trajectory from Results of PCA

Figure 4 represents the results from PCA for 5 different participants using part data in the validation dataset (9000 samples), which are plotted darker with increasing chewing time. The results indicate that the first principal component variations are related to the eating process, and may be related to the texture of food.

5.1.2 Discussion and Hypotheses

We obtained various trajectories that provided food texture information according to the results.

![Figure 4. Visualization of PCA results for 5 participants, showing food texture evolution during chewing](image)

As our features were still in high dimensional spaces after features selection, we decided to apply PCA to the 70-dimensional vector of features originally extracted from wavelet coefficients to be able to map those with the greatest variations into a low dimensional space, and investigate their physical significance.

According to the results of PCA, we could arrive at two preliminary hypotheses.

- Hypothesis 1: We can visualize the chewing segment (from the beginning of the chewing procedure to its end), and we can further surmise that the relative distance between visualized samples differs depending on food textures, e.g., the distance is longer if the food being chewed has a harder texture.
- Hypothesis 2: The beginning of each chewing segment may be good way to describe the textures of different food types in detail.
5.2 Food Hardness Analysis

In Figure 5 all tested eight types of food chewing activities for one participant are illustrated in the same figure and the starting points are connected by lines using validation dataset. Each trajectory in this figure was plotted by using one chewing segment from the sound data.

From the results, two kinds of information could be obtained. First, food softens with the chewing process according to the trajectory from PCA analysis; second, the starting point can describe the hardness of different types of food.

5.3 Evaluation of Food-texture Hypotheses

The food types we selected for this evaluation are listed in Table 3. According to common sense and a reference book [25], bananas are the softest of these foods, cream puffs and cream-cheese-filled bread can be considered to have similar food textures, and lemon bread is slightly harder. Rice crackers are the hardest food, sugar candies are the second hardest, and we can consider potato chips and peanuts to be similar in hardness.

Thus, we defined five categories (1-5) from harder to softer textures according to the average number of strokes for chewing 10 grams of each food defined in the reference book [25] and grouped the food we experimented on by category. Concrete information is listed in Table 8. Each category corresponds to one level of hardness. In other words, we defined five levels of hardness for the foods.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice crackers</td>
</tr>
<tr>
<td>2</td>
<td>Sugar candies</td>
</tr>
<tr>
<td>3</td>
<td>Peanuts</td>
</tr>
<tr>
<td>4</td>
<td>Potato chips</td>
</tr>
<tr>
<td>5</td>
<td>Cream puffs</td>
</tr>
<tr>
<td></td>
<td>Cream-cheese-filled bread</td>
</tr>
<tr>
<td></td>
<td>Lemon bread</td>
</tr>
<tr>
<td></td>
<td>Bananas</td>
</tr>
</tbody>
</table>

We tested 15 participants and we analyzed one segment from each activity for all participants to evaluate the food textures to reach preliminary conclusions according to two procedures.

- Check the average distance between consecutive dots in the variations direction of the first principal component to evaluate hypothesis 1.
- Check the relation between the starting points of each activity to evaluate hypothesis 2.
Table 9 lists the results for the following procedures. The output in our evaluation was True (T) or False (F). From the results in Table 9, hypotheses 1 and 2 are true in most situations (93.3%).

<table>
<thead>
<tr>
<th>Participants No.</th>
<th>Distance order from large to small by categories</th>
<th>Teeth hits in chewing cycles</th>
<th>Evaluation results 1</th>
<th>Evaluation results 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>2</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>3</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>4</td>
<td>1, 2, 3, 4, 5</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>5</td>
<td>2, 3, 1, 4, 5</td>
<td>Y</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>6</td>
<td>1, 2, 5, 3, 4</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>7</td>
<td>1, 2, 3, 5, 4</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>8</td>
<td>1, 2, 3, 5, 4</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>9</td>
<td>1, 2, 3, 4, 5</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>10</td>
<td>1, 2, 3, 4, 5</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>11</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>12</td>
<td>1, 2, 3, 5, 4</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>13</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>14</td>
<td>1, 2, 3, 4, 5</td>
<td>N</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>15</td>
<td>1, 2, 3, 5, 4</td>
<td>Y</td>
<td>T</td>
<td>T</td>
</tr>
</tbody>
</table>

Information on many teeth hits in chewing cycles when chewing very soft food (Y=Yes, N=No) detected manually.

True of evaluation results 1 is occurred in two situations.
- If there are few chewing cycles where teeth hit each-other when chewing very soft food, then the distance between samples according to time in the PCA plot and food hardness is in the same order.

True of evaluation results 2 is occurred in two situations.
- If there are no chewing cycles where teeth hit each-other when chewing very soft food, then the order of the starting point to visualize each chewing segment is the same as the order in the hardness categories.

6. CONCLUSIONS

We proposed a novel method of analyzing eating habits, which characterized activities at meal times from body internal sound signal features extraction using wavelet decomposition. Meal time related behavior classification is a really difficult task especially using such a noninvasive method as using sound since the accuracy was influenced largely by individual differences.

We proposed wavelet feature set to classify activities at meal times. Our method not only demonstrated a high degree of accuracy for identifying meal-related activities (eating hard and soft foods, drinking, and speaking) in realistic situations, but also greater independence regarding individual differences. The results from analyzing food types also suggested that our lower dimension space mapped applying PCA in our feature space is a good descriptor to estimate the hardness of food for individuals and eliminates differences between different people.

This method can be integrated to a healthcare system such as the one demonstrated in paper [26] in order to provide services in daily life. We are building such a system demonstrated in Figure.6, and the system will be improved from the feedback of the medical users in the future. Practically speaking, the sound data recorded over a few days by a wearable sensor is supposed to be sent to a data center and analysis results calculated in the data center would be presented to the user or to his or her doctor. Then the user could make dietary modifications according to the feedback from the doctor using the data from eating habits monitoring system.
ACKNOWLEDGEMENT

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REFERENCES


ABSTRACT

Primary care brings promotion and prevention, cure and care together in a safe, effective and socially productive way at the interface between the population and the health system. The features of healthcare that are essential in ensuring improved health and social outcomes are person-centeredness, comprehensiveness and integration and continuity of care, with a regular entry into the health system, so that it becomes possible to build an enduring relationship of trust between patients and their healthcare providers. The adoption of a successful primary care system premises active participation of users who are familiar with the cooperative and collaborative nature of healthcare delivery. Thus, there is a need for reusable, flexible, agile and adaptable training content with the objective to enable healthcare professionals instill their knowledge and expertise in primary care processes. To this end, social software, such as a wiki, could be used as it supports cooperation and collaboration anytime, anywhere, combined with semantic web technology that enables structuring pieces of information for easy retrieval, reuse and exchange between different systems and tools. In this paper, a semantic wiki is presented as a means for developing training material for healthcare providers regarding healthcare processes in primary care. The semantic wiki should act as a collective online memory containing training material that is accessible to authorized users, thus enhancing the training process with collaboration and cooperation capabilities. It is also proposed that the semantic wiki is stored in a secure virtual private cloud that is accessible from anywhere, be it an excessively open environment, while meeting the requirements of redundancy, high performance and autoscaling.

KEYWORDS

Semantic wiki; user training; primary care.

1. INTRODUCTION

The drive in healthcare to reduce cost and improve quality requires enhanced cooperation and collaboration among disparate healthcare units. Hence, considerable attention has been paid to designing process models of healthcare delivery, including primary care delivery, and on developing healthcare information systems that support intra- and inter-organizational healthcare processes, focusing on reducing (or eliminating) medical errors and improving quality of care (Makris et al, 2009; Wieringa et al, 2003). A primary care system is delivered by a combination of different disciplines such as general practitioners (GPs), social workers, dentists, pharmacists, psychologists, very often working in isolation. This results in lack of coordination of care which, in turn, may result not only in failure to improve patient health, but also in duplication of medical tests and procedures, thereby increasing the cost of care. In some cases, lack of coordination may actually result in detrimental health outcomes. Furthermore, well-defined primary healthcare processes will enable virtual healthcare teams to cooperate in the care of patients (Makris et al, 2009; Wieringa et al, 2003). Thus, one important consideration in primary care system adoption, is to enable and foster active user participation, since users are required to think of their activities as constituents of healthcare processes and, hence, to instil their knowledge and expertise in the definition and automation of healthcare processes while paying due regard to culture.

The development and management of value-added healthcare processes requires extensive and continuing education of healthcare professionals. Properly designed user training material should enable users understand process-oriented healthcare delivery, visualize the inter-organizational healthcare processes, assimilate the logic underlying existing processes and identify areas where redesigning existing processes is required in order to adapt to today’s dynamic healthcare environment (Lenz and Kuhn, 2004; Makris et al,
The knowledge that these intra and inter-organizational healthcare processes contain (e.g., flow of activities, resources involved, physical location, coordination requirements) and the data content must be made explicit through training so that healthcare professionals understand the requirements of the environment and participate collaboratively in its development and adoption. Furthermore, this knowledge could also be disseminated from healthcare professionals to other users to efficiently use the primary care system. This paper focuses on the objective of empowering user-to-analyst interaction, being particularly concerned with designing and developing relevant training material for healthcare professionals, regarding both primary care system development and adoption.

In particular, to enable users understand the concepts regarding healthcare processes in a primary care system, a semantic wiki is used as a collaborative tool that highlights the relevant knowledge expressed by a domain ontology and to develop and provide relevant training material (Chebotko, 2005). The training system architecture is based on a virtual private cloud environment to allow authorized healthcare professionals modify the training material in order to adapt healthcare processes to changing requirements, share healthcare process definitions and access them anytime and from anywhere. Furthermore, the cloud-based semantic wiki proposed possesses several advantages including access control (who has access to the information stored on the cloud and under what conditions), redundancy (effective recovery in case of machine/data failure), high performance and auto-scaling (capacity additions/removals into a cloud infrastructure based on actual usage and without human intervention) (Fitzgerald and Chalk, 2010; Oren, 2006).

2. BACKGROUND

Primary care is the integration of services that promote and preserve health; prevent disease, injury and dysfunction; and provide a regular source of care for acute and chronic illnesses and disabilities. Primary care serves as the usual entry point into the larger health services system and takes responsibility for assuring the coordination of health services with other human services. The primary care provider incorporates community needs, risks, strengths, resources, and cultures into clinical practice. The primary care provider shares with the family an ongoing responsibility for health care. In both the manner of its organization and the methods of its delivery, effective primary care for children and adolescents, including children with special health needs, incorporates and manifests certain essential attributes such as first contact, continued, coordinated, comprehensive, community oriented, family oriented, accessible, culturally competent, developmentally appropriate and accountable (Johansen et al, 1994).

Personal health records (PHRs) can integrate care delivery across the continuum of services and also coordinate care across all primary care settings. Hence, all relevant information for patients is readily available to GPs so that they can issue referrals for medical procedures or they can issue drug prescriptions. One of the biggest hurdles to overcome for the adoption of PHR is a lack of motivation among people to use these records unless faced with live threatening illnesses. In some countries, physician practices, clinics and hospitals are provided with the financial incentives for implementing electronic and personal health records. To this end, there is a need for a two-part education effort. First, providers will have to show their patients what they are making available and how it can be accessed as the various parts of their PHRs go online. Secondly, providers will find a motivation to adopt a primary care system, to believe that such a system can improve healthcare quality and reduce medical errors (Bates, 2010).

Pharmacists, on the other hand, can play a more active role in primary care. Placing pharmacists in the doctor's office instead of in a more traditional role allows for a more collaborative approach to medication management in primary care (Goldman et al, 2010). Therefore, by collaborating, doctors and pharmacists give the best outcome for the patient. Pharmacies can communicate with physicians through ePrescribing systems to clarify prescription orders and process renewal requests (Goldman et al, 2010; Lapane et al, 2010; NGA Center for Best Practices, 2009). EPrescribing is a promising approach as healthcare costs augmentation and poor quality impact are major concerns. Evidence today suggests that the use of ePrescribing can result in (Lapane et al, 2010):

- reduction in costs
• improved patient safety, decreasing the risk of medication errors, reducing oral miscommunications regarding prescriptions and providing warning and alert systems at the point of prescribing (drug-drug interactions, drug-allergy interactions, drug appropriateness etc)

• improved coordination of care

• administrative efficiencies.

Healthcare systems have been slower to adopt ePrescribing standards. ePrescribing must be understood in the context of the whole medicine use process. Beyond these central stakeholders – doctors and pharmacists – are many other healthcare professionals who are potential users of ePrescribing if and when they need to review a patient’s medication, like staff of insurance agencies and hospital staff (Lohr et al, 2010; Trend Micro, 2010).

The motivation of individual healthcare professionals to use primary care system is equally important. Everybody who will use primary care system needs to understand the overall vision of a more robust primary care and the change that accompanies a primary care system implementation. But they also need to be motivated by a primary care system that is easy to use, and helps them accomplish their own tasks. To help achieve this, users will need to be trained. The aim of training is to get staff up to speed with basic healthcare processes, so they can work effectively. But training can also build up confidence, reveal concerns or pick up important bugs or problems within a system.

Unfortunately, there is a lack of focus on training. Are healthcare professionals open to change? For a successful primary care system implementation to occur, healthcare professionals will need to focus on necessary decisions and changes. This means allocating extra time for training. All healthcare stakeholders should collaborate to encourage widespread adoption and optimal use of standards-based primary care system through collaborative development and delivery of education resources, training, and support (eHealth Initiative, 2006). Several training materials are provided worldwide, focusing on educating healthcare professionals to use the primary care system. These efforts are particularly concerned with adopting and using the primary care system and not with designing and developing value-added primary healthcare processes. A training material that supports the active participation of healthcare professionals both in system’s development and adoption is needed.

3. MOTIVATING SCENARIO

Healthcare delivery is, nowadays, characterized by the need for increased cooperation and collaboration among functional units. Hence, considerable attention has been paid on designing new healthcare processes or redesigning existing ones, according to current requirements (Lenz and Kuhn, 2004; Makris et al, 2009; Wheeler and Wheeler, 2009). This requires active user participation so that users’ knowledge and expertise is incorporated into healthcare process definitions. In turn, this requires an effective user-to-analyst interaction which can be facilitated by a user awareness activity on healthcare process management concepts which calls for a suitable and adaptable training content to be made available to users anytime and from anywhere.

As part of the primary healthcare process physicians order examinations and prescribe drugs, in addition to specifying diagnosis based on objective and subjective elements. To illustrate the main principles of the training approach proposed, consider a healthcare process scenario concerned with e-prescribing. A patient contacts her/his physician regarding a health problem and the physician, in turn, after consulting the patient’s PHR, issues an e-prescription, which is sent to the pharmacist. In this way, physicians select medications that are on formulary and are covered by the patient’s drug insurance and are being informed of lower cost alternatives such as generic drugs. In addition, physicians can access a timely and clinically sound view of a patient’s medication history at the point of care, decreasing the risk of preventable medication errors (Bratsas et al, 2009).

The above scenario provides an example implementation of an ePrescribing service, integrated into the primary care system: A physician uses an ePrescribing application which is interfaced to a PHR system, reads the summary record of his/her current patient and selects one or more drugs from the Insurance Organization’s formulary based on information regarding eligibility status and ID numbers of the medication list covered. Upon selection of one or more drugs by the physician, the ePrescribing application performs validation checks (e.g. regarding drug interactions, patient allergies and medication history) to either clear the prescription or return alert information to physician. In case of a clear prescription, the prescription is stored,
as pending, in the medication profile area of the insurance organization’s designated data center. A pharmacist connects to the insurance organization’s cloud infrastructure, selects the patient’s prescription and executes it. Thus, the patient or a delegated person thereof collects the prescribed drugs from a pharmacy of his/her choice (Puustjärvi and Puustjärvi, 2006).

Figure 1. A training ontology for the ePrescribing process

Figure 1 shows an ontology for the ePrescribing process. The ontology includes for example the following information (Puustjärvi and Puustjärvi, 2006):

- ePrescribing is executed by a physician and it is targeted at a patient.
- An e-prescription of a patient may precede other e-prescription of the patient.
- Each e-prescription includes a drug.
- Each drug has a price, and it may have one or more substitutable drugs.
- Each drug corresponds to a medicinal product.
- Each drug belongs to a product group.
- Each personal health record (PHR) is associated with a patient and the patient and his/her physician can write information on it.

Design or redesign of the ePrescribing process model can be performed by manipulating already defined objects, providing flexibility, agility and reusability of the training material designed.
4. A SEMANTIC WIKI ARCHITECTURE ON A CLOUD

The need for providing training material for primary healthcare processes requires a collaborative and cooperative training environment so that users of primary care system not only acquire knowledge about the training objects but they also learn the relations between them. The emerging social dimensions of the Internet are exemplified in new and dynamic interactive tools such as wikis. Social networking is a popular pastime for many trainees, and increasingly, such activities are transgressing institutional boundaries such as the provision of virtual learning environments (Berners-Lee et al., 2001; Bicer et al., 2005; Wheeler and Wheeler, 2009). Wikis allow for collaborative knowledge and can be helpful in learning models (Bratsas et al., 2009; Landefeld and Sack, 2009).

In particular, semantic wikis allow users to add semantic annotations to the wiki content, offering better navigation and information retrieval (Bratsas et al., 2009; Oren, 2006). Hence, nowadays, semantic wikis constitute a popular semantically enhanced collaborative knowledge management system, mostly because it tends to make semantic technologies accessible to non-expert users and that they make the inherent structure of a wiki accessible to machines beyond mere navigation (Anand et al., 2010; Huner and Otto, 2009; Landefeld and Sack, 2009). Users can query the annotations directly or create views from such queries, navigate the wiki using the annotated relations and introduce background knowledge to the system. Semantic wikis extend traditional wikis in the way that they allow structured knowledge to be described in a formal language, instead of processing solely hypermedia-based content. This is either be done by appending metadata to wiki pages or by including knowledge inside the unstructured text by using extensions to the wiki markup language. The latter approach is used by the SemanticMediaWiki project (Oren, 2006), which extends the existing wiki markup to enrich hyperlinks between wiki pages with semantic relations. The approaches have in common that they interpret the existing wiki pages as entities, and hyperlinks as relations among them.

In this paper, a prototype system of knowledge acquisition is presented to support training in primary healthcare processes that consists of the following modules:

- An LMS system called JoomlaLMS which supports interfaces with Web2.0 technologies and external applications.
- The Semantic MediaWiki (SMW) as a tool to acquire and share knowledge.
- The OntologyEditor extension of SMW to develop ontologies and ensure consistency of the knowledge base by a set of knowledge repair algorithms.
- The Halo extension of SMW to facilitate the authoring, retrieval, navigation and organization of semantic data in SMW.
- The Halo Access Control extension of SMW to protect content, allowing easy administration of access rights and user groups (Bratsas et al., 2009).

This prototype system aims at identifying and serving users’ needs when they are trained to support primary healthcare processes. To this end, users’ behavior and profiles have been taken into account in the design of the prototype system.

The training system proposed has been implemented onto the Amazon cloud infrastructure that provides a flexible, scalable and low-cost cloud computing platform. Users of the semantic wiki collaborate using the same shared datastore for storing and retrieving the semantic annotations (Smith, 2006). Amazon Simple Storage Service (S3) is used to provide a highly durable storage infrastructure. Amazon provides a secure cloud infrastructure in terms of physical security, backups and cloud services security. In particular, Amazon EC2 security includes a stateful firewall, signed API calls, instance isolation and network security such as distributed denial of service attacks, man in the middle attacks, IP spoofing and port scanning. Amazon S3 security enables to determine how, when, and to whom have to be exposed the information stored on the cloud. Amazon S3 APIs provide both bucket- and object-level access controls, with defaults that only permit authenticated access by the bucket and/or object creator. In addition, in order to ensure that information will not be intercepted while in transit from a node in the Internet to cloud services, Amazon S3 is accessible via SSL encrypted endpoints and these points are accessible from within Amazon EC2 (Amazon Web Services, 2010; Baron and Schneider, 2010; Buyya et al., 2009). For networking and security issues, Amazon Virtual Private Cloud (Amazon VPC) was used, which integrates with EC2 and functions as a secure bridge, enabling the healthcare organization that provides the training material to connect his existing infrastructure to a set of isolated Amazon web services and compute resources via a Virtual Private Network (VPN).
connection using industry-standard encrypted IPsec VPN connections (Amazon Web Services, 2010; Baron and Schneider, 2010; Buyya et al, 2009). In this context, it is ensured that only users with specific IPsec VPN connections can access the training material included in the semantic wiki developed.

5. RESULTS

The approach proposed in this paper is concerned with capturing the knowledge found in healthcare processes of the primary care system and in structuring this knowledge in terms of an ontology that contains all relative concepts, instances of concepts and relations between them. The semantic wiki relates the basic entities defined in the ontology with the corresponding text. Thus, the training user is enabled to search through the semantic wiki for an ontology construct, understand its meaning and usage with the help of the supportive text and navigate to associated ontology constructs. In this way, an in-depth understanding of each healthcare process is ensured.

Semantics wikis address core problems of traditional wikis: consistency of content (same information on many pages), accessing knowledge (finding and comparing knowledge from different pages) and reusing knowledge. With regard to the creator of the training material, the main advantage of the proposed model is content reusability. From the trainee’s point of view, the main advantages are semantic search, knowledge or conceptual navigation and knowledge dissemination and ease of use without further education and training.

The cloud solution has significant advantages to healthcare organizations such as cost saving, accelerated time to delivery, offloaded maintenance and management to the cloud, elastic resources, redundancy and scalability. More importantly, due to the information sharing capability, healthcare professionals can share standardized and best practice medical protocols thus improving the quality of care provided. In addition, the virtual private cloud approach ensures that training content will always be available to authorized users.

6. CONCLUDING REMARKS

Healthcare is an increasingly collaborative enterprise involving a variety of activities (administrative, paramedical, nursing and medical) that are interconnected into healthcare processes in a manifold manner and are performed within and outside healthcare organizations. This paper takes the stance that a process-oriented view of primary healthcare delivery contributes to cost containment and quality improvement that healthcare professionals need an effective training aid that facilitates their participation in the adoption of a primary system. Thus, a prototype approach to structuring training content in relevant healthcare processes is proposed. The approach is based on a semantic wiki implemented on a cloud environment. Thus, it defines a general ontology, refines the general ontology by adding all ontology constructs required, implements the semantic wiki infrastructure and implements the semantic wiki in a virtual private cloud. Due to the encouraging results of the approach described, it is intended to evaluate it extensively using more complex healthcare processes.

REFERENCES


ASSESSMENT OF SKILLS AND ATTITUDE OF DENTAL STUDENTS AND INTERNS TOWARD DENTAL INFORMATICS IN KSU

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ABSTRACT
Objectives: This study aimed to (i) assess basic dental informatics (DI) skills and computer readiness of undergraduate dental students and interns at the College of Dentistry, KSU, (ii) assess students and interns’ attitude toward dental informatics, (iii) to investigate the relationship between DI skills and attitude along with other factors such as age, computer and internet accessibility.

Methodology: A paper-based questionnaire arranged in five sections was distributed to all undergraduate dental students and interns at the College of Dentistry, KSU, Riyadh, Saudi Arabia. The questionnaire sections were modified from previous studies instruments. Section one focused on participant’s demographic data such as gender, age and academic level; section two addressed participant’s current use of computer applications; section three included questions addressing participant’s frequently used medical search engines and sources of information; section four included questions exploring participant’s attitude toward DI; section five, included several questions to assess participants’ basic computer and DI skills in various tasks including typing, emailing and other basic computer applications. The results of the questionnaire were analyzed using SPSS©V17.0.

Results: In total, 320 students (including dental interns) responded to the questionnaire, 56% males and 44% females. The participant age was (21.7 ± 1.7 years; mean ± SD). Skills and attitude were calculated using the study instruments. The participants were familiar with the basic computer skills (skills mean was 68.3% ± 23.5), and had positive attitude (attitude mean was 71.7% ± 25.5), with a significant correlation between skills and attitude (r =0.60, P<0.01). Most of the participants (98.8%) have computer at home and have been using it regularly for (8.5 ± 3years; mean ± SD). However, (92.5%) of surveyed participants reported that they have familiarized themselves with computer applications through personal study and self experience. Computers and Internet were used mainly (ranging from always to frequently) for e-mail (92.1%) and personal use (85.5%). On the other side, utilization of the computer and Internet for academic activity was the least (63.4%). Furthermore, 85.9% of participants used the Internet mainly as a source of information, followed by lecture notes (80.5%). Google Scholar was used by 73.4% of the participants as the highest used searching engine among other searching engines including Pub Med, Ovid, Web of science, and MD consult.

Conclusion: Despite the good computer skills and the positive attitude for undergraduate dental students and interns in this study, however a relatively low level of utilization of these skills in clinical and academic activities was observed. A positive relationship was observed between level of computer application skills and participants attitude, which support the introduction of formal DI training/courses for undergraduate students and Interns.

KEYWORDS
Dental Informatics, computer skills, user attitude, medical informatics, e-learning, dental education.

1. INTRODUCTION
The revolution of information technology and the great advances in computer capacity can effectively be utilized to enhance and improve dental practice and education. Computer usage in dental education has grown as well to enhance traditional teaching strategies, and to provide new methods of learning (Ahmed.I.Albarrak 2010a). In the United States (US), the proportion of dental offices (generalists and specialists) with computers has increased from 11% in 1984 to over 85% in 2000 (Schleyer et al. 2006). In 1997, almost 80% of dentists in the US had computers in their offices, more than 30% have access to the
Dental informatics (DI) is a subset of medical informatics that is a maturing discipline involving in the application of computer and information sciences to improve dental practice, research, education and management (Haux 2010; Kirshner 2003; Schleyer & Spallek 2001; Schleyer 2003a; Schleyer 2003b). The first reported use of computation for medicine was in 1968 in a dental practice at the National Bureau of Standards by Robert S. Ledley (Ledley 1968; Schleyer 2003a). Dental informatics can be defined as the division of medical informatics dealing with the acquisition, storage, processing, retrieval, and application of biomedical data, information, and knowledge to improve dental care, education, research, and administration.

Dental informatics will not replace 'hands-on' care and treatment from a dentist, nor will replace the social quality of face-to-face interaction (Kirshner 2003). In contrast, the science of DI can play an important role in improving the character of the doctor-patient relationship positively (Kirshner 2003), improves health, health care, public health, and biomedical research (Mantas et al. 2010).

Evidence based dentistry (EBD) - one of the DI supported field - which is the use of current best evidence in making decisions about the care of individual patients. EBD can also be integrated with the “clinical decision support systems” (CDSS) to offer up-to-date information on treatment options and drug interactions, which could reduce errors in practice and improve the quality of the patient care and safety. EBD and CDSS can be integrated with the “electronic medical/dental records” (Bleich and Slack 2010; Healey and Lyons 2002; Mendonca 2004).

An example of utilizing DI in education is the “computer-aided learning” (CAL), which can be used for distance learning to allow students to work in their own time and place. It also allows the use of sound, videos and animations (Gupta et al. 2004). “Computerized patient simulations” - a form of CAL - can significantly improve the knowledge and skills of the students and successfully transfer these skills to the clinical sitting (O'donnell et al. 2011).

Dental informatics cannot be utilized if basic skills and infrastructure are not in place and used appropriately (Flores-Mir et.al. 2006; Shu-Sheng Liaw 2002). Many obstacles need to be addressed if DI is to be appropriately integrated in dental practice and education. These obstacles may include physical, technical or psychosocial barriers in the form of perceptions and attitudes (Flores-Mir et.al. 2006). The success of computer utilization was largely dependent upon the faculty's and learners' attitudes toward computers. Approximately 77% of the variance of intent to use information technology was explained by attitudes toward computers (Hebert and Benbasat 1994). In general, no matter how sophisticated and how capable the technology, its effective implementation depends mainly upon users having positive attitude towards it (Shu-Sheng Liaw 2002). If dentists perceive that DI is valuable for practice management or practice efficiency, there will be a greater chance of more general acceptance (Flores-Mir et.al. 2006).

In the Kingdom of Saudi Arabia (KSA), the highest increase of computers and Internet adoption was found to be by nurses. It increased from 5% in 2007 to 14% in 2009. Nurses use the computer and Internet mainly for updating patient file databases (Saudi Communications and Information Technology Commission 2010). However, No previous published studies have been found regarding the skills and attitudes toward DI among dental students and interns in the KSA.

The Dental College in King Saud University (KSU) is considered the first university-based dental training institution in the Arabian Gulf. It trains male and female dentists to provide dental care throughout the country. The first group of students enrolled in the College was at the end of 1975. The College has six academic departments, Department of Restorative Dental Sciences, Department of Prosthetic Dental Sciences, Department of Pediatric Dentistry and Orthodontics, Department of Periodontics and Community Dentistry, Department of Oral and Maxillofacial Surgery, and Department of Oral Medicine and Diagnostic Sciences. It has two campuses, the Diriyah University Campus which is the main school building and the Malaz University Campus.

Part of the University goals are to enhance students' skills so that they use the computer effectively by introducing courses and to lay a foundation to the new vision of self-learning that will provide the students with the learning resources that help them self-study and develop their knowledge and skills.
This study aimed to (i) assess basic dental informatics (DI) skills and computer readiness of undergraduate dental students and interns at the College of Dentistry, KSU including Internet search, data entry, searching and typing (ii) assess students and interns’ attitude toward dental informatics, (iii) to investigate the relationship between DI skills and attitude along with other factors such as age, computer and internet accessibility.

2. METHODOLOGY

2.1 Subjects

This study was conducted at College of Dentistry, KSU in Riyadh, KSA. A paper-based survey consisted of several sections modified from previous published procedures (Ahmed.I.Albarrak 2010a; Rajab and Baqain 2005; Uribe and Marino 2006; Webster et al. 2003), was distributed to all dental students and interns to assess skills and attitudes of undergraduate dental students (first to fifth level) and dental interns toward DI. Data collection took place during the second semester of 2010/2011 academic year.

2.2 Survey Instrument

The survey instrument contained multiple sections; section one focused on participant’s demographic data such as gender, age and academic level; section two, addressed participant’s current use of computer applications; section three included questions addressing participant’s frequently used medical search engines and sources of information; section four included questions explored participant’s attitude toward DI; section five, included several self-evaluating questions to assess participants’ basic computer and DI skills in various tasks including typing, emailing and other basic computer applications.

Skills measurement instruments: 17 Self-evaluating questions were employed to identify participants’ level of proficiency in various tasks including typing, email, creating power point slides, literature searching, creating handouts with tables and other basic computer applications.

Attitude measurement instruments: 29 questions consisted of two parts. In the first part, direct Yes/No items were used, such as “computers often go faulty, computers distract from patient care, all dentists should be able to use a computer, computers make life easier, interested in DI courses” and other questions. While the second part explored the attitude through self-evaluating questions regarding the importance of some basic computer and DI skills.

2.3 Data Analysis

Pearson correlation analysis was employed to assess the correlation between participants' attitude, skill and other parameters. Descriptive and correlation analysis were generated using SPSS©V 17.0.

3. RESULTS

3.1 Demographic Data

A total of 709 questionnaires were distributed, only 320 were returned with a response rate of 45.1%. Males constituted (56%, n=178) and (44%, n=142) were females. Distribution of students in each level is illustrated in Figure 1. The participants’ age was 21.7 ± 1.7 years, (mean ± SD).
The majority of the participants (98.8%) have computers and Internet accessibility at home. However, only 50.2% have accessibility to computers and Internet at the College. Furthermore, the mean rank given by participants for the quality of the computer and Internet availability and accessibility at the College was poor (2.2, 2.1 respectively) on a 5-point Likert scale (1= very poor, 5= very good), Indicating the limited availability of Internet and computer services at the College.

Regarding the number of years of using computers, (59.6%) of the participants were using computers for 6 to 10 years. Most of participants (92.5%) were familiar with using the computers through their personal study and experience. Only 18.2% of the participants were familiar with using computers through a course in the University, mostly from the first and second level students (31.1% and 34.9% respectively) as shown in Figure 2.

Most of the participants (85.9%) were using the Internet as a source of information (ranging from always to frequently) and the majority used it for email and personal use (92.1% and 85.5% respectively). On the other hand, 63.4% of the participants were using computers for academic activities. A significant correlation was observed between using the computer for academic activity and skills (P<0.01). There is also a significant correlation between using computer for email and personal use along with skills and attitude (p<0.01).

Internet was the mostly used source of information (85.9%) followed by the lecture notes (80.5%). On the other side, using the scientific journals was the least frequent source of information (23%). Surprisingly, 41.8% of the participants reported rarely or never using the scientific journals as a source of information.

Google scholar was the mostly used search engine for dental information searching reported by the participants (73.4%), followed by Pub Med (45.1%), as illustrated in Figure 3.
3.4 Participants Attitude and Skills toward Dental Informatics

The questionnaire had 17 items aimed to evaluate the participants’ skills and 29 items to evaluate the attitude which then both were graded as a scale out of 100%.

Nearly two thirds of participant (78.8%) had skills higher than 60% (mean of skills was 68.3% - SD=23.5%). There was no significant difference in skills between students’ academic levels. With regards to attitude assessment, 81.4% of the participants had attitude higher than 60% (mean of attitude was 71.7% - SD= 25.5%). A significant correlation was observed between skills and attitude (r=0.60, P<0.01). According to the DI interest questions, 89.9% of participants were interested in having more DI training, and 76.5% were interested to have a degree or a course in dental informatics. In addition, 74% of the participants were interested in a course to improve their computer skills.

4. DISCUSSION

The results of the current study demonstrated that nearly all dental students and intern participated in the study had computer and Internet accessibility. This finding is similar to the outcomes of surveys conducted in Europe, United Kingdom, and in Jordan (Grigg et al. 2001; Mattheos et al. 2002; Rajab & Baqain 2005). Such constructive findings could help and support in the introduction of DI in the curriculum.

The majority of the participants (78.8%) were familiar with the basic computer skills. Which is in consistent with a study conducted on the undergraduate medical students in KSU (Ahmed.I.Albarrak 2010a). Future consideration should be given to improve the students’ current skills and to integrate these skills in the clinical practice. Mattheos et al. suggested that, basic computer literacy should be a requisite for dental school admission so that students will be able to handle applications in the field of dentistry effectively (Mattheos et.al. 2002).

Compared to other studies conducted in the same field (Ahmed.I.Albarrak 2010a; El Tantawi and Saleh 2008; Webster et.al. 2003), the undergraduate dental and medical students at the University of King Saud (Ahmed.I.Albarrak et al. 2009) revealed positive attitude toward DI regardless of their academic level. This positive attitude is an important indicator of willingness and first step in effective DI integration in curriculum. Furthermore, participants’ responses indicated their perception of the importance of computers and DI in their study and future career.

Several studies have been reported on dental informatics and the use of computers and Internet in dental practice and their potential use as an educational tool (Ahmed.I.Albarrak 2010b; Rajab & Baqain 2005; Schleyer et al. 2003). Previous studies have revealed that a significant relationship exist between computer attitude and its use in institutions and practice. On the other hand, other studies findings suggested that, lack of adequate training and experience is one of the main reasons why practitioners do not use technology in their practice (El Tantawi & Saleh 2008; Grigg and Stephens 1999; Hu et al. 2009; Lang 1995; Schleyer & Spallek 2001; Schleyer et.al. 2003; Smith et al. 2009).

A course in health informatics was introduced within the first year curriculum in the Dental College, KSU since year 2009/2010. At the time of this study conduction only the second level students had the chance to attend and complete this course. Furthermore, a mandatory course in computer skills was introduced in the preparatory year. This computer course started only three years ago, only level 1 and 2 had this course. Nevertheless, this study revealed no significant differences between the skills and attitude of different academic levels including the first and second levels, which could be due to the participants had been using computers and Internet years before entering the College. Approximately, more than half of the participants (59.6%) were using the computer for 6 to 10 years. In addition, this study finding implies that most of the participant gained their skills and computer knowledge through personal study and self experience outside the University. Another explanation could be the level of the courses, which was evaluated by first and second year students as average (33.3% and 40.3% respectively) and poor/very poor by 17.8% and 32.3% of the first and second year students respectively.

Furthermore, the majority of the students are interested in courses to improve their computer skills. A basic computer skills assessment should be conducted and courses should be provided according to the students’ level to address their needs (Ahmed.I.Albarrak 2010a; Link and Marz 2006). Dental informatics courses should also be added to the undergraduate dental curriculum since most of the participants reported
their interest to learn more about it. In the Kassebaum et al. Study, majority of North American dental schools (86%) reported the implementation of DI courses in their curricula, and (82%) desired to increase the DI courses even further during the next few years (Kassebaum et al. 2004). Based on a survey study conducted by William Hendriscon et al; in 2006, at least 25% of North American dental schools, found that sixteen dental schools in the academic year 2002-03 required their participants to purchase or lease laptops as a matriculation requirement and a number of these schools contracts with a commercial vendor to supply a digital version of all curriculum materials and textbooks bundled with the required laptops (Hendricson et al. 2006).

Findings of the current study demonstrated as well that, Internet was the most frequent source of information followed by lecture notes and books, while scientific journals were the least frequent source of information. Students who rarely or never used the scientific journals (41.8%) were mostly from first, second and fourth levels. Findings of a study that took place in Chile (Uribe & Marino 2006), reported that lecture notes were the mostly used source of information followed by the Internet. Using the Internet and lecture notes could demonstrate that, despite the participants’ computers and Internet availability, they lack the sufficient DI skills to use the scientific journals. The design of the curriculum can be another factor for not using the scientific journals. According to Gupta et. al., lecture notes were mostly used because they contain the relevant information required for exams. While scientific journals were used by the least students, because it's difficult to find information in scientific journals and they are long winded and complicated (Gupta et.al. 2004).

The students’ enthusiasm to use the Internet as a source of information and the growing support for the idea of integrating e-learning and DI in the education process (Feeney et al. 2008) to enhance the learning process, develop problem solving skills, facilitate conducting new methods of learning and increase the levels of educational experiences (Ahmed I. Albarrak 2010a; Gjerde et al. 2004). Also, this can reduce the dependence of the students on the lecture notes.

As reported in a study conducted by El Tantawi in 2008, this emphasizes the need to avoid duplication of educational material through traditional and computer-based routes, leading to waste of students’ time (El Tantawi & Saleh 2008). Poor quality of computer and Internet services which were reported by the participants underscore the importance of improving the accessibility and services of computer and Internet for students. This is likely to affect implementation and success of web-based teaching and learning activities.

In the University’s educational strategy, DI should be explored to allow students to focus more on managing their own learning and to work at their own time and pace. At the point of clinical care, dentists have various information needs. For example, Strother, Lancaster and Gardiner surveyed 500 dentists and found that they needed information on new techniques in dentistry, followed by information on products and equipment among other reasons for information seeking (Strother et al. 1986). To meet practitioners’ information needs more efficiently during clinical work; various strategies have been proposed, developed and implemented in the literature to provide the practitioners with DI skills and to develop health information systems.

5. CONCLUSION

Existing University computer and DI courses were found to have no significant effect on students’ competency and attitude. These courses were inadequate to facilitate students and interns acquisition of necessary DI related skills and to integrate the information technology in the future practice. Consequently most of the participants gained their current computer and DI skills and knowledge outside the University campuses.

Despite the good computer skills and the positive attitude, for undergraduate dental students and interns in this study, however a relatively low level of utilization of these skills in clinical and academic activities was observed. The positive relationship between level of computer and DI skills and participants attitude supports the introduction of formal DI training/courses for undergraduate students and interns. It is necessary for further research to be conducted to evaluate and assess such DI and computer courses/training on students’ performance, competency, and attitude.
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THE CARE FOR PLANNING AND CONTROL IN A FRAMEWORK FOR HOSPITAL MANAGEMENT

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ABSTRACT
The paper presents a hierarchical framework for medium/short term planning and control of Healthcare delivery systems which deals with standardization, rationalization and effective measurement of assets capacity. The incorporated architecture is transposing information and communication methodologies, in the shape of Enterprise Resources Planning (i.e., ERP), from the production domain to the Hospital Resources Planning (i.e., HRP) frame. It is designed to translate successful control functions at all different levels of planning in a hospital. This is required for system’s flexibility, strategic decision support, material and resources and production control, patient volume admission and treatment schedule, budgeting analysis. Basically the vision coordinates procedures of operation management: Master Schedule (i.e., MS), Material and Resources Requirement Planning (i.e., MRP), Distribution Requirement Planning (i.e., DRP), Decision Support Systems (i.e., DSS), Finally Assembly Schedule (i.e., FAS). These modules need to be liaised, in an effective while efficient way, by a central engine of information sharing. Furthermore, based on the main holistic vision of the hospital, the material and resource planning & control for a patients’ admission schedule are elaborated in terms of required inputs, designed outputs, control mechanisms, correlated links and knowledge claims. A capacity driven system is fleshed out. This work provides an extremely valuable methodological architecture to healthcare systems that recognizes the strategic role of coordination between resources and requirements. It summarizes the principal factors and relationships that such a modelling tool should incorporate. Implications of the proposal are discussed evaluating hardware and software requirements, gains and gaps in terms of costs, services and quality. The framework is planning to be as a reference base in detailed short term planning for earnings in health care services. Recommendations for future implementation and research development have been finally formulated.

KEYWORDS
Hospital Resources Planning, Decision Support Modelling, Resource allocation, Optimization

1. INTRODUCTION
The increasing, while stronger, request for efficiency into services is of great concern in the worldwide healthcare delivery system. Nowadays, national government are facing with ageing population and consequent increasing request for health care services (OECD 2011). Jurisdictions are trying to drive health spending in product and service slowing down while efficient managing the concerned costs. They are pushing forward to limiting the national level of health care expenditure, as this influences the economic position (with a range, in percentage of the gross domestic product for year 2008, from 11% of France to 9.1% of Italy and 8.7% of United Kingdom and 9% of Spain and 10.5% of Germany and 8.2% of Japan and 16% of United States, with an average amount of expenditures of 3000 €/per capita in European countries (Source OECD-2011)) of a country in the international context. The attention is actually focused on scrupulous care of effective delivery of medical services. This is tying up to improve performances and system’s organization in order to reduce the capital investment while assuring a constant high-quality of service to patient (Lavis et al., 1994). The European Health board pushes towards, albeit very late, Information and Communication Technology (i.e., ICT) investment as support to an efficient management of health “issue” (the slice as percentage of total investment in health arrangement is 28.6% in United Kingdom,
18% in France, 15.3% in Germany, 6.4% in Italy and 4.5% in Spain with a total investment amount of 9 billions of euro (Source: Health Industry Insights 2010\(^2\)). The common way of thinking is that billing and activity evaluation could be controlled by efficient operational management strategies supported by efficacious ICT tools (Rhyne et al., 1988). The investment, besides the pursuit for efficiency of health structures, is looking forward to raising the quality of service. Notwithstanding, the complexity of healthcare system is currently not complying with a good/integrated ICT tool to the management of care (Trimmel et al., 2002). Past projects, with application in hospitals, about DIOGENE (Borst et al., 1999), ARCHIMEDE (Breant et al., 2000), HELP (Gardner et al., 1999), BICS (Tech et al., 1999), HISCOM (Bakker et al., 1999) manifested their limited support. Great troubles went on the attempt to apply these tools from micro to general frame (Botta-Genoula 2006). Considerable resources in the implementation of integrated mechanisms (supported by technology as well as system and employees) of enterprise coordinated planning are actually spending. It is striving to use target solutions of proven success into the manufacturing environment (Davenport 1998; Backhout et al., 1999; Graves 2002). The strategy, analysis, design, planning, programming, control and decision making procedures are set up to weight up all necessary steps in order to provide client/patients oriented services with effectiveness of supply and efficiency in performances.

In this paper authors are going to discuss how coordination across involved resources/entities is of crucial importance in the process of a productive delivery of service to patients. The paper has made up for developing the foundations of a modeling tools that enables the assessment of key procedures in the process of service design. It has been conceived through an extensive search and synthesis of literature from a variety of sources and knowledge. Described within this paper is the process used to form the framework, the framework itself, and how this can now enable the construction of practical tools for health managers. Furthermore, the paper investigates how the theoretical framework has to work in practice, analyses strengths and weaknesses and opportunities of its adoption and suggests hits those can contribute towards enabling sustainability of health care system. Besides estimated gains to the application of operation management in health, the work aims to be as a referenced conceptual framework in detailed short term planning for earning in health care service. It was characterized for hospital districts.

The paper is structured as follow. Firstly, differences between services and manufacturing companies in the context of Enterprise Resource Planning (i.e., ERP) implementation, are discussed. A historical state of art on ERP phenomenon is presenting. The medium-short term blocks will discern. Secondly, it introduces the ERP concept in Hospital Resources Planning (i.e., HRP) perspective. A detailed characterization based on correlated links between modules will be proposed. The system is describing as main boxes marking out I/O variables and control mechanism/procedures. The aim is to transpose, while sketching out, procedures and requirements to implement “coordination” in the process of patient admission to services. Flow characterization, hardware and software blocks for gathering and tracking and monitoring and managing are proposed. The paper ends with discussion of area for future and ongoing implementations.

2. ERP SYSTEMS FOR STRATEGIC SERVICES TO CUSTOMERS

During the past years great efforts have been settled in order to face with better management of inventories and scheduling problems (Li 2000). In the last 1960s the development of Material Requirement Planning (i.e., MRP) modules was conceived in order to “organize” calling requirements of dependent demand products. The MRP procedure detects the sudden requirement of materials as needs to arrange finite goods, in the form of family bill of products estimated by a Master Production Schedule (i.e., MPS), in a time shaking forecast. The successor to forward MRP was the Manufacturing Resource Planning (i.e., MRP-II). In such a system manufacturing, marketing and finance aggregate their assets to produce a final schedule optimizing the way in which the system meets the demand placed on it (Vollman et al., 1997). It was called Enterprise Resource Planning (i.e., ERP). It mostly represents a “PUSH” strategy. Its point of view clashes with “PULL” claims based on stock supply.

The ERP architectures are mainly discriminated pointing on “opportunity costs”. Because of an essentially unrepeatable services sort, push instead of pull, mostly in the form of Just In Time (i.e., JIT) (Chase et al., 19995; Persona et. al., 2008), are mainly applied for production and control methodologies in service environment.

ERP is a software package that attempts to coordinate all department and functions of company using integrated modules settled onto a single computer system (Klaus et al., 2000). It requires standardization of data and knowledge to elaborate an integrated vision of organization. The ERP tools aim to liaise all different departments’ needs (Akermans et al., 2002). Customer Relationship Management (i.e., CRM) and Supply Chain Management (i.e., SCM), to enhance respectively collaborations with customers and suppliers/stakeholders, are external processes merged in ERP application (Wang et al., 2005). Traditionally the ERP system objects to translate the long term plans in current short term delivery. Based on customers’ requirements, to consent to business strategies, it joins the material, capacity, supply, dispatching and performance to accomplish needs. As health care services, the business strategy, as well as logistic, production and sales planning (those respond to who and when and where can be treated) are settled and constrained to fulfill governmental duties (in the form of country displacement and/or units arrangements according with health outspending/programs). The medium short term architecture starts and works from the patients’ requirements. It needs to coordinate internal “squads”, external supplier, required capacities/replenishments measurement of performances in closed feedback to the efficient as well as the effective patients care delivery. Notwithstanding, structural problems reveal between traditional vision of ERP system and its usability in services organization. In real hospital lead times cannot defined a priori and vary significantly with utilization, demand and flow (Song 1994). Moreover, alternatives and routing cannot steadily defined but need to be elaborated in optimized shape according to current performance evaluation. A surveying system has to be introduced. Besides, elaboration time needs to be quite null to face with current request. Repository systems have to be arranged as well.

3. PRODUCTION CARE IN A FRAMEWORK FOR HOSPITAL RESOURCES PLANNING

Hospitals are considered extraordinarily complicated services system (Roth 2003; Griffin 2006). They batch role, knowledge, materials, resources, methods and they share common purpose. They have made the commitment to provide services and facilities to face up any form of disease. Nosocomium mainly uses the principle of span of control very effectively. They are the first target for budget capping (Lundin 2000; Cutler 2002). For the reasons as above, national programs are continuously toiling on rationalization of “hospital allotment points” (Blumental 2009). Shortage to coordinate services, and efforts to restrain supply, is the trend to face with budgetary squeeze (Mintzberg 1994; Mossink 2002). The proposed framework, out of the operations (only a medical staff can face them), looks at hospital as health districts from an up level (i.e., in operation management standpoint). It is going to look forward: to initiating and overseeing new programs.
those will improve hospital’s performance; to predicting corrective action in response to unforeseen problems; to optimizing, while minutely controlling, the distribution of human, physical, pharmaceutical and monetary resources; to arranging requirements in a calling claims with a consequent reduction in cost and waste and locking up of capital. The main perspective to efficient manage hospital/clinics is the holistic vision as capacity driven system based on coordination, information sharing and monitoring.

Platform needs to manage scrappy but standardized information, about system/performance/location/configuration/resource/order/supplying/claim, in an unified vision for patient’s care. Resources (e.g., tools, devices, products, materials, medicines, medical and paramedical staff etc…), beds planning and capacity analysis, external assets calling/outsourcing, pharmaceutical requirements, patients assignment need coordinated mechanisms for planning (Mintzberg et al., 1998). Control of goods, services, equipment, resources, calls has to be closed engaged. The architecture of ERP system in services needs to represent a patient centric organization with synchronized physical (including product in the shape of patients and service) and informative flows between the sales and supply, supporting outsourcing/claims, financial accounting, material management organization, human resources area, production planning across plant, controlling measurement, consumer relationship modules.

3.1 Medium-Short Term Hospital Planning and Control

Integration in hospitals has to point on a central planning and control system to monitor patient’s processes and to measure capacity for decision making (Visser 2006). The general plight to face with adopting ERP package in health care services structures, such as hospitals, is the misfit between supported functionalities and service information (Siau 2003). The issue is: ERP is not flexible enough to adapt to formal and incomplete information based on knowledge (Mabert et al., 2001). A reengineering framework for the integrated vision in hospital districts relies heavily on the vast amount of information that has to be steadily brought up to date in order to fulfill current state (Bourke 1994). Thus, technologies and tools needs to support, using I/O interfaces, the information sharing about state as well as the current performance trend (Haux et al., 2004). As above, design techniques and standards have been developed to ensure adequate and trustworthy data (Visser et al., 1999-2007; Blobel 2007). Inputting information into a hospital has been recognized in the form of patients’ anamnesis and current symptomatology state. Moreover, results of medical examinations and patient’s monitoring have to be steadily collected and checked on/for medical diagnosis. Current information about medical treatment/requirement is the starting point for the control of inventory state and drugstore (in the form of required material, drugs dispensing and prostheses collection etc..). Besides, data need to efficiently support supply, outsourcing calls (in the form of required medical specificities/advice, external charges, bid scheduling etc..). Traceability supports billing and operating tasks as to manage the hospital in terms of costs and proceed and practices (Kaplan et al., 2002).

Based on manufacturing perspective, the patient (in the field of row material), like customer while consumer of the services, comes into the hospital/service system with specific requests/treatment needs (Harper 2002). After a triage process (i.e., quality analysis of row material status) and based on current visiting control (i.e., quality assessment), patient needs a chain of treatments (i.e., technologies processes and human expertise) employing hospital medical/paramedic and physical resources (i.e., machines and production tools) in order to assess his status. Good decision-making process requires good information sharing (Pindyck et al., 2005). Cure of patient asks for coordinated calls of different medical departments as well as treatment units and resources (Schneider et al., 1995). This raises the question of integrated information sharing about tools/knowledge displaced across the hospital. Here the complexity of vision is that service needs to be arranged in order to fulfill unsteady while unclear demand-requirements, hardly described in a stochastic way (Groot 1993). Batching and buffering are the tradition way to face with variability and uncertainty. Such an approach should be rightly applied into a hospital, but results in lack of flexibility and high expenditures. Thus, as it is impossible to foretell point of demand without harming, system needs to plan for treatment after requirement’s out-standiness. Forecast is mainly on class based grouping in order to reduce error and variability (Lee et al., 2007). The coordination of current information between actors involved into treatments supplying (in the form of plants and network) is the state of art of the framework. The foreknowledge in trend/history of patient’s cure is of essential importance to quickly make up a proper diagnosis without repetition of tests. These manifest waste of time and cost.
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Hospital Resource Planning - HRP), the authors propose here an integrated architecture that can explode the master schedule admission (it has been used the same model declaration of these authors, i.e., information with the main HRP engine (Fig. 2). Based on the model proposed by Roth and van Dierdonck in 1995 of capital assets subject to shortage, obsolescence, holding costs etc..). Thus, most of this spending for pharmaceutical demand comes from gaps in coverage remains. A decision support analysis module, mainly familiarizes with the introduction of Manufacturing Resource Planning (i.e., MRP-II). In the MRP-II perspective, detailing resources’ requirements/status prospects the efficient and efficacious scheduling of patient, material and resources themselves. A closed loop is engaged between resources requirement module and performance measurement analysis. The same hoop performs distribution requirements and material requirements are evaluated to perform DRGs. A Rough Cut Capacity Planning in the field of manufacturing perspective (Fetter et al., 1969). The appropriateness of information takes system to success. Information is passed across network. In forecasting assessment, manufacturing uses generic bill of materials for planning purpose prior to knowing detailed specification. Capacity for group patients can mainly base itself on prediction of demand in stochastic perspective. Diagnosis Related Groups (i.e., DRGs), borrowed from the manufacturing perspective, detailing resources’ requirements/status prospects the efficient and efficacious scheduling of patient, material and resources themselves. A closed loop is engaged between resources requirement module and performance measurement analysis. The same hoop performs distribution requirements and material planning. The process of drug requirements, as well as supplying and distribution, takes part in the proposed architecture. Efforts to restrain supply cost aid attention at controlling pharmaceutical stocks. Those are currently the most out of control entities (spending on pharmaceutical across European countries has increased from 15.9% of total health spending in 2000 to 17.9% in 2009 (Source OECD – 20011)). The number of patients, as well as their treatment requirements, fixes drugs requests into the planning horizon to scheduled treatments. An order call and/or offshore buying and/or bulk strategy could be engaged in order to assure the service to patients while performing optimization of related costs. It will have to decide on basis of what has already been agreed: an efficacious control of pharmaceutical structures inside the hospital needs introduction. Frequent calls for adding “pharmacare” to coverage are drugs delivered in hospital (in the form of capital assets subject to shortage, obsolescence, holding costs etc..). Thus, most of this spending for pharmaceutical demand comes from gaps in coverage remains. A decision support analysis module, mainly interferes with financial account, Final Assembly Schedule (i.e., FAS) and MRP modules. It shares information with the main HRP engine (Fig. 2). Based on the model proposed by Roth and van Dierdonck in 1995 of master schedule admission (it has been used the same model declaration of these authors, i.e., Hospital Resource Planning - HRP), the authors propose here an integrated architecture that can explode the
requirement for admitted, or planned to be admitted, patient into plans for capacity requirements using the DRGs classification and therapeutic path explosion (Fig. 3). Information on state of clinical patient management and structural organization (i.e., Master Production scheduling - MPS module), on staffing and job design (i.e, Final Assembly Schedule – FAS module), material management and capacity planning (i.e., Material Requirement Planning – MRP module), supply management (i.e., Distribution Requirement Planning – DRP module), financial management and decision making (i.e., Decision support System - DSS) needs communication with a central system to synchronize hospital planning and control in structural coordination.

3.2 Patients’ Admission Control in Capacity driven Hospital Resource Planning

Coordination in medium short term planning for hospitals requires surveying and control of actions. The application of patient’s control sets up based on master plan. It plans resources to qualified services optimizing the amount of money for duties. It guarantees the optimization of services while performing, in forward scheduling, the planning of engaged resources and required materials. I/O software and hardware gathering points need for local inputting and monitoring. Computer pads as well as Radio Frequency Identification (i.e., RFID) need to be installed and to communicate with central elaboration module (properly a computer with installed HRP platform or its branches). The efficient hospital material and resource planning founds on reactive measurement and monitoring. State and information are shared and coordinated between hospital departments across ICT tools and the network. Security and cryptography is set for data transmission and usage. The system, pointing on HRP platform and constrained on hospital skills and department arrangements, needs to capture in a standardized form patient’s admission requests. An unified booking centre coordinates on medium term the patient admission to hospital facilities. Besides the problem of patient’s schedule there is the problem of capacity driven the material requirement and resources scheduling. Those are in closed loop with a final performance evaluation prospect founded on traceability of entities and characterization of time. The reply to inpatient requests for admission will be, in short term assessment, the patient access to scheduled cure. It is in the form of outsourcing for external clinical support if system’s is not provided for, according to configuration and decision making and/or inner capacity assessment. Enquiry in tasks, procedures, performances, materials and scheduling policies have to be contemplated in order to evaluate the system capacity. The platform could manage requirements for scheduled in medium term requirements (i.e., Unified Booking List). An efficient measure of management, from acquisition to disposition, has to be employed. Original data must be collected. Access to relevant data in the hospital is required. It is needed to define a generic bill for incoming requests of cure. It plans for clusters prior knowing detailed design specification (Fig. 3). Based on Diagnostic Therapeutic Paths (i.e., PDTs), each hospital constructs a master schedule clinical plan to arrange generic materials and resources in fulfilling admission. Upon patient arrival, information on wide planning are translated to the individual treatment area and their related plans. The central HRP platform communicates case information to PDT explosion. The use of PDTs is mainly based on DRGs classification. Making group is able to prevent error and variability while efficiently forecasting requirements (Grote, 2009). In PDTs, patient’s anamnesis with personal data and previous clinical requirements (as files about lab test, Rx etc…) could be charted in order to coordinate materials and resources and past knowledge. They are visualized on peripheral pads elaborated on central, but dislocated, engine. The repository of patient case sheet is a close block mechanism based on traceability measurement. PDTs are expected to consume a common set of resources fixing probabilities in groups during hospitalization. PDTs is the path of DRG’s into the service structure. From the generic bill of requirements, system needs to gradually define and evaluate the specific patient’s bill of material and resources to finish designed tasks to cure. PDTs require materials, resources and procedures corresponding to on-state characterization of the Bill of Resources and Materials (i.e., BORM) defined on charts about patient’s state. BORM combines materials and capacity resources in current treatment stages. Warning about availability of materials and resources are launched to the patient admission blocks to forecast requirements and calling treatments and materials based on availability.

The central HRP engine manages networks of call and supply. Using PDTs, and clinical plans of resources and materials, and final assembly performance elaboration, BOMR is updating. It explodes the Gantt chart of requirements (Gantt 1919). As above, system manages queues and arranged booking centres.
Considering aforementioned blocks, a deeper characterization in material planning (Fig. 4) and resources capacity planning (Fig. 5) modules need to be sketched in order to grasp custom specification of patient.

Figure 3. Functional Identification (Shen et al., 2004) of a capacity driven process for patient admission scheduling.

The blocks need to be arranged with a module of planning and information revision. Its action points on orders about resources and material required from inputting pads (e.g., iphone applications for medical records) completed by the hospital staff (thus without waste of time in hand-work transcription and space and traceability for reports). It originates from clinical plan inquires. Financial, administrative and managerial strategies are contemplated, in the form of input, as the plan of requirements. System seeks for availability of material in the inventory warehouse. After checking for status, a dispensing list is given out. The material schedule is then performed. Thus, pharmaceutical and drug plan are elaborated. Calling for supply may be bred. A current revision of stock, after order launching, bases on obsolescence and shortage points on the main information system and the current state requirements. Managerial plans interfere in the form of released lists and warehouse orders.

The resource’s capacity identification module characterizes status of resource and its affecting factors. The resource status needs tagging. RFID technologies and pad may be proposed. Across monitoring, system is able to bypass the stochasticity and variability of lead time. Status availability mainly addresses on measuring overcrowding, priority, release date. A performance evaluation module could be designed as support do decisions (i.e., DSS module). Resource characterization mainly communicates with a human analysing module which characterizes availability of human staff (Belien at al., 2007). It is related to rota elaboration and staff call. Based on rota and with the possibility of external advice, a schedule for human staff and operating resources is linked with the main patient admission block (Fruggiero et al., 2010).

4. CONCLUSIONS AND REMARKS

The nature of the process and product, the awareness of uncertainty, the feedback on entities, the up to date measurement of performances, are important factors to consider into a hierarchical framework for production care in heath planning and control. A working knowledge of the process needs to be modelled in relation to
fix operational practices to optimization. Hospital districts achieve integrated architecture for information sharing and coordination.

In this study authors submitted a systematic approach to capacity driven management. It was provided with characterization inside hospitals. The right handling to hospital management is proposed with manufacturing counter-base. The “Achilles heel” here seems to be information capturing. Authors sketched requirements and procedures to realize production planning and control in hospital on resource capacity optimization. A hierarchy framework, starting from the main hospital resource management engine, to organize procedures inpatient admissions is characterized. Central engine needs to coordinate information to gain effective and efficiency into the system. The framework was called Hospital Resource Management for medium short term planning and control. Software as well as hardware functionalities were required and introduced for its implementation. The medium-short term HRP system needs to bypass uncertainty in lead time and requirements. Procedures to these are proposed with characterization in blocks’ functionalities. Of particular importance here is the accumulation, elaboration and measurement of evidence from the use of new technologies (e.g., pad, RFID etc…). Knowing while fixing relationship in procedures of cure, who and when is or can be call for treatment, a capacity driven application of information sharing with optimal performances is then possible to implemented. According to authors’ experience based on different micro applications (Iannone 2007-2009; Fallon 2008; Fruggiero 2009), the paper aims at a contribution to the hospital service concept in the field of central coordination and planning supporting by ICTs. The work gives some useful guidance in the development of transformation and sustainability of healthcare system. While relating requirements and outcomes to performances, it development and implementation appear of strategic issue. Implementation of platform in current state is performing. Results will be presented soon. As more, the contribution is going to be a research agenda for people who attempt to face with the complex issue of health service management.

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INTEGRATION AND SHARING OF PERSONAL HEALTH DATA AS A CHALLENGE FOR THE FUTURE INTERNET E-HEALTH SCENARIOS

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ABSTRACT
The recent shift in healthcare from reactive to preventive activity results in inclusion of the patient in the healthcare process. To fully integrate the patient in healthcare processes it is of crucial importance to empower them with adequate tools and methods to control their own health. This goal has been getting fulfilled with the development and wide application of e-Health services in various medical domains. One of the important challenges emerging from the implementation of e-Health services lies in enabling seamless management and sharing of patient’s health data. To this end electronic health records and personal health records are being developed with adequate mechanisms enabling the patient to manage their data. Attempts at integrating these two worlds are also being undertaken. However, with the vast amount of work devoted to the design and development of the Future Internet it seems appropriate to match requirements for the medical data maintenance and transmission with the opportunities created by the network of the future design towards fulfilling the needs of innovative e-Health and telemedical applications. In this paper we present the results of our work aimed at the design and experimental implementation of a Future Internet enabled Patient Digital Library integrating Personal Health Records with Electronic Medical Record and Electronic Health Record systems on a content aware network.

KEYWORDS

1. INTRODUCTION

Electronic Health Records and Patient Health Records have gained an important position in the realization of e-Health and telemedicine. Other (bio)medical information repositories also become more and more vital to the needs of the healthcare. It also seems advisable that other data sources, such as repositories of environmental conditions’ measurements, be included in the e-medicine processes. The healthcare of the future should undergo a shift from its current reactive nature to the more preventive one, with a vast support of the ICT-based solutions in this process. At the same time the Internet is slowly undergoing changes to increase its scalability, throughput and enable mass deployment of devices and services. Now seems like the right time for combining efforts invested in the design of innovative e-Health applications with the research aiming at the creation of the Internet of the future. This should eventually enable a patient-centered healthcare based on virtualized networking and information infrastructure [Binczewski et al, 2011].

In this paper we discuss the requirements for the implementation of integrated personal health data spaces. We further look into the opportunities created by the activities aimed at designing the network of the future in the answer to the growing need for efficient connectivity. We attempt to draw a list of questions to the Future Internet designers concerning the implementation of medical data accessibility and delivery anytime and everywhere in an efficient way. To this end we define the personal health data spaces in Section 2. Then, in Section 3, we look into the scenarios of health information transmission between remote sites and actors. In Section 4 we attempt to analyze the Future Internet opportunity for novel way of e-Health implementation through proposing an experimental patient digital library. Finally, in Section 5, we draw conclusions and discuss our further work concerning the planned prototype of the Future Internet enabled patient digital library.
2. PERSONAL HEALTH DATA SPACES

The data of the patient have been traditionally generated by organized healthcare within various medical encounters. Medical units use Electronic Medical Records (EMR) to store and maintain medical data of their patients. Recently, lots of efforts have been invested into the design, development and implementation of so-called Electronic Health Records (EHR). According to the definition by the Healthcare Information and Management Systems Society (HIMSS) “the Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. (…) The EHR has the ability to generate a complete record of a clinical patient encounter.” [HIMSS, 2006] In other words, the concept of EHR assumes integration of data originating from various specialized medical information repositories on the network [NIH, 2006]. The data are integrated across organizations to include all information relevant to a given patient. An EHR network offers several services which enable data discovery and management, ensure the security and privacy of the data and control the business rules concerned with the use of the data. EHRs are essential for future health care services using online patient information, telemedicine and consultations, therefore countries around the world invested in the development of EHR schemes. Some of good EHR examples include systems in Denmark [Bernstein et al., 2005], Finland [Ruotsalainen, 2007], United Kingdom [Mason, 2004] and New Zealand [Mason, 2004].

While EHR enables maintaining the patient data within the organized healthcare settings, an ever larger amount of data is generated by the patients themselves. This is first of all connected with multiplicity of e-Health devices and applications emerging on the market and preventive utilization of these appliances by the patients. This way patients generate data which may be very useful in future diagnosis performed by medical professionals, should the need arise. Such patient-generated medical information is typically stored in a Personal Health Records (PHR). A PHR system is a system that “enables people electronically to manage their health information” [Smolij and Dun, 2006]. PHRs are often implemented as remote services delivered to the patient via the web. One of the first popular implementations of online PHR system is Google Health. Google Health (http://www.google.com/health/) is a web application which allows patients to organize health information in one place, gather medical records from doctors, hospitals and pharmacies, and securely share the information with family members and healthcare organizations. Microsoft has also proposed an implementation of PHR - the HealthVault. HealthVault allows to directly acquire data from external sources (medical devices, healthcare organizations). It is based on a central data repository deployed within a cloud. There are three sources of information in a patient record in HealthVault. The primary source is data downloaded directly from personal medical devices of the patient. The second source is data manually entered by the patient using a personal computer. As the third source of data Microsoft suggests healthcare organizations, that is the data received from EMRs and EHRs. Microsoft’s and Google’s services are the most popular PHR implementation, however PHRs may be also maintained on the patient-owned device, such as stand-alone PHR applications installed on the patient’s personal computer.

EHR and PHR store and enable typical medical information generated by medical professionals and patients. This data is the core of a patient’s personal health data space. However, there exists more information that may relate to the health state of an individual. This concerns any information describing the environment and conditions of patient’s living and activity. Many such data are correlated to various illnesses, for example air condition holds a relation to asthma and sun light parameters may relate to skin diseases [Ichihashi et al, 2003]. Moreover, medicine discovers new such relations every day and one can never be sure if a particular information item concerning a specific living environment parameter would not become crucial for efficient and quick diagnosis of a dangerous disease in the future. Therefore, it is important to also include data generated by environmental sensors in the patient history stored in their personal health data space.

Finally, one other type of information that we believe belongs to the patient’s personal health data space is all the information stored in various biomedical databases and repositories. This first of all relates to the evidence based medicine (EBM) which gains major importance in today’s strategies at diagnosis, therapy and rehabilitation, and may also play a crucial role in prevention or early detection of poor health conditions. Some of the most known EBM repositories of today include PubMed, the Cochrane Library and TRIP. Secondly, the repositories important for the patient’s health include also knowledge gathered within genomic or molecular scopes. An example of the former is the GeneBank, while an example of the latter is the
DrugBank. All these data repositories may be analyzed by decision support services and applications to deliver automated or semi-automated monitoring of patient data against the evidence and knowledge.

To sum up the above discussion of the patient-related data let us define a personal health data space as all information collected in an integrated network of information repositories storing personal data related to the patient’s health condition as generated by medical professionals and the patient themselves, data generated by sensors monitoring the environment in which the given patient stays, and the (bio)medical evidence and knowledge collected by human (Figure 1). The integrated network of information repositories listed above may be defined as the patient digital library. In the next section we identify scenarios of information communication in such a networked patient digital library.

Figure 1. Personal Health Data Spaces: a personal health data space contains information stored in a person’s PHR, data referring to their medical encounters stored in EHR systems, environmental conditions measurements from locations and times of their presence and all scientific (bio)medical knowledge

3. INFORMATION COMMUNICATION IN A PATIENT DIGITAL LIBRARY

In the previous section we defined the patient digital library as an integrated network of information repositories gathering all (bio)medical data which are of importance for the realization of e-Health and telemedical scenarios for the given patient. In the current section we describe those scenarios from the point of view of medical information communication necessary for their implementation.

In a patient digital library two main phases of medical data communication can be distinguished. The first phase is concerned with the acquisition of health data. The other phase is related to the sharing of health data across applications and services.

3.1 Acquisition of Health Data

Acquisition of medical data into the patient digital library is concerned with the addition of new information to the patient’s personal health data space and is related to the following activities:

a. creation of medical documentation in an EMR system and exporting it to the EHR in accordance with the EHR system rules and mechanisms;

b. addition of medical documentation created in a care setting to PHR;

c. manual input of health observations into PHR;

d. automatic input of medical measurements from personal medical devices into PHR;

e. automatic input of environment sensors’ measurements into relevant repositories;

f. increase of (bio)medical knowledge in scientific repositories.

All these six activities may involve transmission of the acquired information over the network (Figure 2).
Concerning (a), the creation of new medical documentation in an EMR system during a patient encounter at a care setting could trigger creation of its copy in the central database of the EHR or at least registering the fact of creation of the new piece of information with the EHR.

The medical documentation may often get transmitted from EMR/EHR to PHR as identified above in (b). This kind of a scenario of data acquisition is among those listed by Microsoft for their HealthVault. It also involves transmitting the medical information to and within the cloud upon which HealthVault is built.

In relation to (c) in the case of web-based PHR systems, where the data is stored in a cloud like in Microsoft’s HealthVault, the data gets transmitted from the patient’s web browser to the web server (and further over to the cloud).

In the case of (d) and (e) we talk about various sensors connected to the network automatically transmitting the collected measurements to the specified repository. The technology of the physical connection of such a measurement device may include both, fixed and wireless connections.

Finally, in the case of (f) data collected in various knowledge repositories may be transmitted to a high performance computing setting where a specialized application analyzes the data and the results of this analysis may get copied into the same or another scientific knowledge repository. Such scenarios were the subject of research performed for example in the ACGT project [Tsiknakis et al, 2006].

All the above scenarios of medical data acquisition may in addition include transmitting all information over the network in order to create backups of information.

### 3.2 Sharing of Health Data

Once the patient digital library is filled with information, the patient may require sharing this information with other individuals or services. This information sharing is concerned with the following:

- a. accessing electronic health records by medical professionals during patient encounters and through telemedical applications and services such as medical teleconsultations;
- b. enabling PHR records for the use by medical personnel during a patient encounter in an organized care setting;
- c. analysis of personal health data space by a remote service or application in order to detect symptoms or provide advice to the patient.

Again, in all these cases communication of health data may occur on the network (Figure 3).

Concerning (a) the medical documentation stored in an EMR or EHR system may be accessed remotely by a medical professional in order to check patient medical history or may be directly attached to the telemedical message, e.g. in a request for teleconsultation.

In relation to (b) PHR data may be enabled for the remote access by a medical professional, for example directly from the HealthVault. This kind of access seems far more flexible than requiring the patient to always bring their PHR physically to the medical encounter, for example on a USB stick.
The (c) scenario involves combining selected portions of information collected in the patient digital library (e.g. combining data stored in EHR and PHR with the scientific knowledge collected in the GeneBank) and transmitting this data to a remote site where a specialized application analyzes the data using artificial intelligence techniques.

Figure 3. Sharing health data collected in a patient digital library (PDL)

3.3 Summary

In the current section we identified scenarios where transmission of health data to and within the patient digital library takes places. This list may be treated as sort of requirements for a network enabling the realization of those scenarios. We discuss how these requirements may be addressed through exploring opportunities opened by the Future Internet in the next section.

4. ENABLING PERSONAL MEDICAL DATA SPACES IN THE FUTURE INTERNET

Future Internet research and development has become one of the most important topics on the European and world ICT agenda. It promises to answer the growing need for efficient connectivity always and anywhere. E-medicine is one of the areas where the emergence of the Future Internet seems a possible factor of creating innovation and supporting the so needed shift from reactive to preventive healthcare [EFII, 2010].

4.1 Future Internet Opportunities for Personal Medical Data Spaces

The Future Internet research and development encompasses the whole spectrum of works aimed at creating a robust, scalable and trustable network of the future capable of mass deployment of devices, services and applications. These works build on the currently existing Internet to enable higher capacity, throughput, and mobility for end users and their needs fulfilled by the increasing amount of specialized networked services. While the Future Internet research is a still ongoing process, some results may already be listed. These include the following:

- **IPv6 protocol definition** and the ongoing mass adoption, which will potentially enable connecting virtually any device, any application and any service to the network, and address them in a far more flexible way than it is possible in the current Internet based in IPv4 protocol;

- **Design of new generation network architectures** which are aimed at ensuring selection of best transmission techniques for the needs of particular applications – one example of such new generation
networks are content aware networks which look into efficient transmission of reusable content [Koponen et al, 2007];

c. Semantic Web design which helps to creates links and relations between information artifacts in order to facilitate understanding of information by machines – this will eventually help to enable services and applications to automatically perform the difficult tasks of information discovery and combination, and making decisions upon that information.

All these possible features of the Future Internet are important to the patient digital library we defined above. The possibility of seamless connection of multiplicity of devices, sensors and applications to the network thanks to (a) allows to simplify the process of health data acquisition. New generation network architectures mentioned in (b) promise to efficiently and seamlessly transmit the data over the network. Finally, (c) can help to quickly discover and analyze the ever-increasing amount of information related to individual patients.

4.2 Architecture of the Patient Digital Library in the Future Internet

In order to understand the capabilities the Future Internet may offer to innovative e-Health applications, we designed an architecture of the Patient Digital Library taking advantage of these capabilities. We also believe that our work may contribute to better shape the Future Internet towards particular needs of e-Health applications. In this subsection we describe the architecture of our Patient Digital Library and shortly list requirements put before the designers of the network of the future.

The prototype design of the Patient Digital Library application has been based primarily in the capabilities offered by the IPv6 protocol and content aware networks. We believe that health data may be treated in a way similar to multimedia content, allowing the network to decide if and how the content be transmitted to the requesting network node (i.e. requesting application) and from which content source holding copies of the requested content. The semantic layer of the network of the future is introduced through the utilization of standard e-Health vocabularies, terminologies and ontologies, such as for example ICD-9 and ICD-10 standards, for the content annotation. The architecture of the prototype design of the Patient Digital Library is presented in Figure 4.

![Figure 4. Future Internet enabled Patient Digital Library](image)

The personal health data space in the prototype Patient Digital Library includes an EHR, a PHR and a scientific knowledge repository. We assume realization of EHR with the use of open source EHR software.
PHR in our design is based in the creation of a Family e-Health Gateway and storing the whole PHR at the home of the patient. The concept of a Family e-Health Gateway is immersed in the low-cost PC-based home gateway used for homecare scenarios by the OLDES project [Novak et al, 2009]. Finally, an example scientific repository is built with the use of the registry of medical cases constructed within the Wielkopolska Center of Telemedicine project [Kosiedowski et al, 2009]. In our design we assume that the PHR is backed up as a mirror created on another Family e-Health Gateway (installed for example at the home of the patient’s parents). Appliances connected to the Patient Digital Library include example personal medical devices (Nonin Onyx II 9560 BT pulse oximeter and Tanita BC 590 BT digital scales with body analyzer), personal access devices (a personal computer and a smart phone) and an example specialized application for the analysis of the information contained in the personal health data space (enabled as a remote service).

We assumed that within the scope of the prototype design of the Patient Digital Library the Future Internet may support this application with the following capabilities resulting from the scenarios identified in Section 3:

- IPv6 protocol should be used for connecting all Patient Digital Library nodes as well as data access devices (patient’s personal access devices) and any remote services accessing the collected data – resulting from the need to flexibly connect multiplicity of devices and services within or to the Patient Digital Library;
- the network should treat each system holding personal health data space information as a content source – resulting from data sharing scenarios a, b and c;
- the mobile device which can act as a personal medical device measurement gathering point should be enabled as a content source on the network – resulting from data acquisition scenarios d and e;
- the network should create copies of the selected content at a selected node of the network on request – resulting from the data acquisition scenario b and f;
- the network should be capable of limiting and controlling access to the given content on behalf of the patient – general requirement resulting from the need to enable patient as the controller of their personal health data space;
- the network should be capable of delivering the requested content according to the capabilities of the requesting application (e.g. delivering medical documentation originally created with the use of HL7 v3 standard as a HL7 v2 message) – resulting from data acquisition scenario a.

The above-listed requirements were discussed with our colleagues at the Warsaw University of Technology who design the content aware network of the Future Internet implementation developed within the Future Internet Engineering project. They contributed to the detailed definition of the content aware network architecture and protocols.

5. CONCLUSIONS AND FURTHER WORK

In this paper we defined a personal health data space as integrated information collected in EHR, PHR, scientific knowledge repositories and databases gathering environment parameters. We further discussed the prototype design of a Patient Digital Library in the Future Internet. This Patient Digital Library is developed to enable efficient management and sharing of patients’ personal health data spaces on the network. We believe that the Future Internet should create opportunities for novel experience in health information acquisition, sharing and accessing. Some of the capabilities of the Future Internet that we wish to analyze as appropriate for the needs of the personal health data space utilization include the use of the IPv6 protocol and a content aware network for the transmission of health data.

To date some of the early implementation works concerning the development of the Future Internet enabled Patient Digital Library have been completed. We will continue these works during the upcoming months. Next, integration with the Future Internet Engineering system is planned to perform experiments towards analyzing the capabilities of the designed network of the future. As far as our application is concerned, further work should be invested into the analysis of scalability, inclusion of other data sources (i.e. environmental sensor measurements) and enriching the Patient Digital Library with the Semantic Web layer.
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APPLICATION OF VIRTUALIZATION TECHNIQUES IN SUPPORTING SCRUB NURSES WORK

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ABSTRACT
The article presents one of the sages of works over the ‘Virtual Hospital” computer system, the aim of which is improvement of hospital processes based on ICT technologies. The attention has been drawn to supporting scrub nurses work within the scope of using complex surgical instrumentarium. It has been demonstrated how such virtualization methods as modeling and computer animation can lead to preparation of training materials for nurses. Those materials will be distributed by means of modern techniques such as RFID or Augmented Reality.

KEYWORDS
Surgical equipment, techniques of virtualization, scrub nurses, training materials, ICT

1. INTRODUCTION

Medicine is characterized by a high level of dynamics and development. Progress of medical knowledge is accompanied by progress in the sphere of medical technique particularly within the sphere of medical equipment including medical instruments and robots. Such progress is connected with constant generation of vast amount of information (concerning e.g. the manner of specialist equipment servicing) which is not always accompanied by technical and organizational possibilities within the scope of their popularization and readable message. Firstly it causes difficulties in acquiring new knowledge by interested groups of medical workers, secondly it limits usage of knowledge in health services.

At present there is a problem of limited access to knowledge resources in many organizations. Valuable knowledge resources stay sometimes unobserved or wasted in the organizations activity [Lifelong Learning Programme, (2008)]. Moreover knowledge resources are often lost from the hospital due to such factors as staff turnover and flow, costs savings or incorrectly prepared documentation [Chase, R. L. (1998)]. Whereas, the proper knowledge management is able to reduce medical errors and their cost [Abidi, S. S. R. (2001)].

From the hospital functioning point of view tacit-operational knowledge resources are particularly important. Their owner is a person - doctor or nurse with long experience and developed skills. Access to such knowledge resources is difficult, it is not direct but it is realized by means of behavior observations of a person possessing those resources [Nonaka, I. & Nishiguchi, T. (2001)]. This knowledge is unformalized and unique. An example of such knowledge resources may be surgeon’s knowledge related to the method of manual activities performance during complicated surgeries or scrub nurse knowledge within the scope of servicing a complex surgical instruments.

It is necessary to focus on knowledge of workers who should be highly trained and who require “just-in-time” training and education to maintain their skills. This represents a tremendous investment in intellectual capital for the hospital industry [Lori J. Morgan, L. et al. (2005)].

With reference to medical staff dealing with usage and service of surgical instruments, the following problematic areas have been identified, which inspired the authors to undertake further research over methods of shaping skills of scrub nurse group employed in casualty-surgical wards:

− high level of surgical instruments differentiation resulting from variety of surgical operations. Every type of surgical operation requires application of other instrumentation set (e.g. arthroplasty of knee joint requires other set of instrumentation than arthroplasty of hip joint, shoulder joint, elbow joint etc.),
complex structure of surgical instruments requiring performance of assembly and disassembly activities during the surgical operation, very often in stress-inducing conditions,

frequent exchange of equipment resulting from short fitness for use lasting usually one year. Due to specificity of public procurement process the new set may vary from the previous one because of changing the manufacturer whose product was chosen by tender,

low amount of training courses resulting from specification provisions of crucial ordering conditions,

limited possibility of exercising using the surgical instruments by staff in view of sterilization procedures.

It should be added that at present, training within the scope of instrumentarium usage lasts on average 2 months and takes the forms of: theoretical and practical training, whereas practical training depends on assisting - observing the person, being educated and participating in the training, during surgical operations.

In the course of carried out research, the following practical problem has been identified: how to shape effectively staff skills within the scope of surgical instrumentarium usage and service during procedures and how to deliver necessary knowledge on that topic during the procedure?

Solution of so identified problem may be divided into three task areas:

1. Collecting information about surgical instrumentarium and the way it is operated - gaining tacit knowledge and formalized one.

2. Transformation of the gained information into the formal representation - readable for the receiver.

3. Making the information resources available to receivers independently from the place and time.

Meeting the problem of knowledge management in the health care, works over elaboration of complex system supporting access to necessary knowledge resources by hospital staff during realization of hospital processes were undertaken on the Faculty of Organization and Management in the Silesian University of Technology. System elaboration is a part of a research development called: "Virtual Hospital" financed by The Polish National Research and Development Center [Virtual Hospital, (2009-2011)].

2. SHORT CHARACTERISTICS OF "VIRTUAL HOSPITAL" SYSTEM

"Virtual Hospital" is a complex computer system the aim of which is to support hospital processes. It is an IT "enhanced copy" of the real hospital organization. This copy represents mainly the following organization elements: material resources, human resources (employment structure and patients), information resources, building and surrounding topology and in the first place hospital processes. Virtual Hospital is an extended IT platform collecting and popularizing complex and originally dispersed resources of knowledge needed for effective management of hospital organization, treatment quality and care of patients improvement. This platform integrates modern ICT (Information and Communication Technology) technologies and methods such as human body modeling, computer modeling, RFID (Radio Frequency Identification), GIS (Geographical Information Systems), CMS (Content Management Systems). The substantial contents of a system is based on thematic knowledge repositories made available to four groups of users: doctors staff, nursing staff, technical staff and patients. Whereat access to knowledge resources is personalized and limited by authorizations of a particular user group.

Repositories present the following knowledge areas:

- medical knowledge area including knowledge concerning treatment methods and care over patient, working methods, manual actions,
- operational/technical knowledge area connected with usage of specialist medical and IT equipment as well as activities connected with keeping the medical equipment on the run,
- administrative knowledge area which focuses on problems of organization resources management, in particular finance resources and human resources management.

The system includes different forms of contents presentation so as its readability is the highest for different recipients. Drawings, films, simulations and computer animations are in particular such forms.

Figure no 1 presents a schematic concept of "Virtual Hospital" system operation.
Knowledge resources gathered in thematic knowledge repositories are implemented to CMS and GIS class systems and then made available in three ways:

- by means of RFID technology. Through this technology, knowledge is made available in a contextual method in a particular time and place with usage of *on time* and *just enough* principles. Identifiers (RFID tags) which become intermediaries in access to determined places in the repository, readers and PDA palmtop computers are elements of this technology.
- by means of desktop and laptop computers with access to the network,
- by means of augmented reality technology AR, the essence of which is putting additional information in the form of graphics or text on the real image. Special glasses with built-in cameras are elements of this technology.

CMS class systems support actions connected with knowledge repositories creation and making them available basing on simple web applications. Shaping content and manner of its presentation in the service managed by CMS, takes place through the Internet network by the user interfaces based on forms and modules.

GIS system is a complex computer software for saving and presentation of graphic data of spatial character [Longley P. A. and others (2006); Gotlib D. et al., (2007)]. GIS system was used in the "Virtual Hospital" system in order to reflect digital building maps with equipment. Whereat GIS program interface is integrated with CMS system.

One of the thematic areas taken into account in the "Virtual Hospital" system is the "instruments menu" area where one can find information on training courses concerning surgical instrumentarium.

3. **RESEARCH METHODOLOGY OVER VIRTUALIZATION TECHNIQUES APPLICATION IN SCRUB NURSES WORK**

The aim of research was to gain, organize, process, gather and then make available the information resources in the form of training materials supporting scrub nurses work within the scope of surgical instruments operation. The article presents research results with usage of instruments for arthroplasty of knee joint, carried out on the basis of research scheme in the figure no 2.
Gaining and organizing information on surgical instrumentarium

Video recording and taking photographs of surgical operations
Video recording and taking photographs of arranged activities connected with usage of surgical instrumentarium including assembly and disassembly
Hospital documentation analysis including catalogs of surgical instruments

Research aim

Methods, instruments used

Interviews with scrub nurses

Virtualization of surgical instruments: Computer modeling
Activities virtualization with usage of surgical instruments: Computer simulations

Information processing into the form of models and computer animations

UML diagrams, CMS: Drupal

Gathering information in repository

PC, RFID, AR

Popularizing information resources

Figure 2. Research schema within the scope of virtualization techniques application for supporting scrub nurses work, source: own elaboration

Fig. 3 presents pictures of prepared instrumentarium for arthroplasty of knee joint (a) and the moment of selected surgical instruments elements assembly (b). Depending on instruments type, their assembly takes place both before the procedure and during the procedure. Particularly in the second case, usefulness and speed of assembly are extremely important, all the more so that it takes place on leading surgeon's command.

Figure 3. Photographic registration: a) surgical instrumentarium, b) assembly moment of surgical instruments

Completion of pictures and films made during operation was arranged recording with scrub nurse participating in it who was inserting and taking out the instrumentarium from the boxes and assembling and disassembling the instruments.

Fig. no 4 presents a picture of the whole instrumentarium which serves for carrying out the procedure of knee joint arthroplasty indicating ipso facto the complexity and the related difficulty in speedy usage of instruments. Chosen computer models of instrumentarium before and after assembly of an instrument and computer model of a box with instrumentarium elements were presented next to the pictures.
Pictures of particular instrumentarium elements and video recording of arranged activities connected with using surgical instruments were sources for creation of computer 3D models and then for preparation training materials including animated instruction films.

Prepared training materials were introduced into the "Virtual Hospital" system as another resource aiming at improvement of nursing staff abilities.

4. AN EXAMPLE OF "VIRTUAL HOSPITAL" SYSTEM OPERATION IN SCRUB NURSES WORK

Basis for "Virtual Hospital" system creation was a choice of a target environment in which system would be created. With relation to the assumptions that the elaborated system should be available for authorized users in any place and at any time by means of Internet browser, many technologies enabling realization of this task were analyzed. Solution that turned out to be the most suitable for the realization of the conceptualized aim are CMS class systems which are specialist Internet applications used currently for creation, updating and development of Internet services. CMS system called Drupal [http://drupal.org/] was used for creation of "Virtual Hospital" system IT implementation.
Within the scope of system creation, the range of activities performed by the scrub nurses during assistance at surgical operations was recognized. Mainly they consist of a set of actions connected with:

- preparation and checking in respect of completeness and assurance of sterility requirement of equipment and instruments used during the procedure,
- help for surgeons while putting on surgical clothes and surgical gloves,
- giving appropriate instruments and dressings to the operating surgeons,
- observing conduct principles connected with instruments during and after the procedure including preparation of instruments for sterilization.

Recognized activities and duties connected with scrub nurses work were basis for elaboration of Use Case Diagrams depicting interactions taking place between the user and IT system. Fig. 5 presents Use Case Diagram of "Virtual Hospital" system by the user of scrub nurse category.

![Use Case Diagram](image)

Figure 5. "Virtual hospital" system Use Case Diagram by the user of scrub nurse category, source: own elaboration

The elaborated diagram of use cases was used for creating the interface for user in the category of scrub nurse. Within the framework of the interface the following thematic areas making the knowledge resources available were planned in the scope of:

- Medical procedures - including list of medical equipment and medical apparatus used for realization of particular types of procedures, moreover medical procedures descriptions connected with those procedures and check lists enabling verification of performance correctness of a particular procedure or completeness of instruments set prepared for a chosen procedure,
- Procedures concerning sterilization of surgical instruments used during procedures,
- Training materials concerning assembly and disassembly of complex instruments sets used in the arthroplasty procedures,
- Rooms models - including GIS digital maps presenting particular floors and hospital rooms and interactive models of rooms performed in 3D panorama technologies.

Virtualization techniques are best reflected in the area of system concerning trainings within the scope of complicated instruments used for arthroplasty procedure sets assembly. Pages include training materials set which comprise photographs, schemes and animated models demonstrating step by step a procedure of a particular instrument assembly. Fig. 6 presents the example of page with training materials concerning instrument assembly.
Another element supporting the nurse within the scope of necessary instruments set completeness control for a particular procedure is a check list presented in the fig. 7. The list is completely interactive - items on the list include links to pages with detailed description of a particular instrument.
5. CONCLUSION

The article presents the next stage of works on creating system for improvement of hospital processes. This system is based on ICT technologies. A problem of huge knowledge increase in the health care sector was indicated. The effective usage of this knowledge depends on efficacy of mechanisms supporting knowledge management taking into consideration both gaining knowledge and especially tacit knowledge, and moreover gathering and making the knowledge available to proper persons and in proper time.

“Virtual Hospital” System seems to meet the challenges of the modern IT systems in health care. The advantage of the system is connection of modern information-communication technologies including RFID and AR technologies which enable access to contextual knowledge with simple presentation forms of knowledge using virtualization techniques.

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INFORMATION INTEGRATION OF DIVERSE LABORATORY DATA SOURCES USING INFORMATION SUPPLY CHAINS

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ABSTRACT

Information integration in disciplines such as drug discovery poses major challenges, as often only data from unstructured or semi-structured information sources is available and is in many cases neither semantically consistent nor in a form which can be easily extracted and shared. One of the issues at present seems to be with current frameworks is its inability to cope with diversity of sources and changing information types and hence rather seen as constraint than support. Therefore there are evidences of growing demands for information integration and information sharing in drug discovery laboratories. In this paper, we present an approach for integration of experimental data in highly diverse, semi-structured scientific domains and promoting collaboration by supplying information at the right time in the right context to the right users. The paper describes how subject oriented specific Information Supply Chains (ISC) can be established in a flexible manner to integrate required information and thereby balancing information supply and demand. We introduce the concept of ISC using a model based on Research Description Framework (RDF) and demonstrate how ISCs can help the decision process by making required information available at the time needed using a case study approach.

KEYWORDS

Cooperative systems, Semantic networks, Tree data structures, Information integration.

1. INTRODUCTION

The investigation of a set of new physico-chemical and biological properties require adaptation of existing or introduction of new laboratory protocols which affect the underlying framework for information flow in drug discovery in many ways. In terms of data integration and data sharing, protocol changes pose numerous challenges, i.e. data matching, identifying underlying semantics (Searls 2005; Goble et al. 2005). Such a proliferation of data hinders development of best practices, guidelines and standardisation of vocabularies to construct generic ontology that avoid semantic conflicts as described in Anjum et al. (2007). Both of which are necessary to enable sharing of data and information across domains, within a context as outlined in Khan et al. (2004) and Pulvermacher et al. (2004). An important aspect in integrating, sharing and reusing scientific data is the ability to have access to provenance information; in fact this is seen as a key requirement for establishing trust and worthiness of the information (Prat & Madnick 2008). Reuse of information is related to its validity and timing – the more that is known about how particular information was derived the more it is trusted (Boulos & Wheelert 2007). In this respect the concept of just-in-time (JIT) information management is appealing with the aim of providing the right information for the right users at the right time (Yeh et al. 2006, Saito et al. 2007). In relation to this, Kerschberg and Jeong (2005) presented critical success factors in establishing JIT architecture. They highlighted that understanding of users information needs, namely preferences, biases and the decision-making context are the most crucial requirements towards a successful ISC in JIT environment.

As experimental designs in researching new drugs are heavily dependent on hypothesis generation, it also depends on trusted information. A key enabler in establishing trust is lineage information of relevant data, i.e. how the data were derived and how they were used in conclusions (Bose & Frew 2005; De Roure & Goble 2007). Hence lineage and provenance information provide for additional context and enable reuse of data by allowing verification of the results. In this respect the ontology and semantic web based approaches
are used increasingly in managing information flows of supply chain management (SCM). Managing information flow has significant relevance to drug discovery process as it targets cooperation and communication by establishing well defined processes (Cutting-Decelle et al. 2006). Balance in information demand and supply of information are increasingly considered in integrating information flows any domain of knowledge using the metaphor of ISC as they have many commonalities with physical supply chain (Sun & Yen 2005).

In this study we test feasibility of ISC and have extended the model to apply JIT- strategy in tackling information supply and demand for drug discovery. We modelled JIT by the use of information dependency relation that is analogues to Bill-of Material (BOM) in SCM (Sun & Yen 2005) and have incorporated this structure in personalised views to infer information relationships within the context of drug discovery research workflows. We have used determination of potential immunogenicity of therapeutical proteins as a case study as it is dependent on timely information integration of different scientific research workflows.

The following sections explore ISCs in more detail supported by a case study in which a prototype ISC framework is introduced and its result discussed in the light of information integration and information availability. Finally the paper suggests key abstractions of the ISC framework and discusses the contributions of this prototype in drug discovery process.

2. INFORMATION SUPPLY CHAINS: CONCEPT AND MEASURES

In order to derive a conceptual model of Information Supply Chain (ISC), in the sections below we introduce requirements of information sharing followed by a discussion about provenance axes of information. We then present why and how information needs to be balanced with regards to its supply and its demand which underpin the modelling of semantic consistent information flows. This semantic consistent information will then be configured as ISCs to support drug researcher’s personal views and needs. In order to monitor information supply and demand in an ISC we introduce the concept of information completeness to measure the performance of an ISC.

2.1 Concepts of Information Supply Chains

Similar to a physical supply chain of business administration, an ISC addresses information demands in its information network. Development of an ISC framework needs to analyse information sharing requirements, both in terms of issues and opportunities, and failure to do so have similar consequences as we experience in a physical supply chain management; unbalanced demand leads to either information overflow or deficiency (Cutting-Decelle et al. 2006). Hence management of SCM and ISC share the same goal, namely balancing demand and supply; however, information flow and management in SCM differs from ISC in that the former deals with flow of materials whereas the latter deals with flow of information (Sun & Yen 2005). Nevertheless concepts, methods, goals and philosophy of SCM can greatly improve information sharing and can be – as we will demonstrate - directly applied towards ISC.

2.2 Information Dimensions of Scientific Records

Decisions and predictions in drug design need relevant information at the right time. Such information is usually bound to specific domains with their own semantics and is subject to individual preferences (Karger et al. 2003). In order to be trustworthy a scientific information reaches into particular information dimensions of what, why, who, when and how the information was assembled (Becker & Chambers 1988). This information dimension yield conceptually directed graphs along basic provenance axes that are derived from root information referred to as information unit. In this research an information unit is treated as a scientific record of relevant information across the scientific discovery process that constitutes an assembly of individual data capture events for each step; for example, from obtaining information about an adverse effect to project initiation, raw data generation, and result to conclusion.
2.3 Information Dependency Relation of Information Units

Access to specific information is required only at specific time points or events along a particular workflow (Sun & Yen 2005). For example, in order to design an assay, access to drug and target information is essential. This information however is not required routinely when conducting the assay. In this phase, on the other hand, it is essential to have access to the information about observed issues when similar assays are carried out. Hence, having access to relevant information at the appropriate time is identified as a key requirement for efficiency. Such efficiency is related to understanding the relationship of information units among each other in the temporal and the semantic domain. Figure 1 demonstrates such a relationship of information units. It shows how laboratory workflow steps (denoted as time points t=1, t=2 and t=3) are dependent on specific information (denoted as arcs).

![Figure 1. Information dependencies in the context of laboratory workflows](image)

Analogous to a Bill-of-Material (BOM) of a finished product that is derived from parts and components, an Information Dependency Relation (IDR) models information units using the same principle (Sun & Yen 2005). For example as depicted in Figure 2, a report in a clinical investigation is dependent on information about the actual investigation and interpretation of results obtained during the investigation. Hence, an IDR model is a tree like data structure rooted from an information unit that provides the desired output or summary of interlinked information.

![Figure 2. Example of an Information Dependency Relation of a Report](image)

2.4 Information Completeness and Information Balance

To apply an IDR model to an instance of an information unit, it is necessary to measure information completeness (IC). It can be measured as the ratio of all required information unit instances for that particular
information instance versus actually present. For example, to conclude an investigation, information about Sample, Drug, Clinical Issue and Hypothesis must be present. If all required information is indeed linked to the Investigation then said information is 100% complete. On the other hand, if, for example, Hypothesis is missing the resulting IC is lowered to 75%.

The IC of an information instance can be computed as follows:

$$IC = \frac{\sum Ipresent}{\sum Irequired}$$  \hspace{1cm} (1)

where $Ipresent$ are information unit instances that are present and $Irequired$ represent information unit instances that are required by the underlying IDR model.

The IC of information will therefore approach a value of 1 if it is said to be completed with regards to required information dependencies. An IC for an ISC ($IC_{ISC}$) can be computed on the basis of individual IC values ($IC_n$) of all information instances that are published into the ISC:

$$IC_{ISC} = \frac{\sum IC_n}{\text{Count}(IC)}$$  \hspace{1cm} (2)

The values for $IC_{ISC}$ will range from 0 – no information dependency satisfied – to 1, which signals a complete information set with regards to satisfying information dependencies. Such an IC value gives an indication of how complete particular information is and is suitable especially when such information is integrated and used in complex queries; we have used IC values in determining the demand and supply of required information which is demonstrated in the following section.

3. ISC IN IMMUNOGENTICITY STUDY: A CASE STUDY

Immunogenicity has recently drawn much attention as severe adverse effects from the treatment with therapeutical proteins may affect the health of patients (Bader 2004). In the best case, antibodies, produced as a result of humoral immune response, do not seem to alter pharmacokinetics of the drug and hence may still exhibit its desired therapeutical effect. In other cases, however, these antibodies may even cross-react with native proteins and start inducing unpredictable severe side effects. However determination of immunogenicity is not straightforward as it is influenced by many known and yet still unknown parameters and this phenomenon poses a threat to predict immunogenicity (Barbosa & Celis 2007).

Following section introduces a case study to determine potential immunogenicity by demonstrating the feasibility of an ISC framework to tackle timely information availability.

3.1 Case Study Generation for Experiment Setting

In determining potential immunogenicity of a therapeutic protein, derived conclusions from several assays need to be appropriately integrated as each assay has its limitations. These assays are carried out in different laboratory conditions and hence require a common understanding of its underlying experimental designs, results and its conclusions. We recognise that elicited information traverse domain boundaries and subject to specific semantics and vocabularies used in a particular domain. We attempt to present a case study which involves capturing of this information from two independent workflows. The case study demonstrates that the results of the individual workflows lack constructing a sense, but when integrated provide a meaningful conclusion (Figure 3). The diagram shows how two workflows are integrated using ISC (integrated information flow is shown in the middle). Integration is achieved by publishing relevant data and information from the workflows into the ISC using common agreed terms and vocabulary that are defined in the underlying ontology.
In the first workflow, it is tested whether fragments of therapeutical protein are expressed on the surface of specialised cells and thereby potentially attracting the humoral immune system. Protein fragments from specialised cells from donors that were treated with a therapeutical protein are analysed (Figure 3, left). If protein fragments from the therapeutical protein are detected using sophisticated analytical techniques, the conclusion of this workflow is that the therapeutical protein is potentially immunogenic. In order to further strengthen the potential immunogenicity a separate independent workflow is introduced. This workflow starts when a clinical issue is reported after a patient has been treated by a therapeutical protein. In this case, the second workflow presents ELISA technique where blood is analysed to determine the presence of antibodies (Figure 3, right). Conclusions from both the workflows, when integrated on the basis of the same therapeutical protein, enable the researchers to determine the possible immunogenicity of the drug.

3.2 Test Cases and Analysis of the Case Study in the Context of ISC

Worthiness of conclusion, as outlined in the case study above, is bound to have timely access to all relevant provenance data of underlying scientific records. For example, a scientist familiar with a specific assays technology needs different provenance of information than a non-expert in order to have trust in obtained information. Hence, particular data that is considered by one user may not be considered at all by another user. For this reason having timely access to relevant information to support conclusions is of paramount importance.

In order to establish the fact mentioned above, test data were collected from safety immunology laboratories that were involved in the case study. In total, 130 information resources were captured, categorized using agreed ontology and annotated to provide provenance information. Information included extracted summary data from different information formats such as investigations held in PDF or Word, regulations shown on power point presentations, procedures of testing principles, actual data from observations, results from conducting experiments and data from five patients that were made anonymous. About 30 irrelevant information sets were introduced to test how the ISC framework would deal with “noisy data” in real case scenarios.

In order to determine information integration using ISC approach quantitatively, we introduce precision and recall across different information dimensions and in addition information completeness as outlined in section 2.4 to demonstrate an overall performance of the test system. Specific queries are formulated for which adequate answers require integration of information that is spread across different information units. For example to obtain information about adverse effects such as immunogenicity of therapeutic proteins relevant information needed to be integrated and retrieved from clinical issues, patients, assays of blood samples and its interpreted results. Comprehensibility of obtained information for answering such a question requires a measure of how complete the retrieved information set is. This experiment reveals how much information dependencies were satisfied and then the finding was verified by interviewing a focus group. The focus group consisted of three immunology experts.
Measuring trust in obtained information was approached using details of provenance information and observation of scientists how they viewed such information. Finally, visualisation of information that is how the graphical user interface displayed information resources was assessed by directly observing scientist how they used the ISC framework.

3.3 Proposed ISC Framework

The ISC framework was designed to be implemented using RDF/S based on XML notation. Key abstractions of information units (see section 2.2) were taken as the basis for designing an RDF/S based framework. Identified information units were mapped into RDF classes and from there subclasses defined. All classes were routed from top class Information Unit, which itself was a RDF class. Main classes were considered immediate subclasses of class Information Unit. For example, class Report, Observation and Project respectively were all main classes. However, these classes had a too wide scope in providing semantically consistent information as these information containers may have spanned organisational boundaries that did not provide sufficient detailed contextual information necessary to satisfy trusted provenance information. Hence, the more specialised an Information Unit was the more semantically consistent its information source was considered. For example, Protocol defined subclasses such as Guideline, SOP, Regulation etc. and each of these specialisations provided specialised contextual information.

![Figure 4. RDF based ontology for high level abstraction of information unit data model in case study](image)

The prototype of the ISC framework was organised as an ordered set of specialised Information Units which were connected through concept Information Channel. Information resources were published using Universal Resource Identifiers (URI) into the concept Information Channel. This allowed merging identical resources - published and annotated in different locations that used agreed concepts - and yielded additional information along labelled edges which were not present in the original (unmerged) data set (Brickley & Guba 2004). The Information Channel concept allowed for setting up highly specific queries within a semantic context that were the basis of ISCs; that is, individual information elements – e.g. type of assay used in certain experiments, issues arising in interpreting an immunological profile of a given sample, etc. – could be linked together into an ISC using same underlying concept while providing trust by provenance information through common agreed annotation mechanisms (Figure 5).

![Figure 5. Information Supply Chain model](image)

We have modelled information dependency relationship (IDR) using the domain and range concept provided by RDF Schema. The schema allows generating a particular graph with specific information
sources dynamically: for example Information Unit of type Clinical Investigation may be dependent on Information Units of type Hypothesis, Issue, Drug and Sample (Figure 6).

![Diagram](image1.png)

Figure 6. Instance of an Information Supply Chain model with associated IDR model of a Clinical Investigation

For integrating information based on ontology, external RDF ontology description model was used which enabled the researchers easy configuration and adaption of ontology to test feasibility of the framework.

### 3.4 Experimental Setup

An ISC was configured to collect and integrate specific information about predictions of immunogenicity of certain therapeutic drugs and was used for assessing search performance quantitatively using precision and recall (Shafi & Rather 2005). Additionally, information completeness was calculated and contrasted with obtained search performance results.

Specific terms such as immunogenicity were used in various specialised contexts with the goal to obtain either wide range of information or very specific answers such as conclusions derived from integration of relevant and particular results. In order to test the performance of the IDR concept within the context of an Information Supply Chain, two search strategies were setup: One using the IDR concept contrasted by a search that was “solely” based on interlinked information units within the Information Supply Chain, i.e. without an underlying IDR model. The difference between the two search strategies manifests how the targeted information unit instance, i.e. therapeutical protein, is queried. Without an associated IDR model a search selects for example a patient directly based on exhibiting immunogenicity as adverse effect (Figure 7a). In contrast, a search that uses an underlying IDR model selects the patient based on all information units which report immunogenicity as adverse effect and is linked to the therapeutical protein of interest. It is the IDR model that links an instance of a patient with all possible instances of therapeutical proteins that are associated with the term immunogenicity (Figure 7b). Hence ISC using IDR execute queries in a much wider information network than without an IDR model and supports rich integration.

![Diagram](image2.png)

Figure 7a (left) and Figure 7b (right). a): Search mechanism within ISC only b) Search mechanism within ISC using IDR model. Note that the IDR model is used to link related information instances (denoted as Information Dependency Relation) and associated information in a given workflow.

Search initiator includes domain specific terms along scientific workflows of safety immunology with the aim to provide answers to potential immunogenicity of a therapeutical protein. These queries were executed by using four different search approaches to test the ISC search performance.
Two of the approaches were used to establish a baseline against which the ISC approach was compared, namely a non-semantic simple search and an approach that was based on annotations using properties. These queries were executed by using four different search approaches to test the ISC search performance.

i) Simple search to query information within all information resources without any restriction on its information type, e.g. immunogenicity, adverse effect. It served the purpose of establishing a baseline.

ii) Semantic search which used defined properties to search for terms albeit not constricting on a certain ISC. It served as a baseline of semantic queries not based on ISC.

iii) ISC search using defined properties to search for terms across a selected ISC, e.g. immunogenicity as adverse effect in patients in ISC immunogenicity.

iv) ISC search using IDR model which was based on a selected ISC and was extended in using dependent information instances based on its underlying IDR model e.g. immunogenicity as adverse effect related to therapeutical proteins in ISC immunogenicity where information was integrated on the basis of related information instances from the information dependency relation model.

3.5 Results

This section aims highlighting key findings that were obtained from assessing feasibility of proposed ISC framework. In order to test the performance of the framework with regards tackling information availability we have formulated five specific queries in assessing information integration capability: From basic search term such as ‘immunogenicity’ up to complex queries that included search terms and concepts across different scientific workflows (Table 1).

<table>
<thead>
<tr>
<th>Query #</th>
<th>Query</th>
<th>Search Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Search all information related to immunogenicity</td>
<td>immunogenicity</td>
</tr>
<tr>
<td>2</td>
<td>Search all protocol related information about immunogenicity</td>
<td>immunogenicity, protocol</td>
</tr>
<tr>
<td>3</td>
<td>Search all information in which immunogenicity is reported as an adverse effect</td>
<td>immunogenicity, adverse effect</td>
</tr>
<tr>
<td>4</td>
<td>Search all patients in which immunogenicity is reported as an adverse effect</td>
<td>immunogenicity, adverse effect, patient</td>
</tr>
<tr>
<td>5</td>
<td>Search all drugs that were concluded to exhibit a potential immunogenic effect and have been reported in clinical studies to be linked in adverse effects</td>
<td>Potential immunogenicity, clinical study, adverse effect</td>
</tr>
</tbody>
</table>

Each query was executed using one of the four aforementioned (see section 3.4.) search approaches and precision and recall of obtained information was recorded. In addition, Information Completeness (IC) was measured for ISC using IDR approach. General assumptions were that all relevant information was published into appropriate information channel. The search performance is summarized in Table 2.

<table>
<thead>
<tr>
<th>Query</th>
<th>Simple</th>
<th>Semantic</th>
<th>ISC</th>
<th>ISC using IDR; ISCIC = 0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Precision</td>
<td>Recall</td>
<td>P</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>0.81</td>
<td>1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>0.80</td>
<td>0.40</td>
<td>0.83</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0.90</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The results showed that executions of ISC based queries performed significantly well in answering more complex questions. The most complex query (query 5, Table 1) could only be answered by ISC using IDR model and hence demonstrated superiority in integration capability over an ISC without an IDR model. The calculation of recall considered all retrievable information without restricting to specific information channel, which otherwise would result in an R value of 1. Calculated IC values indicated that the information content was not exhibiting all necessary details despite the fact the search performed well (i.e. precision showed value of 1). This was in agreement with the overall IC value for the ISC (IC = 0.6), which suggested that
demand and supply of information was not in balance. Collaboration was encouraged in supplying particular information that was not present based on information dependencies, as exemplified in Figure 8a: four instances of specific information for a particular information instance (in this case, protocol_0005) needed to be supplied if the information set were said to be complete. These dependencies were inferred from underlying IDR model and were displayed on a separate page which listed first required information units (in the case of protocol_0005 Procedure, Target, Result and Regulation) and then information unit instances that satisfied the condition in forming a relation to the root information (here, again protocol_0005) which is demonstrated in Figure 8b.

![Figure 8a](left) and Figure 8b (right). a) Four information dependencies are indicated for information instance protocol_0005, however only two are present. b) Details about the information instance demonstrate the imbalance of required information versus actually found based on the underlying IDR model.

The underlying IDR model could be easily modified to suit the personal requirements of a scientist. The same information instance, protocol_0005 in Figure 8, was accessed with a slightly modified IDR model, in which Regulation was not considered relevant for a Protocol. This resulted in three dependencies for the same particular information instance and only one information instance supplied the information demand based on the personalised IDR model.

3.6 Discussion

The obtained results indicated that precision increased when using semantic searches in general (including both ISC search approaches) that were based on precise terms on available information set. It showed that executions of ISC based queries performed significantly well in answering more complex questions where a “simple” search could not retrieve any information. This is because in semantic less searching approach underlying domain models necessary for integrating relevant information were missing. This was in fact evident in the most complex query (query number 5 in Table 1) where information integration along three different information units was necessary and hence could only be accomplished when Information Dependency Model was introduced in using IDR model approach. In addition, since an ISC was setup for specific information types, it avoided “noisy” data which were not assigned to an information type. Although recall was higher in simple searches using a non-semantic approach, the precision was poor, as the search included noisy data without any relevance, i.e. information units that were not part of an ISC, nor were properly categorised still were retrieved by the search.

In general, it could be observed that search results based on IC (i.e. searches on the basis of information integration using IDR model) are understood by the users once the result was cross-checked against the IDR model. Collaboration was encouraged in supplying particular information that was not present based on information dependencies, as exemplified in Figure 8 and 9. In fact, in this example, the information was short on supply, as only two information dependencies were satisfied. This concept animated to browse
through the information demand and supply chain by visualizing all required properties and its values from a particular information instance that were required to satisfy the IDR model.

Information with low IC value indicated low information consistency and was confirmed by inspection of scientists with regards to provenance information. However, relative meaning of ICs, e.g. how much better was an IC value of 0.5 compared to 0.6, could not be established. Still, these highly specific ISCs provided for a powerful collaborative framework for information integration - especially in cases when IDR models where matching particular scientific workflows and hence supporting the JIT concept by signalling information demand directly within the workflow. Missing information required for conclusions – even if preliminary – could be spotted quite easily and made available timely.

The usability aspects of the framework was interpreted as the major strength of the framework mainly in information retrieval and building context areas, however visualisation and navigation of information and how it related to other information as well as data entry of new or missing information were indicated as the limitation of the framework. Especially navigating the information space within an ISC involved opening and closing of many screens and remains an open issue in terms of usability.

Although obtained results indicated superior search efficiency of an ISC framework they should not be over interpreted as first the number of test instances (130) may have been in fact too small as to allow a real appreciation of what the capabilities and limitations of the framework was. Second, only one information channel was implemented in the test scenario which in a real world setting would be probably much higher. And third, maintenance of an ISC would require attention and organisational level policy as to when and why certain information needed to be published into an information channel.

Yet, the results were promising for an ISC framework to tackle information integration in a flexible and expandable way, balancing information supply and demand through implementation of a suitable IDR model and allow seamless expanding of underlying ontology and concepts. These concepts can be summarised as follows:

1) Highly specific up-to-date and trusted information providing provenance of scientific records based on personal preferences, analogous to a BOM in SCM.

2) Information publishing right at the source and contextual linking with related information which can be related to JIT.

3) Establishment of shared or sharable ontologies across the information channels, enabling commonly agreed categorization of information. In SCM this accomplished through Service Level Agreements.

In addition, as eluted above, information provenance needs to be put in agreed concepts in order to increase trust and collaboration, especially between different organisations. Hence, in support of the view presented by Simmhan et al. (2005), provenance information along an “untrusted” information channel crossing semantic boundaries is a key challenge and needs further investigation.

4. CONCLUSION

We presented in this paper a novel approach of information integration using the metaphor of Information Supply Chain and extended it with a model based on Information Dependency Relations. We believe that such a model is able to help balancing information supply and demand and supports flexible integration of information through personalised views. In fact, using an ISC framework based on Information Dependency Relation Model – that is supporting information integration by an information dependency relation structure - allows executing complex semantic searches. Information within an ISC is integrated on the basis of semantic consistent context. Such a context is provided by the underlying ontology model of information units and allows monitoring information supply based on personal preferences which is achieved by testing as to whether given information instance satisfies its underlying information dependency model.

In using a prototype ISC framework in the case study it became apparent that certain key abstractions, i.e. information units, influence precision and recall of retrieving relevant information in drug discovery processes. For example the better the information is categorised such as “Investigation” using a common agreed ontology and in doing so putting into a context the better is its precision when it needs to be retrieved later. The presented framework demonstrates use and feasibility of ISCs to manage information integration, federation and information overload based on technologies and concepts from SCM.
ACKNOWLEDGEMENT

The project is based on a dissertation delivered to obtain the degree of Master of Science in Information Management Systems (ISM) at the University of Liverpool. We acknowledge the help and support of Dr. Bryn Roberts, who acted as the sponsor of the dissertation and Dr. Harald Kropshofer for providing information and test cases with regards to immunogenicity detection of therapeutical proteins.

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SUPPORTING DIAGNOSTIC DECISION FOR EARLY DETECTION OF A NEURODEGENERATIVE DISEASE ON A BEHAVIOURAL ALTERED PATTERN BASIS

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ABSTRACT

This paper describes the various aspects and steps of a multidisciplinary project called BEDMOND which aims at the development of an ICT-based system for the early detection of Alzheimer’s disease (AD) and other neurodegenerative diseases on the basis of data assessment with health professional criteria. BEDMOND project addresses a system that supports the decision making process for the doctor, automating the information process related, first, to the recognition and modelling of the daily activity performed by the elder while being at home and, then, to the interpretation of deviations and behavioural changes detected. The system is a future-market extension for current tele-assistance technology and service enhanced with smart-home environment. BEDMOND considers that daily activity under two main scopes: first through the elder’s daily routine -considered as a sequence of activities of daily living (ADL) - and then concretely through some specific behaviours highly concerned with mild cognitive impairment (MCI) typical symptoms (oversights and forgetfulness –medication intake, appointments, etc.-, disorientation –spatial and temporal-, loss of interest and isolation, etc.). First the requirements of such a behaviour pattern based assistant are discussed, then the system architecture deployed is introduced; next step deepens into the applied reasoning layers for the situation recognition, interpretation and data representation layers. Finally, next steps and some conclusions are also depicted.

KEYWORDS

Early detection, cognitive decline, behaviour pattern.

1. INTRODUCTION

The BEDMOND Project [1,2] aims at developing an ICT-based system for an early detection of AD and other neurodegenerative diseases, focused on elderly people while living at home. With such an early detection health professionals can later on apply an also early treatment which will help the elder to live longer in an independent way at home by delaying as long as possible AD appearance. The project started in June 2009, and it is just finishing its implementation phase, prior to test in real environment and situations until May 2012. Five sheltered homes will be equipped with the smart-home and tele-assistance technology involved (unobtrusive and low-cost) in order to validate the complete system for about a year time.

BEDMOND is based on a continuous monitoring of the elders’ behaviour during their daily living so it can be matched against a user activity profile, set up within a training period. The results of this periodical matching can provide relevant information to the health experts to evaluate whether an AD at early stage could appear to start. So, all the data gathered by the BEDMOND system, initially taken from home sensors network, later processed to daily activities recognition patterns and finally interpreted through a rule-based engine (where health professionals knowledge is the key), will be later, periodically presented to the medical expert to determine whether, at the sight of the reports, activity by activity, the behaviour changes shown may mean the beginning of a cognitive decline or just a casual deviation. After detection, health experts will
very likely apply a pharmacological treatment to the elder and BEDMOND system will keep on monitoring
user behaviour in order to assure that the supported treatment takes effect on the delay of AD appearance.

2. NATURE OF THE PROBLEM

The motivation of the activities and the work presented here are mainly driven by the demographic changes
and the related increasing prevalence of neurodegenerative diseases. The progressive ageing process of
European population will bring out an increased number of people at risk of needing care. Indeed, studies
estimate a duplication of the number of people with dementia (one of the age related diseases) every 20
years, if today’s age-specific prevalence rates persist [3]). As the prevalence of dementia increases with age,
it is estimated that the risk for dementia doubles every five years after the age of 65 and that nearly 50% of
people aged 85 and older suffer from AD [4]. Currently, international estimations come from 30 million
people in the world suffering from dementia, most of them in developing countries (66%). Moreover, 4.6
million new cases are expected to occur every year and in 2050 people suffering from dementia will reach a
number of 100 million. According to the European Community Concerted Action on the Epidemiology and
Prevention of Dementia Group [5], there are 5.5 million people estimated with dementia living in Europe.

There is considerable interest in the ability to diagnose dementia of the Alzheimer type in the earliest
possible stage of the disease. The earliest diagnosis is critical for families and clinicians for a planning and
management of the disease in terms of drug treatment and behavioural interventions. It is known that people
with Mild Cognitive Impairment (MCI) have a higher risk of developing AD compared with older persons
without discernable cognitive impairment. An early diagnosis allows an early treatment, aiming on slowing
the course of the AD, and therewith supporting an autonomous and independent living of the patients in the
privacy of one’s home. Diverse studies suggest that first indicators, that raise suspicions of a possible
neurodegenerative disease, are subtly manifested in patients’ daily behaviour patterns. Thus, an interest
emerged for developing a technological system that can record and code behavioural changes occurring in
the daily life of elderly persons applying low level sensors in the home.

3. PREVIOUS WORK

AD is an irreversible, progressive brain disease characterized by the development of amyloid plaques and
neurofibrillary tangles, the loss of connections between nerve cells in the brain, and the death of these nerve
cells. Scientists don’t yet fully understand what causes AD. Research conducted and funded by the US
National Institute on Aging (NIA) and others is advancing the field of AD genetics [6]. The early-onset AD is
caused by a number of different gene mutations on chromosomes 21, 14, and 1, and each of these mutations
causes abnormal proteins to be formed. Scientists know that each of these mutations causes an increased
amount of the beta-amyloid protein to be formed. Beta-amyloid (Abeta) is a major component of AD
plaques, one of the crucial pathological findings in AD [7]. Moreover, Abeta may play a role in prediction
the conversion of MCI to AD. Most cases of Alzheimer’s are of the late-onset form, developing after age 60.
In this case, the risk factor is related to the apolipoprotein E (APOE) gene found on chromosome 19. Several
studies confirmed that the APOE ε4 allele increases the risk of developing AD. Another possible risk-factor
gene, SORL1, was discovered in 2007. Researchers found that when SORL1 is present at low levels or in a
variant form, beta-amyloid levels increase and may harm neurons.

On the other hand, advances in biomedical sciences are boosted by the introduction of new non-invasive
imaging technologies. Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) or
Computerized Tomography (CT), are now widely used to diagnose the development and progression of
several pathologies, including cardiovascular diseases and cancer. Now, the combination of all those imaging
techniques is becoming more and more relevant. Recently, amyloid tracers for PET-MR imaging have been
developed. Therefore, in the near future PET-MR imaging combination may become an important tool for in
vivo amyloid screening, contributing to early diagnosis as well as evaluation of treatment response in AD.

Concluding, the study of the early detection of neurodegenerative diseases is being widely carried out
looking for the root and causes of the brain degeneration, through several biomedical brain-centred fields,
namely through genetics and proteomics and then through neuroimaging. However, much less has been done
through the detection and analysis of different symptoms that rapidly appear to show externally, namely through behavioural changes in the person.

4. PURPOSE

On a basis of a behavioural change recognition and interpretation, BEDMOND development pursues the early detection of a neurodegenerative disease, by means of both, an intelligent processing of the data gathered from the person activity while being at home and an adequate and professionalized manner to periodically present this processed information to the doctor. Several steps are to be tackled, from the requirements specification to the field trials for system testing.

4.1 Requirements of a Behaviour Pattern based Assistant

In order to gather the needs and requirements of both, caregivers and health professionals, a mix of quantitative (questionnaires) and qualitative (focus groups) methods was applied in two European countries (Spain and Austria). A total number of 13 caregivers and 10 health professionals participated in the focus groups. Additionally, in both countries 21 questionnaires were applied to caregivers and 20 to health professionals. Results from focus groups could show that there are several observable changes that indicate the beginning of the disease such as: personality changes (e.g. sadness, apathy), cognitive deterioration (e.g. forgetting appointments or taking medication) and behavioural changes (e.g. personal hygiene, abandonment of activities). Based on these results a questionnaire was designed in order to collect detailed information about the frequency and severity of the behaviours indicating the start of the AD. The questionnaire structure included the following sections: 1) Socio demographic data; 2) Symptoms in people with neurodegenerative diseases; 3) Possible benefits of BEDMOND system; 4) BEDMOND system acceptance and functions.

Because of a question of limited space for this paper, we will introduce the results obtained directly from health professionals, who definitively specified the same behavioural changes as those indicated by caregivers. They only added a new category: biomedical changes. Feedback from health professionals resulted in a long list of behaviours that are indicating AD. The most frequent rated behaviours can be seen below in table I.

<table>
<thead>
<tr>
<th>PROBLEM BEHAVIOUR</th>
<th>FREQUENCY (%)</th>
<th>BEDMOND SYSTEM CAN HELP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forgets what day it is</td>
<td>57.9</td>
<td>31.6</td>
</tr>
<tr>
<td>Reduction of attention</td>
<td>52.6</td>
<td>15.8</td>
</tr>
<tr>
<td>Loses, misplaces or hides things</td>
<td>47.4</td>
<td>36.9</td>
</tr>
<tr>
<td>Forgets medical appointments, important dates or taking medication</td>
<td>47.4</td>
<td>57.9</td>
</tr>
<tr>
<td>Reiterative behaviour (ask the same question continuously, to do the same action repeatedly,...)</td>
<td>47.3</td>
<td>26.3</td>
</tr>
<tr>
<td>Increased strategies to conceal the errors (self-justification)</td>
<td>47.3</td>
<td>10.6</td>
</tr>
<tr>
<td>Difficulty with coordination and organization (Problems to do the cooking, shopping,...)</td>
<td>47.3</td>
<td>36.9</td>
</tr>
<tr>
<td>Difficulties in coming up with the correct word (they use words like: “give me that” instead of “give me the plate”)</td>
<td>42.2</td>
<td>10.6</td>
</tr>
<tr>
<td>Lack of interest in things and abandonment of profitable activities</td>
<td>42.1</td>
<td>15.8</td>
</tr>
<tr>
<td>Changes in personal hygiene (showering bad or refused, not wanting to shave...)</td>
<td>42.1</td>
<td>26.3</td>
</tr>
</tbody>
</table>

A main requirement was coming from the elder at home. BEDMOND system was planned to be as unobtrusive as possible to not disturb the elder person living at home during daily life activities and not hide
relevant behavioural deviations. In contrast, results from focus groups with caregivers and health professionals during the requirements phase highlighted that such systems must have some added value/benefit for the user at home to raise their acceptance.

4.2 BEDMOND System Architecture

The findings of the requirements phase of the BEDMOND project have been fed into scenario writing. The main stakeholders are elderly people living at home, caregivers (being the ones providing daily care and feeling responsible for the elderly) and remote health professionals. The scenarios describing the future use and impact of the system from a stakeholders view have been used to identify actors, use cases and features which were modelled with Enterprise Architect in Unified Modeling Language (UML; [8]) and lead to the first iterations of the system architecture and the database model. The BEDMOND system is meant to be a platform and a hub exchanging information between these stakeholders and a tool to fulfil the BEMOND goals of supporting diagnoses and treatment.

Because of the involvement of different local and remote stakeholders the architecture is split into a home and a server side. To achieve a maximum of data security and a minimum amount of data transfer the raw data is stored on the home side and only pre-processed data is transferred to the server side. Main components of the server side are - besides the server interface and the server side database - the caregiver and health professional interfaces. Low level sensor data will only be stored in the home side database which is important for privacy reasons as well. At the elder’s home smart sensors are installed and the core components URC/UCH [9] and HOMER [10] are used and integrated. Only pre-processed data is transferred over safe and secure connections to a server where higher level processing, back-ups, user registration and management, etc., take place. The needed components to achieve alarm generation are all put on the client side, so that they can also work offline for safety and security reasons. Finally Google Calendar is used to store appointments and create reminders in a ubiquitous way.

The integration of the URC/UCH as applied in BEDMOND allows the integration of devices and services by using just one communication protocol towards the user interfaces. URC/UCH technology also brings scalability and adaptability to the BEDMOND system, allowing its future expansion by the development of APIs with “plug and play” capabilities and an efficient and seamless integration of new home automation devices (new sensors, actuators) and new services. And what is more important, also on the area of user interfaces, UCH permits a high degree of freedom on the choice of the technology and protocols used in the User Interfaces. For instance it is possible to have web based interfaces, TV based interfaces, speech driven UIs, screen readers for visually impaired and even BCI systems.

The HOMe Event Recognition System (HOMER) integrates the local sensors and performs pre-processing. It is based on an Apache Felix OSGi, which enables modularity and execution on various operating systems with the Java Runtime Environment (JRE). This fact is another aspect of hardware abstraction and independence. The usage of an OSGi framework provides remote maintenance and individual adaptability of the system: the components, in the form of bundles, can be remotely installed, started, stopped, updated and uninstalled without requiring a reboot of the system. The interactions and dependencies between bundles are handled by the framework itself. Standards for medical device communication and home automation networks are integrated to enable communication to appropriate devices. These technologies are to count on important aspects for an AAL service platform (security, modularity, extendibility and interoperability).

4.3 BEDMOND Intelligence: from Home Sensor Data to Disease Diagnostic Representation

4.3.1 Data Acquisition (Sensors)

The sensors used within the smart home network for activity detection are commercial-off-the-shelf and low-cost, namely conventional Konnex (KNX) home automation sensors [11] and other wireless sensors with a proprietary protocol. The commercial partner IBERNEX has also developed a phone call detector for incoming and outgoing calls and a piezometric sensor for pressure detection which also allows tracking the heart and respiratory rates while resting in bed. This couple of new sensors is integrated within the tele-
assistance system provided by IBERNEX. All of these sensors, as well as the tele-assistance system, are applied and connected to HOMER. Communication is established via RF-link to a gateway, which is USB-connected to a PC. All the sensors are battery powered and therefore do not need any cables, which eases the positioning and mounting in the home. Table II lists some of the non-expensive and non-invasive sensors integrated in the current BEDMOND acquisition system prototype.

Table 2. List of sensors and home location

<table>
<thead>
<tr>
<th>Room</th>
<th>Furniture</th>
<th>Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bathroom</td>
<td>presence / motion sensor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reed switch</td>
</tr>
<tr>
<td></td>
<td>Cabinets and drawers</td>
<td>reed switch</td>
</tr>
<tr>
<td></td>
<td>Shower panel</td>
<td>temperature sensor</td>
</tr>
<tr>
<td></td>
<td>Toilet (floor)</td>
<td>pressure sensor</td>
</tr>
<tr>
<td></td>
<td>Plug (shaver, hairdryer)</td>
<td>power plug sensor</td>
</tr>
<tr>
<td>Kitchen</td>
<td>Refrigerator, freezer</td>
<td>pressure sensor</td>
</tr>
<tr>
<td></td>
<td>Microwave and oven</td>
<td>power plug sensor</td>
</tr>
<tr>
<td></td>
<td>Cooker, Toaster, Coffee machine</td>
<td>power plug sensor</td>
</tr>
<tr>
<td></td>
<td>Washing Machine</td>
<td>power plug sensor</td>
</tr>
<tr>
<td></td>
<td>Drawers (cutlery)</td>
<td>reed switch</td>
</tr>
<tr>
<td></td>
<td>Chair</td>
<td>pressure sensor</td>
</tr>
<tr>
<td>Bedroom</td>
<td>presence / motion sensor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bed</td>
<td>pressure sensor</td>
</tr>
<tr>
<td></td>
<td>Wardrobes and drawers</td>
<td>reed switch</td>
</tr>
<tr>
<td>Living room</td>
<td>TV, VCR, DVD, CD</td>
<td>power plug sensors</td>
</tr>
<tr>
<td></td>
<td>Sofa, chairs</td>
<td>pressure sensor</td>
</tr>
<tr>
<td></td>
<td>phone</td>
<td>phone sensor</td>
</tr>
<tr>
<td>Hall</td>
<td>Drawers, Entrance door</td>
<td>presence / motion sensor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reed switch</td>
</tr>
</tbody>
</table>

4.3.2 Situation Recognition

The reasoning layer deepens into several levels, regarding the different sensors involved and the information provided by them. A first raw description divides the set of rules of the BEDMOND system into a couple of main blocks: low level and high level layers, two consecutive reasoning steps. Low level layer is related to information retrieved directly from sensor events or a basic data fusion. It is what BEDMOND calls the basic step in “Situation Recognition” phase. Some specific sensor events are able to provide relevant information by themselves; this is the case, for example, for the events triggered by the technical alarms (smoke and water leak). A single alarm event is informative enough to make the system react automatically to prevent a risky situation. A next level of processing could include a counting of the number of alarm events registered; for example, if the system receives a certain number of alarms in a certain period of time, the system could reason in the way to detect a hazardous behaviour of the person living at home (“basically processed data”). Another sub-level in this basic main block concerns the combination of data provided from several sensors. With a pressure sensor detecting the person in the sofa and a power consumption plug sensor activated by the TV set, the BEDMOND system can determine that the person is currently watching TV at that moment (“combining raw unprocessed data”). If those events are further processed, for example taking into account the moment of day when they are triggered and their repetition during several days of the week, a type of sub-activity of daily living being performed by the person can be inferred (“combining basically unprocessed data”).
4.3.3 Situation Interpretation

But this is not enough to build a model or pattern of the daily activity of the person. In BEDMOND scope, a daily routine pattern - as much accurate and detailed as possible - is highly relevant and has to be built, because any single deviation might be important for the physician to early diagnose a neurodegenerative disease. And here it comes up the high level layer of reasoning, what BEDMOND calls the “Situation Interpretation” phase, mainly divided in two main blocks: on the one hand, the behaviour modelling and tracking and, on the other hand, the behaviour interpretation and actuation modules.

Rules regarding the first main block can be considered as “software developers” rules whilst the second one is obviously devoted to the health professional’s knowledge and experience. Both of them also include several sub-levels. Starting from the previous basic reasoning level, BEDMOND learns and sets up an activity of daily living (ADL) like, for instance, taking breakfast. This concrete ADL is made up of a sequence of several sub-activities previously registered: open the cabinet and take a cup → open the refrigerator and take the bottle of milk → ... This reasoning level for ticketing the sub-activities and subsequent ADL is really relevant for the early detection of a neurodegenerative process because some changes on the sequence or the duration of certain sub-activities in such ADL may provide interesting information for the doctor. In a similar way it occurs to the next step of BEDMOND reasoning: there is a requirement for building the daily routine of the person, as a new sequence of ADL (sleep → get up → breakfast → personal care → home tiding → lunch → ...), taking into account that any deviation, change or even disappearance of an ADL in the daily routine sequence is a prodrome or early symptom of MCI too.

Up to this stage, the situation interpretation planned in BEDMOND could be common to many other applications taking profit from human behaviour monitoring techniques (“software developers” reasoning). However, a second level (set of rules) concerns strictly the application field in which this project is aligned: the MCI detection as the clue for the onset of a pathologic cognitive decline. Apart from some changes in the daily routine, it appears that some specific behaviours of the person are considered as potential MCI symptoms, like some of those listed in table I. This detection is not directly correlated with deviations upon a behaviour pattern, though some of them can be assimilated, up to a certain extent, to changes in the way that some ADL are performed. There is no behavioural pattern for reminding appointments, for example, but this kind of forgetfulness must be registered for an early detection of MCI. This level is much linked to sensor data fusion and to an imaginative but reliable way of detection. The third level of reasoning for this first main block deals with the deviation calculation when comparing the behavioural pattern versus the daily tracking.

Last levels rise up after measuring deviations over the pattern, regarding firstly the interpretation of those deviations and secondly the actuation required after such interpretation. Health professional criteria are now in the rule sets. These rules define the domains of the personality related to the executive function where the changes or deviations should be included (memory, disorientation, social affairs, etc.) but mainly and overall set the limits for the deviations in order to be considered as mild or critical.

4.3.4 Diagnostic Assistant Presentation

The data representation level is also a high-level layer, probably the most important one since it can decide whether the tool is useful (friendly and usable) or not. In this paper the focus is on the data representation approach for the health professional as main end-user of the system. The main challenge was not about how to get the information to show but mainly about how to present the information to the user. This is also a relevant part of the reasoning machine behind the BEDMOND system, and it has been briefly introduced in the previous chapter. The main motto to get a usable and friendly tool for the clinicians was double: adapt relevant part of the reasoning machine behind the BEDMOND system, and it has been briefly introduced in the previous chapter. The main motto to get a usable and friendly tool for the clinicians was double: adapt relevant part of the reasoning machine behind the BEDMOND system, and it has been briefly introduced in the previous chapter.

Among these international scales for screening and scoring CD, the Clinical Dementia Rating (CDR) scale was selected. This scale presents two advantages over the rest: first, it scores CD in a range coming from the same status (score “0”) up to the severe cognitive impairment (score “3”), being MCI - the detection target - in the middle of the range (score “1”); besides, different behaviours to detect are classified into six domains (memory, orientation, judgement and problem solving, community affairs, home and hobbies and personal care), and each of these domains can also be scored, providing relevant information for the health professional. Simplification is tackled through visual tools providing main conclusions at a glance. On a traffic-light interpretation basis, the information is quickly shown on green, yellow and red colours.

4.4 Next Steps

Within the BEDMOND project, the team has performed an extensive analysis of requirements for a behaviour based pattern assistant for the early detection and management of neurodegenerative diseases. An interoperable architecture has been specified and integrated in the BEDMOND platform, which follows the requirements of modularity, interoperability, and extendibility. BEDMOND team is currently finishing the system prototype modules: data acquisition, behaviour pattern modelling, activity tracking, deviation calculation and MCI interpretation. The current focus has stepped from the rule based engine implementation for “situation recognition” and “situation interpretation” in the “medical language” of the health professional up to the information presentation for the three types of users: elder at home, caregiver and health professional. Information representation is done by means of the application of adapting and simplifying criteria for the health professionals to get a quick conclusion about the information periodically reported: on the one hand, BEDMOND uses their international screening scales and questionnaires to classify and score the cognitive decline status and behavioural symptoms related; on the other hand, BEDMOND applies their own knowledge to configure and interpret the deviation values under a simple traffic-light colouring model. A laboratory prototype for technical validation and performance testing has already been set up to test the whole functionality and interfaces accessibility and usability. As a next step expert trials followed by first trial site installations in Spain and Austria are planned.

Beyond the BEDMOND project, some other new and emerging technologies could be integrated as enhanced functionality providers for a more accurate and extended behavioural characterization and also as assistive aids and home automation for ADL execution: indoor and outdoor identification and location technology both, for the person and for the objects, sound and speech technology, new smart-home sensors, actuators, smart objects and medical devices (portable or wearable), affective technology for emotional state and stress situations detection, etc.

5. CONTRIBUTION OF THE PAPER

This paper -and BEDMOND project related- explores a new field for the early detection of neurodegenerative diseases, going through an ICT ad-hoc system which has its basement on current and future tele-assistance services over a smart home environment. Some behavioural changes occurred while being at home, objectively detected, recognized and interpreted through health professional’s criteria can rapidly inform the doctor about the appearance of some MCI symptoms at an early stage so then clinic test can be applied to certify whether a pathological cognitive decline is about to start or not and drug treatment started.

6. CONCLUSION

The risk of undergoing dementia is associated so much to genetic factors as environmental. Although potentially is a strong genetic risk [12], the genetic factors are not modifiable at the moment. The environmental factors can modify the risk of undergoing dementia by their influence on the moment of the clinical expression of the symptoms, although they do not influence the presence or global absence of pathology, contributing to ‘brain reserve’ or ‘cognitive reserve’ [13,14,15]. But this is just a way to tackle a preventive step of the neurodegenerative disease. Meanwhile, health professionals are searching for a tool for the early diagnostic so that they can early apply clinical test and pharmacological treatment to slow down the disease progression. Combining tele-assistance and smart home technologies, we are able to provide the doctor with such objective information about behavioural changes prior to the disease is patent.
ACKNOWLEDGEMENT

The authors wish to thank all the members of the BEDMOND Project Team, the ones close to end-users for their efficient work done while specifying requirements, the researchers highly involved in the Ambient Assisted Living environment and technologies to apply and, finally, the market oriented companies of the consortium guiding our development for the project results impact. This project is sponsored and partially funded by the European AAL JP and the National Funding Agencies from Austria, Portugal and Spain.

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THE USE OF THE INTERNET TO SUPPORT BREASTFEEDING: AN EXPLORATORY STUDY OF BREASTFEEDING SUPPORTERS’ EXPERIENCES

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ABSTRACT

Motherhood is thought to be one of the biggest events in a woman’s life and breastfeeding is expected by many to be a natural and effortless task. However many women find themselves in difficulties when breastfeeding for diverse reasons. Breastfeeding support is offered by clinical professionals and nonclinical voluntary organisations, as a way to help women to overcome the difficulties they experience. This study set out to explore how voluntary non clinical breastfeeding supporters use the Internet to deliver support to breastfeeding mothers. Breastfeeding supporters believe that Internet and mobile applications have the potential to extend the support offered to breastfeeding mothers. With this in mind this study offers insight on how Internet applications can be used by breastfeeding voluntary organisations.

KEYWORDS

Breastfeeding, Technology Acceptance, UTAUT, Internet Interventions.

1. INTRODUCTION

The World Health Organisation (WHO) recognises breastfeeding as the natural way to feed infants and young children (ECC, 2008). In the UK the Department of Health (DoH) recommends exclusive breastfeeding for the first 6 months of an infant’s life in accordance with the guidance issued by the WHO (DoH, 2003). Babies’ benefits from breastfeeding include reduced mortality in preterm infants, reduced infant morbidity from gastrointestinal, respiratory, urinary tract and middle ear infection and less atopic illness (Renfrew, 2006). Mothers also benefit from breastfeeding including reducing lower risk of premenopausal breast cancer (Newcomb et al., 1994), lower risk of ovarian cancer (Schneider 2nd., 1987) and enhancing attachment to the infant (Tarkka, Paunonen & Laippala, 1999).

However despite the benefits, only 35 per cent of UK babies are being exclusively breastfed at one week, 21 per cent at six weeks and 7 per cent at four months and 3 per cent at five months (Unicef Baby Friendly Initiative survey in 2005 - www.babyfriendly.org.uk). These numbers are deemed to be very low, in fact amongst the lowest in Europe (ECC, 2008). The biggest decrease in breastfeeding rates occurs in the first 4 weeks after birth and mothers report lack of confidence, problems with infant latching or suckling and lack of encouragement and support as the main reasons for discontinuing breastfeeding (Tarkka, Paunonen & Laippala, 1999). Supporting mothers while breastfeeding their babies have a positive impact on the duration and exclusivity of breastfeeding. It also increases the likelihood of breastfeeding for longer (Sikorski et al., 2003).

Mothers in the UK have access to support with breastfeeding through their GP’s, health visitors, midwives and voluntary organisations. The “extensive, efficient and crucial” role of breastfeeding support voluntary organisations to support mothers while breastfeeding is recognised in the evaluation report of breastfeeding practice projects conducted by the DoH (Department of Health, 2003). Interventions developed by voluntary organisations include home visits, drop-in clinics and telephone support. The use of the Internet to support breastfeeding is thought to be a way forward to promote and support breastfeeding (Heinig, 2009).

Despite the number research on the use of Internet interventions to support breastfeeding is somewhat limited in the literature.
This study aims to understand the perceptions, views and use amongst breastfeeding supporters of Internet applications to support breastfeeding women. It also seeks to understand acceptance issues surrounding this phenomenon.

2. ACCEPTANCE THEORIES

User acceptance is a fundamental factor of failure or success of any information system endeavor (Davis, 1989) and as such it has been substantially researched and studied. The study of user acceptance of information systems has led to the development of models such as the Technology Acceptance Model (TAM) (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). These are useful for understanding attitudes and behaviors related to information systems and their use.

TAM anticipates that 2 factors determine user acceptance: perceived usefulness and perceived ease of use and these two factors influence a user’s attitude towards a system (Davis, 1989). The model has been used extensively across several different information systems and Internet usage, including online consumer behavior (Chen & Huang, 2006), Internet usage (Porter & Donthu, 2006) and Internet intervention to manage depression (Lai et al., 2008).

However regardless of the strong support received, particularly from empirical studies, researchers admit that the model lacks consideration to external variables (Venkatesh, 2000). An extension of TAM was proposed by Venkatesh and Davis (Venkatesh & Davis, 2000), TAM2 to include social influence and cognitive constructs in an attempt to further explain perceived usefulness and usage intentions. Venkatesh later on developed an integrated model in an attempt to incorporate a number of acceptance theories named the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003).

UTAUT model combines eight previous acceptance models and the result is translated into four core constructs: performance expectancy, effort expectancy, social influence, facilitating conditions; and four control variables: gender, age, experience, and voluntariness of use.

Although most of the technology acceptance research to date has been quantitative, lately there is an increasing number of studies applying qualitative methods of inquire to investigate technology acceptance (Wu, 2009). Biljon and Renaud (Van Biljon & Renaud, 2008) studied the factors influencing mobile phone adoption by older users. They used the constructs of UTAUT along with other constructs from different acceptance theories to identify the factors influencing mobile phone acceptance during interviews. Song et al (Song, Drennan & Andrews, 2009) study on Chinese consumer’s perceptions of using new mobile technology also employed acceptance theories constructs to create broad categories in their research.

This study used the four constructs from UTAUT in order to explore the acceptance of Internet and mobile applications amongst breastfeeding supporters: Performance Expectancy, Effort expectancy, Social Influence and Facilitating Conditions (see table 1). This approach is thought to provide a framework to investigate not only aspects related to usefulness and ease of use translated by the UTAUT into Behavioral Intention and Use Behavior but as well as investigate relational or social factors of using Internet applications to provide breastfeeding support.

Table 1. UTAUT Constructs and definitions (Hennington et al., 2009)

<table>
<thead>
<tr>
<th>UTAUT Construct</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Behavioral Intention</td>
<td>The strength of one’s intention to perform a specified behavior</td>
</tr>
<tr>
<td>Performance Expectancy</td>
<td>The degree to which an individual believes that using the system will help him or her to attain gains in job performance</td>
</tr>
<tr>
<td>Effort expectancy</td>
<td>The degree of ease associated with the use of the system</td>
</tr>
<tr>
<td>Social Influences</td>
<td>The degree to which an individual perceives that important others believe he or she should use the new system</td>
</tr>
<tr>
<td>Facilitating Conditions</td>
<td>The degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system</td>
</tr>
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</table>
3. METHODOLOGY

This study was designed using qualitative research methods as they are helpful to understand the significance and circumstance of the phenomena being investigated (Kaplan & Maxwell J., 1993). We recruited and interviewed 17 women providing support with breastfeeding. The sample was recruited after a presentation by the researcher of her research during the Annual General Meeting of the Breastfeeding Network in Ayr (Scotland) in November 2010. Twenty five women put themselves forward to be interviewed after the presentation, as they were very interested in the research and wanted to contribute sharing their experiences, perceptions and views on supporting breastfeeding women using Internet applications. We selected seventeen women based on the geographic diversity and roles in providing support. Amongst the participants 13 were voluntaries, 3 were employed by the BfN and ABM (Association of Breastfeeding Mothers) and 1 was employed by the NHS as breastfeeding community programme coordinator. They were all non-clinical supporters, with different roles in providing breastfeeding support including helpers, supporters and tutors.

Helpers are mothers who breastfed their own children and had introductory training in breastfeeding matters to become peers to the mothers attending drop-in breastfeeding clinics. Helpers work under the supervision of supporters. Supporters are also women who breastfed their children and are trained in feeding related issues, listening and counseling skills in order to support breastfeeding mothers. Supporters work in groups, maternities wards, on the support line, do home visits and work closely to health professional. Tutors are also trained as supporters who are responsible for training new helpers and supporters.

Each participant took part in semi-structured telephone interviews that last an average of 40 minutes. Byrne (Byrne, 2004)suggests that “qualitative interviewing is particularly useful as a research method for accessing individual’s attitudes and value”.

The study obtained ethical permission from Brunel University Ethics Committee. All participants consented to take part in the study and consent was recorded and archived. The participants ranged in age from 25 to 65 years old. They were based in various regions of the UK: East Scotland, South East England, East England, London, Wales and the Midlands.

An interview guide was designed to serve as basis to lead the semi-structured interviews. The interviews sought to explore the use, insights and contextual information on how breastfeeding supporters use the Internet in their daily routine to provide breastfeeding support. The guide also considered the UTAUT theory constructs to investigate acceptance issues during the interview.

All interviews were recorded and transcribed. Thematic analysis was used for encoding the information gathered during the interviews (Boyatzis, 1998). NVIVO qualitative data analysis software was used to facilitate the coding process. The coding exercise supported the identification of themes and consequently the analysis of the relationships between them allowing the researcher to understand this phenomenon.

Common themes emerged as we explored and connected codes and different views amongst supporters from different family settings, exposure to the technology and breastfeeding role. We then clustered the emerging themes under categories either related to the constructs of the UTAUT theory or as independent cluster of themes (Boyatzis, 1998). We also explored the data from a deductive perspective to understand the women’s experiences in using Internet and mobile applications to deliver online support.

In order to avoid accidental misleading evidence and to confirm the findings the researcher revisited the text, codes and themes several times to verify the interpretation of the data. Furthermore validity was tested through independent coding by the second author and compared with the original coded segments. The results from the data analysis are discussed in the following section.

4. RESULTS

All women interviewed used the Internet in their daily routine with some using it more often than others. They all agreed that the Internet played an important part on how they communicated with people. The interviewees reported several types of Internet use including shopping, online banking, emails, searching and browsing. Most of them had used emails, message boards and social networking sites to support breastfeeding women. A number of interviewees also identified their use of text messages as a way to support breastfeeding women. That was very interesting as the research reviewed previously had not reported the use mobile communications to support breastfeeding.
The themes arising from theory-driven codes were clustered into categories linked to the UTAUT theory constructs and our results are summarized in table 2. This approach facilitated the presentation of the findings and on formulation of further research (Boyatzis, 1998). It also provided an understanding of the factors thought to be predictive of breastfeeding supporters’ acceptance of using Internet applications to provide Internet support to women. Furthermore, it also helps in choosing theoretical constructs which may prove to be of interest to explore further using different methods (Wu, 2009).

In addition to the insights on this phenomenon as the result of the deductive approach related to the UTAUT model we also discovered a new determinant of usage that emerged inductively from the data analysis: the role women have in providing breastfeeding support. The next sections will discuss the results related to these areas.

Table 2. Theory-driven categories and themes

<table>
<thead>
<tr>
<th>Categories</th>
<th>Themes</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort Expectation</td>
<td>Personal barriers to use the Internet to support BF</td>
<td>Supporters and helpers are volunteers and as such personal issues that can be in the way to allow them to use the Internet often take precedent to the use of the Internet</td>
</tr>
<tr>
<td></td>
<td>How easy it is to use the Internet to support BF</td>
<td>How easy supporters think it is to use the Internet to support BF</td>
</tr>
<tr>
<td>Facilitating</td>
<td>Confidence to use the Internet to support BF</td>
<td>How confident supporters are to use the Internet to support BF</td>
</tr>
<tr>
<td>conditions</td>
<td>Home based work</td>
<td>A number of supporters do work from home and this has an effect on their use of the Internet to support BF</td>
</tr>
<tr>
<td></td>
<td>Shared resources with family members</td>
<td>Most of the supporters indicated that the I.T. resources they had to access the Internet are often shared with family member</td>
</tr>
<tr>
<td></td>
<td>Personal resources</td>
<td>Most of the interviewees used their personal I.T. resources to access the Internet</td>
</tr>
<tr>
<td>Performance</td>
<td>How Internet technologies are perceived to support BF</td>
<td>A number of women had ideas and suggestions on how the Internet can be used to support BF</td>
</tr>
<tr>
<td>Expectancy</td>
<td>BF supporters perceptions of peers use of the Internet</td>
<td>Supporters talked about how they perceive their BF supporters peer’s use of the Internet, generally and also to support BF</td>
</tr>
<tr>
<td>Social Influences</td>
<td>Reasons why BF mothers might want to be supported using the Internet</td>
<td>Supporters elaborated on the reasons mothers might want to be supported using Internet and mobile applications.</td>
</tr>
<tr>
<td>Role in providing</td>
<td>Expectation from other BF supporters</td>
<td>Women indicated that because other supporters use it they feel they also need to do so.</td>
</tr>
<tr>
<td>support</td>
<td>How the role and commitment in providing BF support influences usage of Internet applications.</td>
<td>The relationship between the role supporting women and the use of mobile and Internet applications</td>
</tr>
</tbody>
</table>

Key: BF – Breastfeeding

4.1 Performance Expectancy

Performance expectancy impacts Behavioral Intention as theorized in the UTAUT (Venkatesh et al., 2003). The interviewed women discussed their expectations of how Internet and mobile applications can support women during breastfeeding. They all agreed that the Internet is a very useful addition to offer support to mothers. They see it as a way to reach women that might otherwise not be able to access support while breastfeeding, particularly the use of emails and message borders.

We found here a direct association between a woman’s role in providing breastfeeding support and their Performance Expectancy beliefs. Supporters and tutors seem to have higher expectations, particularly with regards to Face-to-Face capabilities offered by videocalls: “I know that Skype is out there and can be great, that might be a possibility of supporting one day looking at positioning and attachment.” BF Supporter seconded to the DH as feeding advisor
Videocalling is perceived as a very promising alternative, as they also believe that it can deliver a new level of interaction and availability. This might be related to the level of experience supporters and tutors have with delivering one-to-one intervention. Helpers, supporters and tutors alike are also keen to use text messages and emails to deliver support: “I think txt messages would be a very good way forward because it is much less intrusive than with a phone call you need to be able to sit down however long to have a conversation.” BF Helper

Overall we found that all women involved in providing breastfeeding support had strong positive beliefs with regards to Performance Expectancy. The interviewed women also had the perception that mothers seeking support are also very supportive of using Internet and mobile applications. The reasons for that can vary from personal preference to medical or mobility conditions: “A lot of mums would find a lot easier to contact via internet rather than go to groups as can be tricky to travel, if they have had c-sections or if they’ve got mobility issues like there are no groups by or they need more immediate help.” BF Supporter and Tutor

4.2 Effort Expectancy

Effort expectancy is also theorized to impact usage via behavioral intention (Venkatesh et al., 2003). The interviewees reflected on their perceptions of how easy it is and how confident they felt to deliver breastfeeding support using Internet or mobile applications. Most of the supporters agreed that it was easy and felt confident about using it. When exploring this issue, we found association between the level of experience on using the Internet discussed by the supporters and how easy they perceived to deliver online support. Most of the women were quite experienced Internet users and saw using it as an extension of their daily use of the Internet and mobiles: “I do feel confident, not to the point I am doing programming, but using it and knowing pretty much the limitations of the technology and feel quite comfortable” BF Supporter/Tutor

The interviewed women seemed to think that the performance of the Internet applications they used to provide support was good. They all had broadband access and therefore the speed of access was not an issue. Some women reported some technical issues like weak wireless signal or low computer processing capacity. However, despite the technical issues which can potentially impact the performance of the applications, the women interviewed were willing to use Internet and mobile applications to provide support.

4.3 Social Influences

Social Influences have a different connotation in voluntary organisation, with influencing the perception about technology being the means to affect intention of use (Venkatesh et al., 2003). Amongst voluntary breastfeeding helpers, supporters and tutors the use of Internet and mobile applications was no-mandatory and therefore internalization and identification are the mechanisms used to influence others (Venkatesh & Davis, 2000): “It does make a big difference. They recognise I am the person with the computer skills. If there is somebody who wants to be supported by email for example they will send this to me. I mean not even only a local level, I got someone from Manchester I was never going to meet her, but it was like “Oh yes, xxx will do that” BF Supporter

Venkatesh et al theorized that women are more inclined to be sensitive to other’s opinions when forming an intention to use new technology (Venkatesh & Davis, 2000). Amongst the interviewees some seem to take the role to influence and shape how other peers perceive using the Internet to deliver support with breastfeeding: “I guess most people would know how much time I spend on the internet. People know use emails a lot. I guess other local supporters and trainees know I like researching things and if they want to find out some information sometimes they ask me and I will give them links to all sorts of things. So I guess I haven’t managed to disguise it, but I wouldn’t say that I am seeing as an internet expert, no” BJ/N Director and BF supporter

4.4 Facilitating Conditions

According to UTAUT (Venkatesh et al., 2003)Facilitation Conditions impact directly the usage behavior. It is conceptualized as how much an individual beliefs he is provided by the organisation with an infrastructure
to use the system. In this study the majority of the women providing support with breastfeeding do so in a voluntary basis and therefore used I.T resources that are available to them within the family unit (laptops, PC’s, printers, Broadband): “I am responsible for the resources I use to access the internet (from home). I’ve got unlimited access and I feel I have enough resources to do what I need. It is my own computer. The house has got a computer as well.” BF Supporter

Some supporters who are employed by or directors of voluntary organisations are able to recover some of the cost of the broadband. Support and training to use I.T. facilities is not structured and happens in an informal manner: “For what I use it for I think it has been trial and error. Kind of sitting on my own and finding out what I am doing. It has grown a bit organically really the charities in their use of technology” BF Supporter

Despite the uncoordinated use and ad-hoc support experienced by the voluntaries, we didn’t find a negative perception of the facilitate conditions amongst the interviewed women, nor did we found a relationship between facilitating conditions and use of Internet or mobile applications to provide online breastfeeding support. This may be due to the use of applications that don’t require demanding resources to be operated (i.e. emails, social networking) and the supporters use them as matter of routine.

4.5 Role in Providing Support

This additional determinant of usage emerged from our inductive analysis. As mentioned before there were 3 roles amongst the interviewed women: helpers, supporters and tutors. Usage of Internet or mobile applications to deliver support (Use Behavior) is influenced directly by them. Helpers seldom are in a position to offer one-to-one support whether in a face-to-face or online intervention. Supporters, on the other hand, are the volunteers who can deliver one-to-one online support as they have the skills to do so. Their level of involvement in the delivery of the supporter also seems to influence usage. Supporters who are at the forefront of the organisation, responsible for running drop-in centers, home visits and telephone support are very positive with regards to online support: “It just about having a multi-prone approach. I think if we ran the rest of the BfN the way the drugline is run so there is access to one-to-one, access to support, there is signposting, but there is also written information that’d be great. I think if people actually doing the support line think that Skype or videocalling would work then I am all for that.” BF Supporter.

Within the role we also found that the family setting has an influence in the usage of Internet or mobile applications amongst the supporters. Supporters with young children reported the children’s need for attention take precedence over using the Internet overall and consequently impacts the use of applications: “I find it tricky with the baby when the computer is on as she tends to try and push buttons. Once the baby is sleeping during the day, which is not very often, is when I try to catch up with things around the house rather than looking into the Internet. Also trying to sleep when baby sleeps as baby is still wakes up a few times into the night other that look into the internet.” BF supporters

On the other hand supporters with older children, who are able to use computers unsupervised, report an increase in the competition to use the computer resources available in the family. This consequently impacts the availability of the resources and access to the applications to delivery support online: “It can be difficult to fit in as my children are growing up and we have just one computer at home, but on the other hand you can do things quite quickly.” BF counsellor

5. CONCLUSIONS

This paper is the result of a pioneer research with the objective to explore the use of Internet applications to support breastfeeding. Breastfeeding support organisations are indeed using Internet and mobile applications to extend the support they provide to mothers seeking information, reassurance and help during their breastfeeding experience. The interviewed supporters, helpers and tutors agree that this presents an opportunity to reach women that might be not reached otherwise.

Breastfeeding mothers are known to use the Internet to obtain information and support (Laborde et al., 2007). A small number of studies and projects using the Internet to delivery interventions to support breastfeeding women have been conducted to date. These studies are based on interventions managed by medical professionals and involved a limited number of professionals and women. This limited research on
the use of Internet interventions to support breastfeeding seems to indicate the suitability of this type of interventions to support women. While this is valid to understand some aspects of using Internet applications to support breastfeeding, it excludes the work of voluntary breastfeeding support organisations, which have a good record of reaching and supporting women who are least likely to breastfeed (Department of Health, 2003). Early research also fails to explore acceptance issues surrounding this phenomenon both in clinical or non-clinical setting.

Issues of privacy, suitability, possibility of litigation and lack of guidelines to handle email supported intervention were raised by physicians supporting nursing mothers (Thomas & Shaikh, 2007). Equally breastfeeding supporters expressed similar concerns with using emails to support breastfeeding women. The benefits of using email support including accessibility and tailored information were also discussed by breastfeeding supporters. Supporters and physicians seem to think that the mothers receiving this intervention felt supported and grateful for it. However supporters to have a better understanding of the mother’s perceptions on obtaining support via email. Arguably, email support can have an impact on the continuation rates, as it provides encouragement to mothers.

Feasibility and acceptance of infant feeding video support after hospital discharge was the subject of a study conducted by Annie Roberts (Roberts et al., 2009). Whilst it showed that women were enthusiastic about it, it also raised concerns about security, availability of the technology and impact over the future of the existent services. Breastfeeding supporters see using videocalls as a very promising way to deliver support, albeit they also have similar concerns. However supporters also see the cost benefits related to this type of intervention and the possibility to reach women who for one reason or another are house bound.

In general the interviewed women perceived the technology as very helpful, easy to use and appropriate to their needs. We also identified a new determinant of usage beyond the UTAUT constructs: The role and level of involvement in providing breastfeeding support. Within this determinant we found that family size and age of children seem also to be influential the use of Internet and mobile applications to provide online support. The study also indicates that developing structured web-based intervention including moderated forums, videocalling applications, web-chat and mobile applications is perceived by the interviewees as a way forward to expand the reach and availability of breastfeeding support.

As with any other study, there were limitations. In the study we did not interview any clinical professional providing breastfeeding support. This should be explored in a future study as breastfeeding support is also delivered by clinical professionals. Their views on using Internet and mobile applications to provide breastfeeding support are an important part of this phenomenon and will contribute to build a better picture.

There was also the limitation imposed by the word requirement of this paper. Other themes emerging from the data unlinked to the UTAUT constructs have not been discussed in this paper for this very limitation. For this, an extended version of this paper would be necessary. Although we discussed how supporters perceived the mother’s views on receiving support through internet or mobile applications, we were not able to explore the impact of this type of support on any breastfeeding outcomes (e.g. initiation, duration or management of breastfeeding).

A further study is to take place to explore acceptance issues and any impact of this type of support on breastfeeding mothers. The combination of the results of both studies is expected to offer deeper insight of women’s acceptance, needs and expectations of using the Internet and mobile applications to support breastfeeding. These findings are expected to support the development of interventions to support women while breastfeeding their children.

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E-ID MEETS E-HEALTH ON A PAN-EUROPEAN LEVEL

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ABSTRACT
Information and communication technologies are more and more becoming an inherent part of our life. This is particularly manifested in the fields of electronic government and electronic health care. Identification, authentication, and data privacy protection are the key elements to ensure both secure and reliable transactions and trust in the applied technologies. So far, European governments and public administrations have rolled out eID (electronic identity) solutions and put in place proper eHealth infrastructures that are tailored to national needs. Globalization and the opening of the EU internal market have raised the demand for interoperable solutions across national borders in order to allow citizens to use own eGovernment and eHealth infrastructures also abroad. For this reason, the European Commission has started several initiatives with the aim to establish interoperability between different national solutions. The large scale pilot STORK strives for the goal to enable mutual recognition of electronic IDs between EU Member States. Another large scale pilot called epSOS provides a pan-European framework for the secure and reliable exchange of patient health data. In this paper we review and compare both large scale pilots from several perspectives. We further investigate how synergies between both pilots can be exploited so that epSOS can reap the benefits of STORK to replace paper-based identification procedures with a fully-fledged electronic one.

KEYWORDS
eID, electronic identity, eHealth, STORK, epSOS

1. INTRODUCTION
The emergence of information and communication technologies (ICT) has had a significant influence on various parts of our daily life. Since nowadays more and more transactions are processed online, secure and reliable user identification over the Internet has become an important topic. One popular field of application is eGovernment, where eIDs are used to unambiguously identify citizens within administrative and governmental procedures (Siddhartha, A. 2008). Another area that has been heavily influenced by ICT during the past years is healthcare. The utilization of information and communication technologies in the context of healthcare services has been commonly known under the term eHealth.

Both, in the field of eID and in the area of eHealth various independent approaches and solutions have been developed during the past years and decades. These solutions are mostly tailored to the requirements of a certain country. Hence, interoperability between different solutions is often not ensured by their nature. With the increasing mobility of people, interoperability has become a significant demand. The European Union has already reacted on this and is currently supporting several large scale pilots (LSP) that aim to improve interoperability of existing solutions on a pan-European level. In the field of eID, the LSP STORK (Secure Identity Across Borders Linked) (Ivkovic, M. et al 2009) attempts to establish a pan-European interoperability infrastructure for the mutual recognition of eIDs across EU Member State boundaries. Similarly, the LSP epSOS (European Patients Smart Open Services) (epSOS, 2010) aims to facilitate cross-border activities in the context of eHealth services.

Although, the LSPs STORK and epSOS run independently from each other, both rely on the two basic concepts ‘user identification and authentication’ and ‘electronic signatures’ within their proposed use cases. Therefore, it is meaningful to search for synergies between the two LSPs in order to reap the benefits from each other and to achieve better results in a more cohesive and efficient way. In this paper we identify these synergies and show how they can be used to improve the pilots. By discussing several use cases we further show how these synergies could be turned into concrete results, which all users can benefit from.
To provide the reader with a comprehensive understanding of the topic, the remainder of this paper is structured as follows. Section 2 introduces the two LSPs STORK and epSOS, describes the projects’ main goals and reports on already observable results. Subsequently, in Section 0 a comparison of the two projects is made. Synergies that may be exploited to fill certain gaps are identified and discussed in Section 4. Possible solutions implementing and using the identified synergies are introduced in Section 5. Finally, conclusions are drawn.

2. THE EUROPEAN LSPS STORK AND EPSOS

During the past years, eID and eHealth have turned out to be more and more topics of increasing importance and interest. Due to the advancing globalization and the opening of the European internal market, the demand for interoperability between different closed systems has been increased to the same degree. Especially in the European Union, several attempts are currently made to improve the compatibility of Member State specific solutions in the fields of eID and eHealth. In this section, basic concepts and objectives of the two LSPs STORK and epSOS, which aim to tackle the issue of eID and eHealth interoperability, are briefly introduced.

2.1 LSP ‘Secure Identity across Borders Linked (STORK)’

With the increasing need for secure and reliable authentication mechanisms over the Internet, most European countries have rolled out their own eID infrastructures in the last years. Missing central coordination and varying national legal requirements have led to significant differences in current country-specific solutions. Due to these differences, interoperability between EU Member States eID solutions is not ensured by their nature, which in turn makes cross-border user authentication a hard task.

STORK aims to tackle this issue by establishing a cross-border interoperability framework that builds upon already existing national eID solutions. In this way, subsidiarity of EU Member States is ensured and national solutions remain untouched. At the same time, interoperability with foreign eID systems is established. The STORK interoperability framework comprises two different authentication models. Applying the so-called ‘middleware model’ service providers integrate all foreign eIDs using a country specific middleware. Alternatively, the STORK framework also supports a ‘proxy model’. Following this approach, each country runs a single gateway – a so called ‘Pan-European Proxy Service (PEPS)’. Cross-border transactions are delegated from Service Providers (SP) to their national PEPS instances, which act as gateway and subsequently forward the transaction to the responsible foreign country’s PEPS. The actual eID authentication process itself is carried out in the citizen’s home country. Finally, the obtained identification and authentication data is again returned through the PEPS infrastructure back to the requesting Service Provider.

Several EU Member States like Austria or Germany rely on the middleware model due to scalability issues, or liability and data protection policies. In this paper, however, we focus on the proxy model, since it has turned out that this model has a higher potential for synergies with the epSOS project.

The proposed STORK authentication framework has already been implemented and is currently evaluated by several pilot applications (Leitold, H. and Zwattendorfer, B. 2010). Experiences that have been gained so far have shown the ability of the proxy model to enable secure and reliable cross-border user authentication.

Figure 1 illustrates a typical STORK authentication process of a European citizen (originating from country B) at a Service Provider (SP) located in a foreign country A on an abstract level. In this cross-border scenario, both countries (Member State A and B) rely on the PEPS approach. In a first step, the citizen of MS B wants to access a certain application at the Service Provider located in MS A using her eID. Starting the cross-border authentication process, the Service Provider contacts its national PEPS A instance. PEPS A forwards the authentication request to the citizen country PEPS B instance where the authentication process actually takes place using domestic Identity Providers (IdP) and/or Attribute Providers (AP). After having successfully authenticated the citizen, PEPS B assembles the identity data into an authentication token and transfers this token back to PEPS A. In this process step, PEPS B asserts PEPS A that the citizen has successfully authenticated with a certain quality at a certain point in time. In a final step, PEPS A returns the identity and authentication information to the requesting SP where access to the service is granted or denied for the foreign user.
2.2 LSP ‘European Patients Smart Open Services (epSOS)’

While STORK aims to make existing eID solutions interoperable, the goal of the large scale pilot epSOS is to achieve interoperability for eHealth services on a pan-European level. In particular, epSOS aims ‘to develop a practical eHealth framework and ICT infrastructure that will enable secure access to patient health information, particularly with respect to a basic Patient Summary (PS) and ePrescription (eP, including eDispensation - eD), between European healthcare systems’ (epSOS 2010).

According to (Heider, G. 2010), ‘the main functionality of the epSOS LSP environment is the provision of patient health data stored in patient’s home country to a health care professional providing health service in a foreign country’. Besides the secure and reliable transmission of patient health data, identification has been identified as a key element of the epSOS LSP. Reliable identification and authentication mechanisms are vital to unambiguously identify patients and to ensure that privacy-sensitive health data is protected and accessed by authorized health care professionals (HCP) only. Even though identification is a vital prerequisite, the main objective of epSOS is the cross-border provision of patient health data. Basic building blocks of the infrastructure proposed by epSOS are the so called National Contact Points (NCP) that act as interfaces between different national eHealth infrastructures. According to (Kolitsi, Z. and Wilson, P. 2010), an ‘epSOS NCP is identifiable in both the epSOS domain and in its national domain, acts as communication gateway, and establishes a Circle of Trust amongst national Trusted Domains’.

At a high level view, Figure 2 illustrates a typical identification process within the epSOS project. Currently, the identification process of e.g. a patient of Member State B takes place at the Point of Care (PoC) in Member State A and is carried out by an authorized HCP. In the example of patient identification, the HCP is responsible for verifying the foreign patient’s identity by checking a passport, driving license or health insurance card. To additionally check whether the patient allows the cross-border transfer of her sensitive health data between institutions of Member States A and B, the HCP needs to verify certain patient’s identification data in the patient’s home country. In a first step the HCP submits the patient identity verification request through her PoC to the NCP of Member State A. NCP A then forwards the identity verification request to the NCP of Member State B where the patient originally comes from. At NCP B the identification data is verified using national infrastructures. Having successfully verified the patient’s identity, a special Patient ID uniquely identifying the patient within the epSOS context is returned from NCP B to NCP A and finally to the HCP stationed at PoC.

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1 A point of care (PoC) defines a hospital, a medical office or any other point where a patient could receive healthcare.
The conceptual similarity between an NCP and PEPS, which is a major component in the STORK infrastructure, is evident. A comparison of the frameworks that have been developed in STORK and epSOS is given in the next section.

3. COMPARISON

The interoperability objectives of the two LSPs STORK and epSOS are very similar. Both projects aim to establish interoperability between country specific solutions rolled out on the large scale. In this section, we look at similarities between STORK and epSOS in more detail and analyze their significant differences in order to facilitate the identification of potential synergies.

The most apparent similarity between STORK and epSOS is their operating principle: both large scale pilots aim to facilitate the secure and reliable cross-border data exchange between EU Member States while retaining already existing country specific infrastructures. The architectures of STORK and epSOS are basically comparable as being illustrated in Figure 3. Both LSPs rely on national gateways, through which cross-border data exchanges are processed. All gateway instances belong to a so called Circle of Trust that is based on agreed policies of a particular governance structure in order to mutually establish trust relationships. In STORK, these gateways are called PEPS, while epSOS refers to these components as NCP. Nevertheless, the basic intention of using one single gateway per EU Member State is the same in both LSPs.

In both projects, data is exchanged but not shared between different Member States. Thus, the requested information is forwarded by the involved gateways for temporary use only, but is never stored in the foreign
country’s infrastructure. Besides the overall architecture, the conceptual and technical design of those gateways is very similar. Both, the PEPS and NCP concepts internally rely on a platform independent model and make use of web standards based on XML for cross-border communication and data exchange.

Besides these similarities, there are also some significant differences. One apparent difference is the kind of information being exchanged across borders. While STORK basically exchanges only simple attributes, epSOS proposes the exchange and transformation of complex documents. Another major difference is the use case. While STORK supports the cross-border identification and authentication of citizens only, epSOS additionally aims at the cross-border exchange of patient health data. Even if both LSPs rely on a common XML-based transport protocol, further differences can be found on message level. For instance, STORK only supports a request/response messaging mechanism, whereas epSOS additionally relies on a notification message. However, for identification and authentication both projects rely on the well-established Security Assertion Markup Language (SAML) standard (Cantor, S. et al 2005).

Even though STORK and epSOS have some apparent similarities, also several significant differences between these two LSPs have been identified. Nevertheless, there is much potential to use synergies between these projects. The following section identifies potential synergies by sketching appropriate use cases.

4. SYNERGIES

This section identifies common use cases and shows on an abstract level how STORK and epSOS processes can be combined together so that epSOS can benefit from the outcome and findings of STORK. Thus, examples are given on how cross border electronic identification can be successfully integrated into the eHealth world of epSOS.

By having a deeper look at the STORK uses cases and protocols, the following epSOS scenarios could be realized using STORK functionality (Campari, C. et al 2010):

1. Patient identification
2. HCP authentication
3. Patient consent signature
4. Signature verification of foreign signed prescriptions

4.1 Patient Identification

Within the epSOS world - before being medically treated by a HCP - the patient needs to be uniquely identified. Currently, epSOS foresees identification using paper-based documents only. By the help of STORK, patients from foreign countries could be identified using their national electronic ID. The only things required are Internet access, a web browser, and a token reader (depending on the underlying technology of the eID) at the point of care (PoC).

Figure 4 illustrates a successful epSOS patient identification process based on the STORK architecture. In this example, the traditional authentication process used in epSOS is enhanced by supporting foreign eIDs. For that, no major modifications are required. The traditional epSOS authentication process is just enhanced by a fully-fledged electronic one. From a STORK perspective, the national NCP acts as simple service provider, which triggers the cross-border authentication process. The Patient-ID received via STORK can still be used for verification at the citizen country NCP. Thus, no adaption is necessary in the actual epSOS process flow.
4.2 HCP Authentication

The use case of HCP authentication is very similar to the use case of patient identification; hence we continue without a detailed analysis. In addition to a unique ID for the HCP also authorization attributes are requested during authentication. These authorization attributes specify a certain role and guarantee that the HCP has the appropriate rights and profession to medically treat the patient (e.g. to prescribe medicine for recovery). A HCP authentication is usually started directly from the epSOS web portal.

4.3 Patient Consent Signature

A major objective of epSOS is the access to patient’s data across borders. For such a data exchange, an additional permission by the patient is required. epSOS manages this additional authorization requirement by relying on a patient’s consent. Thus the patient explicitly gives her consent for cross-border data transfer, which is verified by the NCP. By combining both LSPs, the create-signature functionality of foreign eIDs through STORK could be used for signing the patient’s consent. In this scenario, the process flow steps and the modules involved are equal to the ones shown in Figure 4. There is no change in the process flow, only the exchanged data is different.

4.4 Signature Verification of Foreign Signed Prescriptions

In this scenario, it is assumed that some kind of medicine needs to be dispensed to patient A in country B. However, the medicine to dispense has already been prescribed in country A and patient A has an electronic prescription for it. The aim of this use case is to verify an electronic prescription (issued by a HCP in country A) in country B. For that, the functionality of a national PEPS could be enhanced by signature verification to verify the ePrescription’s signature.

5. IMPLEMENTATION PROPOSALS

Identification, authentication and electronic signatures are key elements of the eHealth sector. Secure identification and authentication of patients or HCPs is also an essential part of epSOS. Electronic signatures are helpful for securing and authenticating cross-border data exchange of patient summaries or electronic prescriptions. Section 4 has identified common use cases where STORK and its developed eID
interoperability framework could support epSOS in its processes. This section goes a little bit more into
detail and tries to point out how a liaison between STORK and epSOS could be achieved.

5.1 Identification and Authentication

epSOS defines uses cases where unique identification and authentication of patients or HCPs is required. Currently, the identification process of e.g. a patient by a HCP is based on traditional ID documents such as passports or driving licenses. However, for retrieving a unique patient identifier also STORK could be used. STORK has already developed and implemented a framework for identification and authentication across borders. In its common interface specification (Alcalde-Moraño, J. et al 2010) STORK has defined an attribute reflecting an eIdentifier which could simply be used as PatientID in the epSOS context. If required, also a new attribute could be defined. The STORK protocol has been specified open and flexible in such a way that new attributes can be introduced easily. Therefore, no change in the original message format would be necessary, only an agreement on organizational level of both projects. This easy adoption of new attributes can also be used for HCP authentication and authorization. In epSOS, HCPs must have appropriate rights or roles to e.g. access foreign patient data. Those roles could be mapped to STORK attributes and transferred to the requesting PoC.

STORK functionality should be easily integrable into an epSOS portal because both, STORK and the current epSOS authentication services rely on the SAML Web SSO profile (Hughes, J. et al 2005). However, both projects build upon a different set of SAML bindings and protocols. Thus, a common agreement on used bindings and protocols needs to be negotiated between both projects. Additionally, the contents of the exchanged assertions need to be defined in detail in order to be accepted by the respective services.

5.2 Signature Creation and Verification

Several epSOS use cases rely on the secure exchange of documents across borders, such as the transfer of patient data or electronic prescriptions. To guarantee the authenticity of those documents electronic signatures are applied. Nowadays, most eID tokens can be used to create electronic signatures. The STORK interface specification supports the creation of electronic signatures on documents using the STORK protocol. This functionality could be used in epSOS for e.g. patient’s consent signing. Since STORK supports signing of arbitrary XML data, no special amendments for epSOS would be required.

Usually, besides signature creation, it’s essential to verify documents that are signed. Currently, STORK does not support the verification of digital signatures but only the validity check of digital certificates. However, it would be advantageous to enhance the current implemented certificate validation request/response protocol to additionally support signature verification. To keep the verification process similar to the creation process, in STORK just an additional attribute indicating a signature verification request needs be introduced. At the moment, signature creation within STORK is based on the OASIS DSS protocol (Pope, N. and Carlos Cruellas, J. 2007) thus also signature verification should follow this standard.

6. CONCLUSION

Secure identification and authentication play important roles in daily live when using online services. Especially in applications where sensitive data is transferred or processed, security is an inevitable requirement. Popular fields where unique identification is required are e.g. the eGovernment or eHealth sectors. Currently, most applications in these fields are designed to satisfy certain needs of one country only and cross-border communication is limited. However, the European commission has started several initiatives and research projects to overcome these interoperability issues. The LSP STORK focuses on the interoperability of national EU Member States’ eID solutions. Similarly, the project epSOS aims on facilitating the exchange of patient or health data across borders.

Although both projects are carried out independently, several synergies can be identified. The most apparent similarity between STORK and epSOS is probably their basic architecture. Both projects rely on a single gateway per Member State – a so-called PEPS in STORK terminology and a NCP in the epSOS world. Those gateways are responsible for the cross-border data exchange and hide the national and country-specific
solutions. Nevertheless, also differences between both projects exist since STORK focuses on the secure exchange of simple identification data, whereas epSOS tries to facilitate the cross-border exchange of complete documents.

However, both projects can be combined to enhance certain general use cases to full online services. For example, for patient identification the epSOS concept currently relies on paper-based IDs only. To avoid such a media break, we have shown how the STORK framework could be integrated into the epSOS architecture to support the recognition of foreign electronic IDs, too. This could be easily achieved since both projects base on well-established standards such as SAML. In general, the use of standards and open interfaces is essential for re-using concepts in other projects and establishing interoperability.

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THE OPEN-SOURCE INTEGRATING THE HEALTHCARE ENTERPRISE (IHE)

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ABSTRACT
IHE has an increasingly great importance in delivering optimal patient care [1]. By pushing the integration of well-accepted standards in the healthcare domain, the IHE initiative improves interoperability between heterogeneous systems. The work described in this paper strives to give researchers enough information about open-source applied to IHE to get started with small-to-medium scale medical informatics research projects. In this context, we present free / open-source implementations of several IHE Profiles participating in the architecture of a very precise yet common motivation scenario: the medical document exchange. The objective of this work is to show that open-source applications may be successfully used in sensitive contexts such as healthcare, provided that scope and potential issues are well considered. Discussion at the end of this work informs on strengths and weaknesses of the presented frameworks as well as of the open-source model itself.

KEYWORDS

1. INTRODUCTION
Integrating the Healthcare Enterprise (IHE)-enabled technologies have been gaining momentum [2]. IHE is an initiative led by the healthcare industry and professionals. It is sponsored by the Healthcare Information and Management Systems Society (HIMSS) and Radiological Society of North America (RSNA). IHE’s objective is the support of optimal patient care, by solving interoperability problems encountered in the communication between heterogeneous healthcare systems. In order to make the integration of systems easier, IHE combines well-established standards, such as DICOM, HL7 and W3C standards, in specifications that intend to address specific clinical needs. Specifications are called Profiles in the IHE terminology.

There exist commercial-grade implementations for many IHE profiles, which can be found in IHE’s product registry. Since implementations are to make their way into the healthcare infrastructures, which have strong requirements in terms of security and liability, the IHE group proposes a way of checking the compliance of these solutions by testing them against other vendor implementations. This event is worldwide and is called “Connect-a-thon”[2]. There are various Connect-a-thon events around the world and results are generally saved on dedicated servers by organizing region (USA[3], Europe[4]…). Participants, which successfully passed the tests are given an IHE conformance certificate, called “Integration Statement”. This statement can be a strong selling argument.

Aside from commercial implementations, IHE also found a way out into the open-source domain in the form of Free and Libre Open Source Software (F/LOSS) or Open Source Software (OSS) more generally. Many quality implementations are available today in public repositories. This document provides a list of some popular free and/or open-source implementations and provides two feature matrices offering a per-actor and per-transaction view. The objective of this work is not to analyze existing solutions, but rather show the benefits and issues of using open-source in a sensitive context such as medical informatics.

1 http://product-registry.ihe.net/PR/home.seam (viewed 21 February 2011)
2 http://www.ihe.net/Connectathon/ (viewed 21 February 2011)
4 http://connectathon-results.ihe-europe.net/ (viewed 21 February 2011)
5 http://www.sourceforge.net (viewed 21 February 2011)
The next sections of this paper will provide some insight into research, which has already been done on open-source applied to medical informatics. A motivation scenario is then discussed as a basis for the selection of the open-source IHE implementations. Towards the end of this work, some popular implementations are presented along with a discussion about their benefits and potential issues.

2. RELATED WORK

Numerous papers have been written about open-source frameworks applied to medical informatics. These works typically fall in one of these categories: framework surveys, studies on usage of open-source in medical informatics, open-source maturity/quality measurement.

First, the number of surveys and studies related to clinical applications suggest that open-source in mainstream developments has definitely attracted interest from the healthcare sector [3]. A relatively recent study [4] confirms the existence of an active OSS development community focusing on health and medical informatics, yet hospitals seem slow to follow [5]. Numerous surveys about existing frameworks and standards have been published [6][7].

Although open-source in medical informatics is taking attention, its adoption rate varies greatly across the globe. The very sensitive nature of the healthcare IT primarily raises questions about liability. A study published in 2007 shows that open-source software adoption in Quebec by health care organizations has still many barriers to overcome [8], supposedly due to lack of proper information and internal political pressures. Another study shows that in UK, the future of open-source software implementation in the public sector is uncertain [9]. Even if there is evidence that a change is occurring, a major shift from current outsourcing deals doesn’t seem to be happening anytime soon. In the U.S, where the health expenditure is the biggest in the world, open-source electronic health record systems seem to be at the center of the discussion [10]. Another very serious study [11] suggests that F/LOSS-related services in Europe could reach a 32% of all IT services by 2010. Unfortunately, we do not have corroborating data to verify this. So, even if there is evidence through studies, that open-source is taking off in the public sector and healthcare, it is not yet clear what to expect in the future.

Finally, this work would be incomplete without a word on maturity models in open-source. According to its definition, the open-source maturity model (OSMM) is a formal methodology for assessing the maturity of a given open-source software. OSMM from Capgemini is a practical method based on two axes and two levels. OSMM from Navica has been exposed in [12], but the Navicasoft’s website seems to be down for a long time. The Method for Qualification and Selection of Open Source Software (QSOS) described in [13] is a four step iterative evaluation process based on criteria split into three axes: functional coverage, risks for the user’s perspective and risks from the service provider’s perspective. Open Business Readiness Rating (OpenBRR) is an assessment methodology aiming at the integration of company constraints. A comprehensive comparison between QSOS and OpenBRR has been published in [14]. Finally, the QualiPSo Open Source Maturity Model (OMM) described in [15] is also based on three levels, each one requiring the software to comply with different elements of trust.

Ultimately, the research in this paper does not intend to supersede any of these previous works (surveys), but indeed complement it. Our focus is not on analysis through OSMM methods, but showing instead a concrete case in medical informatics where open-source tools are particularly well suited.

3. MOTIVATION

Some situations may arise, where large commercial infrastructures may notsuit the very particular needs of some healthcare deployments. Since they represent major investments in terms of time, resources and infrastructure, their use is often restricted to highly sensitive applications both in terms of patient safety and security.

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7 http://www.navicasoft.com (viewed 21 February 2011)
8 http://www.openbrr.org/ (viewed 21 February 2011)
On the other hand, some deployments often require limited resources and fast response, because they are limited in scope and simple in application. This holds particularly true in medical informatics research projects. In this context, the medical data exchange scenario [16] fits particularly well within this type of limited-scope deployment. It is conceptually simple, all actors are known in advance and require relatively few resources to deploy and test.

A rapid analysis of this scenario shows that the medical document exchange involves the participation of one or more source actors (typically hospitals) injecting medical documents into a repository, one or more consumers consuming them (hospital units or general practitioners) and a central repository managing document entries. The picture below illustrates this scenario.

![Figure 1. Typical document exchange scenario actors](image)

This scenario has already been extensively described in the IHE IT Infrastructure Technical Framework [17][18][19] both in terms of IHE Profiles and Transactions. The figure below, taken from the Technical Framework, shows exactly the same deployment based on IHE actors.

![Figure 2. IHE Document Exchange](image)

In terms of IHE profiles, the medical data exchange scenario illustrated above involves a registry and repository, which are responsible for the management of the document entries. The IHE Cross-Enterprise Document Sharing (XDS) profile provides that kind of functionality. Furthermore, in order to associate patients described in the documents to entries in a patient index, IHE provides the Patient Identity Cross-Referencing (IHE PIX) and the Patient Demographics Query (IHE PDQ) profiles. The first bridges identifiers from different domains (usually hospitals) for the same patient and the latter provides demographics. Finally, the Audit Trail and Node Authentication (IHE ATNA) profile handles security and audit logging. Those profiles may also have dependencies on other profiles, such as Constant Time (CT) or Cross-Enterprise User Assertion (XUA), which handle time synchronization and user assertions respectively.

Since many free implementations exist for individual IHE Profiles, the medical document exchange scenario provides thus a good motivation scenario. First of all, the modularity of its architecture makes for a higher probability of finding related implementations. It is obviously more complicated to find a “do-it-all” solution, than finding the implementation of a single profile. Second, since actors and transactions are
translated by IHE in terms of specifications (IHE Profiles are based on specifications), it is somewhat certain that different implementations will communicate almost seamlessly. Finally, since the scope of this deployment is rather small and usually limits to a few hospitals and a few care providers, the cost-effectiveness of an open-source solution is a major motivation.

The following sections present some popular IHE implementations that provide the necessary building blocks necessary to architect this scenario (partially or fully) or are complete implementations of it. Two reference feature matrices are provided that give some information about the implementation status for the tested platforms.

4. OPEN-SOURCE IHE IMPLEMENTATIONS

The provided open-source implementations proposed below are part of a selection provided by an extensive, but non-exhaustive compilation from several sources\(^9\)\(^10\). There exist many other free and open-source alternatives, but to date, those listed below seem to be the most popular and some of them are used in large-scale healthcare deployments, although no specific criteria has been used in their choice.

**IHEOS.** IHE Open Source (IHEOS) is an implementation of the Cross-Enterprise Document Sharing (XDS) profile developed by the National Institute of Standards and Technology (NIST) for the testing of certain IHE Profiles.

**O3-XDS.** Open Three Cross-Enterprise Document Sharing (O3-XDS) is an open-source initiative from the Open Three (O3) Consortium. This project was activated by the SSIC-HECE & DEEI in cooperation with the Dipartimento di Scienze Medico Diagnostiche e Terapie Speciali and the Università degli Studi di Padova in Italy. O3-XDS provides a modular and portable XDS registry and repository actor implementation.

**HIEOS.** Health Information Exchange Open Source (HIEOS) is an open source implementation of Integrating the Healthcare Enterprise (IHE) Cross-Enterprise Document Sharing (XDS.b) and Cross Community Access (XCA) integration profiles, enabling longitudinal records. HIEOS’ core services can be used in federated, hybrid or centralized model scenarios.

**IPF.** The Open eHealth Integration Platform (IPF) is an extension of the Apache Camel routing and mediation engine. IPF provides domain-specific languages (DSLs) for implementing general-purpose as well as specific Enterprise Integration Patterns, such as HL7-specific integration solutions. These DSLs are extensible via Groovy's meta-programming features. IPF may be easily embedded into Java applications and also provides support for deployments inside OSGi environments. In addition to its many features, IPF also provides failure recovery and high-availability features support.

**OpenXDS.** The Open Cross-Enterprise Document Sharing (OpenXDS) project is the document sharing component of the OpenExchange\(^11\) platform. It provides an implementation for the IHE Cross-Document Sharing Registry and Repository actors, as well as an implementation for both the IHE Cross-Community Access (XCA) actors.

**OpenPIXPDQ.** The Open Patient Identity Cross-Referencing and Patient Demographics Query (OpenPIXPDQ) project is the patient identification management component of the OpenExchange platform. It provides an implementation for the IHE Patient Identifier Cross-reference (PIX) Manager and Patient Demographics Query (PDQ) Supplier actors.

**OpenATNA.** The Open Audit Trail and Node Authentication (OpenATNA) project is the audit management component of the OpenExchange platform. It provides an implementation for the IHE Audit Record Repository of the ATNA profile.

**CONNECT.** Initially developed by U.S federal agencies to support their health-related missions, CONNECT is a software solution for healthcare applications. Now available to all organizations, CONNECT has become an open-source solution providing Health Information Exchange (HIE) at both local and national levels. CONNECT uses the Nation-wide Health Information Network (NHIN) standards and governance.

**MS-XDS.b RI.** Microsoft XDS.b Reference Implementation is Microsoft’s implementation of the IHE XDS.b Document Registry and Repository actors. It also provides implementations for client-side ATNA logging, Secure Node actors and is available only for the Microsoft Windows\(^\text{TM}\) platforms.

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**IHE Profiles.** IHE Profiles is a comprehensive set of Eclipse/OSGi plugins implementing the client-side of many IHE profiles. The project was initiated in the context of Open Health Tools, an association of influent actors in the healthcare sector. IHE Profiles provides support for the following profiles: ATNA, MPQ, PAM, PIX, PDQ, SVS, XCA, XDR, XDS and XUA.

### 4.1 Feature Matrices

The feature matrices below show a synthetic view of the differences between implementations. The first matrix highlights the actors implemented by the different frameworks. The second shows the implemented transactions. The data shown below in the matrices was collected from statements available from the Connect-a-thons. Not all frameworks were tested in the laboratory. For some frameworks, no Connect-a-thon statement is available (CONNECT project) or is available only partially (IPF). This comparison does not give any measure on the quality or maturity of the solutions.

<table>
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<tr>
<th>Profile</th>
<th>IHEOS</th>
<th>O3</th>
<th>IHEOS</th>
<th>IFS</th>
<th>OpenXDS</th>
<th>OpenATNA</th>
<th>OpenKMIP</th>
<th>ISX-OSI-RX</th>
<th>IHE Profiles</th>
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<td>Patient Identity/Oasis-Reference Manager</td>
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<td>Patient Identity/Oasis Reference Consumer</td>
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![Figure 3. Feature matrix by actor](image-url)

[1] No Connect-a-thon statement available.
IHEOS is a testing platform, but its source-code is valuable for system implementers. O3-XDS seems rather simple to install, however the lack of proper documentation and the long inactivity (unreachability) of its associated website allows for emitting only reserved judgments. HIEOS provides an extensive documentation and a rather solid implementation of the XDS.b IHE Profile. IPF comes with A-grade documentation, a rock-solid implementation of many profiles and extensibility though the Apache Camel routing and mediation engine. It is packed with lots of features, but looks quite hard to deploy. The subprojects of the OpenExchange platform (OpenXDS, OpenPIXPDQ and OpenATNA) provide a good implementation, share the same core interfaces and are made to work together seamlessly. They are really simple to deploy, but the documentation somewhat lacks in detail. Client-side interfaces are provided under the Open Health Tools (OHT) IHE Profiles subproject. The CONNECT project is huge and was first developed as a support platform for Nation Wide Health Information Networks (NHINs). As good at it is, it may not be suited to small research projects. Microsoft’s reference implementation is a solid IHE XDS implementation for Windows. It was successfully deployed by our team in one medium scale project. This project uses the less permissive Microsoft Public License (Ms-PL). Finally, IHE Profiles, a subproject of the OHT initiative

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provides a very solid implementation of many client-side IHE actors for a wide range of profiles (amongst which XDS, PIX, PDQ, ATNA, XUA …).

As far as the motivation scenario is concerned, HIEOS, CONNECT, IPF, OpenExchange and Microsoft’s Reference Implementation can be used as reference implementations for the repository and registry, since all of them support the Document Registry and Repository actors and provide implementations for transactions ITI-41, ITI-42, ITI-43 and ITI-18. However, only IPF, OpenExchange and CONNECT may be used as complete platforms, since others do not provide an implementation for IHE PIX and PDQ server-side actors. The integration between MS-XDS.b RI and IHE Profiles OHT project (OHT Bridge) has been successfully tested in a real case scenario, Medicoordination, as described in [20][21].

Performing an objective comparison between different implementations is very difficult and often dangerous. Some frameworks are straight implementations of particular use cases along with dependencies (document sharing framework for example), while others like CONNECT are large-scale platforms that support Nation Wide Health Information Networks (NHINs). Although a comparison is not directly feasible; the previous matrices may still be used as references. Difficulties encountered when trying a straight comparison between different implementations raise interesting questions. What should be used as a comparison base? How should we compare different open-source solutions providing the same services? These are rather sensitive points and have been devoted lengthy discussions in other papers (see Section 2).

Using open-source frameworks for medical applications does present some issues and disadvantages. Firstly, it is often difficult to measure their maturity / quality objectively. The Connect-a-thon statements used in this survey merely assert that vendors are IHE-compatible in some profiles; they are not a measure of their quality. To make this study more complete, these solutions should have been analyzed through the lens of open-source maturity/quality measurement methods like the ones described earlier. Furthermore, unlike commercial solutions where the support is directly provided by an independent company or by the vendor itself, a team of programmers may have to be hired just for the deployment and maintenance of the open-source platform. Finally, the image of open-source is not sufficiently clear at this time. Often people are more likely to trust commercial solutions, because they indirectly associate a high production cost with quality.

Fortunately, there are strong benefits in leveraging open-source solutions. In the motivation scenario described in the paper, the fact that different implementations exist for the same IHE profile is beneficial. Using implementations from different vendors in the same project reduces the dependency of a particular actor towards a vendor (vendor lock-in), resulting thus in risk (if the company goes bankrupt) and transience (if the company changes direction of business) mitigation. Moreover, open-source frameworks make source-code available to the developers. As soon as problems or bugs are detected, they can be directly tracked and patched; the framework can thus be updated and shared back with the community, improving its liability over revisions. Finally the reduced cost, generally limited to associated exploitation costs, is a major asset for projects where reduced resources are a requirement (typical in applied research projects).

6. CONCLUSION

As discussed previously, the use of open-source implementations in healthcare applications is generally good, provided that the scope of its application is limited and risks are correctly measured. Modularity, control and reduced costs are certainly a major added-value for any research project.

Unfortunately, open-source is not always associated an enjoyable image in the context of very sensitive healthcare applications. Documentation is very often incomplete or hard to understand and the infrastructure is sometimes really painful to deploy and maintain. Moreover, implementers often do not provide models for the maturity or even quality of their projects, making it difficult to unravel the good from the bad.

ACKNOWLEDGEMENT

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THE GENERIC QUALITY ASSURANCE MODEL (GQAM) FOR SUCCESSFUL E-HEALTH ACQUISITION IN RURAL HOSPITALS

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ABSTRACT

The e-health evolution has the potential to aid management of scarce resources and improve quality of services within healthcare. However, their implementation continues to fail. Amongst other reasons, the lack of project quality management is found as a key contributor to the failure of e-health solutions implementation projects in rural hospitals. Hence, a Generic Quality Assurance Model developed in this study for the successful acquisition of e-health solutions in rural hospitals to enable improved quality of care and service delivery. The study used triangulation of qualitative and quantitative research approaches, in terms of which a case study approach was adopted.

KEYWORDS


1. INTRODUCTION

In the recent past, we have seen major advances in ICTs driven by the increasing need to develop and organize efficient ways of providing healthcare services. Consequently, there have been rapid increases in the adoption of ICTs in healthcare, collectively known as “e-health”, which promises to have an enormous impact on all healthcare elements. According to Chu (2007), the key drivers for e-health are the quality, safety, effectiveness and efficiency of healthcare services.

In South Africa, we have seen an increase in e-health developments that have the potential to improve healthcare services. These include innovations that have reduced healthcare costs, improved quality, increased accessibility and enhanced the delivery of healthcare services (Braa & Hedberg, 2002:113–127; Seebregts & Singh, 2007).

These e-health developments are also viewed as a vehicle that can bridge the digital divide between rural and urban healthcare centres (Ruxwana, Herselman & Conradie, 2010). They promise to facilitate the capability to find solutions for the challenges that the rural healthcare sector is faced with (Ruxwana et al., 2010) and to extensively transform healthcare services delivery and patient care, as well as to facilitate the management of the healthcare system throughout the world (Louw & Hamner, 2002).

E-health developments are, however, faced with several challenges that appear to be hindering their implementation. Some of these challenges are associated with the legal and regulatory environment, the limitations of the technology and the patients’ trust, and mainly those associated with the failure of information technology (IT) projects (Mbananga, Madale & Becker, 2002; Heeks, 2002; Braa & Hedberg, 2002; Standish Group, 2004). Over a decade, several scholars have investigated the success and failures of IT projects, where they identified several factors of success (DeLone & McLearn, 2003; Gable, Sedera & Chan, 2008; Standish Group, 2001) and failure (Standish Group, 2004; Jones, 2004; Matta & Ashkenas, 2005:3). Interestingly, most of these factors associate to those that can positively effected by appropriate adoption of project quality management, through element of quality assurance. Hence, a question worth investigation is whether the adoption of quality assurance models can add value and ensure success of IT projects, especially in rural context?
This study is such a research initiative. The aim of this study was to develop a Generic Quality Assurance Model (GQAM) that can be used to add value and ensure successful acquisition of e-health solutions in rural hospitals in the Eastern Cape Province in order to improve the quality of care and service delivery. This study is of the view that the lack of emphasis on quality assurance (QA) as a subset of project quality management when implementing IT solutions is one of the major contributors to implementation challenges and failure.

1.1 Problem Statement

The ICT revolution has affected the healthcare sector tremendously by providing solutions that enhance information access, storage, retrieval and analysis, as well as the dissemination of accurate patient medical history. However, the critical implementation of these e-health solutions essentially transpires in the developed world with a limited scope in the developing world. As stated by various researchers, this is due to many challenges linked to the digital divide, which compromise the implementation of ICTs, including, lack of infrastructure, services and know-how, limited resources, low literacy levels and professional isolation (Herselman & Jacobs, 2003; Littlejohns et al., 2003).

Conversely, the lagging implementation may be due to the higher failure rate of IT project implementation, as reported in the Standish Group’s CHAOS reports (Standish Group, 2004). South African healthcare ICT initiatives are no exception, although there is limited literature on their success or failure. The few studies conducted on healthcare projects in South Africa show that the failure rate is projected to be higher than that of developed countries owing to the challenges and limitations the country is faced with (Mbananga, Madale & Becker, 2002; Heeks, 2002; Braa & Hedberg, 2002). Heeks (2002) and Matthews (2007) further mentions that most information system projects in developing countries fail either totally or partially.

Conversely, other scholars, driven by the continuous confusion on the IS success and their value to organizations, are of the view that there needs to be an understanding for IS success in order to combat its failures, thus researched at IS success measurement models. An important contributions come from those IS success models developed by scholars such as DeLone and McLean (2003), and Gable et al. (2008), which identified that the IS success is multi-dimensional.

However these models have focused on the quality of the product- the solution, and have not particularly addressed the aspects of quality from the project management context, which includes all the processes and activities of the performing organization that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken (PMBOK, 2004). The project quality management also enforce quality processes of the actual products, which are stated by IS success models.

Though there are several studies conducted in the context of project quality management, with methods and models developed, the ICT projects continues failure. In particular, these studies on project quality management, not carefully addresses the element of QA and its adoption in rural context, thus making this study novel as it further investigates the adoption of QA in rural hospital context which has never been done before.

Evidently the introduction of project quality management has increased project success. In support of this, Jones (2004) states that the six most common problems identified when observing failed projects include poor project planning, poor cost estimating, poor measurements, poor milestone tracking, poor change control, and poor quality control, which could all be identified and mitigated through QA. As a result, successful IT projects generally exhibit higher expertise in all of these six areas. Remarkably, these six problem areas are related to project management rather than to technical expertise. It thus becomes evident that inadequate project quality management, especially the lack of QA, is a contributing factor to the failure of projects.

1.2 The Present Study

The present paper focuses on essential elements for a generic quality assurance model that can aid successful implementations of e-health in rural hospitals in South Africa. The aim of the study was to determine the essential components for QA model and to develop a GQAM that will aid successful implementation of e-health solutions in rural hospitals. The following general question and sub-questions were posed:
What are the components of a generic quality assurance model (GQAM) to assist rural hospitals in the Eastern Cape Province in South Africa with the successful acquisition of e-health solutions?

- Sub-question 1: what are the QA methodologies used in e-health acquisition for rural hospitals?
- Sub-question 2: how do these methodologies aid successful e-health acquisition in these rural hospitals?
- Sub-question 3: what are the challenges experienced when applying these methodologies in rural hospitals?
- Sub-question 4: what sensible model can be adopted to overcome these challenges and to improve the quality assurance processes used in e-health acquisitions in rural hospitals?

2. METHODS

A multiple-case study methodology was applied. This is a type of qualitative research design whereby the researcher investigates a chain of single entities, phenomena or cases confined by time and activity and collects detailed information by using a variety of data collection procedures during a sustained period of time (Creswell 2003:12). According to Yin (2002), a case study of this nature is an empirical investigation of an existing event within its environment. It is mainly used when the boundaries between the event and its environment are not clearly evident.

The overall purpose of adopting a qualitative research approach for this study was to gather non-numerical data to help explain and develop a GQAM for e-health acquisition. Accordingly, the methods used to obtain qualitative information included questionnaires and interviews. The information derived from these instruments was combined into a GQAM that depicts the activities that should be included to ensure quality in e-health acquisition in order to be successful in implementing such solutions in rural hospitals.

2.1 Sampling

Purposive sampling was applied in this study to sample the various hospitals and participants. According to Babbie (2005: 189) purposive sampling involves the selection of the units to be observed on the basis of one’s own judgment about which ones will be the most useful or representative. Thus, hospitals surveyed were those serving rural communities and using the five e-health solution implemented by the Eastern Cape Department of Health (ECDoH). Only hospitals providing primary care and that are generally the point of first entry for patients in the different regions (the former Transkei and Ciskei) were selected.

2.2 Participants

As indicated in the above, purposive sampling was adopted to select the participants for this study. Participants from the five cases included senior management, project managers and coordinators, the IT directorate and e-health team representatives from the ECDoH. Representatives from the vendors of the solutions; and the solution user community (doctors, nurses, radiographers and other hospital staff). In addition, experts in the project quality management fields, both in industry and academia, were also involved. In total, there were 35 participants from, from which the data were collected over a period of 18 months.

2.3 Ethics Approval

Ethics approval from the Eastern Cape Department of Health and the Nelson Mandela Metropolitan University was obtained before any information was gathered from any of the healthcare centres concerned. Furthermore, informed concern was signed with participants before interviews were conducted.
3. RESULTS

In order to develop a the GQAM several research sub-questions were answered, of which key findings are presented in the following subsections, starting with the first sub-question.

3.1 QA Methodologies used in e-health Acquisition for Rural Hospitals

Generally, the respondents agreed that there was a general quality management strategy in place, and these strategies were developed in terms of a quality management system and standards. However the implementation of these strategies and their use on a project implementation level seems to only be prevalent in the vendors that supply the e-health solutions. On the other hand, the participants were not as confident about the level of detail of the strategies and their applicability to the project implementation level in ensuring quality. This was further supported by the participants, showing no awareness of any quality manual in place for projects to follow. Throughout the organizations there were common limitations: all participants revealed the non-existence of a “lessons learnt” knowledge base, which is an integral part of QA and a key for improved quality and continuous improvement in organizations and projects.

Furthermore, the findings revealed that there is a need for improvements in the existing methods covering the areas of traceability, accountability, quality upfront, customer involvement, independent QA and the use of modern tools and techniques in e-health acquisition in the Eastern Cape.

It can therefore be concluded that QA methodologies exist in the participating organizations. However, there is much to be done to promote awareness of these methodologies for guiding QA at project level, such as the development of a quality manual or policy with detailed QA principles and standards that have to be followed. It would also be useful to have a “lessons learnt” knowledge base, where all the lessons learnt from projects can be stored to aid success and provide points of reference in future projects.

3.2 The Perceived Value of Methodologies to Aid Successful e-health Acquisition in these Rural Hospitals

The findings reveal that greater value is added by adopting QA methodologies in projects. The findings collected using the various instruments reveal a consensus that, although QA does not guarantee project success, it does aid the project team in achieving its project objectives, evaluating progress and identifying risks, changes and actions to mitigate those risks identified earlier in the project lifecycle. The findings do, however, show that there are limitations in the current methodology and if these are addressed earlier on in the project lifecycle, greater value can be added throughout the project process, as depicted on the questionnaire findings below:

- 67% of the participants agreed that QA activities adopted have assisted in achieving project goals, while 33% strongly agreed
- 56% of participants agreed that there were existing shortcomings and weaknesses in their current QA activities, while 44% strongly agreed
- All the participants perceive QA as being an integral part of project success, as 78% disagreed and 22% strongly disagreed when asked if the system implementation process would have been successful without the QA activities.

The above findings reveal positive feedback on the value added by QA in e-health solutions and in project success. However, there is room for improvement in this regard, as the participants indicated that there are weaknesses in QA activities. The participants were also probed with regard to the key elements of existing models or based on their experiences of QA that they view as being essential and that they believe are required. The purpose of this was to find out the existing gaps in current project models.
3.3 Challenges Experienced when applying these Methodologies in Rural Hospitals

Although some of the challenges experienced result from other factors, an effective QA methodology would have helped to identify and mitigate possible risks earlier on in projects. All the data collection instruments used have highlighted the weaknesses in existing QA methodology, especially in the key principles such as quality upfront, user involvement, clear accountability, independent QA evaluations, the use of QA tools and techniques, qualified staff, traceability and continuous improvement. It is however clear that most of these challenges are related to and are the results of the adopted QA methodology weaknesses. All participants indicated that there are existing challenges with the adopted methods; when asked on specific QA problems experienced during the project, the following are the interviews abstractions:

- “The lacking user involvement and user requirements leads to deployment of un-required solutions” (Respondent 1).
- “The sites do not take ownership and accountability of the solutions” (Respondent 2).
- “Limited QA activities in general is the problem, roles and responsibilities, communication, involvement, reviews, evaluations, testing and training” (Respondent 3).

3.4 The Sensible Model for e-health Acquisitions in Rural Hospitals

In literature, there are several models, methods and standards relating to QA. The literature reveals that, in order to have an impact on project success, there is a need for standardized methodologies. It is also evident that QA activities include several elements that have some form of review, inspection, approval and testing; which are an integral part of the methodology for solution implementation (Standish Group, 2001; ISO, 2007; Ruxwana et al., 2010).

Most factors contributing to the success of IT projects includes most, if not all, the factors can be achieved with QA adoption within a project. Indeed, the existing standards and models do not provide context-relevant guidelines on quality, but a generic view of quality management. Hence it is key to consider the different complexities of rural areas in South Africa and to have a model that is relevant to the context and developed within the culture. In addition to the literature study, it was important to collect primary data on the burning issues and key factors relating to QA in solution development within the e-health sector in South Africa. Hence, the expert’s reviews were conducted to reflect on experiences of the challenges inherent in implementing existing quality methods, standards and models in South African organizations; as summarized below:

- “The challenge to implementation of QA methodologies is the lacking understanding of their intent and benefits; which then results to resistance from the project team, especially if it changes their norm of doing things. Therefore the elements of the most sensible model include awareness and change preparation for those who are involved” (Respondent 1).
- “The challenge is education, knowledge, understanding, and implementation of these methodologies in organizations. As a results people are resistant to use them, as they don’t know their intent, benefits, and they don’t understand how they can implement them within their processes” (Respondent 2).
- “The most sensible model for QA is the one that enforce standardization of the project activities to a certain degree; with the aim to support continuity and maintenance of such solution” (Respondent 3).

There was consensus on the fact that models or methods that are customized to fit a certain environment can enforce standards and quality in solution design processes, and these models should be used in a way that fits the culture of the environment and can only be successful when driven by its users.

4. DISCUSSION

The findings obtained from the data collection instruments, such as the interviews, questionnaires, expert reviews and literature study, revealed that there are QA methodologies for e-health solution acquisition in rural hospitals in the Eastern Cape Province. It is also important to note the critical support of these findings for literature relating to the importance of QA in solution design and implementation. The findings reveal the
perceived critical role played by QA in ensuring project success. However, there are challenges and weaknesses in implementing QA methodologies.

It was clear that there was no standardized methodology for implementing e-health solutions in the selected hospitals. Although the contracted vendors adopted their own methodologies, these seemed to focus more on product development, thus the quality aspects were those that focused on solution functionality as per specifications. This therefore highlights that project management and QA that ensure the generic quality from a project process perspective was found to be lacking; hence, the challenges were experienced at the end, with most solutions.

Evidently, most problems that exist could have been identified and resolved earlier if QA had been adopted in the process of acquiring these solutions. However, there was no defined process for the solutions to follow, so each solution followed its own different methodology which led to several challenges such as those linked to: traceability; accountability, sustainability, support and maintenance; training; awareness and involvement; compliance and standardization; requirement analysis and readiness assessment; continuous improvement; independent QA, evaluation and knowledge base; quality upfront; qualified staff; and, QA tools and techniques.

The findings also reveal that the most sensible QA model is one that puts the solution’s stakeholders first, defines quality from their perspective and develops a means to ensure that the specified expectations are met. From these findings the key elements of such a model should be: user awareness and involvement; training and support; standardization; clear accountability through roles and responsibility and stakeholder maps; promoting and enforcing the management of a knowledge base; traceability of expectations through continuous reviews; relevant and customized to fit the environment in which it is used; providing support for meeting technical and human expectations; and, facilitating continuous improvement. Based on these findings, the proposed GQAM was developed.

5. PROPOSED SENSIBLE QA MODEL

According to Arsham (2006), a model is an external and explicit representation of a part of reality as an individual sees it; who wishes to use the model to understand, change, manage and control that part of reality. The purpose was to develop a GQAM for successful acquisition (i.e. development and implementation) of e-health solutions in rural hospitals in the Eastern Cape Province for improved quality of care and service delivery. In order to develop and test this model it was necessary to identify the QA methodologies that are currently used in rural hospitals for e-health solutions acquisition (sub-question 1); to further evaluate the adopted QA methodologies to determine if they were the most sensible methodologies for successful acquisition and to determine their role in ensuring the acquisition success, their shortcomings and adoption challenges in system acquisition (sub-questions 2-4).

In order to develop such a model in a manner that is relevant and fits the context of its implementation, a user involvement approach was adopted where the e-health team and other relevant stakeholders were involved. To further ensure that the model was within the general practice and can fit any typical Solution Development Life Cycle (SDLC), experts’ reviews were also considered. This representative involvement was adopted in a series of cycles to formulate the model elements, designs and testing. The study process happened through the four phases followed. The first two phases focused on case studies where the data were collected to answer the research questions using data triangulation to provide findings and conclusions. The findings obtained from the case studies were then used in phase 3 to develop the first draft of the QA model in layers. The layers continued through to phase 4 where the draft QA model developed from the case study findings evolved until the final GQAM was produced. In phase 4, the GQAM was used as input to the cycles for developing a QA value chain (excluded in this paper), which provides the implementation guidelines.

5.1 GQAM Layers

The purpose of GQAM is to aid the successful acquisition, that is, development and implementation, of e-health solutions for rural hospitals. This can be achieved by using the GQAM as a blueprint for the fundamental elements and project quality management processes that need to be followed to ensure that quality will be met in the end, irrespective of who is implementing the solution. This model is referred to as
“generic” as it can be used for any e-health solution acquisition project, for any adopted systems development method, and for any given context for ensuring quality within project management processes. This model encompasses five layers and each layer or stage comprises functions or processes to be executed that have different interlinking deliverables, as depicted in Figure 1 below:

Figure 1. GQAM for e-health acquisition in rural healthcare

This model was built from the inside out, with users forming the central point of departure, with other stakeholders being considered through to the outer layer of continuous improvement of the processes adopted inside and the implementation of the model. The table 1 below summarizes the layers and their core focus.

Table 1. Method layer summary

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<tr>
<td>1</td>
<td>Identification of each project stakeholder and understanding their different roles and influence in the project and its success becomes critical.</td>
</tr>
<tr>
<td>2</td>
<td>This layer focused on user involvement, user needs and expectations as quality drivers</td>
</tr>
<tr>
<td>3</td>
<td>This is about considering the existing organizational methods, principles and standards for projects. This includes adoption or adaptation of methods and principles.</td>
</tr>
<tr>
<td>4</td>
<td>This layer fosters QA as a subset of project quality management</td>
</tr>
<tr>
<td>5</td>
<td>This layer recognizes QA as an integral part of continuous improvement in project processes, activities, knowledge base, deliverables and methods.</td>
</tr>
</tbody>
</table>

6. CONCLUSION

The purpose of this study was to develop a GQAM for the successful acquisition (of e-health solutions in rural hospitals in the Eastern Cape Province for improved quality of care and service delivery. In order to develop this model it was necessary to identify the QA methodologies that are currently used in rural hospitals for e-health solution acquisition in order to further evaluate the QA methodologies adopted and to determine whether they are the most sensible methodologies for successful acquisition. In addition, to
determine their role in ensuring acquisition success, their shortcomings and the adoption challenges in system acquisition were also outlined.

The findings presented show that there are QA methodologies which are used, although there is no formalization or standardization of the processes of applying these methodologies. It was found that, although this is the case, the QA methods had a great impact on project success. These methods were found to have several weaknesses which if considered could add more value when corrected. This study has indeed developed the GQAM which can be used to ensure e-health solution success in rural hospitals by overcoming the challenges and further introducing standards that will support sustainability and future maintenance of these solutions, while facilitating user buy-in and ownership through increased user involvement levels.

REFERENCES


EVALUATION OF CHITS’ DATABASE

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Quezon City, 1101 Philippines

ABSTRACT

Database design is an integral part of the application design. A good database design should be well planned and structured to satisfy the needs of the users. Its goal is to achieve minimum redundancy and maximum performance over time. The purpose of this research is to critique the database design of Community Health Information Tracking System (CHITS), a free and open source software designed to aid local health centers and rural health units in the Philippines, by applying the norms of a good database design. The testing is done by applying the best practices of database design that is generally accepted today. Evaluation showed that there were minor and major flaws found in the design and the researchers suggest remodeling the database design of CHITS and documenting the process to achieve its full capability.

KEYWORDS

CHITS, database evaluation, database design standards, relational database, data integrity, normalization

1. INTRODUCTION

An application software, dedicated specifically for management of data, is only as good as its database management system. Its overall performance is dependent on the design of the database. The availability of the data and the capacity to manage it efficiently are essential (Atzeni et al. 1999). It should be able to manage collections of data that are large, shared and persistent, ensure the reliability and privacy, and must be efficient and effective (Atzeni et al. 1999).

Database design can be defined as the process of capturing relevant information of an enterprise and mapping them on an underlying database management system (Storey et al. 1997). The evolution of database design methodologies or process is dynamic and relies on generally accepted principles or best practices. The early design process is to produce a database that is flexible and can easily adapt to changing user requirements and the latter design focuses on optimizing the performance for the currently known requirements (Teorey & Fry 1980).

A design methodology is usually composed of separate steps. It is a good practice to follow these steps in database design. Modern methodologies agree on a well-affirmed decomposition of the database design into the following steps: requirements analysis and specification, conceptual design, logical design, and physical design (Batani & Ceri 1998).

Requirement Analysis and Specification. It involves establishment of organization objectives, derivation of specific database requirement and documentation of those requirements agreeable to the management and the database designers (Lum et al. 1979). This involves interviews on both the producers and users of data and using the information to produce formal requirement specifications (Teorey et al. 2009).

Conceptual Design. It involves representing the informal requirements of an application in terms of formal and complete description, but independent of the criteria for representation used in database management systems (Atzeni et al. 1999). It produces a conceptual schema and refers to a conceptual data model. Conceptual data model allows the description of the organization of data at a high level of abstraction without considering yet the implementation aspects (Atzeni et al. 1999).

Logical Design. It involves translation of the conceptual schema defined in the conceptual design into a model adopted by the database management system. It produces a logical schema and refers to a logical data model. A logical model represents data in a way that is still independent on the physical requirements (Atzeni et al. 1999). Formal techniques for verification and quality of the logical schema are often used. In a
Physical design. It involves translation of the logical schema into physical schema. It refers to a physical data model. This model takes into account the specific database management system and the criteria of the physical organization of the data in the system (Atzeni et al. 1999).

1.1 Database Design Standards and Best Practices

(Atzeni et al. 1999), (Buxton et al. 2009), (Sciore 2009), and (Wertz 1993) all stated database design standards, best practices, and important concepts in the design process of a relational database. Major design issues (Theorey & Fry 1980) that affect database performance can be avoided by adhering to these standards and best practices.

1.1.1 Documentation

A documentation is needed to facilitate interpretation of the schema itself and to describe the properties of the data that cannot be expressed directly by the constructs of the model. The documentation needs to show the description of the entities of the schema with their name, an informal definition in natural language, the list of all the attributes and the possible identifiers. It should also show the relationship with their names, description, list of entities involved together with their cardinalities. It can also document some constraints on the data. The use of the data dictionary is important when the schema is complex and it is laborious to specify all the attributes of entity and relationship directly on the schema.

There should also be a documentation of requirements in the form that is agreeable to the management and database designers (Theorey & Fry 1980).

1.1.2 Constraints

A constraint restricts the allowable records in a table. The database system ensures that the constraints are satisfied by refusing to execute any update request that would violate them. (Sciore 2009) enumerated four types of constraints: key constraints, null value constraints, referential integrity constraints, and integrity constraints.

Key Constraints. A key is a minimal set of fields that can be used to identify a record. Specifying a key constrains the table to have duplicate entries. Although a table can have several keys, one key is chosen to be the primary key. Primary key fields must never be null.

Null Value Constraints. A null value is a placeholder for a missing or unknown value. A null value constraint asserts that a record cannot have a null value for the specified field.

Referential Integrity Constraints. A foreign key is a set of fields from one table that corresponds to the primary key of another table. Specifying a foreign key asserts referential integrity, which requires the non-null foreign key value to be the key value of some record.

Integrity Constraints. These specify what it means for the database to reflect reality. They can detect bad data entry and enforce the “business rules” of the organization. An integrity constraint may impose requirements on a single record, a table, or a database.

1.1.3 Naming Conventions

The objectives of naming standard are usually to reduce ambiguity in interpreting the meaning of entities and attributes, reduce the possibility of “synonyms”, and reduce the possibility of “homonyms”. Good naming conventions make the database design self-documented.

(Simsion 1994) and (Wertz 1993) suggest guidelines for naming entities and attributes.

Entity Naming

• The name of an entity must be in singular.
• Entity names must be brief. They are usually nouns.

Attribute Naming

• Using the “home” entity name as the first word or words of the attribute name. The term “home” entity is introduced to cater to foreign keys, whose home entities are those in which they appear as primary keys, and for attributes inherited or rolled up from supertypes and subtypes.
• Abbreviations in attribute names must be avoided, unless they are widely understood in the organization. Use a standard set of abbreviations to assure consistency.
1.1.4 Normalization

The aim is to represent all data items as attributes of tables that obey a restrictive form called as a normal form. These normal form definitions limit the acceptable form of a table so that it has certain desirable characteristics that avoid various kinds of anomalies. It eliminates inadequate and redundant relationships.

For most relations, the Third Normal Form is a good design objective. It avoids most of the problems common to bad relational design. Boyce-Codd, the Fourth, and the Fifth Normal Form handle special situations that arise occasionally.

2. CHITS

CHITS is a free and open source software designed to aid local health centers and rural health units in the Philippines (Bañez n.d.). It was pioneered by Dr. Herman Tolentino through a grant from the International Development Research Centre of Canada.

CHITS was built to handle general health care services like general patient consultations, child and maternal care services, and family planning services. Another feature of CHITS is generating reports that follow the Philippine Department of Health Field Health Service Information System (FHSIS) standards. The data flow chart of CHITS is shown in Figure 1.

Local Health Centers are the front line health service provider all over the country (Bañez n.d.). Large of volume of data is processed within the health centers and this is done manually and very prone to errors and inconsistencies. Consolidation of paper records is also time consuming, making the information derived from it less relevant to the national health system and to the communities who generate the data.

CHITS intends to improve on the record management. It goals to make quality reports, generate reports fast and easy data access within the local health center. Automating critical areas of public health data
management, health center personnel are somehow eased with the burden of manually consolidating reports and could provide more in providing health care services to their patients (Bañez n.d.).

For local health centers in the Philippines, it has been a challenge to consolidate data from each reporting units into a cohesive and relevant whole. Reports generated are still paper based and very prone to error and alteration. Consolidation and organization of records are also time consuming making the information less relevant to the national health system and the communities who generate the data. CHITS was developed to handle such problem. As useful as it can be, the application is as good as its database system. It is important to establish a well structured database design to maximize its capability. Achieving an acceptable database performance for all users has become a complex task. There are trade-offs to consider like cost and performance. Acceptable performance for all the application users should be the goal (Teorey & Fry 1980). The database should also be flexible and can adapt to any changes. Rapidly changing requirements as exhibit in the healthcare system should be handled by the database. It should be adaptive to changing requirements (Teorey & Fry 1980).

3. DISCUSSION

To evaluate the database design of CHITS, the researchers examine its database schema with the aid of database tools – phpMyAdmin 3.3.3 and DbVisualizer 7.1.4.

The following parameters are checked: entities and attributes name, null value constraints, primary keys, foreign keys, normalization, and documentation.

Entities name, attributes name, null value constraints, primary keys, and foreign keys are checked using the phpMyAdmin table viewer and table structure viewer, and the DbVisualizer columns view. Names are checked for consistency and other conventions discussed in section 1.1.3. Keys and references are checked for each table. Sample and pre-loaded data are also checked.

The references view of DbVisualizer is used to display all the tables with their corresponding primary keys and other attributes. The references view also shows the table connections if any.

3.1 Documentation

There is no documentation available for CHITS and its database design. CHITS is an open source project, which means its source code is available for anyone who wants to contribute. The absence of a proper documentation for its database can slow down database administrators and managers in understanding the workflow of the software. There should be a clear and precise documentation of every single important transaction, process, and action that took place. This will give a reference point whenever a problem arise. Naming conventions, servers, database directories are a few things that need to be properly documented to help future developers maintain consistency in the database environment.

3.2 Constraints

CHITS has a total of 187 tables. Each of the tables are checked if they satisfy the four constraints discussed in section 1.1.2.

3.2.1 Key Constraints

There are fifteen tables in CHITS with no primary keys (e.g. m_lib_weekly_calendar, m_consult_mc_prenatal). A table with no primary keys defined will run into problems like duplication of data that will cause other data integrity issues.

3.2.2 Null Value Constraints

The fields of each table that require value are specified to be NOT NULL. Below is a snippet of the schema.

```sql
CREATE TABLE IF NOT EXISTS `game_user` (  `user_id` float NOT NULL auto_increment,  `user_lastname` varchar(100) NOT NULL default '',  `user_firstname` varchar(100) NOT NULL default '');
```
All of the fields except for user_email are defined to be NOT NULL. This is good since most of the attributes should be required fields. An attempt to insert an incomplete data will be rejected. However, almost all of the attributes are defined to be not null. This might be an issue if we want to add an entry, and some of its columns are not very important and can be added at a later time. Looking at the schema snippet above, user_cellular is defined to be not null. What if the user has no cellphone? Or is it assumed or is it required for a user to have a cellphone? It might be the case, but with no documentation, it cannot be verified.

### 3.2.3 Referential Integrity Constraints

One of the main issues with CHITS is that no foreign keys are defined. No connections can be found in any of the tables as shown in Figure 2. By inspection and analysis, some of the columns in a table can be verified to be a primary key of another table. The problem is that they are not explicitly defined. With this, m_family_member table can have a family_id which do not exist in m_family table. It might be the case that the validation is done at the business layer, but it is best if the relationship is already established and seen at the database design. SQL provides way to specify the foreign keys of a table and it is best to use it.

### 3.2.4 Integrity Constraints

Integrity constraints are not defined in CHITS. Having 187 tables, it will take a long time to define all the integrity constraints. As a consequence, the data inserted are not checked or validated with the corresponding business rules at the database level. However, the business rules can be enforced on the business layer. The control and logic are implemented on the business layer, so better put the rules and restrictions here.
3.3 Naming Conventions

3.3.1 Entity Naming
Among the 187 tables of CHITS, 30 of them (e.g. childcare_indicators, errorcodes, m_consult_appointments) are in plural form and the rest are in singular. This is inconsistent.

Most of the table names are composed of one to three words. There are few with four and five words for their name, but this is helpful to properly describe the entity. All the table names are nouns, and this follows the convention.

3.3.2 Attribute Naming
One thing to consider here is to determine if the foreign keys are defined. The foreign keys, however, are not defined for the entire schema. By inspection, we can see some attributes prefixed with the “home” entity name (e.g. for table m_consult_mc_postpartum, there is a column consult_id which may reference the table m_consult). The relationship cannot, however, be verified unless we go up to the business and logic layer. Verifying the relationship through the business layer is difficult and time consuming.

While the names of tables and columns must be kept short, they should also be self-explanatory. A few of the table and field names use abbreviations and acronyms (e.g. fhr_location and aog_weeks from table m_consult_mc_prenatal). We do not know what fhr and aog means. Most of these are medical terms which are difficult to understand if one is not used to them.

3.4 Normalization

The rule for First Normal Form or 1NF is eliminating repeating groups (Wertz 1993). From review and analysis, most of the relations are in their 1NF. Only few tables appear to be not in 1NF. For instance, the table m_consult_lab_sputum. Table 1 shows the columns of the table. We can see some repeating columns (e.g. sp1_collection_date, sp2_collection_date, sp3_collection_date). The appearance, reading, and lab_diag are also repeating. They are numbered from 1 to 3. Since there is no documentation, it cannot be concluded that there are only three occurrence of this type of consultation at all times. This repeating group must be separated by creating a new table.

<table>
<thead>
<tr>
<th>TABLE_NAME</th>
<th>COLUMN_NAME</th>
<th>TYPE_NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>m_consult_lab_sputum</td>
<td>consult_id</td>
<td>FLOAT</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>request_id</td>
<td>FLOAT</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>patient_id</td>
<td>FLOAT</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sputum_period</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>lab_timestamp</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp1_collection_date</td>
<td>DATE</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp2_collection_date</td>
<td>DATE</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp3_collection_date</td>
<td>DATE</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp1_appearance</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp2_appearance</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp3_appearance</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp1_reading</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp2_reading</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>sp3_reading</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>lab_diag1</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>lab_diag2</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>lab_diag3</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>lab_diagnosis</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>user_id</td>
<td>FLOAT</td>
</tr>
<tr>
<td>m_consult_lab_sputum</td>
<td>release_flag</td>
<td>CHAR</td>
</tr>
</tbody>
</table>

According to the Second Normal Form or 2NF, non-key attributes are functionally dependent on the entire primary key (Teorey et al. 2009). There should be a one-way relationship between two attributes such that at any given time, for each unique value of A, only one value of attribute B is associated with it through
the relation. The first thing to consider here is to check if the primary keys are defined for all the tables. However, as discussed in section 3.2.1, there are fifteen tables with no primary keys. The normalization process cannot be continued without defining the primary keys first.

When designing a database from scratch, determinants, other than the key, and the columns they determine are identified and separated into another table to make the relation in 2NF. In an existing design, the relationship of the tables must be established to check the relations of the keys and to check if there are no repeating columns. However, as discussed in section 3.2.3, the foreign keys are not defined. Thus, no relationship can be established.

Assuming that the relations are established, we want to know if the relations will be in 2NF already. Using Table 1 as an example, its primary key is defined to be request_id. There is a table m_consult whose primary key is consult_id. Table m_consult contains columns user_id and patient_id which are also columns in table m_consult_lab_sputum. There is a duplication of columns. The two columns should not be included in table m_consult_lab_sputum anymore.

The rule for Third Normal Form or 3NF is each nonkey attribute of a relation must be functionally dependent on the key and nothing else (Wertz 1993). Most of the tables of CHITS are not in 3NF. Not only that they are not in 3NF, but the columns of some tables are not properly associated with the tables. For instance, the table m_dental_fhsis with primary key record_number. It contains columns patient_id, age, and gender among others. Columns age and gender are most likely to be functionally dependent to the patient_id which is not defined as primary key. This violates the 3NF. They are also not fully functionally dependent on the primary key. Thus, this also violates the 2NF.

4. CONCLUSION

CHITS is an open source project, extending it requires understanding the underlying database design. Upon evaluation, it has been found that there are issues and flaws in the database design, such as, the constraints are not properly enforced, tables are not normalized, and the absence of proper documentation. A database design that is flawed is not only difficult to maintain, but also will not scale very well. In addition, the data is at a high risk, and eventually affecting the overall performance of the application.

CHITS is very useful, but there is still room for improvement, particularly in the underlying database design. Proper database analysis with complete documentation leading to a design that conforms to standards and best practices will provide an increase in the applications stability and performance.

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AN INTEGRATED APPROACH TO STANDARDIZED AND AUTOMATED EXTRACTION OF CLINICAL PROCESS CYCLE TIMES

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ABSTRACT
Optimization of clinical pathways is one of the key elements of quality improvement initiatives in hospitals. The management of time-critical diseases such as heart attack and stroke – although highly standardized – can be more or less time-consuming depending on the workflow bottlenecks in a particular hospital. To identify bottlenecks in a process that overall can be accomplished within one or two hours, requires a thorough understanding of both workflow and durations each of the sub-processes take. Having in mind the interoperability issues in hospitals, the division- and system-crossing collection of process cycle times is still a challenge. An aggravating factor is the lack of a detailed patient-oriented view that follows the complete treatment process rather than just a few key procedures. Furthermore, along this path, healthcare IT solutions do not allow a continuous collection of timestamps.

Our investigation focuses on a novel way of acquisition and communication of timing information along the clinical pathway of time-critical diseases in the context of various clinical standards (e.g. DICOM, HL7 etc.) and systems (e.g. hospital information system, radiology information system, imaging modalities, lab information system etc.). Beside the consideration of clinical standards and systems, this paper presents that the documentation of timestamps along a pathway represents a promising opportunity to follow and potentially guide patient flow over several departmental and system borders. We propose a generic model based on Event-driven Process Chains (EPC) that consists of 21 modules that are connected to each other with process interfaces. The missing link between clinical systems and the patient process is drawn by embedding selected IT-timestamps into this newly developed clinical process model and assigning them to the appropriate events in the model. In this paper, the assignment of timestamps is described based on the example of the dedicated modality sub-process defined in the developed clinical model. The presented technical and process-oriented view will provide the basis for an automated and standardized acquisition of process cycle times. This will allow hospitals to analyze clinical processes in greater detail than ever before, to determine new quality indicators and to further optimize processes by eliminating bottlenecks. In time-critical diseases this typically directly translates into an improved outcome for patients.

KEYWORDS
Process modeling, process cycle time, process monitoring, key performance indicators, timestamps

1. INTRODUCTION
Optimization of clinical pathways is one of the key elements of quality improvement initiatives in hospitals. The management of time-critical diseases such as heart attack and stroke – although highly standardized – can be more or less time-consuming depending on the workflow bottlenecks in a particular hospital. To identify bottlenecks in a process that overall can be accomplished within one or two hours, requires a thorough understanding of both workflow and durations each of the sub-processes take. During a hospital stay, a patient crosses several departments, which are based on various information system-catchment areas. This set of departments and IT-system boundaries represent process interfaces that must be bridged. On object-level (patient, blood sample etc.) the interfaces are connected temporarily by a local transformation of the objects. At the level of IT-systems, however, these interfaces very often do not exist. The lack of interoperability, i.e. the ability of an information system to participate in a complex information management
process in a concerted fashion with a number of other information systems (Channin, 2009), is a major problem for any type of standardized and automated process monitoring because it complicates a digital information exchange, thus, hinders the full exploitation of the potential use of data.

Our investigation focuses on a novel way of acquisition and communication of timing information along the clinical pathway of time-critical diseases in the context of various clinical standards and systems. Subsequently, the results and the characteristic clinical process flow in diagnostics are consolidated. Terms such as timestamp, event, cluster, process cycle time and the taxonomy of the acquisition of process lead times are introduced. The assignment of timestamps to the clinical process is finally exemplified in a section of a newly developed clinical model.

2. METHODS

Prerequisite for the acquisition of process lead time is the knowledge of the processes. These characteristic clinical processes and events are to be identified and brought together in a process model including relationships (sequence, parallelism, alternative, cycle). For modeling purposes, Event-driven Process Chain (EPC) is used as process modeling language. The EPC is a methodology for a semi-formal description of business processes and is central to a variety of reference models. The language has been developed by SAP AG and IDS Scheer AG in a collaborative research project in the early nineties (Keller, 1992). IDS Scheer AG, a software and consulting company, has furthermore developed the ARIS Toolset (Architecture of Integrated Information Systems), a worldwide common business process modeling architecture, which is very often used for reference modeling by means of EPC (Fettke, Loos 2007). The EPC-method is characterized by clarity and an integrated tool support in practice. It is one of the most commonly used methods in business modeling (BPM expo, 2011).

An EPC represents the temporal and logical dependencies of events and processes, and also allows the explicit notation of events, where process performance measurements can be done. For these reasons, the EPC is very well suitable for clinical process measurement efforts. Furthermore, the clinical task-oriented EPC-notation enables non-technical professionals - like physicians or other clinical staff - to understand the modeled clinical process quickly and easily. On top of that, we use ARIS for our modeling purposes.

The availability of process-related timestamps will be considered on the basis of existing clinical standards in the hospital system environment. The missing link between IT and the clinical process is drawn by embedding selected IT-timestamps into a newly developed clinical process model and assigning them to the appropriate events in the model. The assignment of timestamps to the clinical process is finally presented based on the example of the dedicated modality sub-process defined in the clinical model.

3. CLINICAL STANDARDS AND SYSTEMS

The clinical standard DICOM (Digital Imaging and Communications in Medicine) defines the format and mechanism for exchange and storage of information in a radiological environment (DICOM, 2010). DICOM includes a large number of specific services and the producers are committed to their implementation because of so-called „Conformance Statements“. By comparing the declarations of different systems, basically it is possible to determine, whether they can interact with each other (DICOM, 2009). The second important clinical standard, Health Level 7 (HL7, 2011), standardizes the transfer of patient information between IT systems outside the radiology department of a hospital in the catchment area of the hospital information system (HIS). A HIS supports patient care, documentation, organization and administration in a hospital (Huang 2010; Haas, Kuhn 2007).

Modalities are known as imaging systems in the medical industry. The term modality may relate to a specific device (e.g. CT-scanner no. 2) or to a class of devices (e.g. modality = CT) that use the same technology (Ralston, Coleman 2009). Depending on the type of modality one or more image acquisitions may be performed during an examination. Modalities represent in addition to PACS (Picture Archiving and Communications System), whose task is to store, distribute and display medical images for interpretation and evaluation, the technological core of a modern, digital radiology department (Ralston, Coleman 2009). In addition to modalities and PACS, radiology information systems (RIS) are used here. RIS systems are
responsible for both administrative and clinical functions of a radiology support and control to relieve the staff from administrative tasks and improve the quality of radiological examinations (Huang, 2010).

The RIS can generate so-called worklists based on DICOM (DICOM worklist), which can be accessed by modalities for planning examinations. They also contain patient data, details of the examination orders, the procedure parameters and appointments. In return, a modality is able to generate so-called Modality Performed Procedure Steps (DICOM MPPS), a structured information (such as start time, end time, status, dose, material consumption etc.), which can be sent to the RIS at the beginning (“MPPS in progress”) and the end (“MPPS completed”) of an examination (Noumeir, 2005). One way to obtain information on the procedure during the process is to extract them from the log files of the modalities. Log files are generated by the manufacturers’ procedures e.g. for maintenance purposes or for fault analysis and can be read automatically by remote service connections. The timestamps provide time information about each image acquisition contained in a log file and act as complementary information to MPPS-time indication of the beginning and the end of the entire examination. Table 1 summarizes the standardized exchanges between systems.

Table 1. Interoperability of clinical systems (in accordance with (Wirsz 2000))

<table>
<thead>
<tr>
<th>Systems</th>
<th>HIS</th>
<th>RIS</th>
<th>PACS</th>
<th>Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIS</td>
<td>HL7</td>
<td>HL7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIS</td>
<td>HL7</td>
<td>HL7</td>
<td>HL7/DICOM</td>
<td>DICOM</td>
</tr>
<tr>
<td>PACS</td>
<td></td>
<td></td>
<td>HL7/DICOM</td>
<td>DICOM</td>
</tr>
<tr>
<td>Modality</td>
<td></td>
<td></td>
<td>DICOM</td>
<td>DICOM</td>
</tr>
</tbody>
</table>

The initiative IHE (Integrating the Healthcare Enterprise) (IHE) has been developing frameworks using standard protocols for the construction of clinical workflow scenarios. The objective includes the support of communication between clinical information systems (e.g. HIS, RIS, PACS), the optimization of clinical workflow and elimination of rigid and proprietary solutions by the greater inclusion of standards such as DICOM and HL7. The first scenario was originally developed for radiology. Over the last years, scenarios for other domains, such as cardiology, IT-infrastructure, laboratory etc., have been developed. They are summarized and published in so-called Technical Frameworks. A familiar example is the first scenario “Scheduled Workflow”, which was developed for radiology domain (IHE).

4. INTEGRATIVE TIME ACQUISITION IN DIAGNOSTICS

The patient care process can be divided into several distinct sub-processes during an inpatient hospital stay (see Figure 1). While admission as well as discharge takes place only once, several diagnostic and therapeutic procedures can be consecutively repeated. In the following, the diagnostic process is exemplarily described. The diagnostic process is selected, since in this phase examinations are carried out in the catchment area of RIS systems and modalities (as CT, MRI etc.) and therefore the automatic generation of additional, clinical and relevant timestamps, as described in the previous section, is possible.

Figure 2 shows the schematic structure of the diagnostic sub-process in the field of radiology. The process can be further divided into sub-processes. First, a modality examination is requested (request). In the ideal case, required patient data are automatically transferred from the upstream HIS into the RIS; otherwise they are entered manually and supplemented by additional data (diagnostic problem, contraindications etc.). Subsequently, the examination is planned (planning), which includes both the scheduling and planning of the procedure itself. The received request is assigned by RIS to an examination room (i.e. a specific modality). The modality can retrieve independently the DICOM worklist from the RIS and assume it into their local worklist.
Following the preliminary planning activities preparatory arrangements in the examination room (e.g. cleaning of the room, sterile coverage, and preposition of materials) are made (preparation). At the same time, the patient is transported to the radiology or is waiting there already. Subsequently, the patient can be prepared for the examination (disinfection, puncture, positioning on the table, anesthesia, etc.). To begin the next step, the examination itself, the registration of the patient at the modality is required. For this, the patient data can be selected from the local worklist of the modality and the examination (procedure) can be started. Acute patients who are registered later in the worklist, or not registered, are preferred here. In the last case, the patient registration has to be done manually at the modality. If the registration has been completed and examination protocols at the modality have been started, the DICOM MPPS information about the start of the study (“MPPS in progress”) is generated by the modality and transmitted to the RIS (Noumeir, 2005). Before the start of the first image acquisition, the table has to be positioned, the patient’s position on the table has to be reviewed (possibly the patient will be placed first) and the modality will be adjusted. During an examination run, one or more images or image series are acquired by use of modality-specific protocols, sequences or applications. Studies may be repeated several times in series until all necessary images are captured in sufficient quality, and variety of images are sufficient to state the diagnosis with high confidence (see Figure 3).

Figure 2. Schematic structure of the diagnostic process

After completion of the examination, the information, as described in the previous section, is compiled by the modality and sent together with existing patient and order data via DICOM MPPS to the RIS (“MPPS completed”) (Noumeir, 2005). Details of timing of the examination runs (duration between MPPS in progress and the launch of the first image acquisition, number and length of image acquisitions, time after the last image acquisition up to MPPS completed etc.) can be obtained from the log files at the modalities. Then the documentation is completed and the results processed (processing). In addition, the transport of the patient and after-care activities is initiated. Parallel interpretation, evaluation and reporting of medical findings can be started. Finally, the report will be distributed to the responsible healthcare professionals and archived in the system among other documents (report distribution).
5. DEFINITIONS AND CLASSIFICATION OF THE ACQUISITION OF PROCESS CYCLE TIMES

The temporal distribution and sequence of individual steps of the patient process is essential for the detection of lead times. A (partial) process or process step is initiated by a start event and ends with a final event. The dates of these events are marked with a timestamp. Selected valid timestamps are the interval boundaries between the start and end events of a process or process step. An event is a date that marks the occurrence of a defined system state (DIN 69900) and thus allows the collection of a timestamp. For monitoring relevant timestamps (i.e. events in the context of the model) we defined a framework for clustering the whole process into sub-processes (see Figure 4). The process cycle time corresponds to the time period for the execution of all time-determining process steps in a process chain that follow each other when performing a clinical task. The clinical process cycle time can be obtained using the time difference between timestamps of the final and initial event of the process chain. Selected process lead times can be used to draw conclusions on quality metrics – referred to as key performance indicators (KPIs). An example of this is the door-to-balloon time (time from patient arrival at the hospital [door] to the primary coronary intervention [balloon] in patients admitted with heart attack).
6. DISCUSSION AND CONCLUSION

The current interaction between medical devices and IT-systems in hospitals is characterized by inadequate interoperability and integration. One challenge is the IT-department and cross-system detection of patient-related process lead times. For this reason, the available clinical information and imaging systems have been investigated using the example of radiology and the DICOM-standard regarding the collection and communication of timing information. It was found that DICOM MPPS provides a valuable service for the acquisition of process lead times. This requires, however, that both the modality and the connected RIS-system support MPPS. The DICOM conformance statements provide a way to compare several systems for interoperability with each other. With the implementation of the IHE scenarios also the interoperability across the entire process (e.g. in radiology) will be ensured. As a complement to MPPS also modality logfiles could be used, particularly to obtain information about the exact procedure run, because procedure duration of modalities can vary widely. The described method of process monitoring may be very helpful for identification of bottlenecks in clinical workflow.

In addition to the technical improvements of “time acquisition”, in order to deduce statements about process execution times, it is necessary to integrate IT-timestamps into a patient process model. For this purpose a generic EPC model was created that consists of 21 modules, which are connected to each other with process interfaces. The modules can be called and executed repeatedly during the run of process. Figure 5 illustrates as an example the module which models the process flow at a modality. Such kind of modeling a modality examination process allows the use of the process in both diagnostics (e.g. CT) and in therapy (e.g. coronary intervention). As shown in the figure, events whose timestamps should be collected after instantiation of the process were labeled. By following the process continuously and calculating the time difference between the final and the initial event of the process chain, the process cycle time can be determined. As shown in Figure 5, the length of an image acquisition (t (acquisition finished) – t (acquisition started)) and/or of the entire examination (t (procedure finished) – t (procedure started)) can be calculated and documented. In addition, the sources of the timestamps (DICOM MPPS and modality log file) are identified. After instantiating the EPC model, the clinical process lead times can be obtained automatically and standardized using formation of time difference in the described manner.
The developed EPC model was tested with specific care pathways for completeness and was extended towards timestamps. Due to the chosen modeling methodology and the development of reusable and callable modules, it meets the requirements for standardized detection of process lead times. In respect of automated acquisition of IT-timestamps during the process instantiation at hospital, the interoperability issue is
addressed. However, not all timestamps provided in the model are currently available in clinical systems. In cases of unavailability, providing a possibility of automated generation of appropriate IT-timestamps is recommended. In addition, a further extension of the model to capture more events that have to be measured with the objective of process cycle time acquisition is possible.

EPCs are used for modeling purposes mostly at the lower levels of process hierarchy. This level of detail is also necessary for performance measurement. On conceptual or technical level other methods such as Business Process Modeling Notation (BPMN, 2010), Unified Modeling Language (UML, 2010) or Business Process Execution Language (BPEL, 2011) are often used. Additionally there are other healthcare-specific approaches to clinical process mapping and improvement as presented in this paper. An example of an UML-based clinical process model is the Module Library for Medical Process Models (MoBimeP), which was developed for the standardized clinical pathways mapping and the a-priori pathway modularization at the Ilmenau Technical University in Germany (Eisentraut, 2008). The Patient Journey Modeling Architecture (PaJMa) - as another approach - focuses especially the patient flow. It focuses on the patient’s movement through a healthcare organization and on providing a visual representation of the processes involved in a patient journey (McGregor, 2008). The Breakthrough Series Model for Improvement (MOI), developed by the Institute of Healthcare Improvement (IHI) in U.S., is another patient flow based approach initially developed for manufacturing and business domain. It aims “breakthrough” quality improvements while reducing costs (Curry, 2006). Lean Thinking’s Value Stream Modeling, as further patient journey modeling technique, supports the reengineering of healthcare processes by using the lean paradigm derived from the field of manufacturing (Curry, 2006). Both last mentioned techniques - Breakthrough Series Model for Improvement and Lean Thinking’s Value Stream Modeling - predominate in the field of process reengineering in healthcare. However, the MoBimeP library and the PaJMa model were specifically designed for healthcare and are therefore more suitable for clinical modeling purposes. In future work, both approaches need to be considered and compared to the patient process mapping and modeling technique introduced in this paper.

In summary, it is established that a patient's process-oriented view of timestamps represents a promising opportunity to accurately monitor the patient flow over several department and system borders. The conformity of medical devices and IT systems to the IHE Technical Framework represents the technical foundation for the interoperability of the systems involved and therefore for the continuous acquisition and transfer of time information. Both will provide the basis for a standardized and automated acquisition of process cycle times. This can lead to more accurate analyses of clinical processes, determination of novel quality and performance indicators and optimization of processes by reduction of lead times – ultimately, to an improved quality of care especially in time-critical diseases such as heart attack and stroke.

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A NEW DEBATE FOR TURKISH PHYSICIANS:
E-DETAILING

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ABSTRACT
The study presents an empirical analysis of the attitudes of Turkish physicians towards e-detailing practices compared to face-to-face (F2F) detailing. The findings reveal that although physicians have positive perceptions and attitudes toward e-detailing, in some points they are still undecided and/or have doubts. The structural model of the antecedents and attitudes revealed that affect, convenience and informative content are the major factors that influence the attitude of Turkish physicians in a positive manner, whereas the personal interaction is found to be a negative factor. Physicians’ age and frequency of calls received from the representatives are moderators. The present study can be seen as an addition to pharmaceutical marketing, an under-researched study field in Turkey and e-detailing in particular.

KEYWORDS
Detailing, electronic detailing, pharmaceutical companies, physician attitudes

1. INTRODUCTION
Although detailing is accepted as one of the major communication tools for the pharmaceutical industry, its’ efficiency has begun to decline for a number of reasons; e.g. increasing costs, inefficiency in interactions or time pressure on physicians. Since e-detailing is spreading in the pharmaceutical market, factors that influence physician attitudes need further understanding.

Turkey is known as the 7th largest pharmaceutical market in Europe (IEIS, 2011). Public health policy is based on pharmaceutical quality and wide and easy access to pharmaceuticals. In such a large market, companies try to outrival each other via F2F detailing along with all other competencies. Despite the companies’ growing interest about pharmaceutical e-detailing which may increase communicational efficiencies, to our best knowledge, it has not been examined in the Turkish literature yet. Thus, there remains a dearth of research that examines Turkish physicians’ attitudes towards e-detailing. The present study represents an attempt to analyze the factors that influence their attitudes towards e-detailing compared to F2F detailing. A structural model of the antecedents and the attitudes is also proposed.

2. FACE-TO-FACE DETAILING AND E-DETAILING
Detailing can be defined as F2F calls, where pharmaceutical sales representatives (PSRs) communicate pharmaceutical and marketing information to physicians (Molloy et al. 2002). Compared to other industries, marketing communications of pharmaceutical companies are more problematic due to the derived-demand structure and wide legal restrictions. Global pharmaceutical industry utilizes detailing as the major marketing communication tool to facilitate interaction between the physicians and PSRs. Detailing activities have been widely examined so far (e.g. Chimonas et al. 2007; Caudill et al. 1996; Bansal and Das 2005; Aggarwal 2010; Harris 2009; Søndergaard et al. 2009); e.g. it was revealed that physicians appreciate the educational value of the information provided by the PSRs, and PSRs influence physicians’ prescribing behavior.

Yet, the factors that physicians take into account may not always be in the best interests of patients and society. Detailing activities may raise ethical questions when PSRs are equipped by their companies with sales promotion tools, such as monetary benefits or gifts. Several studies revealed that physicians do not
consider gifts as unethical (Brett et al. 2003) and they can be more willing to attend sales meetings when sales promotion tools are offered (Ziegler et al. 1995). Gifts or sponsorships, such as expense-paid seminars, affect the prescribing behavior of physicians in favor of the promoted product (Orlowski and Wateska 1992; Dedeoglu 2005). High costs of F2F detailing and sales promotion tools, inefficient sales efforts, biased and insufficient information about the medications and physicians’ limited time decreased attractiveness of F2F detailing (Bates et al. 2002; Heutschi et al. 2003; Trucco and Amirkhanova 2006; Alkateeb and Doucette 2008; Montoya 2008). To examine more patients, mainly due to increased financial pressures, physicians allocate less time to PSRs (Davidson and Sivadas 2004; Gleason 2001). Thus, providing sufficient information about the products has become a challenge for PSRs. Roughhead et al. (1998) indicated that PSRs promote products’ benefits and leave the risks out. Moreover, growing number of PSRs resulted in more PSRs struggling to contact almost the same number of physicians (Pesse 2007; Sinha and Kaushik 2010). Due to the limited physician time, increasing Internet usage of physicians and the use of technology for product information, the industry initiated e-detailing (Davidson and Sivadas 2004). Digital technology and the use of Internet enables distant, (un)synchronized, high reach and high quality interactions in diverse formats such as telephone co-browsing, scripted or virtual detailing, interactive voice response, video conferencing and interactive voice conferencing and e-mailing (Bates et al. 2002, Heutschi et al. 2003).

E-detailing has received considerable attention by researchers as well. The studies mostly focused on the adoption of e-detailing (Masood et al. 2009, Alkateeb and Doucette 2009), its benefits (Bates et al. 2002; Heutschi et al. 2003), costs and its’ effects on new prescriptions (Gonul and Carter 2010). Several studies (Bates et al. 2002; Heutschi et al. 2003; Trucco and Amirkhanova 2006; Alkateeb and Doucette 2009) emphasized that in a quest to increase efficiency and effectiveness, e-detailing may complement, but not substitute F2F detailing. E-detailing activities of pharmaceutical companies mostly include delivering information about clinical trial data, indications, side effects and prescribing guidelines for complex diseases.

2.1 Sources of Influence on Attitudes towards e-detailing

An attitude is a lasting, general evaluation of people, objects, advertisements, or issues. An attitude has three basic components: affect (feelings), behavior (intentions), and cognition (beliefs) (Solomon 2009). Once a negative attitude becomes part of a person’s value system, it is hard to change. Thus, considering e-detailing as a new marketing tool, one can suggest that pharmaceutical marketers should focus on forming positive attitudes at the outset so as to achieve a higher level of positive attitudinal commitment.

The sources of influence on attitudes towards e-detailing can be classified in 7 categories: informative content, personal interactions, convenience, affect, samples, supplementary services and frequency of calls.

**Informative Content:** The main aim of the PSR calls is to alter the physicians’ way of thinking about the medication via providing information (Greene 2004). Despite that, PSRs are generally criticized for providing information about the benefits and glossing over the risks, e.g. side effects, drug interactions (Roughhead et al. 1998). Thus, the cognitive evaluations of the physicians regarding the informative content of the detailing should be analyzed. Used either to complement or substitute F2F detailing, e-detailing activities should focus on informative content primarily. Previous research compared the informative content of the two detailing types and revealed that the physicians consider e-detailing more informative when compared to F2F detailing (Davidson and Sivadas 2004). E-detailing facilitated information pull of physicians in necessary amounts and on their own time and accord.

**Personal Interaction:** E-detailing facilitates interactive communication between the PSR and the physician via electronic media. Yet, it has its limitations. Studies showed that the most physicians like to exploit F2F calls for information gathering and social interaction (Flanagan et al. 2003; Heutschi et al. 2003). PSRs are deemed as vital information sources by the physicians. Yet, frequency of PSR calls may have a dual effect on the physicians’ attitudes towards e-detailing. Considering the time pressure and increased number of PSRs interrupting during patient calls, frequency of PSR calls can be perceived as overwhelming. In such a situation, physicians’ attitudes could be in favor of e-detailing. Less frequent PSR calls may give rise to negative attitudes towards e-detailing especially when physicians seek F2F interaction. Physicians may refuse e-detailing calls since during F2F calls they may be offered other promotion tools, e.g. product samples, monetary benefits/gifts (Orlowski and Wateska 1992; Harris 2009; Sondergaard et al. 2009).

**Convenience:** It was found that most physicians favored e-detailing due to its convenience (Davidson and Sivadas 2004). Physicians can reach e-detailing resources on their own convenience; i.e. they can pull
the exact information they need on their own time and accord. The convenience may be in terms of time, place and the amount of the information. That kind of convenience may be also seen as beneficial, especially when physicians’ time allocated for PSR calls is seen as stolen from patients’ examination time. Gleason (2001) revealed that 72% of e-detailing took place after the work hours. Public authorities generally favor the idea that the best time to accept PSR calls is after the work hours (Flanagan et al. 2003).

**Affect:** Affect captures an individual’s feelings towards the attitude object; here, detailing. It may enhance the positive/negative experiences which may have some bearing on the beliefs and attitudes of the consumers (Solomon 2009). Affect was found to be a strong predictor of behavior via cognitive processes (Cohen 1990; Bodur et al. 2000).

**Product Samples:** E-detailing also has its limitations due to the lack of instant access to product samples. Free samples have statistically significant effect on prescribing behavior of physicians (Mizik and Jakobson 2004; Gonul et al. 2001). Thus, lack of instant access to product samples may influence physicians’ attitudes towards e-detailing negatively.

**Supplementary Services:** To be sure that physicians have access to any information they need, supplementary services, such as providing easy and fast access to Internet, e-preparation of physicians before the F2F calls to ensure that they get information they need and follow-up details may be offered.

**Frequency of Calls:** The increasing frequency of F2F calls may be ineffective due to the declining value of communication; physicians may get overwhelmed and reject further PSR calls (Bernewitz 2001). Physicians facing such a dilemma are found to be more likely to develop a positive attitudes towards e-detailing (Alkhatteeb and Doucette 2009). Then again, physicians who take less frequent PSR calls may also need to access medication information from other sources, such as e-detailing.

### 3. FIELD SURVEY

In order to find out Turkish physicians’ attitudes towards e-detailing and their beliefs about conditions under which e-detailing can succeed, a survey was conducted. The population consisted of Turkish physicians who are currently employed at university hospital. Since the physicians who work at a faculty of medicine are highly involved in education and new drug R&D activities (Buharali 2009; Lerer 2002; Feldman 1994; Haux et al. 2002), they may receive more frequent calls from PSRs. It was found that the physicians working at the university hospitals are more hesitant against pharmaceutical marketing practices (Anderson et al. 2009). Thus, a population of university practitioners is expected to facilitate objective evaluation of attitudes towards e-detailing. The sample consisted of Turkish physicians who are currently employed at departments of medical and surgical clinical sciences at Ege University. Ege University is sampled due to the convenience in getting research approval from faculty management. After a pilot test with 10 respondents, the questionnaire was revised so that inapplicable questions and ambiguous wording could be avoided. The data collected during the pilot test indicated that 35% of the respondents have positive attitudes toward e-detailing. Considering that there are 418 physicians at medical and surgical clinical sciences, at a 5% precision level and 95% confidence level, the sample size was determined as 190. Yet, only 149 physicians agreed to participate, thus, the precision level increased to 6.15%. Physicians, in general, were not willing to participate in a survey about detailing activities as they were not particularly interested in a topic that is an interest of PSRs. The questionnaire included statements about the physician’s perceptions of and attitudes toward e-detailing and their beliefs about conditions under which e-detailing can succeed. 5-point Likert scale of ranging from ‘strongly disagree (1)’ to ‘strongly agree (5)’ was utilized. Scales that aim to measure the attitudes were adapted from Caudill et al. (1996) and Davidson and Sivadas (2004). Profile of the sample appears in Table 1. 30% of the respondents were reluctant to spell out their departments; the reason for this reluctance may be attributed to the consequences of their direct relations with the PSRs. A missing value analysis revealed that compared to those who spelled out their departments, those who did not spelled out their departments believe that F2F detailing of medicines suit their general needs better than e-detailing ($t_{147}=2.4 \ p=.018$) and that it is more effective due to the fact that they can more easily access product samples compared to e-detailing ($t_{107.6}=2.6 \ p=.011$). Furthermore, in general, they were undecided about the efficiency and effectiveness of e-detailing, in comparison to other physicians, who revealed positive attitudes toward e-detailing. Similarly, compared to those who divulged their monthly household income, 14% of the respondents who hesitated to spell out their monthly household income believe that F2F detailing of
medicines suit their general needs better than e-detailing ($t_{35.7}=2.94$ $p=.006$) and that F2F detailing of medicines is more effective due to the fact that they can more easily access product samples than e-detailing ($t_{29.4}=2.3$ $p=.031$). These findings may indicate a conflict of interest that influences their general attitude.

Table 1. Profile of the sample

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td></td>
</tr>
<tr>
<td>Female</td>
<td>74</td>
<td>50.3</td>
</tr>
<tr>
<td>Male</td>
<td>73</td>
<td>49.7</td>
</tr>
<tr>
<td>Missing</td>
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<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>100</td>
</tr>
<tr>
<td>Marital Status</td>
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<tr>
<td>Medical clinical sciences</td>
<td>82</td>
<td>78.8</td>
</tr>
<tr>
<td>Surgical clinical sciences</td>
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<td>21.2</td>
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<tr>
<td>Missing</td>
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<tr>
<td>Total</td>
<td>149</td>
<td>100</td>
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</table>

<table>
<thead>
<tr>
<th>Age (Mean=36.27, Std.Dev.=10.19)</th>
<th>Monthly Income (1$=1.5 TL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23-28</td>
<td>1000-1500$</td>
</tr>
<tr>
<td>29-34</td>
<td>1501-2000$</td>
</tr>
<tr>
<td>35-40</td>
<td>2001-2500$</td>
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<tr>
<td>41-46</td>
<td>2501-3000$</td>
</tr>
<tr>
<td>47-52</td>
<td>3001-3500$</td>
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<td>53-58</td>
<td>3501-4000$</td>
</tr>
<tr>
<td>59-64</td>
<td>4001-4500$</td>
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<tr>
<td>Missing</td>
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<tr>
<td>Total</td>
<td>5501-6000$</td>
</tr>
<tr>
<td></td>
<td>6000$ +</td>
</tr>
<tr>
<td></td>
<td>4001-5000$</td>
</tr>
<tr>
<td></td>
<td>5501-6000$</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of calls received form PSRs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>4</td>
</tr>
<tr>
<td>Rarely</td>
<td>26</td>
</tr>
<tr>
<td>Occasionally</td>
<td>46</td>
</tr>
<tr>
<td>Sometimes</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
</tr>
</tbody>
</table>

Although physicians have positive perceptions and attitudes toward e-detailing, at some specific points they are undecided and/or have doubts (Table 2). They do not believe that e-detailing of medications suit their needs better than F2F detailing and e-detailing is more efficient than F2F detailing on the whole. Yet, when probed about specific benefits of e-detailing they have positive evaluations. They appreciate that, in case of e-detailing, they can (a) pull the information they need and organize their own time, (b) conduct a longer research about the medication and (c) reach additional information via hyperlinks. They also believe that F2F detailing can be more efficient than e-detailing because they can (a) more easily obtain product samples and (b) closely interact with PSRs. Statements about attitudes towards e-detailing and F2F detailing are reliable, with Cronbach alpha of .919 and .819 respectively.

Table 2. One sample t-test of the respondents’ evaluations

<table>
<thead>
<tr>
<th>Statements*</th>
<th>Mean</th>
<th>Std. dev.</th>
<th>t</th>
<th>df</th>
<th>Sig.</th>
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<tbody>
<tr>
<td>I perceive e-detailing positively.</td>
<td>3.26</td>
<td>1.09</td>
<td>2.92</td>
<td>148</td>
<td>.004</td>
</tr>
<tr>
<td>My attitude toward e-detailing is positive.</td>
<td>3.32</td>
<td>1.16</td>
<td>3.33</td>
<td>148</td>
<td>.001</td>
</tr>
<tr>
<td>E-detailing of medicines suits my general needs better than F2F detailing.</td>
<td>2.74</td>
<td>1.02</td>
<td>-3.05</td>
<td>148</td>
<td>.003</td>
</tr>
<tr>
<td>In general, E-detailing is more efficient than F2F detailing.</td>
<td>2.68</td>
<td>1.03</td>
<td>-3.75</td>
<td>148</td>
<td>.000</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing since I can organize my time on my own</td>
<td>3.31</td>
<td>1.24</td>
<td>-3.05</td>
<td>148</td>
<td>.003</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because it is more informative.</td>
<td>3.00</td>
<td>1.11</td>
<td>0.00</td>
<td>148</td>
<td>1.00</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because it allows me to conduct longer and deeper research about the medicine.</td>
<td>3.28</td>
<td>1.15</td>
<td>2.99</td>
<td>148</td>
<td>.003</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because hyperlinks can provide additional drug information.</td>
<td>3.26</td>
<td>1.15</td>
<td>2.72</td>
<td>148</td>
<td>.007</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because I can obtain to authentic information about the side effects and drug comparisons.</td>
<td>2.97</td>
<td>1.23</td>
<td>-0.27</td>
<td>148</td>
<td>.799</td>
</tr>
<tr>
<td>In general, F2F detailing is more efficient than e-detailing.</td>
<td>3.26</td>
<td>1.02</td>
<td>3.05</td>
<td>148</td>
<td>.003</td>
</tr>
<tr>
<td>F2F detailing is more efficient than e-detailing since I can easily obtain product samples</td>
<td>3.58</td>
<td>1.07</td>
<td>6.61</td>
<td>147</td>
<td>.000</td>
</tr>
<tr>
<td>F2F detailing is more efficient than e-detailing because of close interaction with PSRs.</td>
<td>3.24</td>
<td>1.10</td>
<td>2.62</td>
<td>146</td>
<td>.010</td>
</tr>
<tr>
<td>F2F detailing is more efficient than e-detailing because it is more informative.</td>
<td>2.83</td>
<td>1.06</td>
<td>-1.94</td>
<td>147</td>
<td>.054</td>
</tr>
</tbody>
</table>

* Test value is 3 (neither agree nor disagree) + Insignificant
Providing detailed information and allowing physicians to pull information on their own time are the two main reasons that explain perceived efficiency of e-detailing (Table 3). The effect of the former factor is higher than latter. To understand why the capacity of e-detailing to facilitate longer research about the medicine and provide hyperlinks for further research failed to explain physicians’ evaluations, further analysis is done. Pearson correlations reveal that only those who receive infrequent calls from PSRs believe in the high efficiency of e-detailing since it facilitates longer research ($r_{147}=-.16, p=.05$) and provides them useful hyperlinks ($r_{147}=-.24, p=.000$). Frequency of PSRs calls is assessed as a “pure moderator” (Sharma et al. 1981) between the use of e-detailing as a preparatory tool before F2F calls ($r_{147}=-.04, p>.05$) and attitudes towards e-detailing ($r_{147}=-.06, p>.05$). As the frequency of F2F calls increases, attitudes of the physicians, who appreciate e-detailing only as a preparatory tool before F2F calls, towards e-detailing are negatively affected. Frequency of F2F calls is also a “pure moderator” between the use of e-detailing as a follow-up tool after the F2F calls ($r_{147}=0.04, p>.05$) and physicians’ attitudes toward e-detailing ($r_{147}=-.06, p>.05$). As the frequency of F2F calls increases, attitudes of the physicians, who appreciate e-detailing as a follow-up tool, are positively affected. The interaction effects of these supplementary services are significant, beta coefficients are $-53$ ($t=-2.14, p<.05$) and $.65$ ($t=1.97, p<.05$) respectively. Age is also found to be a “pure moderator” between usage of Internet ($r_{147}=-.05, p>.05$) and physicians’ attitudes toward e-detailing ($r_{147}=-.10, p>.05$). The younger the physicians, the more they tend to use the Internet and the more positive their attitudes towards e-detailing are. The interaction effect is significant (beta coefficient=1.09 $t=2.26, p<.05$).

Table 3. Regression analysis of the antecedents that influence perceptions of e-detailing’s efficiency

<table>
<thead>
<tr>
<th>Regression Coefficients</th>
<th>Unstandardized Coefficient</th>
<th>Std. Error</th>
<th>Standardized Coefficient</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: In general, E-detailing is more efficient than F2F detailing - $F=66.658$ df=2/146 $p=0.000$ $R^2=0.477$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>.558</td>
<td>.195</td>
<td>2.87</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because it is more informative.</td>
<td>.411</td>
<td>.070</td>
<td>.444</td>
<td>5.89</td>
<td>.000</td>
</tr>
<tr>
<td>E-detailing is more efficient than F2F detailing because I can organize my time on my own.</td>
<td>.276</td>
<td>.063</td>
<td>.325</td>
<td>4.31</td>
<td>.000</td>
</tr>
</tbody>
</table>

Table 4. Regression analysis of the antecedents that influence perceptions of F2F detailing’s efficiency.

<table>
<thead>
<tr>
<th>Regression Coefficients</th>
<th>Unstandardized Coefficient</th>
<th>Std. Error</th>
<th>Standardized Coefficient</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: In general, F2F detailing is more efficient than e-detailing - $F=43.613$ df=2/144 $p=0.000$ $R^2=0.377$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.312</td>
<td>.222</td>
<td>5.91</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>F2F detailing is more efficient than e-detailing because it is more informative.</td>
<td>.042</td>
<td>.081</td>
<td>.415</td>
<td>4.99</td>
<td>.000</td>
</tr>
<tr>
<td>F2F detailing is more efficient than e-detailing because of close interaction with PSRs.</td>
<td>.246</td>
<td>.078</td>
<td>.265</td>
<td>3.18</td>
<td>.002</td>
</tr>
</tbody>
</table>

Physicians disagree that e-detailing will fail ($t_{148}=-4.16, p=.000$). Although they think that it is valuable ($t_{148}=3.78, p=.000$), they are unsure about their feelings about e-detailing; they neither agree nor disagree that e-detailing is an attractive concept ($t_{148}=1.63, p>.05$). They do not believe that e-detailing is as effective as F2F detailing ($t_{148}=-2.26, p>.025$). Although they disagree e-detailing will substitute F2F detailing ($t_{148}=-7.32, p=.000$), they also believe that e-detailing can substitute some F2F detailing calls ($t_{148}=-2.25, p=.025$). E-detailing is proposed to be successful only when it is used to find out whether F2F call is necessary or not ($t_{148}=-4.10, p>.000$) and to give more information to the physician after the F2F call ($t_{148}=-6.93, p=.000$). They are unsure whether gifts/incentives given them to promote e-detailing will help or not ($t_{148}=-1.96, p>.05$). The ideal interval of an e-detailing call/record is 3-4 minutes. We can propose that physicians’ attitudes towards
e-detailing are not strong. They appreciate it and think that in some cases it can be useful, yet, they do not have positive feelings.

**Model Estimations.** The sources of influence on attitudes towards e-detailing are analyzed by structural equation modeling. To analyze the associations between informative content, personal interaction, convenience, affect, product samples, supplementary services, and the attitudes and reveal the causal structures, path analysis was used. The hypotheses investigate both direct and indirect influences;

H1: Positive evaluations of the informative content of e-detailing lead to more positive attitudes towards it.

H2: Positive evaluations of the nature of F2F detailing allowing for more personal interaction lead to less positive (negative) attitudes toward e-detailing.

H3: Positive evaluations of convenience of e-detailing lead to more positive attitudes towards e-detailing.

H4: Positive affects lead to more positive attitudes towards e-detailing.

H5: Positive evaluations of F2F detailing due to its nature allowing instant access to on-the-spot samples lead to less positive (negative) attitudes toward e-detailing.

H6: Offering supplementary services lead to more positive attitudes toward e-detailing.

H7: Higher frequency of PSRs calls leads to more positive attitudes towards e-detailing.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Supplementary Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informativne Content</td>
<td></td>
</tr>
<tr>
<td>Personal Interaction</td>
<td></td>
</tr>
<tr>
<td>Convenience</td>
<td></td>
</tr>
<tr>
<td>Affect</td>
<td></td>
</tr>
<tr>
<td>Product Samples</td>
<td></td>
</tr>
<tr>
<td>e-Preparation</td>
<td></td>
</tr>
<tr>
<td>Use of Internet</td>
<td></td>
</tr>
<tr>
<td>e-Population</td>
<td></td>
</tr>
<tr>
<td>Follow-up to call</td>
<td></td>
</tr>
<tr>
<td>Frequency of Calls</td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td>-018 -011 -026 -006 -000 -000 -000 -000 -000</td>
</tr>
</tbody>
</table>

Notes: (1) The rows show total, direct, and indirect effects respectively. (2) + indicates insignificant results.

The majority of the hypotheses are supported. The fit measures indicate a satisfactory fit of the model ($\chi^2$ =6,352; df=8; p=.608; CFI= 1.000; RFI=.949; RMSEA= .000) (Table 5). Favorable perceptions of informative content (H1 supported $p<.05$), personal interaction (H2 supported $p<.05$) convenience (H3 supported $p<.05$), and affect (H4 supported $p<.05$) resulted in positive attitudes towards e-detailing. Yet, the influence of personal interaction on physicians’s attitudes towards e-detailing is found negative. This result may stem from the fact that during F2F calls, physicians can access product samples and monetary benefits/gifts. The direct and indirect effects statistics show that affect, convenience and informative content are found to be the important factors that influence the physician’s attitudes in that order. The findings support previous findings about informative content (Roughhead et al. 1998; Davidson and Sivadas 2004); personal interaction (Bates et al. 2002; Heutschi et.al. 2003; Trucco and Amirkhanova 2006; Montoya,2008), convenience (Flanagan et al. 2003) and affect (Cohen 1990; Bodur et al. 2000). H5, H6 and H7 are not supported; it cannot proposed that the more product samples made available by PSRs, the more supplementary services provided and the more frequent the calls are, the more/less positive attitudes the physicians develop towards e-detailing. Additionally, the majority of the physicians believe that e-detailing can flourish when it is used to complement F2F call as a follow-up tool.

![Figure 1. The model](image-url)
4. CONCLUSION

The present study analyzes the attitudes of Turkish physicians towards e-detailing compared to F2F detailing. The findings reveal that although the physicians’ attitude towards e-detailing is positive, at some specific points they are still undecided or have doubts. Reaching detailed information and pulling information on their own time are the factors that explain physicians’ positive attitudes toward e-detailing. The respondents who receive infrequent calls from PSRs appreciate e-detailing since it enables them to do longer research and provides them hyperlinks for additional information. Furthermore, F2F detailing’s capacities to provide detailed information and close interactions with PSRs are found to be the reasons that explain its efficiency.

The structural model demonstrates that physicians’ perceptions of informative content and convenience of e-detailing and their feelings positively and lack of F2F interaction negatively influence their attitudes. It can be proposed that F2F detailing is preferred because of personal interaction. Frequency of PSR calls moderates the relationships between several variables and attitudes towards e-detailing, e.g. as the frequency increases, the physicians, who appreciate e-detailing as a preparatory tool before F2F calls, develop negative attitudes. This may be due to the time pressure on physicians. Hence, using e-detailing even as a preparatory tool may become a burden for them. On the other hand, as the frequency of F2F calls increases, the physicians who appreciate e-detailing as a follow-up tool after F2F calls, develop positive attitudes towards e-detailing. As the frequency increases, physicians may be overloaded and appreciate e-detailing at all times. Thus, in competitive markets where physicians receive lots of F2F calls, e-detailing may even be positioned as a substitute to F2F detailing. In other markets, e-detailing can be used as a tool that complements F2F detailing. Pharmaceutical companies should convince physicians of the benefits of e-detailing. To form positive attitudes towards e-detailing, companies may rely on informative content and conveniences it offers to physicians. They should also remove the physicians’ doubts regarding the lack of personal interaction with PSRs by offering, for instance, some interactive online communication services.

This study has its limitations. Due to the difficulty in collecting questionnaires, the precision level ended up higher than intended. Moreover, the sample might not represent the general Turkish physician profile. Thus, the findings may not be generalized. Yet, this study can be seen as a preliminary effort to analyze Turkish physicians’ attitudes towards e-detailing, a new marketing communications tool in the market.

REFERENCES


ABSTRACT

In the large, sparsely populated, but resourceful Norwegian county of Sogn & Fjordane, there is need for electronic messaging between the primary care service and hospitals. Several years and significant resources have been spent setting up this initiative which attempts to take the paper out of paperwork. A consortium of local organisations established in 2006 is still working to this aim. The question remains though as to why this desired transition to a paperless form of communication has not taken place? Barriers initially appear technological in nature, but this paper argues that local initiatives in the health sector can easily be hampered by stakeholders, both large and small, whose influence greatly shapes how and when actions are implemented. The electronic messaging project has had success in key areas, with impacts both at regional and national level. Due to modest national regulations and standards open to interpretation the obstacles have been harder to overcome than our many high mountains and deep fjords. This article discusses the challenges faced and the strategies chosen by using the four components of Leavitt’s Diamond.

KEYWORDS

Medical informatics, Electronic Messaging, Community e-Health Services, e-Health Infrastructure

1. INTRODUCTION

Electronic sending of referral and case summary messages between health centres and hospitals could have considerable, positive impacts on the operation of health services. The National Health Directorate have defined referrals, and case summaries together with electronic laboratory replies as the basic messages to be implemented first between and within different health trusts (HDIR, 2011). Appropriate use of Information and Communication Technology (ICT) combined with organisation development to improve the quality of health services and increase efficiency. Electronic communication can enable hospitals to reduce costs and increase service quality in a short space of time; it can help health centres reduce the amount of paper work; simplify administration and facilitate a range of positive secondary effects, such as helping municipalities meet their budget commitments, while also delivering higher quality services; it can also benefit commercial actors such as software developer’s who profit from new purchases and program upgrades. The economic savings are documented as being significant (Aanesen et al., 2006); with time saving benefits achieved through electronic communication between and within the different health organisations.

The transition from a paper to electronic format is not, however, a straight forward one, even with the electronic highway and standards in place. Vendors are expected to coordinate their development of basic messages. Each message version has to first undergo a certification procedure at a national level. This is followed by rigorous local test period, (HDIR, 2011). Training, establishing new procedures and a possibly some reorganisation is required.

This paper explores and analyses the transition from a paper based to a paperless, electronic communication. This process was planned to take less than a year, however, five years later is still not concluded; this paper seeks to answer the question; ‘why has the desired transition to an electronic form of communication not taken place?’
To begin with the theoretical framework is outlined (Section 2), followed by a presentation of the methodology (Section 3). The article, then considers the case study example using Leavitt’s (1965) theoretical framework (Section 4) before discussing elements of the development (Section 5) and final concluding comments on the analysis.

2. THEORETICAL FRAMEWORK

Leavitt’s Diamond (1965) has been chosen as the framework to explore both the social and the technical perspectives in implementing ICT in the local health sector. It is a tried and tested model that highlights the challenges found in implementing new technological processes.

According to Leavitt (1965) any organizational change has to be based on four, interdependent components that together represent an organization. The main point being that change in one area for instance by introduction of new technology, leads to change in the other areas and vice versa. Introduction of technology leads to creation of new or changed tasks, but will also have an effect on the organizations structure and the people affected by the change. According to Leavitt the management's primary mission is to ensure balance between the four components. The four components are:

- Tasks to be performed – Goals
- People who perform tasks – Participants
- The technology used – Technology
- Organization structure – Social Structure

Using the diamond model as an analytical model can give insight into the interdependence between technology, people, tasks and organisational structure. It is a framework that illuminates key elements in the change process. The way we use it to analyse a complex change process involving a number of different organisations we see this as a first step in understanding the development. It gives an overview to be able to identify particular points of interest rather than getting a complete explanation this would require a deeper analysis into the complex relationship within and across the involved organisations.

3. METHODOLOGY

As action researchers the authors of this paper have been involved in the process since the project was initiated. Our participation has been as partners in the process. Data has been collected through interviews, participant observation and as action researchers we took part in the process (Larsen, 2007a, Larsen, 2007b, Larsen et al., 2008, Larsen and Strand, 2006) and our conclusions are grounded in action research (Greenwood and Levin, 2007). Data sources are minutes from meetings in the partnership and project reports from 2006 to 2010 and our own researchers’ memos from the participating in the process. Data is presented as a case study. This format as we understand a case study as “the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances” (Stake, 1995). This study is a single case looking into implementation in a specific region. According to Yin the strength of the case study is that it both covers a contemporary phenomenon and its context (Yin, 1981). These findings are from a single case, but can also serve as a “force of example” (Flyvbjerg, 2006) for other regions.

4. CASE DESCRIPTION

The case study region, Sogn & Fjordane, is one of 19 counties in Norway covering 18 623 km² of mountains and fjords, with approximately 107 000 inhabitants. The local health trust, Helse Førde, run the three local hospitals and was early adoptor of electronic communication technology, between its facilities. They were also early adaptors of electronic communication with primary health care services, but the paper version of the message had to be sent in parallel and processed accordingly, because the communication channel were not sufficient secured.
Paperless sending of referral and case summary messages between health centres and hospitals was and still is a priority goal of the local health trust and also the municipalities and general practitioners (GPs). A straight forward diffusion of technology was envisioned in 2006. The municipalities in the county was also early adopters, being first to order secure health infrastructure to all health centres in 2007. Three health centres were selected as pilot municipalities Flora, Luster and Gaular, as they covered all three patient record systems in use by GP’s in the area, had sufficient technical infrastructure in place, and could take on the extra work. Implementing electronic messages require changes that go deep in the municipalities and involve training, new procedures, the reallocation of resources and new organizational structures.

4.1 Goals

The National Health Plan (HOD, 2008) states that appropriate use of ICT combined with organisational development and a stronger focus on collaboration and cooperation can make it possible to attain health policy aims, namely improve quality of services and increase efficiency. In addition it is an aim to give patients access to timely and appropriate information. While the health sector is implementing this strategy, has been noted that change is occurring at a “snail’s pace” (Chaffey, 2008).

The goals in this project are in line with the national goals; however participants have different expectations concerning how and when to achieve these goals. Helse Førde supported by the regional Helse Vest are both concentrating on cost reductions and improving of quality of services. Most health centres and GP’s are concentrating on reducing paper work and simplifying administration; at the same time savings will increase as other electronic message types are adopted. In addition to these primary users, municipalities also wish to cut cost and deliver higher quality services to their residents and commercial software developers want to achieve their profit goals. These slight but significant differences in agenda were not sufficiently taken into account, leading to diverging goals and allocation of resources between the different organisations.

4.2 Participants

There are a number of national and local actors involved in making the change happen.

Norsk Helsenett (NHN) is responsible for the security of the national health infrastructure for sending electronic messages. Locally three contact points have been established, each responsible for different parts of the region. These contact points worked together with NHN and the municipalities in planning the integration with NHN’s secure infrastructure.

The Directorate of Health is a specialist directorate and an administrative body under the Ministry of Health and Care Services and the Ministry of Labour and Social Inclusion. The Directorate is administered by the Ministry of Health and Care Services.

The Norwegian Centre for Informatics in Health and Social Care (KITH) contributes to coordination and cost-efficient application of information technology in the Health and Social Care sector, mainly through the standardisation and coordination activities.

The Agency for Public Management and Government (DIFI) aims to strengthen the government’s work in renewing the public sector and improving the organisation and efficiency of the government administration.

The management of ICT resources was moved out of the county in 2004 to the regional service Helse Vest IKT. As such decision makers situated in Bergen and technical personnel located in Bergen and Førde have to be consulted and involved in any changes taking place. Helse Førde were project owners until 2010. Then Helse Vest IKT took over the project ownership.

The project had the support of both the organizations and the medical professionals involved; a motivated task force consisting of dedicated professionals with relevant experience and background in all the necessary health service levels. Project participants were employed in their line organizations. Despite their expertise, formal backing and support they had difficulty completing the implementation according to plan.

Decision makers and technical personnel at the medical and municipality offices had to be informed and involved. Implementation could have not been achieved without their active support even though Sogn & Fjordane has a moderate scale it involved 26 municipalities and 36 health centres. These health centres are a diverse and heterogeneous group with regard their size, available resources and professional (GP's, nurses, secretaries). In the three pilot implementations, at least one staff member in each of the organisations had to take active part in the project work. This usually was a member of the secretary staff, but doctors were also
participating, bringing insight and interest to the process, particularly with regard the development of new quality assurance systems and procedures. All health centres are required, as part of their code of conduct, to have quality assurance measures in place, but the introduction of electronic messaging may require an update of these systems. Eventually all the health centres and their employees will need to know and is trained to use the new infrastructure.

Several stakeholders that in the end played a critical role in the implementation were, more or less, ignored during the project start up. These included the software suppliers for electronic patient records and communication platforms, and the infrastructure providers, who were not considered to be core actors, as they were “only” delivering software according to an established standard. All claimed to be supporting the standards, but in the end all had to develop or improve their software to comply with the standards and make their products interact seamlessly. As such their role in the transition was clearly underestimated.

4.3 Social & Organization Structure

A number of actors work together to ensure that health and care services in Norway are integrated and coordinated, and make use of electronic communication to facilitate and improve coordination and services.

4.3.1 National Structure

Samspill 2.0 (HOD, 2008) is a national initiative geared to promoting the implementation of electronic messaging. Samspill 2.0 puts special emphasis on implementation through consolidation of tasks and processes, engaging actors, ensuring local anchoring and using checklists to control the process.

The Norwegian association of local and regional authorities (KS) have developed a strategy which aims to promote the use of ICT as a tool to improve efficiency and quality in health and care services within the municipalities (KS, 2008a, KS, 2008b).

The Norwegian medical association and The Norwegian nurses organisation hold important positions both as professional associations and as trade unions, and as such can influence their members with regard to supporting and participating in the implementation process.

KITH, DIFI, and NHN are actors for standardisation and coordination of ICT based solutions.

4.3.2 Local Structure

Sogn & Fjordane is a challenging region owing to the great distances covered, demanding topography and dispersed population constantly putting local infrastructure and communication to the test. But there is access to digital infrastructure and there are interested and qualified persons with the skills to utilize electronic services in an efficient way. The health trust, Helse Førde, has three hospital due to the challenging geography.

The municipalities and the 36 health centres delivering primary care are organised differently. Sogn & Fjordane is a region with many small municipalities that have a tradition of working together to develop infrastructure and services. The health centres are a diverse, heterogeneous group. Each centre employs just a few people who complete a range of tasks. The medical staffs are working in private practices operating on contracts with the municipality.

Helse Førde and the municipalities in Sogn & Fjordane have organised their cooperation in a way that ensures involvement, commitment and communication at all levels. The organisation is based on existing and proven collaboration models. It also includes a set of specific agreements between the partners. Among other the “agreement for electronic collaboration”, this includes procedure handbooks for starting-up and operating the electronic message service.

4.4 The Technology Used

Numerous technical challenges had to be addressed in the project. Both the hospital's and the medical office's computer systems had to be adapted and reconfigured, and new software modules developed and tested internally in the hospitals. Initially, software suppliers and developers to the health centres claimed to have working products ready for implementation.
A number of systems (see Figure 1) have to exchange information in a secure and flawless way to the right address and without any loss. All of them have to comply with national standards that are continually revised. Any safety mechanisms such as organizational and personal certificates have to be installed.

Figure 1. The technology issues (Helse_Førde, 2009)

The new, compulsory infrastructure for safe and fast information transfer, NHN, had to be integrated with the current communication platform. But the integration was not easy; as the solution did not function well with the existing municipal infrastructure. A new national solution had to be developed before the necessary boxes and configuring firewall could be set up successfully. These unforeseen developments and the necessary testing of the new software at many levels along with the implementation of necessary infrastructure contributed to the project delay. The estimated finish date, in 2006, has been moved several times. At present it is estimated, that all municipalities will have the electronic messages by autumn 2011.

Changes in one of the systems can sometimes influence the other systems. It was found that even if the suppliers claimed to be following the same standard this didn't guarantee success, this standard allowed too much interpretation to ensure flawless communication. To get the three pilot implementations up and running the most important beneficial action proved to be technical workshops that were held in the summer 2008, where the different software stakeholders met with the project team addressing one problem issue at a time.

In addition to the project in Sogn & Fjordane there are parallel initiatives nationally, each of them requiring the collaboration of the software stakeholders. This has put a strain on the resources available and illustrates the needs for clearer prioritization and coordination between projects at a national level (HDIR, 2010).

4.5 Results

The pilot implementation was started in early 2006 and the plan was an iterative process of testing and debugging with the aim of being ready for deployment to the rest of the county in the autumn. It wasn't until April 2009, that the last technical test was completed in the pilot implementations. In August 2010, 13 of 36 health centres had the two electronic message types up and running. A number of organizational challenges has been revealed with the introduction of new technology. These are outlined briefly.

- **Medical office**: a diverse and heterogeneous group
  - Typically few people with many tasks, different needs, priorities, skills and training requirements
  - Municipal cooperation’s, with common infrastructure and coordination
  - New and adapted quality procedures were needed and were developed
- **Hospital ICT services**
  - ICT services are no longer part of the local health trust but the regional health enterprise, increasing the distance to between actors and decision makers and making access to resources more difficult
  - Parallel processes and major ongoing restructuring added to the challenges
  - Project responsibility was transferred to Helse Vest IKT in 2010
  - New procedure handbooks for start-up and for operation were developed
- **Suppliers of infrastructure and software**
  - National requirements for infrastructure did not fit in the established municipal collaboration set up.
Adaptations to infrastructure and to national standards are slow, and when new versions are released can have unintended consequences. Example, a new national standard of a message envelope was released in 2009. This caused a stop in the by then completed pilot implementations, all suppliers needed to adjust their software requiring a new test period.

The standards allow a high degree of freedom when it comes to interpretation we experienced that it had been interpreted slightly differently by the different suppliers.

The number of suppliers and too few national measures to ensure coordination and optimal resource management. Small technical ad hoc workshops were found to be necessary prior to and during testing. Suppliers did not allocate resources and people to this project as needed.

Late fall 2010 additional difficulties arose after one of the vendors made changes to their system, as a consequence Sogn and Fjordane is now running paper and electronic messages in parallel.

5. DISCUSSION

Using Leavitt’s (1965) Diamond model as a frame of reference this discussion will consider the challenges faced and the strategies chosen in the implementation. Most notably that changes in technology can lead to changes in tasks, participants and structure. New tasks require new competence, adaptation to new roles and, more often than not, the creation of specialized teams. Some of these changes are already outlined in the results. Much of the delay has been linked to what many think of as the “technical” aspects of the project, but we would argue that it really can be traced back to the missing interaction between the many actors involved.

- When different suppliers did not prioritize development and testing for this project simultaneously, progress automatically halted
- When the delivery of the national secure infrastructure, ordered in 2007, were delayed by two years, progress and local initiative suffered
- When a new component was needed in the hospital system DIPS. Helse Vest IKT decided to programme their own component. They met difficulties and eventually ended up purchasing a third party off the shelf module. This could have been done in the first place
- When in 2010 one of three software companies acquired one of the other companies involved, priorities shifted and progress dropped
- When national projects involving the same software suppliers are initiated and run in parallel, expected resource allocation and priorities shifted to the national project

The error made was an early overemphasis on the technology aspect. Indeed, new software had to be developed by different suppliers to ensure safe and secure information flow, to the right address with confirmation as intended. But at the same time not enough emphasis was placed on identifying, diagnosing and addressing scepticism and resistance to change, resource allocation, and the need to develop new procedures for new tasks and provide training for the people who perform them.

Even with only three pilot implementations the number of participants in the process was relatively large. There were two main organisational levels involved: personnel at the local health centres and at the main hospitals. In addition the municipalities’ normally provide infrastructure for the health centres, and several tiers of software suppliers on both sides were needed to make the changes happen in a coordinated manner. Organizational or social structures between the participating organisations and individuals were not taken into account during the process. Neither was the need to establish interactions between the actors involved.

The lack of commitment from suppliers has been unfortunate for the project progress. It is one thing to say they comply with a standard and another to have a tested solution. But both the hospitals and primary care facilities will have opportunity to send and receive electronic messages when the physical secure infrastructure is in place.

The strategy derived from the process addresses the scepticism and resistance to change:

- Mobilization: In the spring, summer and autumn of 2009, the plan was to diffuse the message exchange to further municipalities. This required mobilization and coordination of efforts from all participants. Open information meetings were arranged in January. Health centres were closely followed up during deployment
- Top-down: One motivation for an initiative must come from above - national regulations and priorities must be followed by funding to provide a holistic development. The national initiative (HOD,
2008) for increased use of electronic messaging is an example of such an initiative, but the allocation of resources was divided between health trusts and municipalities. According to the end users this was inefficient because each recipient had to do their own negotiations with the same suppliers.

- **Bottom-up:** Primary health service and municipalities must be motivated to participate and to be involved in the process. At a management level there must be a commitment for the transition to take place and achieve its aims. At employee level motivation is greatly shaped by information, involvement and adequate and appropriate training.

- **Anchoring:** In addition to the bottom-up perspective it is essential to define common goals. It is not sufficient that individuals or ICT departments engage in the process alone. Involvement from all employees, doctors and assistants involved in the transition must be ensured. It is important that the solution becomes a service between health centres and the hospitals, and that underlying protocols and standards are hidden from the medical professionals. Priority must be given to procedures and practices and must be developed in conjunction. Health centres, dependent on the municipalities, need greater support.

In a sparsely populated and geographically extensive county like Sogn & Fjordane, the anchoring at regional level has also been important. To solve common problems related to information technology the region has a designated task force called IT-forum. Its e-Health workgroup, who were the steering group for the project, is made up of IT and medical professionals from the health trust, the municipalities, research centres and the regional public sector. These work both formally and through an informal social structure. This group has concentrated on the diffusion of health care related technology in the region, paying particular attention to the exchange of information between different organisations and organisational levels.

- **Training:** The health centres are busy day to day operations. It is often only one person in the medical office who receives training to ensure the quality of the interaction. This is inadequate. Technical training in the operation of the system (communication) and for medics (system level) must be separated.

- **Quality assurance systems and procedures:** All Health centres are required to have a quality assurance system, but the introduction of electronic message exchange requires an even stronger attention to this quality assurance system (HOD, 2011).

### 6. CONCLUSION

The project has, in at least two respects, been regarded as best in class nationally; a new secure infrastructure service became available enabling integration of secure messaging in the municipalities shared infrastructure. And a set of quality procedures which, sets the basis for implementation of electronic messages between health trusts and health centres. The pilot implementation has been completed, and deployed to an additional ten health centres. However due to technical problems that have not been prioritised, progress in the region has halted. The process has showed that the electronic messaging systems are very fragile and easily prone to faults; changes in one component affect other applications, in a domino effect.

Both national and local level organisations have learned from the process. Engagement from the actors is important, but there is a need for coordination between the numerous actors involved. The process show how a number of actors can influence and delay projects. Further it is our experience that the standards have been too weakly defined and therefore allowed a large degree of freedom when implemented into the software components. This caused problems when changes made in one module influence the operation of another module rather than seeing it in a total system perspective.

The initial aims of the project were optimistic and technologically focused. The process was envisaged as an easy roll out of new technology without any consideration of the other components influencing the process. This proved to be unfeasible and a new more considerate strategy was developed taking into account the number of stakeholders.

It is important to solve technical problems and have the solutions in place according to the agreed standards. The end user should not be overly involved in solving technical issues but should prioritise internal routines and practices, to ensure that they are in line with national codes of practice. Experience from the project shows that the health centres need support in order to achieve this.

Motivation for the process must come from both "top-down" and "bottom-up" strategies. There also needs to be mechanisms in place that ensure motivation across organisations and supply chains. Resources and people needed to be allocated in a coordinated effort to achieve technical breakthrough and new procedures...
needed to be developed. The most important factor influencing the success of such a project comes down to how different actors are engaged and encouraged to coordinate their work and to put in place stronger national coordination and routines for introducing new software. National strategies, such as Te@mwork 2007 (HOD, 2007) have tried to ensure the flow of information, but this project's experience is that greater formal coordination is needed to ensure timely development and implementation.

REFERENCES


DETECTING GAIT DISTURBANCE WITH ANGULAR VELOCITY OF BOTH ANKLES

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ABSTRACT

The detection of health problems from daily activities is difficult because its symptoms are very slight and everyone has his own characteristics in his actions. This paper presents a method to detect slight gait disturbance of users. It investigates balance and decline of walking, consulting the normal distribution of healthy gaits. An experiment reveals the method is superior to a commonly used method in the detection of gait disturbance, which varies with each user. The method enables proactive prevention of accidents caused by decline of the elderly and fatigue of workers.

KEYWORDS

Gait, walking balance, decline, symptom detection, normal distribution, body sensor network.

1. INTRODUCTION

If we can measure how the elderly are declined in their daily life, we can identify the elderly who need supports from others. We can concentrate our limited social and medical resources to support them. We can reduce cost, keeping high quality of social services. If we can detect workers who try to accomplish their jobs in spite of fatigue, we can avoid misfortune of their family caused by sudden accidents such as troubles in brain blood vessels. The body sensor network (BSN) (Varshnev 2007) tries to solve the problem, but solutions have been hard to be found because people are not aware of getting declined or tired. The elderly believe their stability. Workers try to continue working, proud of their duties. Personal characteristics of body movement gathered from user activities make the problem harder to be solved. We must detect symptoms of decline and fatigue in early stages, in spite of wide variety of personal characteristics.

The architecture of BSN has been studied to gather real-time data for a long time. Some works have reported specific data items sensed from a body contribute to medical treatment for patients. Valtazanos and \textit{et al.} has reported that the movement of human joints measured with wireless sensor works better than model based analysis for diagnosis of elderly patients recovering from a fall (Valtazanos 2010). However, these works do not address the detection of symptoms of decline and fatigue in early stages. They cannot accommodate characteristics which change depending on each person.

In this paper, we propose a method to detect decline of the elderly and fatigue of workers in early stages. The method contributes to prevent potential serious accidents from occurring. The method pays attention to gaits of target users. People usually disturb their gaits slightly without any consciousness, when they are declined or tired. The goal of the method is to detect the slight gait disturbance in their daily life or their usual working activities. To achieve the goal, the method assumes a target user wears a small angular velocity meter on each of their ankles. When the user walks as usual, the meters record the movement of the foot. The movement records are analyzed, consulting the normal distribution of the healthy gaits. An experiment has revealed the method can detect slight gait disturbance even users themselves are unaware of. The method is also proven to be effective to find abnormality from gaits which varies with each individual. The proposed method brings a solution to detect symptoms of decline and fatigue in early stages.
2. WHAT WALKING IMPLIES?

2.1 Barometer of Health

Walking is a common activity in almost all kinds of people. More or less, they walk in every activity of their daily life. Each of them takes a specific gait, a manner of moving the foot. The mechanism of human gait involves synchronization of the skeletal, neurological and muscular systems of the human body. Disorders of the systems of persons necessarily appear as their unusual gaits. Disturbance of gaits implies a health problem or fatigue of the person, even though he is not aware of it.

Gait disorder is one of main criteria to diagnose and assess the progress of a disease or rehabilitation. In actual medical works, BBS and TUG are common method to assess the walking ability of a person. BBS (Berg 1989) assess the balance of the human body from 14 check times associated with daily activities. It needs a medical doctor to check the items for a person. TUG (Podsiadlo 1991) measures the time needed to walk a predetermined route. The joint team of University of Ulster and University of Bath has analyzed human gait with accelerometers to assess the patient status of a specific disease (Yang 2010). These works assume actions users conduct intentionally. Meanwhile, our goal is to detect symptoms in early stages of elderly decline or job processes of workers getting tired. We cannot assume users would conduct specific actions for the detection. It is necessary to detect them in daily activities of users. The detection also requires the identification of slight disturbance even users themselves are unaware, because the symptoms generally appear as small difference from usual movement. The methods assuming users conduct specific intentional actions cannot be applied to the detection of decline and fatigue in early stages.

2.2 Body Sensor Network

We must measure the decline of the elderly from their daily life activities as well as detect fatigue in usual working activities. It is necessary to provide small and light sensors which neither impose extra loads on the elderly nor interfere with actions of workers to accomplish their jobs. Sensors should work for a long time to gather data while users behave as usual. Data sensed from one part of a body are not sufficient to detect symptoms for abnormality in many cases. Usually, we should integrate many kinds of data sensed from various parts of a body. The sensors should be equipped with a wireless communication function to transmit sensed data to a computer which integrates data from various parts in the analysis (Garg 2010). To satisfy these requirements, there are many studies on architectures of the body sensor network (Varshnev 2007).

However, these studies have not clarified the association of decline or fatigue with a specific data item sensed from a body. Another item to be considered is individual characteristics. This paper investigates user gaits to prevent potential serious accident. However, we should be aware everyone has his own gait. The above methods have left the accommodation of individual characteristics to each application. The issue is not simple, because we must distinguish an abnormal status from normal ones for each user.

3. WALKING ABILITY ASSESSMENT FROM ANGULAR VELOCITY

3.1 Assessment in Daily Life

The proposed method gathers gait data from target users, aiming at prevention of the elderly from running into dangerous situations, or at detection of unaware fatigue of workers engaging in long jobs. Though users may take many kinds of behaviors, we assume walking can be recognized with some methods such as SATIRE (Ganti 2006) or the one proposed by Iso (Iso 2006). Either in watching the elderly or detecting fatigue of workers, we should gather gait data from target users in their daily activities, without pushing any heavy loads on their body and mind. Figure 1 shows the overview of our method. As the figure shows, users have to wear only a small angular velocity meter on the ankle of each of their feet. The meter shapes a square of 38mm and weighs 17 gram, which is small enough to bring no extra load on users. The meter takes 3-
dimension angular velocity, and transmits its readings to a server computer with Bluetooth. The readings indicate the swing of a user foot. When the walking ability of the user declines, unusual movements would appear in user gait. We detect unusual movement from the angular velocity data gathered from each of user feet.

![Angular Velocity Meter](image)

**Figure 1. Overview of method**

Our method aims to detect unusual gaits in an early stage. The detection in the early stage of the decline of the elderly or the worker process of being tired would enable us to prevent users from running into a serious situation. Users wear the meters on their feet in daily life. Our method will take angular velocity data in stable walking states, which are identified with the regularity of the wave of user foot swings. The data gathered in daily life contribute to finding symptoms of the decline or the fatigue. We will analyze angular velocity logs from two aspects; the difference between the two feet for the waling balance of the user, and the difference of the current data from past for the decline. Note that the wave of the right foot swing differs from that of the left foot swing in the phase, though the shape of them is almost same. Our method shift the phase of the foot swing wave to compare the movement of the left foot and the right foot. Given two waves, the phase of one wave is shifted so that it might be identical to that of the other. The Pearson correlation coefficient is calculated for sampled data on each wave, to investigate the similarity of the shape of the waves.

### 3.2 Phase Shift to Compare Angular Velocity

If given two waves have a same shape, the shift of their phase makes peaks of each wave located in the same point. The shift enables us to distinguish the difference of the two waves. For the phase shift, we should calculate the difference of the two waves. As the figure 3.4 illustrates, we derive the difference as follows,

1. We identify the frequency element which has the largest amplitude in each wave with Fourier transform. It is referred as to the prime element, which corresponds to the simplest approximation of the original wave.

2. For the two original waves, we calculate the phase difference of their prime elements from the cosine wave. Without losing generality, each prime element can be represented with complex number $a + bi$. We can derive the phase difference of an prime element from the cosine wave with expression,

$$
\angle F(\omega) = \arctan \frac{\text{Im} F(\omega)}{\text{Re} F(\omega)}
$$

where $\text{Im} F(\omega)$ and $\text{Re} F(\omega)$ are the image part and the real part of the complex, respectively.

3. We calculate the difference of the phase of the given two waves, taking the cosine wave as a base. The phase of one wave is shift by the difference.
If any problem happens to a user, some effects relating to it often appears the gait of the user. But, at the same time, since those effects are very slight, two waves from the left and the right foot, or two waves in the past and the current resembles with each other. From our experience, it has turned out that the phase shift with the prime element usually succeeds in synchronizing large peaks and bottoms, while small differences of the two waves get vivid. It works well to differentiate the two waves. The figure 3.2 shows the graphs of the angular velocity from the left and the right foot. The upper two graphs correspond to a gait when a user walks in a normal state. The lower ones show a gait when the user walks with a 2 kg weight in his left foot. The wave graphs without phase shift are located in the left side, while the shift ones are located in the right side of the figure 2. As these graphs indicate, the phase shift is very effective to make the difference of the two gaits vivid.

3.3 Balance Assessment

The balance in walking is regarded as a good index of the walking ability. The proposed method pays attention to the difference between the left foot movement and the right foot movement. We measure the angular velocity from the both ankles. There is little difference in the angular velocity in normal gaits, while specific difference appears when users feel something strange in one side. The method judges the balance in walking according to the following procedure.

1. The method picks up a specific cycle of the left foot movement. It also takes one cycle of the right foot movement which follows the former. In these cycles, one foot is up, while the other is on the ground, i.e., the peak of the right foot movement is almost a half cycle behind the left foot movement. The angular velocity from the right foot is converted with the phase shift so that the first peak of its prime element would coincident with that of the left foot angular velocity.

2. As it is shown in figure 3, at every sample point from a peak to its next peak of the angular velocity from the left foot, the method calculates the Pearson correlation coefficient between the angular velocity from the left foot and that from the right foot. The higher the calculated value, the fewer problems the user has.

3. The method judges whether the balance is normal according to specific criteria, which are explained in the later section.
3.4 Decline Assessment

When the elderly get weak or workers get tired, they feel more difficulties in walking than active time. Some users show their decline in one foot movement of their gaits, and others in whole gaits. To detect the decline, the proposed method compares the current gait with that in the past as follows.

1. The phase shift operation is applied to make the current movement of one foot coincident with the past movement of the same foot. The Pearson correlation coefficient is calculated from the two waves. The calculated value is high, if there is no problem in the current movement. On the contrary, a low value would be calculated for declining users. The same operation is taken on the movement of the other foot.
2. The method derives the average of the two Pearson correlation coefficient values, so that we can detect decline in either of one side gaits or the whole gaits.
3. The method detects decline based on specific criteria, which are explained in the succeeding section.

3.5 Criteria for Judge

Since everyone has his own characteristics in gaits, it is almost impossible to make general criteria which can detect abnormal gaits of anyone. Criteria should be set individually.

The proposed method aims to find a health problem in an early stage. It assumes to be introduced from the time in which a user is healthy enough. Suppose we record many gaits in healthy conditions. The method uses the records to judge whether a user may have health problems. When a user is healthy enough, he would take almost same gaits. The Pearson correlation coefficient of two waves in healthy states is assumed to follow a normal distribution. When we assess the balance, the two waves indicate the movement of the left foot and the right foot in the same gait. In case of the decline assessment, the two waves are sampled from a specific side foot in different gaits.

Once we derive the mean $\mu$ and the standard deviation $\sigma$ in a normal distribution of the Pearson correlation coefficient, we apply the 3-sigma rule to fix criteria to assess the current gait compared with healthy ones from view point of the balance and the decline. Suppose $x$ be the Pearson correlation coefficient calculated using the current gait. The nearer $x$ is to $\mu$, the higher the probability for the normality of the current gait. If $x$ stays in the confidence interval $[\mu - \sigma, \mu + \sigma]$, we can say the current gait is normal with the probability of 68%. The probability that the current gait is normal is less than 5% if $x$ is out of the confidence interval $[\mu - 2\sigma, \mu + 2\sigma]$. Users who have $x$ in $[\mu - \sigma, \mu + \sigma]$ is assumed to be healthy, while we regard users should have health problems if $x$ stays out of $[\mu - 2\sigma, \mu + 2\sigma]$. The remaining users are suspected to have problems.
To assess the balance, we have derived the Pearson correlation coefficient between the left foot movement and the right foot movement from a gait. Many gaits in healthy states enable us to get the mean and the standard deviation which represent the characteristics in healthy states. For the given current gait, we also calculate the Pearson correlation coefficient in the same manner. The identification of the confidence interval of the calculated value enables us to judge the normality of the given gait.

For the decline assessment, our method first makes a combination of waves representing the movement of a specific side foot in two different healthy gaits. It calculates the Pearson correlation coefficient between the combination. The Pearson correlation coefficient for the other side foot is obtained in the same way. As a representative value of the two Pearson correlation coefficient values, we use the mean of them. Our method repeats to produce representative values from many combinations of healthy gaits to attain the mean and the standard deviation of them. These are obtained, assuming the normal distribution of the healthy gaits. When a new gait is given, the method selects one healthy gait at random. For each side of feet, it calculates the Pearson correlation coefficient between a combination of the given gait and the healthy gait. The mean value for both side feet is the representative value of Pearson correlation coefficient for the combination. For any combinations of the given gait and a healthy gait, the same calculation is taken to get the mean of the calculation results. Using the mean calculated from all of the combinations, its confidence interval is identified, consulting the normal distribution of the healthy gaits. The identified confidence interval enables us to judge the decline in the given gait.

4. EXPERIMENTAL RESULTS

4.1 Outline of Experiment

We compare our method with TUG from viewpoint of the detection precision, because TUG is one of commonly used methods to detect abnormal gaits in actual medical works. TUG uses the walking speed of an examinee to judge his walking ability.

In the experiment, 10 examinees, who are healthy male twenties, stand up from a chair on a specific signal, take round walks to a point 3m away from the chair, and sit on the chair again. We have measured the round walking time, that is, the time from the signal issue to the sitting-down on the chair. In the experiment, all examinee wear angular velocity meters on their both ankles to record the foot movement. Examinees take the above round walking in 4 cases; they wear no weight on both feet, a 2kg weight on one foot, a 4kg weight on one foot, and a 2kg weight on each foot. Each examinee takes 10 trials for each case.

The Pearson correlation coefficient is calculated from angular velocity records, according to the procedure explained in section 3. From data sampled in the case where examinees wear no weight, we have calculated the mean and the standard deviation of the Pearson correlation coefficient. For the balance assessment, we check the correlation between the both feet, while all combinations of 10 trials, i.e., \( \binom{10}{2} \) trial pairs are used to calculate the mean and the standard deviation for the decline assessment. On the other hand, we calculate the mean and the standard deviation of the round walking time for TUG. Based on the 3-sigma rule, we have judged suspicious cases and warning cases for both of TUG and our method.
4.2 Result and Its Implication

Figure 6 illustrates the result of the experiment. We have tried to detect all trials where examinees wear weights. Since 10 examinees take 10 trials for each of 3 cases where they wear any weight, we calculate the mean of detection ratio for all examinees and its dispersion. Each bar in the figure shows the average ratio of the detected ones to all in a case labeled below. We have calculated the mean, $\mu$, and the standard deviation, $\sigma$, for TUG and our method as explained in section 4.1. In each trial, we have obtained the round walking time and the Pearson correlation coefficient for TUG and our method, respectively. The left graph compares TUG and our method, assuming the judge criterion that the value obtained in a trial stays out of $[\mu - \sigma, \mu + \sigma]$, which means the examinee is suspicious or should be given a warning. On the other hand, the right graph shows the difference of these two methods, assuming the judge criterion that the obtained value is not included in $[\mu - 2\sigma, \mu + 2\sigma]$, which means we should warn the examinee. The range attached to the top of every bar in the graphs indicates the dispersion of the detection ratio.

In every case, the proposed method is superior to TUG in the detection ratio. The experiment result reveals that our method has higher recall ratio than TUG for the detection of abnormal gaits. In addition to that, the dispersion of our method is much smaller than that of TUG. Though everyone has his own gaits, our method has been proven to be robust enough for the individuality of gaits. Both of the methods show the poor detection ratio in the right graph, compared with the left one. Since all examinee are healthy young males, they can walk smoothly to some extent, even if they wear weights. It is considered to decrease the detection ratio. Especially, when an examinee wears a light weight on one foot or a same weight in each foot, he might keep the walking speed, but slightly lose his usual walking rhythm unconsciously. Our method can detect unusual gaits better because of the slight and unconscious rhythm disturbance.
5. CONCLUSION

The detection of health problem in early stages prevents serious accidents from destroy our happy life. The early symptom of decline and fatigue would appear in walking ways of people. To find abnormal symptoms in early stages, this paper presents a method to detect the slight gait disturbance of users. From the view point of the balance and the decline, the current gait of a user is analyzed, consulting the normal distribution of his healthy gaits. An experiment has revealed the method is superior to a commonly used method in the ability to detect slight gait disturbance, even if characteristics of gaits depend on each user.

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Short Papers
VIRTUAL REALITY AS A COMPLIMENTARY THERAPY FOR PAIN MANAGEMENT

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ABSTRACT

Treatment of any type of disease depends mainly on patient’s psychology as well as conventional therapy. In term of pain, it is usually related strongly with patient’s psychology and need for conscious attention. Earlier literature reported that patients can control their symptoms and pain related disease if they can make their thought away from their disease. Virtual Reality (VR) is a well-known technique used to distract patients' thoughts away and boost his or her self-esteem and confidence. This result in tremendous improvement in patient’s mind, and inner feeling; which clinically improves the immune system. Virtual Reality is considered as a complementary psychological therapy used in conjunction with conventional therapy. This kind of therapy creates a computer-based virtual world for patients to cope with their diseases and experience better life. Many VR environments were developed and tested such as Snow World and Spider World to help patient manage their pain and fear. This paper discusses the effect of virtual reality as one of the complementary therapies which distracts patient’s attention away from their pain. advantages and Challenges are also presented.

KEYWORDS

Virtual reality, pain management, complementary therapy.

1. INTRODUCTION

According to Rampton, et al (2006), the term complementary therapy refers to the practices, systematic and comprehensive concepts of health and disease, diagnostic and therapeutic procedures, in medical treatment, which differ from the conventional treatments. A complementary therapy is used in conjunction with traditional therapies for different goals. It includes Yoga, Massage therapy, Herbal remedies, Naturopathic medicine, and many others. As reported by Jane Hart (2008), Complementary therapies could be excellent for pain management. Also C. Hoffman (2007), concludes that complementary therapy has an effective impact on reducing the distress of symptoms and side-effects associated with breast cancer and its treatments, as well as the psycho-emotional aspects of coping with this traumatic experience.

Hoffman (2004) views Virtual Reality as a therapy to be complementary psychological intervention when used in conjunction with conventional therapy. This kind of therapy creates a virtual world for patients to cope with their disease by immersing themselves in this computer generated world.

During the past years, many researches and studies was conducted to prove the positive impact of virtual reality on different type of patients such as Peretz B et al (2000), and Schneider, Susan et al, (2007), and Gregg, Lynsey et al (2007) such as relieving stress, depression, and anxiety symptoms for breast cancer patients, thus, helping them to cope with chemotherapy. Indeed, a number of clinics (such as Vision Counselling) are already established using this technique for panic attacks, quit smoking, weight loss, pain management, and performance anxiety.

VR is considered one of the promising methods as a complementary therapy. This technique is used to employ the power of the mind. In other words, VR therapy refers to the use of imagination to gain a positive influence.

In the field of medical complementary treatment, VR is considered to be one of the best technologies for distraction used by psychologists, according to Hoffman (2004). It could be used before, during or after the
traditional therapy, according to patient's situation and diseases, for pain management. Hoffman (2004) used VR to control pain, thereby, improve patient quality of life. VR in the medical area focuses on:

1. Effectiveness in controlling pain.
2. Positive influence in the outcome of surgery.
3. Helping patients to cope with difficult therapies (e.g. chemotherapy).

2. PERFORMANCE CRITERIA AND RESULTS

VR performance evaluation is obtained by measuring level of pain for patients after each VR session which is called a "Measure of Assessing Pain", this is a global measure of ten degrees which help patient care provider assesses pain according to different patients. The scale starts at 0 (no pain) to 10 (pain in the worst case) for patient self assessment, as reported by Yudcovitch. Face and behavioral scales can be used to express patient's pain as shown in Figure 1.

![Pain Rating Scale](figure1.png)

Figure 1. Pain Assessment Scale (Yudcovitch)

Stimuli on healthy volunteers. The results of functional magnetic resonance imaging showed large increases in activity in several regions of the brain that are known to be involved in the perception of pain, but, when the volunteers were involved in a virtual-reality environment during the stimuli, the pain-related activity drawn.

The results of virtual reality pain distraction have been unusually strong and consistent results, and the results obtained by Hoffman with his team at HTLAB have been independently replicated by burn centers in other countries. The used of high quality VR system and software, would show much stronger VR analgesia was reported by Hoffman (2004). For example, in one laboratory study conducted by Hoffman, 1 out of 3 participants showed clinically meaningful reductions in pain during VR. That’s fairly impressive. But, in that same double blind study, 2 out of 3 subjects randomly assigned to receive a wide field of view VR helmet showed clinically meaningful reductions in pain as shown in Figure 2 from Hoffman (2004). That’s a massive improvement in VR analgesia, just by using good VR system. A cheap helmet cost only 2K and the high technology helmets now cost about $35,000 U.S. dollars. But such high prices should come down during the next five years or so. Hoffman (2011), believes that the cost of a good VR helmet will probably drop to 15K within the next five years.
a). No Virtual Reality system is applied.

b). Virtual Reality session is applied, with a significant reduction in Pain signals

Figure 2. Pain Related Brain Activity

Usually, breast cancer patients spend many hours in clinic treatment, while receiving chemotherapy, which leads to weariness and sometimes depression. It has been observed that the use of virtual reality greatly helps in reducing and speed up the time as reported by Schneider et al (2007) and shown in Figure 3.

Figure 3. Perception of Time (in minuets) While Using VR

3. CHARACTERISTICS OF IMMERSIVE VR

VR technology has a number of positive characteristic according to Beier (2000), which can be summarized as follow:

1. The ability of VR’S HMD to view the environment as a natural or real environment. It allows the user to look around, walk around, and even fly in the virtual environment.
2. The powerful rendering of objects enhances the perception of depth and the sense of space.
3. The virtual environment relates to the people size properly and provides realistic interaction through the use of gloves and other devices which allow to control, operate, and manipulate it.
4. The auditory, haptic, and other non-visual technologies could enhance the full immersion in the virtual world.

All of these properties enhance the effectiveness of VR as a distraction technique; hence increase its power in alleviating pain.
4. CHALLENGES

As stated by Hoffman (2011), the challenges for VR pain distraction that faced them during their work are availability, cost and ruggedness of virtual reality goggles. The VR Head Mounted Device (HMD) that is most effective for pain distraction. HMDs are currently 90 degree diagonal field of view (big eyepieces that stimulate a lot of peripheral vision to help maximize the illusion of going inside the computer-generated world). Such high technology VR HMD tend to be very expensive, and at least with Rockwell Collins HMD, the miniature displays in the HMD often break, which is expensive to fix and takes a long time to repair. High quality HMD came recently on the market, which has proven its ruggedness.

Many burn patients found it uncomfortable to wear a VR HMD on their head, and this was especially true for patients with severe burns on their head or face. Furthermore, even if patients don’t have serious burns on their head or face, the conventional high technology VR HMD tends to weigh nearly 2 lbs. So, just the weight itself can become uncomfortable. For sterility reasons, keeping the helmet scrapped in disposable plastic, were also time consuming. This need prompted the design and implementation of a goggle holder that is more comfortable for burn patients. The robot-like arm holds the goggles near the patients' head, so they don’t have to wear the VR helmet on their injured heads. That was an important breakthrough that has made virtual reality goggles easier to use.

Another Challenge, as stated by Hoffman (2011); is that many burn patients receive their painful medical procedures while sitting soaking in a bathtub, and/or while having water sprayed onto them. This water makes it dangerous to wear a conventional VR HMD, so caregiver must avoid using VR during wound care in the scrub tank. Hoffman has designed and built a special VR HMD that uses light, no electricity, so patients could wear the helmet while sitting in a bathtub of water.

There are a number of challenges related technical rezones. Modeling of the 3D objects, defining their behavior and interaction manner, defining object texture and other properties such as degree of reflectance, shininess, and connect all of these with the environment. These processes are time consuming, and make VR systems an expensive alternative, as reported by Derksen.

5. CONCLUSION

In the past few years, the number of studies and research, dealing with psychological and social problems faced by patients and their need of psychotherapy, has increased. Psychotherapy has several methods, which varying depending on the results of their effectiveness, impact, and how the patient accepts it. It has been found that the distraction technique was one of the best psychotherapy methods, while it has the ability to attract patient’s attention convenient activities. Imagery therapy is a kind of distraction technique, which can relieve physical symptoms such as pain, fatigue, and distress, as well as psychological symptoms such as uncomfortable feelings.

Virtual reality considered to be one of the successful imagery as well as complementary methods that helps patients to cope with their pain, it’s defined as a way to immersed mind and body into a computer-generated environment in a naturalistic fashion. Virtual reality is interactive, and it engages several senses simultaneously, as viewed by Vince(2004). These characteristics made virtual reality to be one of the best distraction techniques comparing with other complementary therapy such as humor and relaxation therapy. Pain requires attention VR attracts the attention away from a pain and leaves less attention available to process pain.

According to Derksen, VR in the medical field suffers from various drawback including technical limitations. Virtual world development is complicated and expensive process. Also, in term of usage, there are some difficulties. Virtual reality may cause some side effects on patients such as , disorientation, dizziness and nausea [2]. Although, numerous case studies have been conducted, but still there is a lack of good quality, long-scale study on the effectiveness of virtual reality as a complementary therapy, according to Simone et al, (2006).
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ABSTRACT
In this study, wireless telemedicine and telemedicine applications involving advanced technologies that are used for respiratory diseases are compared and evaluated. This paper evaluates the key components of the telemedicine applications involving respiration system analysis, providing comparative studies of the technologies and techniques used in such systems, including the structure and usability of sensors used, wireless technologies, and classification techniques used for analyzing vital signs.

KEYWORDS
Medical applications survey, wireless medical applications, wireless networks, Zigbee, Bluetooth, WPAN.

1. INTRODUCTION
Respiration is one of the most important systems for human to survive. The primary function of the respiratory system is to supply the blood with oxygen in order for the blood to deliver oxygen to all the parts of the body. Telemedicine is the usage of various telecommunications by physicians and medical institutes that provide healthcare to their patients, which can be used for real time monitoring across long distances. Amongst the benefits of wireless telemedicine are its accessibility, faster access, less cost, freedom and safety & security.

In this study, we focus on surveying the state of the art in leveraging telemedicine for diagnosis and classification of respiratory related disorders. Such study can be divided into four phases: 1) Collection of data, 2) Transmitting and receiving of data, 3) Classification and interpretation of data, 4) Actions taken

2. OVERVIEW OF THE TELEMEDICINE FRAMEWORK
The four major steps involved to facilitate the exchange of vital signs and useful information amongst the patients and/or caregivers to influence decision making process during patient treatment. In phase one, the collection of raw data from patient’s body is performed. This step is implemented by placing various sensors on the patient’s body and collecting different variables that are required. The variables that are collected can be temperature, blood pressure and oxygen saturation, electrocardiogram (ECG) [9], electroencephalogram (EEG), and acceleration [10] etc. During phase two, the raw data which was collected in phase one, will be transmitted as a wireless signal using various wireless radio technologies. At the receiver side, wireless radio signal will be received by a receiver located near a computer or microcontroller. Because of the resource constraints of the sensors, low energy wireless technologies, most commonly, Bluetooth, or Zigbee [11],[12],[13] can be used for WPSAN to transmit the data from the sensors embedded on the patient’s body to a local gateway or cell phone. Data fusion techniques can be applied to the raw data at the gateway stage to clean data by removing redundancies, to facilitate more efficient communication. The data will then be forwarded by the backbone network, leveraging wireless backbone technologies such as Wi-Fi, WiMAX, or UMTS 3G, and possibly through the internet to central server(s) for storing, and analyzing. In third phase,
raw data that has been received will be fed to the computer or microcontroller for extracting useful information. This step may involve sophisticated signal processing techniques for detection, classification, and evaluation of the given information to indicate the patient’s condition. Lastly in the fourth phase, and to close the loop and provide useful feedback to patients and/or caregivers, the framework supports alert mechanism for reporting patient’s adverse events. This step is triggered by the classification techniques to report adverse patient condition e.g. low respiration rate, alerting heart beat rate, etc. by sending a notification to the relevant party e.g. caregiver, in a form of SMS, call, sound alarm or any kind of notification to the responsible personal informing them about the patient’s health status.

2.1 Wireless Patient Area Sensor Network (WPASN)

WPASN consists of one or more sensors, which are attached to the patient or surrounding the patient to measure important vital signs that can be analyzed to facilitate the detection and classification of relevant patient disorders. The key component of WPASN is the sensor, which is a device that responds to a physical and transmits a resulting impulse through wireless radio to a sink node for data fusion.

2.1.1 Sensor Placement

Sensors can be attached on patient in different ways. The sensor can be placed on the shirt or bracelet which is worn by the patient. In [1] [14], wearable sensors were developed in a form of a bio shirt with different types of sensors embedded into it. Bio shirt increases patients’ independence, and allow them to move freely, which gives patients more confidence in using it. As the sensors are hidden in bio shirt, it makes the patient more adapting and accepting of the bio shirt. Sensors also can be attached on the patient skin directly with tape binding or any attaching external objects that patient can get in contact with for example chair, bed, or sofa. Authors in [2] have presented a monitoring system for non-obtrusive meaning of vital signs as respirator and heart activity. Finally sensors can be implemented inside the patient’s body. This can be done by the surgery, similar to a pace maker or we can even use the biosensor [15]. WPASN can be categorized as uni-sensor or multi-sensor systems. Uni-sensor systems use a single unit (single Sensor) used on the patient’s body with one channel of communication allocated to it. Multi-sensor systems use multiple units (multi sensors), either of the same or different types of sensors, on patient.

2.1.2 Uni-Sensor Systems

An example of uni-sensor systems is discussed in [3]. The idea behind this system is to sense breathing pattern by using a nasal thermistor or thermocouple sensor. Therefore, it is only one type of sensor used, which is a temperature sensor this application can be used for monitoring ploysomnography. The mechanism of this application is thermistor based sensor that detects changes of breath ambient temperature (inhalation), and lung temperature (exhalation). A thermistor placed in front of nostril breathing as temperature changes. Another example for single type sensor respiratory rate monitoring system is discussed inErro! A origem da referência não foi encontrada.. The advantages of uni-sensor systems are following. First, it is easy and inexpensive to implement as it only uses one type of sensor and one channel of communication. Second, analyzing the results is also simple as only one type of variable is calculated, so no need for complex algorithms to handle and correlate data from multiple sensors, and therefore, results are directly fed to the system without synchronization. On the other hand, uni-sensor systems may suffer from noisy environment, which affects the accuracy of classification, increasing of false positives and the reliability of the results.

2.1.3 Multi-Sensor Systems

Authors in [5] discussed a monitoring system built using custom developed hardware, which is composed of multiple sensors of different types connected to one wireless board with a microcontroller. In this case, the synchronization of data from multiple sensors can be easy, utilizing one sampling clock from the microcontroller. The sensors are for heart rate, heart rhythm, regularity, respiratory rate, oxygen saturation and body temperature, in addition to a custom made 3 lead ECG amplifiers. Authors in [5] have developed a sensor node architecture called “Biote”, with a considerable smaller form factor. The node architecture is realized using state of the art sensor and wireless crossbow transceivers [19]. One of the main hardware
features is the timely and efficient use of power. The Biote is built into a wrist module which houses an accelerometer, different bio-potential sensor interface, a microcontroller and an RF communication module. The advantage of using multiple types of sensors is that the accuracy and reliability of results is higher compared to single type, as it uses more than one set of measurements, therefore if one is noisy or inaccurate, the end result will still be reliable. Therefore, fusing measurements from multiple types of sensors may involve sophisticated techniques to handle the synchronization of data and filtering of measurement outliers before transmission over wireless. On the other hands, multi-sensor systems are usually complicated to implement, and therefore more expensive compared to uni-sensor systems.

2.2 Wireless Technologies for WPASNs

Most of the applications mentioned above use different types of wireless protocols. Most common protocols used for WPASNs include Zigbee (IEEE 802.15.4 Standard) and Bluetooth (IEEE 802.15.1) with different variations of each technology for low power and long range (e.g. Bluetooth low power [11] [12] [13]). A WPASN is the interconnection of wireless sensors in the range of an individual person; this is typically either attached or within 10 meters of the person [9]. The basic characteristics of WPASN technologies include [9] [10]: 1) Short range, 2) Low power, 3) Low cost, 4) Flexible network topologies. Bluetooth is one of the protocols used in short-range connectivity; many of its features include low cost, secure, and robust. The technology is designed specifically for ease of use and simultaneous voice, data and multi-point communication. It supports a range of 10 meters, which can be increased up to 100 meters with the use of amplifier. Zigbee is a home-area network designed specifically to handle the proliferation of individual remote controls. Zigbee was created to satisfy the market needs for a cost efficient, standard-based wireless network. Zigbee features include low data rate, low power consumption, high security and reliability [10].

2.3 Major Wireless Technologies for Backbone Networks

The rapid growth of the technologies extends the potential for exploitation of wireless medical application market. Nowadays, large-scale wireless network and mobile computing solutions, such as cellular 3G and beyond, Wi-Fi mesh and WiMAX, have an important role in telemedicine backbone networks, where they deliver the medical information and urgent notifications to the medical personal [20]. Wi-Max, short for "Worldwide Interoperability for Microwave Access," refers to any broadband wireless access network for point to multipoint non line of sight access, with a range of 30miles for 70 Mbps. WiMAX is capable of transmitting network signals covering in excess of 30 miles of linear service area, which is much greater than Wi-Fi's coverage of several thousand square feet. Otherwise known as Wireless Fidelity, Wi-Fi is a system of wirelessly connecting devices that use radio waves, allowing for the connection between devices without needing them to be facing one another. Wi-Fi generally uses S-band (2.4 GHz) and frequency-hopping techniques to connect multiple devices together. Wi-Fi has a range of about 1000 feet outdoors and is mainly intended to be used for LAN in residential homes, for public access hotspots, and in business. 3G is the third generation of wireless technologies. It comes with enhancements over previous wireless technologies, like high-speed transmission, advanced multimedia access and global roaming. 3G is mostly used with mobile phones and handsets as a means to connect the phone to the Internet or other IP networks in order to make voice and video calls, to download and upload data and to surf the net.

2.4 Data Classification

Several classification techniques have been discussed on the literature. They range from simple threshold-based technique to using sophisticated models based on fuzzy logic (FL) [7] and/or support vector machines (SVM) to analyze the condition of the patient or the surrounding environment and take a decision based on that. The data classification can be divided into categories according to the techniques that are used. In next section we will describe some techniques used in classification. Threshold-based techniques are used to compare the sensed raw data against some pre-configured thresholds using context-based rules to represent adverse events upon which, a notification or an action needs to be taken to provide help to the patient. Examples of threshold-based techniques have been discussed in [1] [5] [6]. In [1], the bio-shirt contains a temperature sensor, blood oxygen saturation sensor and two-axis acceleration, where digital data outputs of
sensor are patient body temperature, blood saturation and velocity where data was directly sent to the computer and viewed without any notification or calculation on the monitor screen. Authors in [5] have also used the same type of sensor, temperature and blood saturation. Furthermore [6] uses an accelerometer sensor. Then this type of data is classified by measuring against the threshold values, if values exceed the required point, a notification would appear. In addition to this method, another type of data can be in form of a wave. The wave input can be sound signal, ECG signal, heart rate etc. The wave input can be handled by two methods. The first method is comparison; this is when the patient input wave signal is compared with a normal average person wave. If the wave has any irregularities or is not quite the same as the normal wave, then this is a sign that the patient needs to be altered or notified. The other method of handling wave is by manipulation and performing calculation on different wave component. Model-based techniques leverage sophisticated signal process and machine intelligence to extract information from the raw data to be used for accurately detecting and classifying certain disorder from the sensed raw data. Example is to detect seizure from accelerometer information, or classifying respiration disorder from coordinating data from SPO2, and ECG sensors. In paper [7], the respiration signal will be divided into non-overlapped 10- seconds and each segment will be scored as one of the said categories. Using a sampling frequency of 20Hz, 200 data samples were collected for each segment. Two parameters are calculated for each segment, namely respiration energy (ENGY) and rate (RATE).

2.5 Response and Notification

After the interpretation of the data, the notification phase starts. This is the phase of altering or informing the patient’s condition to the required medical personnel E.g. doctors or nurses. Most of the previous articles used two types of equipment which are the Personal computer (PC) and the Personal digital assistant (PDA), and the reason for this is that both devices have the ability to connect to the net and manage information. Mainly the PC is user for monitoring and history tracking purposes. As the PC has large storage area, and stronger processor, it can use for the above purposes. The PC can use different software to aid it in its tasks for example PC can database software to share patients history as well as other type of graphical software that can be used to also to graphically display patient’s health status. On the other hand PDA also known as palmtop, is used mainly in altering or notifying the patient’s condition to the medical personnel and this is because PDA is small in size and can connect to the internet wireless making it more mobile and it can be preset with doctors all the time.

3. CONCLUSION

In this study, we have compared several different technologies involving wireless respiratory monitoring; furthermore we have evaluated the different types of sensors that can be used as part of detection of respiratory-related disorder. We have concluded that multiple sensors generally provide more accurate and reliable results for detection and classification. However, more complexity is required to coordinate the readings from multiple sensors including synchronization and sophisticated data fusion techniques, which is a key to extract useful readings from multiple sensors to facilitate the detection based on multiple sensors. In addition, we have evaluated the different methods of placements of sensors and the effect of that on both patient convenience and accuracy of the measurements. We have divided these methods into three categories, namely; wearable sensors, external embedded sensors (sensors that are attached outside the patient’s body, for example on skin, chair or bed) and internal embedded sensor (sensors which are implanted inside the patient’s body, for example biosensor). Also, we have surveyed the wireless protocols used in each step as part of the end-to-end framework highlighting the major players for both WPASNs and wireless backbone networks. For WPASN, we have discussed the major features and scenarios for Bluetooth and Zigbee technologies. For wireless backbone networks, we have highlighted the major technologies including WiMAX, Wi-Fi, and 3G/4G technologies. Lastly, we have discussed the taxonomy of the detection and classification techniques used for reparatory related illnesses. One of the main classification techniques used is directly measuring against threshold values to compare results; another is when different algorithms or calculation would be added to the data before measuring it against the threshold values.
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PERCEIVED RISKS OF MOBILE HEALTH SERVICES WITHOUT IMMEDIATE OUTCOME

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ABSTRACT
This paper describes an empirical investigation on the roles of perceived risks in the adoption of mobile services without immediate outcome. A theoretical model including perceived risk of using and perceived risk of not using a mobile health application was developed and tested for the context of using wireless text messaging for smoking cessation. An experimental research conducted with 422 participants in the UK and Canada showed perceived risk of not using was a strong motivator while perceived risk of using is a comparatively weaker obstacle to the adoption of mobile health services.

KEYWORDS
Mobile health, information systems, perceived risk.

1. INTRODUCTION
Mobile health services emerging in various parts of the world are providing health promotion advice for people willing to live a healthier life by exercising more, watching their diet, or quitting smoking. Several types of mobile applications have been proposed for that purpose, one of the most frequent being the popular wireless text messaging on cell phones.

In contrast to other mobile services where only one transaction is enough to reach an objective, just one text message reminder is highly unlikely to make people have a healthier behavior. Therefore it would be interesting to see what are the people perceptions regarding the possible obstacles and opportunities in using mobile services without immediate outcome. Thus, it appears that there are two broad categories of questions that would capture prospective user doubts in these conditions.

This paper is an empirical investigation conducted with 422 participants from the UK and Canada on the influence of risk perceptions on the adoption of a mobile health service. The following two sections describe the theoretical background and the research model. Next, research methodology and main findings are presented. The paper concludes with a discussions section.

2. THEORETICAL BACKGROUND
A literature review in information systems (IS), consumer behavior and healthcare research shows the possible existence of two opposite types of risk perceptions expressed by people with respect to a new product or service. These two categories of risk are discussed next.

In an effort to better understand perceived risk and mitigate its effects, consumer behavior research identified several types of risk such as those coming from unsatisfactory performance, cost, or health hazard of a purchase (Lim, 2003): financial (or economic), performance, social, physical (or health), psychological and time risk. These risk facets determine a perceived overall risk that results as trade-off measure between the primary components (Stone and Grønhaug, 1993).

Perceived risk has been gradually used in IS studies to capture the subjective threats in association with the use of a new ICT application. Facets added to the ‘classical’ dimensions from consumer behaviour include personal risk (e.g., fears of identity theft), privacy risk (e.g., fears of disclosing identity to third parties), or source risk (e.g., apprehension of buying online from unknown businesses) (Featherman and
On the whole, the traditional risk facets coming from consumer behaviour knowledge plus additional dimensions specific to IS form a *Perceived Overall Risk of Using* measure that captures all perceptions on possible negative consequences of a new ICT use. The specific facets that enter the trade-off construct and their weights depend on the ICT and of its use situation.

Newer approach in IS research has been discussing another type of perceived risk that would capture user doubts or questions related to not using an ICT application designed to help them (Cocosila et al., 2009). This would pertain to sensitive domains like e-health where users may face an actual or virtual loss by not using a presumably helpful technology application. For instance, users registered in a health promotion program may have a dilemma about subscribing to a mobile service providing reminders through cell phones about daily physical exercise. Not subscribing to such a service might make them fall behind the health promotion program although the consequences would not appear as immediate. These anxieties can be encompassed through a construct termed as *Perceived Risk of Not Using*. Based on the above reasoning, this study poses the research question: *What are the effects of Perceived Risk of Using and of Perceived Risk of Not Using on user intention to adopt a mobile health application without immediate outcome?*

### 3. RESEARCH MODEL AND HYPOTHESES

To investigate the roles of the two opposite types of perceived risk in the adoption of a mobile health application, a theoretical model was built. This model has the general layout of an information technology adoption model popular in IS literature (Venkatesh et al., 2002).

Risk perceived by consumers is a deterrent of completing a purchase. IS studies showed similarly that perceived risk of using is an obstacle to adopting an ICT application (Featherman and Pavlou, 2003). Accordingly, the following hypothesis is proposed:

**H1:** Perceived Risk of Using is negatively associated with Behavioural Intention to use.

Perceived Risk of Using is considered as a second-order construct having individual risk facets (e.g., financial, psychological, etc.) as first-order constructs. For the context of this research, three perceived risk facets are considered meaningful. Consequently, the following hypotheses are proposed:

**H2-a:** Perceived Financial Risk is positively associated with Perceived Risk of Using.

**H2-b:** Perceived Psychological Risk is positively associated with Perceived Risk of Using.

**H2-c:** Perceived Privacy Risk is positively associated with Perceived Risk of Using.

Theoretical reasoning indicates that Perceived Risk of Not Using would act as a motivator for using an ICT application: if people see some negative consequences of not using a technology designed to help them, they would see a risk by not using that technology. Further, if people perceive a risk in not using the service, this would alleviate their anxieties on using. Consequently, the following hypotheses are proposed:

**H3:** Perceived Risk of Not Using is positively associated with Behavioural Intention to use.

**H4:** Perceived Risk of Not Using is negatively associated with Perceived Risk of Using.

### 4. METHODOLOGY

A cross-sectional online experiment was conducted simultaneously with participants in the UK and Canada. The artifact was the use of text messaging on cell phones to provide support to smokers willing to quit smoking. Such initiatives are gaining popularity worldwide and text messaging is a preferred tool to provide mobile support (Obermayer et al., 2004). This type of support needs time, however, to produce effects.

Participants of the experiment were recruited all across UK and Canada with the help with a surveying company. Potential subjects were required to be 18 years or older, to smoke at least occasionally and to be familiar with wireless text messaging on cell phones. Participants were presented an online scenario on how they could receive support for quitting smoking through text messages on their cell phones, if they chose to quit this habit. For increased realism, sample cell phone messages were presented. After the scenario, participants expressed their perceptions through an online survey measuring the constructs of the research model and demographic characteristics.
5. RESULTS

Six hundred invitations were sent to participants meeting the including conditions: 300 in the UK and 300 in Canada. A number of 170 and 252 valid responses were recorded from the two locations, respectively. These responses are part of a larger experiment conducted in the two sites. An ANOVA analysis of the averages of all items measured indicated no significant differences between the two samples \( F(1;41)=0.23; p\)-value=0.63). Accordingly, it was considered all the responses came from one sample of 422 participants. Demographic analysis indicated 53.1% of the participants were female and the average age was 41.2 years. Participants reported 23.7 years of smoking and 93.5 cigarettes smoked per week, on average. Cell phone experience and text messaging experience averaged at 9.4 years and 5.9 years, respectively. Participants reported sending 57.6 text messages and receiving 46.7 every week, on average.

Data were analyzed with Partial Least Squares (PLS) in SmartPLS (Ringle et al., 2005) as this Structural Equations Modelling method is suitable for exploratory models (Bontis, 2004) with formative indicators. Second-order construct Perceived Risk of Using was measured using a repeated indicators approach. After eliminating 3 of the 17 items of the measurement model due to poor significance levels and item-to-construct loading values, all items had significant $t$-values and loadings above 0.7. As all Average Variance Extracted (AVE), composite reliability and Cronbach’s alpha values for first-order constructs were above 0.5, 0.7 and 0.7, respectively, it was concluded that reliability and convergent validity were appropriate (Bontis, 2004). A matrix of the correlations of first-order constructs having on the diagonal the square root of AVE values was then built. As diagonal elements (with values between 0.84 and 0.97) were larger than the non-diagonal ones (having values between -0.25 and 0.53), discriminant validity was considered appropriate. Since reliability, convergent and discriminant validity tests were satisfactory, the measurement model was considered appropriate. Next step was to analyze path coefficients, their significance and the variance explained levels after running SmartPLS with a bootstrap with 200 re-samples. Figure 1 shows these results.

![Figure 1. Results of structural model evaluation. Significance levels: * = 0.05; ** = 0.01; *** = 0.001](image)

Figure 1 shows that 5 out of 6 hypotheses were supported. All three first-order perceived risk facets have a significant contribution to the second-order Perceived Risk of Using. This latter together with the Perceived Risk of Not Using are significant antecedents of the Behavioural Intention to use the mobile health service. The proposed influence of the risk of not using over the risk of using was not confirmed by the data. Of all the first-order constructs in the model, Perceived Risk of Not Using had by far the largest total effect (0.533 significant at the 0.001 level) on the Behavioural Intention. None of the demographic figures collected (age, gender, smoking figures, cell phone and text messaging experience and use, or country) caused significant changes in the structural model.
6. DISCUSSION AND CONCLUSIONS

The objective of this research has been to understand the influence of two opposite types of risk perceptions (of using and of not using) on the intent to adopt a mobile health service without immediate results. The proposed research question was: What are the effects of Perceived Risk of Using and of Perceived Risk of Not Using on user intention to adopt a mobile health application without immediate outcome?

Consistent with previous research in consumer behaviour and IS (Featherman and Pavlou, 2003), it was found that Perceived Risk of Using has a significant negative influence over the Behavioural Intention: if people see risks (no matter whether these are real or not), this becomes an obstacle to adoption. Of the risk facets considered important, psychological and privacy aspects are the most significant. Therefore, to increase the chances of success, developers and promoters of such services should try to mitigate potential user doubts on the justification of the services and the apprehension about disclosing personal data. Concerns about wasting money are highly significant too but comparatively less important.

Perceived Risk of Not Using has a positive and strong influence on the intention to adopt the mobile health service. Therefore, promoters of such services should take into account people concerns about health state deteriorating if not using the ICT. However, risk of not using was not found to alleviate the perception of risk when using the service. Overall, the combined influence of the two risk factors explained 31.2% of the intention to use the mobile service. This appears as a moderately low value, although one should remember that this value refers solely to the influence of perceived risks in an adoption model.

This study involved some limitations, but not more than in similar IS research on ICT adoption. Participants self-selected following the invitation of a surveying company. However, they were recruited across two countries and this added more realism to the research. The experiment was based on a scenario but this is not uncommon in IS studies (Cocosila et al., 2009).

Overall, this study demonstrated that when using mobile ICT for providing health services in lengthy programs with no immediate outcome, Perceived Risk of Using and Perceived Risk of Not Using have opposite effects: the former is an obstacle and the latter an opportunity. As their influence in isolation is non-negligible, they should be included in the more complex models investigating ICT adoption.

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CONTRIBUTION OF AMBIENT INTELLIGENCE TO THE SUBJECTIVE WELLBEING: AN OVERVIEW OF THE ADVANTAGES AND DISADVANTAGES

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ABSTRACT
There is and has been a great deal of research in the field of Ambient Intelligence. However, not many have been conducted in which Ambient Intelligence is described from the viewpoint of construction; thus little is known about the contribution of Ambient Intelligence in regards to the influence on the resident’s subjective well-being through the design of the living environment. Based upon a literature review, this paper gives an overview of the advantages and disadvantages of the applications of Ambient Intelligence in the built environment in relation to the occupant’s subjective well-being, viewed from the health point of being built into the environment. Through this research, the contributions of Ambient Intelligence to the subjective well-being of the residents are determined; thus contributing to the debate about the validity of its applications in Intelligent Homes.

KEYWORDS
Ambient Intelligence, Intelligent Homes, Subjective well-being, Health, Built Environment.

1. INTRODUCTION

Ambient Intelligence (AmI) is put forward as a vision for future generation Intelligent Homes to meet the requirements of the residents [Aarts et al 2009; Garde-Perik, 2009]. It evolved from the paradigm of Ubiquitous Computing at the start of the 90’s of the last century. AmI was first introduced by Eli Zhelka during a Philips Research Workshop in 1998 [Wright et al, 2008]. In line with Zhelka, Weber et al. [2005] describes AmI as: “Ambient intelligence is the vision that technology will become invisible, embedded in our natural surroundings, present whenever we need it, enabled by simple and effortless interactions, attuned to all our senses, adaptive to users and context-sensitive, and autonomous.”[Weber et al, 2005]

Using the definition by Weber et al [2005], five characteristics (Figure 1) of AmI can be composed: AmI is embedded in the surroundings; AmI is aware of its environment; AmI can adapt itself to the requirements of the residents; AmI can be more personalized, because it can adapt itself; AmI can anticipate on the requirements, without the user being consciously aware of changing the system.

According to literature [Aarts et al, 2009; Friedewald et al; 2005, Weber et al, 2005], AmI influences the residents subjective well-being . Diener [2009] states that the definition of Bradburn [1969] is the; which states that the subjective well-being “is a preponderance of positive effect on negative effect.” It emphasizes the presence of pleasant emotional experience.

Current studies of AmI mostly focus on the pros and cons of potential applications of AmI process, [Aarts et al, 2009, Augusto et al, 2010; Araya, 1995; Friedewald et al, 2005] and the adoption process of AmI technology by people [Mohammadi, 2010; Allouch, 2008]. Given this context, AmI is described as ‘embedded in our natural surroundings’, it is remarkable that very little research has been conducted from the view point of design and influence on the living environment. This paper describes this relationship by composing five characteristics of AmI (Figure 1), and gives an overview of the advantages and disadvantages of the application of Ambient Intelligence in the built environment, and creates a theoretical model of the resident’s subjective experiences of such an environment.
2. SUBJECTIVE WELL-BEING

Based upon literature [Frijda, 2005; Allouch, 2008; Mohammadi, 2010], a theoretical model is created that describes the subjective experience as defined by Diener [2009]. In this study the model is used to observe the interaction between residents and Intelligent Living environments as AmI, on determining the subjective well-being of the occupant.

Figure 1. Interaction between inhabitant and intelligent living environment as AmI on determining the subjective well-being of the occupant

In relation to the previously described definition of subjective well-being, it can be argued that subjective well-being can only arise from a positive intention with subsequent positive emotional experiences [Allouch, 2008; Diener, 2009; Frijda, 2005; Mohammadi, 2010]. Frijda [2005] states that the subject observes a situation in his/her own specific way therefore making emotional experiences very subjective which is also determined by their perceived advantages and disadvantages [Mohammadi, 2010; Allouch, 2008]. Mohammadi [2010] adds that the subject’s needs as well as background factors determine the emotional experience.

The judgement of a particular situation, according to Frijda [2005] and Mohammadi [2010], could translate into an internal emotional experience, when a situation is of sufficient importance to the subject to function as stimulation. The assessment of a situation depends equally on multiple valances of the characteristics of a situation and the motivation of the subject.

The relationship between subjective well-being and emotional experience is emphasized by the alleged properties of subjective well-being [Diener, 2009]: i) the extent to which welfare results is subjective, ii) there are positive aspects present, iii) all features in the life of the individual can play a role.

The presence of the above described three properties is confirmed by other studies. The latter property comprises of aspects in which a large amount of research has been already been done and shown shortcomings in. Because of the large numbers of elements, they remain limited; and interrelationships between the factors are often not made [Diener, 2009]. This study focuses on health issues within the built environment in terms of the interaction between humans and Intelligent Living Environments.

3. PROS / CONS OF AMI AND RESIDENT’S HEALTH

The following paragraphs will deal with the advantages as well as the disadvantages of AmI to the resident’s health. The six factors mentioned below are:

Convenience - Ambient Intelligence provides a range of practical benefits of a computer system taking over the common daily activities of human beings [Araya, 1995]. It becomes possible to create self-cleaning/healing materials and maintenance systems, resulting in improvements of the housing quality. Hence this eventuates in the better mental- and physical health of residents [Evans, 2003; Northridge et al., 2003; Matte et al 2000; Sundell, 2004]. A counter argument to this is that the implementations of new domestic technologies does not always lead to a reduction in the amount of household work [Friedewald et al, 2005].

Otherness - Due to the interaction between man and the ‘ubiquitous’ character of AmI, there is potential to profoundly transform our perception of the ‘other’. Technology will fade into the background and become unconsciously used by the residents [Araya, 1995]. Once technology starts to adapt to the resident and
improves the well being of these residents the goal of Ambient Intelligence is achieved. [Aarts et al, 2003]. Araya [1995] on the other hand suggests the ethical argument that the world around us transforms by means of sensing machinery attached to items, thus the ‘thing’ loses some of its ‘otherness’. This applies not only for objects but also for environments [Araya 1995]. This ethical aspect of AmI provides possible advantages because the world around us becomes predictable, causing less mental stress. However, excess predictability and uniqueness, might cause a lack of stimulation which can affect mental health negatively [Evans et al. 1998].

**Personal Control** - It becomes possible for different environmental variables to adjust automatically to the physical condition of the occupant. For example, the environment can adjust the environmental variables during the sleep cycle to optimise sleep conditions and rest, and optimise time spent on sport and physical activities; enabling elderly, sick or disabled people to live independently for longer [Friedewald et al, 2005]. The ability to regulate environmental aspects promotes comfort, which affects mental health in a positive way [Evans 2003]. According to Friedewald [2005], the integration of various functions could distract one from the task. As a consequence a lack of control in such systems can lead to mental health problems [Evans et al 1998; Evans, 2003; Lowry, 1989]. It seems that Intelligent Living Environments can clarify the interaction between the environment and residents by empowering the resident with personal control.

**Social Contact** - Northridge [2003] states that an increase in social interaction improves mental health whereas social isolation affects mental health negatively. Since Information is no longer fixed in time or space, it can be instantly distributed. This increases the possibilities for social contact. AmI can provide interactive and autonomous systems, which can help one to create social contacts and relations which may arise in real time and therefore enrich their social life [Friedewald et al, 2005]. However it must be noted that AmI is only a digital medium, which cannot (yet) be compared to real life social contacts.

**Restorative Elements** – Restorative aspects, as Evans et al. [1998] says, are therapeutic and healing elements which reduce stress and cognitive fatigue. AmI can aid by projecting images of natural elements so as to renew the cognitive energy of the occupant [Evans, 2003]. In contrary it could have a negative effect on residents because of its technological nature.

**Privacy and Security** - In order to realize the above mentioned advantages, systems will need to store personal information. This may cause data security and privacy problems for residents. Literature [e.g. Ackerman, 2004] states that the amount of stored personal data will rise and that people will no longer be able to remain anonymous because of biometric identifications. Punie et al. [2005] describes identity theft, disclosure of personal data, surveillance and risks from implicit user profiling as possible risks.

However, from literature it is not clear what influences privacy violations and the lack of digital security, and the effect cybercrime has on our health. A house’s primarily function is to protect against outside influences and cybercrime is one such outside influence. Evans et al. [1998] declare that security is one of the underlying processes that explain how the built environment affects our health. It therefore seems likely that the lack of security could have a significant negative impact.

## 4. AMBIENT INTELLIGENCE IN THE BUILT ENVIRONMENT

Throughout the development of AmI-like systems, the Built Environment has played a central role as the facilitator of the possible applications. This study presents a project, which shows some of the possible influences AmI can have on the subjective well-being of the residents, illustrating the role of architectural designs in: improving social contact, reducing stress, improving convenience, improving personal control, and making people choose an inconvenience over a convenience.

In this project, funded by the Province of North-Brabant (Dutch Provincial Government), AmI is imbedded in the homes of the elderly. This can be seen in the form of the NetBOX Live (figure 2) which allows for the addition of domotics applications to be added onto the monitoring of the elderly. This device will sort the need for internet connections on priority i.e. an alarm is more important than the streaming of surveillance video. This automization of care services and Smart technology should enable inhabitants, for example the possibility to live independently at home and deal with their health in a comfortable manner and with convenience. Such embedded, environment aware, personalisationable, adaptable, and anticipational intelligence can only make this possibility of a networked tele-care system achievable.
5. RESULTS & DISCUSSION

Literature indicates that the described advantages and disadvantages, and the potential implications on the health of residents, are predominantly associated with the hedonistic experiences of pleasures and pain. This makes it plausible that AmI can function as an ‘emotional’ experience [Frijda, 2005]. The analysis of the pros and cons of AmI and its implications on health shows that the categories of ‘convenience’, ‘otherness’, ‘social contact’ and ‘restorative elements’ have a preponderance of advantages over disadvantages. The category ‘privacy and security’ has a predominance of disadvantages over benefits, while ‘personal control’ can be described as neutral. Some advantages or disadvantages may be deemed more important than others by the subject thus influencing one category or the whole outcome [Allouch; 2008]. The five characteristics of AmI have a large overlap and the various categories have interrelationships between them. The final result has a neutral view due to the likely variations in intensity of AmI.

Although the results largely correspond to those of the pros and cons of the characteristics of the situation, it seems that the health implications are particularly dependent on the intensity of the present stimuli from the built environment [Bergmann et al, 1997; Evans, 2003; Matte et al, 2000]. Research confirms that the intention of the residents to adopt AmI is low due to possible risks towards mental health. Viewed from the health point of the intelligent built environment, this intention has - with the adoption of AmI - no significant improvement in the subjective well-being effect.

It should be noted that the degree that AmI affects the residents’ health cannot be fully determined due to lack of research, which arises from the fact that AmI is still a relatively young vision and the development of its applications are still in their infancy state [Allouch; 2008]. The diversity of potential applications is so large that it does not seem possible to study the influences of all. A second note is that subjective well-being, is valued and perceived differently by everyone. Thus, some advantages or disadvantages can be more important than others for some residents.

Research shows that due to the current financial feasibility and techno centrism a slow integration of AmI is necessary [Aldrich, 2003]. Historically seen, the acceptance of technologies by users is spread over time, underlining the fact that people find only minor changes pleasant in the short term. Important questions must therefore be put to the sustainability and security of AmI. Technological developments in electronics and computer technology are occurring one after another in rapid succession [Augusto, 2010]. But what does this mean for the future?

Professionals who are active in construction need to start thinking about the implementation of AmI in people’s homes. With the rapid pace of developments it is no longer a question of if, but when AmI technologies will be applied in buildings and homes. Other questions are where, when and what exactly in the environment needs to be automated. Such choices must be left to the experts in the field of human behaviour in the built environment. It offers architects and designers the ability to identify the challenges within the living environment and develop Intelligent Living Environments which respond to these challenges. In addition, Araya [1995] states that our perception of a ‘place’ can transform by making information obtained from a specific location accessible anywhere via mobile devices. How does this affect a discipline based on the design of specific places and environments with specific functions? An answer to these questions and the possible consequences that follow are still unknown.

The research brings to light that individual control is an important aspect in the interaction between man and an Intelligent Living Environment. Can choices be changed at the last minute? Is it possible to remain anonymous? How do children respond when they are already playing at fooling the system as an experiment?
The amount of questions might show the great potential of AmI to Intelligent Living Environments as a significant impact on the subjective well-being of the occupant, but also the ‘fear’ of the unknown. Improperly designed or used in Intelligent Living Environments, applications may have the opposite effect and thus reduce the welfare of the resident. As a result of this darker side and the many standing questions regarding AmI it is considered to have a moderately negative to neutral impact on the subjective well-being of the resident when looked at from the health aspect. By conducting further research into AmI as an architectural object in our environment or as our total environment, the concerns may be allayed in regards to the potential of Ambient Intelligence, which is inherent in the vision, as pursuable.

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ICT4DEPRESSION DATABASE MODULE MAKER: DESIGNING A CONTENT MANAGEMENT SYSTEM TO ENABLE THE UBIQUITOUS TREATMENT OF DEPRESSION

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ABSTRACT

The way in which patients are treated for depression has undergone a significant paradigm shift since the advent of e-health and the mobile web. Patients of many socio-economic backgrounds have access to the World Wide Web and smartphone technologies. The pervasive nature of the mobile web enables therapists to adopt new methods for the treatment of depression. The provision of suitably adapted content management systems specifically tailored with ubiquitous treatment in mind is necessary to ensure that the patient receive expert treatment in a real world context. This paper discusses the ICT4Depression Database Module Maker which has been designed specifically to afford the therapist the opportunity to develop their treatments for use by the patient in a mobile and desktop context.

KEYWORDS
Depression; Internet; Mobile Web; Android Smartphone; Content Management System

1. INTRODUCTION

Today, with the pervasive nature of the World Wide Web, the treatment of depression has enabled the transition from a sterile clinical environment to a real-world context. Ubiquitous access to treatment modules in the patients’ home environment ensures that they have instant access to support during times of high stress or in locations that trigger feelings of depression. Furthermore, with ongoing research into the presentation of content on the mobile web it has been possible to develop specifically tailored module content suitable for dissemination via smart technologies. ICT4Depression is an EU funded project (FP7 248778) which aims to develop online and mobile modules for the treatment of depression. To this end, treatment modules that are currently available for web and face-to-face based treatment of depression, are made suitable for use on mobile devices. A further goal of the project is to use various sensors to obtain a better understanding of the patient’s progression and, based on this progression, make suggestions for future treatment. This paper describes the development of a content management system (CMS), “Data Base Module Maker” (DBMM), which enables the therapist to adapt a module previously used in a face-to-face context for use via the web and smart-phone technologies. The paper is structured as follows, Section 2 discusses similar research in the sphere of remote depression intervention, and Section 3 describes the design of the DBMM CMS architecture. In Section 4 a sample interaction with the DBMM CMS is discussed and the subsequent generated module content is presented. Finally, Section 5 presents an evaluation of the application and areas for future research.

2. RELATED WORK

Hicks et al. (Hicks et al, 2004), (McGrath, 2000) undertook a study of the online psychological methods for the treatment of reoccurring pain in adolescents. The patients completed online modules and subsequently answered three to five questions about the information presented. These forms were designed in a similar
manner to those created using the ICT4Depression Database Module Maker. Positive results obtained are encouraging for the ICT4Depression DBMM and its subsequent application. Haack et al. (Haack et al., 2005) conducted a pilot study using an online counselling application. Usability was at the core of the application design process. Just as with the final ICT4Depression application, the experimental group had immediate access to the online counselling intervention. But unlike the ICT4Depression application, it was not developed to be displayed on the mobile device. Therefore, the initial content management system (CMS) did not require the same complexity. In the literature review undertaken by Miller et al. (Miller et al., 2002), e-health sites and private practitioners that provide treatments via an online platform were assessed. The consensus among professional groups and quality experts supported the practice of medicine online in an existing patient-physician relationship. This study showed that physicians currently remain wary of communicating by e-mail with patients and as such a more secure and personable method that is available through the ICT4Depression application would be favoured.

3. ANALYSIS AND DESIGN

In order to design the ICT4Depression Database Module Maker (DBMM) Content Management System (CMS) for the deployment of specifically tailored module content on the World Wide Web and in an Android application, an analysis of the content to be presented and the structure thereof was performed. Of great importance in this analysis was the requirement for presentation of the content both on mobile devices and on personal computers. The DBMM MySQL database (DB) has been normalised to ensure that it is relational in nature. The CMS was developed for use as a web based application storing the content in MySQL 5.1.37 DMBS and hosted on an Apache Tomcat 2.2.13 using PHP 5.2.10 scripting language ensuring that was W3C compliant. Modules are entered into the CMS via the therapist input screen (TIS), which then uses the PHP scripts to store them in the DBMM MySQL DB. Modules are comprised of a series of navigation screens, text-based content pages and patient exercise pages. Once stored in the CMS, the modules are created both for the web browser and for the android application using further PHP scripts. The module content displayed on the mobile phone is more concise and is visible in fig 1, its web based counter-part is more verbose.

4. SOFTWARE PRESENTATION

This section presents a sample therapist interaction with the DBMM and the resulting outputs. The therapist, who is known by the system, logs into the ICT4Depression DBMM and initial welcome screen is displayed.
Here, they are presented with one of four options: Start new module; Edit saved module; Make module; and View module. When the therapist selects the start new module option, they meet with a second screen entitled “Enter Module Title”. In the available text box, they enter the title of the module. When they click on the make new module button, a script is run and a new directory is created in the server where the module content will be stored. The title of the module is stored in the DBMM DB. The third page in the new module section that the therapist completes is entitled “Complete Module Pages”. They enter the title of that page in the title text box and select one of three page types from the type drop down list: text; button; or exercise.

When the therapist selects the text option, a section text area is displayed. The first time the text option is selected, the section is numbered 1 the section value is incremented on subsequent text options being selected. This method facilitates the therapist with the option of separating text content over a number of pages on the mobile application. The module content is typed or pasted from another document into the section text area. There are three actions that may be performed on the module content: add link; add image; and add list. When the therapist selects the button option from the type select box, six buttons and their corresponding title text fields appear. The therapist enters the name that will appear on the generated button and the title of the page that it will link to. When the exercise option is selected the therapist is confronted with a text area where they can type the instructions for how to complete the exercise or activity. When the add question button is depressed, a text area is displayed entitled Question 1. Here, the therapist types their first question. They then select from one of three response types: text; drop down list; and text area. The text input type option will generate a text input field in the generated module, the spinner option will generate a drop down list in the generated module from which the patient can select a response and the text area option will generate a text box that the patient can use to record longer thoughts in the activity area of the module.

Three buttons appear at the bottom of this page entitled: “Add back”; “Add next” and “Add main”. Each of these buttons are clicked in succession. A pop up window appears and the therapist selects the title of the page that its corresponding button will link to when clicked. So, for example, if the therapist clicked on the “Add back” button then the “add back” pop-up window would open. The therapist would type “Introduction” in the page title and click on the “Add link” button. A script would then generate the link that would allow the patient to navigate back to the “Introduction” page when the “Back” button was pressed on the desktop device or the left to right swipe gesture event occurred on the mobile device. The therapist would reiterate this activity for the “add next” and “add back” buttons on the TIS screen. When the therapist is satisfied that they have entered all content relating to that section of the module, they then click on the declaration and submit that page. Upon submit, the subsequently called PHP script disseminates the information and stores it in the corresponding DBMM MySQL DB tables.

Once the content generation script has run, the therapist is directed back to the next page of the DBMM TIS. If they have completed all screens for the module, the therapist selects the “Save and Quit” button and exits the “Start new module” area. They are returned to the initial welcome screen. They can choose to edit the saved module by selecting a module they wish to edit and clicking on the edit saved module. A script is run which presents the therapist with all module content previously entered in earlier sessions. The therapist can choose to edit screens already entered or to add new screens to the module by the same method discussed above. Having completed the entry of the module into the DBMM, the therapist can select it from the make module drop down list on the initial welcome screen and select make module. A PHP script is run which iterates through each of the tables in the DBMM and subsequently generates the html pages for the web application and the android compatible screens for the mobile device. Depending on which type of page is returned, it will either gather content for a button screen, a content screen or a patient input screen. The content will be converted into HTML for the web interface or XML compliant format for the android screens. The associated style sheets will be extracted from the CSS table in the DBMM DB and the information will be written to the files and stored in the web and mobile folders for use by the patient. Once this script has run and the modules have been generated, the therapist will be directed to the initial welcome screen. Here, they can select to view the generated module. A sample of which can be viewed in fig. 2.
5. EVALUATION

In this paper the “Data Base Module Maker” (DBMM) Content Management System (CMS) for the ICT4Depression application was presented. Its utility was in the automatic generation of mobile and desktop modules for use in the treatment of patients with depression. The methods by which the module content was displayed on the mobile and web interfaces were compared. The necessity of the DBMM CMS to automatically generate and adapt web based content for use in a mobile context was highlighted. Due to the necessity to ensure patience adherence, human-computer interaction design metrics such as aesthetic awareness, personalisation of content and the need for reciprocity were considered. The analysis and design of the DBMM CMS architecture was discussed. A detailed sample interaction with the DBMM CMS was displayed and its subsequent generated module content was presented.

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HEALTH CARE FRAMEWORK FOR AFRICAN DEVELOPING NATIONS

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ABSTRACT
The healthcare system in developing nations still has a lot of gaps in it such as the lack of medical professionals, poor or no public health surveillance and improper healthcare records. With the proper use of Information and Communication Technology (ICT) tools, these gaps can be bridged. In this paper we propose an integrated healthcare system composed of three distinct modules that bridge the aforementioned gaps. The three distinct modules are a public health e-surveillance system with the use of mobile devices and the internet, a clinical decision support system and an electronic records database. With the integration of these three modules, the healthcare for developing nations can be greatly improved and the UN Millennium Development Goals 4, 5 and 6 can be met.

KEYWORDS

1. INTRODUCTION
Developing nations are not fully taking advantage of the vast opportunities offered by Information and Communication Technology (ICT) integration into their public healthcare. Winslow (1920) defined Public health as “the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and private, communities and individuals.” Goal 4, 5 and 6 of the UN Millennium Development Goals are to reduce child mortality, improve maternal health and combat HIV/AIDS, malaria and other diseases respectively. According to the Health Metrics Network (2008) in order to hit these goals there should be up to date complete health records, professional medical personnel and sufficient public health surveillance which is greatly lacking in developing nations. With the use of ICT tools to strengthen the public healthcare, these goals can be achieved.

The South African National Tuberculosis Agency (SANTA), a nonprofit organization that carries out tuberculosis surveillance, approached Tshwane University of Technology to develop a surveillance tool for their field workers that will assist in capturing patient related health information in a reliable, efficient and timely fashion. Currently SANTA field workers are using a paper based data capturing tool for this which is inefficient and unreliable. We then proposed a mobile application hosted on a Smartphone to capture and upload the health information to a remote server in real time. However a good data capturing tool is not enough to carry out surveillance. The data captured needs to be analyzed and conveyed as information to authorized personnel for evidence based decision making. For that we added a web based desktop tool.

With further analysis of the millennium development goals and the situation in the developing nation’s rural areas, we realized public health surveillance is not the only public health problem in these areas. There is a lack of professional medical personnel and complete electronic health records; this led us to the development of our integrated healthcare framework. The Health Metrics Network (2008) states that health workers are overburdened by a lot of data needed for analysis from multiple and poorly coordinated subsystems. This led us to designing a single framework with different modules performing separate tasks but communicating and sharing data with each other. The three modules are a clinical decision support system for diagnostic purpose, an electronic health records database system for the storage of patients’ health data and a mobile surveillance system to assist in capturing of patient data while in the field. This framework is still work in progress; the researchers have successfully developed and tested the mobile surveillance...
module and the electronic health records database system. The clinical decision support system is yet to be
developed. The rest of this paper explains the healthcare framework and the different modules that it’s made of.

2. HEALTHCARE FRAMEWORK

WHO defines ehealth as the use of ICT in the health field to treat patients, pursue research, educate students,
track both diseases and patients and monitor public health. Looking at the uses of ehealth and comparing
them to the aforementioned gaps found in developing nation’s healthcare systems such as the lack or medical
professionals and poor surveillance, it can be noted that ehealth systems can be used to bridge these gaps.
Our integrated framework is made up of three modules namely: a clinical decision support system (CDSS),
an electronic health records system and an e-surveillance system. See Figure 1 for framework diagram.

From Figure 1 it can be noted that every module in the framework requires input or gives an input to the
other modules. To have separate systems for each module created by different vendors yet they all need to
communicate with each other is always a problem because in most cases the systems weren’t designed to
communicate and exchange data with each other thus there might be a problem of interoperability of the
systems. Each module is explained in detail in the next subsections.

2.1 Clinical Decision Support System (CDSS)

Wyatt & Spiegelhalter (1991) define a clinical decision support system (CDSS) as “an active knowledge
system which uses two or more items of patient data to generate case specific advice.” These are healthcare
systems designed to assist in clinical decision making and for diagnostic purposes. The four main functions
of these systems as defined by Perreaut and Metzagar (1999) are:
- Administrative functions. They support clinical documentation and authorization of procedures.
- Managing clinical complexity and details such as tracking of patient referrals, tracking of orders,
and preventive care.
Cost Control: monitoring medication orders and avoiding duplicate or unnecessary tests.
Diagnostic Support: they should support clinical diagnosis and treatment plan processes.

According to Berna (2007), there are two main categories of CDSSs that we will incorporate into our CDSS namely: a knowledge based CDSS and a non–knowledge based CDSS.

2.1.1 Knowledge Base Sub Module

A Knowledge based CDSS contains an extensive database with rules that define the advice to be given for each case. The framework proposed in this paper makes use of several approved and published documents currently being used for diagnostics in South African clinics. It uses documents such as the “Standard Treatment Guidelines and Essential Drug List” which can be downloaded from the internet. By adding the information contained in these documents to our systems knowledge database, both professional and non–professional clinicians can diagnose patients with ease.

The knowledge base sub module is made up of several protocols that define each medical problem it is able to diagnose. A protocol in this sense is a set of rules that govern the diagnosis of a patient. Each protocol is built with seven distinct rules as defined by Komaroff et al (1978):

- The protocol needs to be built for a specific problem,
- It should define which type of patient can be managed by that protocol for instance an adult female,
- Identify any related problems that can be managed with the protocol,
- It specifies what information needs to be obtained from the patient, signs and symptoms, what physical examinations need to be done to the patient and what laboratory tests need to be run in order to manage that specific medical problem.
- Since the system is to be used by clinicians, the protocol should indicate what clinical results need referral or consultation with doctors.
- The protocol should include rules that should be used to arrive to a diagnosis.
- Finally the protocol should be able to document each case.

2.1.2 Non-Knowledge Base Sub Module

A non-knowledge base CDSS uses Artificial Intelligence algorithms such as fuzzy logic and neural networks for decision support by learning from past experience and finding patterns in clinical information and procedures.

In our framework we will adapt the Fuzzy Arden Syntax and logic into our non-knowledge base module. The Fuzzy Arden Syntax was first proposed by Tiffe (2003) and is based on the Arden Syntax for Medical Logic Modules (MLM) version 2.5 which is maintained by the Health Level Seven (HL7) organization (Health Level 7, 2008). According to Tiffe (2003) the Arden Syntax is an accepted syntax designed for writing medical rules for clinical decision support systems. The Fuzzy Arden Syntax extends the Arden Syntax in order to process information that is not completely determinate with the help of fuzzy logic (Vetterlein, 2009).

Development of this module is yet to begin once testing of the different artificial intelligence algorithms is done.

2.2 Electronic Health Records

The second module of the framework is the electronic health records module. This module is used for storing patient specific information in order to assist with evidence based decision making. In our design, all patient information is safely stored in an electronic health records database hosted on a remote server that allows access to only authorized personnel.

This module is developed as a web based application that expects input from the clinician and is an interface to the electronic records database that holds all patient information. In this module, you can add, delete and edit patient information, depending on your authorization rights. In addition to that, it also displays the needed summaries, graphs and reports.
2.3 e-Surveillance System

Public health e-surveillance is the electronic collection of public health data for analysis and electronic reporting to those who need to know and can take evidence based action. Agencies like SANTA use surveillance data to monitor and describe specific health events.

The e-surveillance module is made up of a data capturing tool in the form of a mobile device and a desktop web application that is used to process and convey the data captured in a reliable format. Currently there are a few data capturing electronic surveillance tools, to our knowledge, being used in the African developing nations such as:

- **TRACnet used in Rwanda:** TRACnet is a dynamic Information Technology solution for HIV care and treatment that collects, stores, retrieves and disseminates critical patient and drug information in Rwanda. It has been successfully implemented since 2004 in Rwanda and it has close to 400 users in the country (United Nations, 2008).

- **ChildCount+ used in East African States:** ChildCount+ is a free open source software developed by the Millennium Villages that uses short text messages to facilitate and coordinate the activities of the health care workers in the field (Child Count+, 2009).

- **EMIT:** EMIT is a mobile data collection system developed by Cell Life, a non-profit organization in South Africa, that allows field workers to fill forms on their cellphones (Cell Life, 2009).

- **Mobile Researcher:** Mobile Researcher, much like EMIT is a mobile data collection tool developed by Clyral in South Africa. Through a web platform, you can build up a survey and deploy it to your mobile phones (Clyral, 2006).

The four surveillance systems described above are great examples of the use of ICT and mobile computing in health care surveillance. These particular examples listed above do a great job collecting data but do not feedback information to the field healthcare workers, information such as health related advise and alerts, which we believe is a great requirement in Africa due to the lack of medical professionals, funds and the general conservativeness of the African people especially in rural areas.

These examples also lack the ability to follow up referrals. While in the field, the field healthcare workers can refer the patients to a specific clinic. It is a useful thing for these clinics to have a way of following up these referrals acting as a reminder to these patients, thus necessitating a two way link of communication between the clinics and the patients.

Today almost all households, including those in rural areas, have mobile phones; we can use this to our advantage and have a system that sends short text messages to the patients reminding them of upcoming clinical appointments, availability of doctors and just a reminder to take their medicine, etc.

Development of the mobile surveillance module has been completed and tested by the stake holders and it offers the following functionality:
- **Carry out disease surveillance by capturing patient data in the field.**
- **Use of the inbuilt GPS system in the phone to track patient movement and to ensure and verify that the field workers do go out in the field and capture this data.**
- **Camera to capture snap shots which are automatically uploaded to the server.**
- **The camera is also used as a barcode scanner. South African ID books have a barcode of the holders ID number printed in them. The camera is used to scan and read this barcode ID number in order to reduce on human error.**
- **Use of the internal storage / database to store the data in case there is a network failure. The data is temporarily stored in the mobile phones internal database and later uploaded to the electronic health records database once there is network coverage. Once uploaded, this information is deleted from the phones database for confidentiality reasons.**
- **Another crucial functionality we have built into the system is the feedback function. On submitting the various patient data, the feedback function will inform the field worker on how and what to advice the patient for instance “to reduce on his / her sugar intake”.**
- **The mobile system will be able to edit the patients’ personal information.**
3. CONCLUSION

In this paper an integrated healthcare framework for developing nations has been proposed that will assist in the public healthcare of these nations. Our framework builds onto several other systems currently being used in Africa and in the world at large. The Center for Disease Control state that there is a need for the integration of surveillance systems with health care systems. Most of the systems being used at the moment are focused on the surveillance aspect of public health. The system proposed in this paper looks at all aspects of public health and envisages integrating them into one.

A bit of research is still needed for the completion of this project. We have come across several problems while testing the completed modules such as:

- The lack of network coverage in some sections of the rural areas. This was solved by utilizing the internal storage database of the handset if the network is unavailable.
- Field workers and clinicians are computer illiterate.
- High cost of the smartphones used in the field.

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A MULTIDISCIPLINARY E-HEALTH ASSISTANCE PROJECT IN THE BRAZILIAN AMAZON

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ABSTRACT
Brazil is a vast country where those living in remote areas suffer the inequity of poor access to specialist healthcare. Working remotely is considered undesirable due to professional isolation and poor resource availability. Our main objective was to evaluate a multidisciplinary eHealth approach for second opinion delivery in a remote region of the Brazilian Amazon. A multidisciplinary team visited five communities over ten days covering six study areas: gerontology, pharmacy, cardiology, dermatology, odontology and telecommunication engineering. We have demonstrated that eHealth technologies are effective at enabling the exchange of information between experts and remote areas, ultimately supplying a specialist second opinion. The potential for a multidisciplinary approach has been identified.

KEYWORDS
Multidisciplinary; eHealth; telemedicine; Amazon; remote; second opinion.

1. INTRODUCTION
Brazils a country with significant social and health inequalities, is currently undergoing an epidemiologic transition (Habib and Saha, 2010). In recent times there has been a dramatic overhaul of the health system resulting in increased primary care coverage and major progress in public health (Harris and Haines, 2010). However, access to specialist care outside of large urban centers remains poor and it is those living in remote areas that suffer this inequity the most. Specialists often avoid working in such areas due to professional isolation and poor resource availability. As a result, reference hospitals in urban centers have to cope with a large volume of referrals from these areas, leading to congested emergency and ambulatory departments.

Noncommunicable disease (NCD) now represents the majority of the global disease burden and carries serious economic and social implications, particularly in low- and middle-income countries (Alwan and MacLean, 2009). NCDs are responsible for 60% of global deaths (WHO, 2005), 80% of which occur in low- and middle-income countries (WHO, 2008a). Patients living with NCDs benefit from regular evaluation and optimal care requires a multidisciplinary approach, something that is often lacking in remote areas.

Telemedicine’s potential in remote areas has been highlighted previously (Gagnon et al, 2006; Jordanova, 2007), as has the role of technology in facilitating effective chronic disease management (Siminerio, 2010). Few studies exist assessing a multidisciplinary telemedicine initiative. The main objective of this project was to evaluate a multidisciplinary eHealth approach in remote areas without access to expert opinion. Secondary objectives included: a) validation of the software and equipment developed for providing assistance, and b) assessment of the potential of second opinion delivery via telemedicine in locations without experts.

2. METHODS
Ethical approval was granted by the research and ethics committee of PUCRS, Porto Alegre. The receiving site was Rio Preto da Eva, a small municipality located east of Manaus within the state of Amazonas. The delivering site was the Hospital São Lucas/PUCRS, Porto Alegre. Five communities were visited over a
period of ten days and were selected based on – remote location; family physician responsible for all healthcare delivery; either basic, or absence of, healthcare facilities; and low standard of living. A multidisciplinary team consisting of dentists, doctors, nurses, pharmacists, biomedical engineers and various students was created. The project incorporated three main phases: pre-mission, mission and post-mission. The following areas were studied: gerontology, pharmacy, cardiology, dermatology, odontology and telecommunication engineering. Figure 1 summarizes the processes involved.

![Figure 1. A schematic view of the roles of the receiving and delivering sites in the Brazilian Amazon project](image)

**2.1 Pre-mission**

A partnership was established between PUCRS and the Amazon State University. The areas of study and community locations were selected. A multidisciplinary team was generated, incorporating members from both institutions and a variety of professional backgrounds. The tools and technical support were provided by the biomedical engineers. Upon arrival in Amazonas the team received lectures about the local culture. Practical training was provided to ensure familiarity with the equipment and systems being used.

**2.2 Mission**

**2.2.1 Triage and Patient Interview**

All community members aged over 40 were invited to participate. The younger age of 40 was chosen (rather than 65) in order to maximize patient numbers and the impact on health within the communities. An initial assessment was performed and an electronic patient record (EPR) was created on a telemedicine system developed by the Microgravity Center, PUCRS. Everybody was included in the pharmacy evaluation. Information was gathered regarding current medications, medicinal plants and allergies. Patients were then triaged based on relevant systems review, past medical history and family history to one or more of cardiology, dermatology and odontology. A patient interview was conducted regarding specific aspects of the presenting complaint and a relevant physical examination was performed. Information was uploaded to the EPR along with skin/mouth images or an electrocardiogram (ECG), depending on the referred area.

**2.2.2 Image Acquisition**

In order to acquire images of mouth and skin lesions, a Sony digital camera was used with an illuminator developed by the Microgravity Center, PUCRS. A standardized approach was taken for capturing images (Cardoso et al, 2007).

**2.2.3 ECG Acquisition**

A digital ECG machine developed by Micromed Biotecnologia Ltda was used to record the electrical activity of each patient’s heart. The Wincardio telecardiology software developed by Micromed was the platform used for storing each ECG on a notebook computer.
2.2.4 Data Transmission

Data were transmitted via a store-and-forward approach upon internet availability at a speed of 1Mbps. The telemedicine system was programmed to connect to the Microgravity Center’s main server, synchronizing all collected data. Transmissions included Plain Text (via database MySql), images (JPEG) and Digital ECG files (transmitted via File Transfer Protocol). Through using a password protected application on personal computers, the specialists at the delivering site were able to gain access to the EPRs via this server.

2.3 Post-mission

Specialist healthcare professionals at the delivering site analyzed the data and provided an opinion on diagnosis and management, which was converted into an encrypted digital envelope and transmitted to the receiving site’s local healthcare team via email. Whilst the specialist provided a recommendation, the final decision regarding management was the responsibility of the local healthcare team.

3. RESULTS

A total of 111 patients were evaluated during the course of this project. The majority of patients were over 40 years of age; however, due to local demand for health assistance, 19 patients (17%) under 40 were seen and included in the analysis. There were 55 males (49.5%) and 56 females (50.5%). The average age was 54 years (SD = 19; range = 2-95). Table 1 provides a breakdown of the number of consultations within each of the four main clinical areas and a summary of the key findings. Some patients were triaged into more than one area under evaluation and therefore the total number of consultations exceeds the total number of patients. Tables 2 and 3 provide a summary of the information gathered about medications and past medical history, respectively.

Table 1. Summary of the number of consultations and main findings of the eHealth mission

<table>
<thead>
<tr>
<th>Area</th>
<th>No. consultations</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacy</td>
<td>111</td>
<td>66 patients (59.5%) were taking a medication and/or a medicinal plant. The pharmacist suggested an adjustment in 32 (48.5%) of these patients. There were 29 patients taking more than one medication. Of these, five (17.2%) had drug interactions.</td>
</tr>
<tr>
<td>Cardiology</td>
<td>55</td>
<td>32 (58%) ECGs were normal, whilst 23 (42%) were altered. The most common alterations were ventricular repolarization abnormalities and ventricular hypertrophy. The cardiologist suggested an adjustment to medication in three patients (5.5%) and further investigation in six (11%).</td>
</tr>
<tr>
<td>Dermatology</td>
<td>48</td>
<td>19 patients (39.6%) had evidence of mycoses, including pityriasis versicolor, tinea, onychomycosis and superficial mycosis. In five patients (10.4%) the dermatologist suspected malignancy and recommended further investigation.</td>
</tr>
<tr>
<td>Odontology (stomatology)</td>
<td>8</td>
<td>Suggested diagnoses included: hemangioma, fibroepithelial hyperplasia, melanocytic maculae, leukoplakia or candidiasis, fibroma of oral mucosa and Peutz-Jeghers.</td>
</tr>
</tbody>
</table>

Table 2. Most common medications (pre-project)

<table>
<thead>
<tr>
<th>Drug (Class)</th>
<th>No. patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captopril (ACE inhibitor)</td>
<td>19/111 (17.1%)</td>
</tr>
<tr>
<td>Aspirin (NSAID)</td>
<td>11/111 (9.9%)</td>
</tr>
<tr>
<td>Glibenclamide (Sulfonylurea)</td>
<td>4/111 (3.6%)</td>
</tr>
<tr>
<td>Hydrochlorothiazide (Diuretic)</td>
<td>2/111 (1.8%)</td>
</tr>
<tr>
<td>Simvastatin (Statin)</td>
<td>2/111 (1.8%)</td>
</tr>
</tbody>
</table>

Table 3. Most common medical conditions (pre-project)

<table>
<thead>
<tr>
<th>Condition</th>
<th>No. patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>46/111 (41.4%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>14/111 (12.6%)</td>
</tr>
<tr>
<td>Dyslipidaemia</td>
<td>8/111 (7.2%)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>6/111 (5.4%)</td>
</tr>
</tbody>
</table>
4. DISCUSSION

The potential for a multidisciplinary approach to eHealth activities has been relatively unexplored thus far. A successful example is the Réseau en Afrique Francophone pour la Télémédecine (RAFT) project in West Africa (Bagayoko et al, 2006). The RAFT project is a collaborative, multinational, Internet-based network that provides a linguistically and culturally appropriate environment through which doctors can: a) engage in educational activities, and b) seek second opinions through case discussions. It focuses on low-bandwidth technology in order to promote accessibility, although is limited by local infrastructure. Overall, it has achieved great popularity amongst users and has encouraged many doctors to practice in rural areas.

On the whole, our project was successful and provided patients with an expert second opinion that they may not have otherwise received. Many patients required analysis by more than one specialist, highlighting the complex and varied needs of the average patient aged over 40 living in this part of Brazil. Those patients previously requiring referral for a specialist opinion would have been placed on a waiting list. Cases are prioritized according to urgency; a non-urgent case can expect to wait several months. We believe that this study adds to the current literature by highlighting the potential for a multidisciplinary telemedicine initiative.

Within pharmacy, nearly 60% of patients were found to be taking at least one medicine or medicinal plant, perhaps reflecting the age of the population included. An adjustment to medication was recommended in 32 patients, suggesting that they may not receive regular reviews. Potential drug interactions were identified in five patients, an important discovery given the possibility of serious harm. The pharmaceutical care of these patients has been improved through this project.

Within cardiology more than 40% of ECGs were altered, displaying a variety of abnormalities. When placed into clinical context, the cardiologist recommended a medication change for three patients and further investigation in six patients. It is important to identify patients requiring further cardiovascular investigation given the significant morbidity and mortality caused by cardiovascular disease in Brazil (WHO, 2008b).

Whilst a variety of skin conditions were observed in the dermatology assessment, by far the most important finding was the suspicion of potentially malignant lesions in five patients. These lesions require urgent attention involving a biopsy and/or excision, since an early diagnosis can considerably improve the final outcome. Primary healthcare professionals often encounter skin lesions in the Amazon region and, when the diagnosis is uncertain, teledermatology can help prevent inappropriate referrals. This is of benefit to patient care and has been demonstrated elsewhere. The remaining diagnoses can be easily managed locally.

The results from odontology are less reliable and more difficult to interpret accurately. In some patients the specialist was unsure of the exact diagnosis and provided more than one explanation, predominantly due to a lack of information regarding the chronicity of the lesion in question.

An ever present feature within the telemedicine literature is its potential use in remote and rural areas (Gagnon et al, 2006; Jordanova, 2007). There are many isolated communities within the Amazon region that can only be accessed by boat or light aircraft; the former is often lengthy and unreliable in the dry season, whilst the latter is far beyond the financial capacity of the average Brazilian. The barriers to seeking specialist care in such areas are inherently greater and the potential of second opinion delivery via telemedicine may be of increased significance.

Rural and remote locations bring with them both beauty and challenges. Upon arrival in Amazonas the digital ECG machine malfunctioned, probably as a consequence of a sudden increase in temperature and humidity upon leaving the airport. All other equipment and software functioned smoothly and without problems. An internet connection was not always immediately available but data were typically transmitted to the delivering site within 24 hours of collection.

This project has some important limitations. It has recently been identified that within telemedicine there is a lack of good quality cost-effectiveness studies (Wootton and Bonnardot, 2010). A project may be feasible and may help to improve the quality of care delivered to patients in remote locations, but is it better than the next best alternative and is it sustainable? Furthermore, whilst we received positive feedback from the patients and staff involved, it would have been useful to perform a formal qualitative evaluation of their opinions and experiences; this may have provided an insight into the barriers currently obstructing the implementation of telemedicine projects into routine clinical practice. A difficulty in the post-mission phase has been patient follow-up. Thus far we have been unable to collect sufficient data summarizing the final management plans and outcomes for our patients. This is due to a lack of communication from the receiving site.
Within the telemedicine literature there are many descriptions of feasibility projects and very few accounts of integration into routine clinical practice (Obstfelder et al., 2007). This may be due to a lack of clarity regarding the legal implications of telemedicine practices. In Brazil, there is a lack of clarity regarding the financial implications – how can a project become self-sufficient? The health system pays for local staff but who will meet the cost of the specialist analysis and second opinion generation? These are important questions that require further consideration before a multidisciplinary eHealth project can become implemented into routine clinical practice.

5. CONCLUSION

This project has successfully incorporated several areas of technical, medical, and allied health professional expertise into one project, demonstrating that a multidisciplinary eHealth approach is feasible in a remote location and more effective given the complex and varied needs of a typical patient. Several areas of healthcare were explored that ultimately provided patients with a specialist second opinion that they may not have otherwise received. The software and equipment employed in this project have generally been reliable and accurate, and have facilitated the main objective. It is believed that this multidisciplinary eHealth assistance model can be used in any location which has access to an internet connection.

ACKNOWLEDGEMENTS

The authors would like to thank the Amazon State University for their assistance and support throughout this project, as well as the medical specialists and professors from the School of Medicine/PUCRS and São Lucas Hospital/PUCRS, who provided the second opinions.

REFERENCES

DESIGN OF AN EXPERT SYSTEM SUPPORTED PORTABLE CARDIOTOCOGRAPH (CTG)

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ABSTRACT
In this study, expert system supported portable cardiotocograph (CTG) has been designed. CTGs are very useful tools for detecting fetal distress due to lack of oxygen and metabolic acidosis. In this paper, all parts of CTG has designed in details and performance and accuracy have been discussed. The developed CTG device will provide great benefits in terms of maternal and infant health.

KEYWORDS
Cardiotocography, telegynecology, telemedicine

1. INTRODUCTION
Telemedicine is being used for communications and computer technologies for providing interaction between patients and health professionals who are in geographical distance places (European Commission, 2008). Telemedicine provides medical data transfer between two points and helps the prevention, diagnosis, treatment and follow-up processes (European Commission, 2008). Telemedicine methods often used for cardiology, radiology, dermatology, psychiatry medicine fields. Telemedicine applications include teleradiology, telecardiology, telepsychiatry, telesurgery, teledermatology and telepathology (Çoban S. and Engin M., 2005). In this study, telegynecology, a new field of telemedicine, is discussed.

2. E-HEALTH STUDIES OVER THE WORLD
Telemedicine applications were begun in the 1960s. Since then, many studies have been done in the field of telemedicine. Some recent prominent studies are given below.

Garcia et al. conducted a study in 2007. In this study they developed a wireless decision support system for hemodialysis patients using heart rate variability. The ECG data and other information obtained from dialysis patients sent to the server unit and ECG signals are processed and reports generated. Cardiologists can access reports with a web browser (Garcia J. et al., 2007).

Niyato et al. developed a Wi-MAX (Worldwide Interoperability for Microwave Access) based telemedicine system in 2007. Traditional telemedicine systems are using wireless LANs, 2., 2.5. and 3. generation wireless networks. These technologies have some constraints in term of mobility and bandwidth. For this reason Wi-MAX based system is designed by the authors (Niyato D. et al., 2007).

Hu F. et al. developed a system continuously monitoring heart patients via Medical Ad-Hoc Sensor Networks in 2008. Low-cost, real-time remote monitoring of patients with small ECG sensors are possible. The system can work as single hop and multihop (Hu F. et al., 2008).

Valdastri P. et al. developed an embedded bi-directional and multichannel platform that can real-time monitoring various physiological parameters in the body in 2008. In the study, ZigBee used for telemetric connection; temperature and pressure sensors used for measurement. Point-to-Point ZigBee connection was established between user unit and embedded unit (Valdastri P. et al., 2008).

Groning R. et al. developed an insulin pump controlled via SMS (Short Message Service) in 2007. The software is running on the computer creates an SMS when insulin should be given to the patient and sends it...
to the GSM (Global System for Mobile Communications) modem connected to the pump. Information of the amount of insulin must be injected is available in the SMS. Insulin pump after receiving SMS, delivers the information to stepper motor and stepper motor injectes insulin (Groning R. et al., 2007).

Wen C. et al., developed a mobile phone based ECG telemonitoring system in 2008. In this system abnormal heart beat that detected by the holter device are sending over MMS (multimedia messaging service) and GPRS (General Packet Radio Service) environments in real-time. GPS (Global Positioning System) information provided by the holter device is using to detect patient’s position in emergency situations. In addition, a real-time classification algorithm was developed for detection of abnormal heart rates (Wen C. et al., 2008).

Maeda K. et al developed neural networks based interpretation system for fetal heart rate which the authors previously realized by using expert systems in 1998. The authors performed a system to evaluate the measured values offline. The devices which carried by patients are wireless and allows patients move freely. Measured values from patients are transferring to the central computer and interpreting using an artificial neural network software (Maeda K. et al., 1998).

3. DESIGN AN EXPERT SYSTEM BASED PORTABLE CARDIOTOCOGRAPH

CTGs are very useful tools for detecting fetal distress due to lack of oxygen and metabolic acidosis. Doctors can be informed about fetus through relationship between FHR (Fetal Heart Rate) and UC (Uterine Contraction) values which taken from pregnant women via sensors (Sweha A. et al., 1999). In some cases it can be decided to cesarean operation in minutes according this information. Traditional CTGs causes the patient to remain on the bed. In addition, obtained graphics should be interpreted by a doctor in real-time. Therefore, a system which includes a portable CTG and a central computer that interprets graphics will be very useful. This is the main motivation of this study.

Furthermore, the uterine contractions which have specific frequencies and intensities can show beginning of labor. The main cause of newborn deaths is premature birth (Yurdakök M., 2008). care of premature babies is very difficult and expensive. Therefore, all efforts should be on prevention of early labor (Kesim M. et al., 1997). Damages of early labor in terms of infants are: respiratory distress syndrome, apnea, problems on preservation of body temperature, infections, malnutrition, hypoglycemia, hyperbilirubinemia, cerebral hemorrhage, patent ductus arteriosus, anemia, necrotizing enterocolitis, and retinopathy of prematurity (Payaslı M. Ö., 2007).

In Turkey, approximately 100,000 premature births occur for every year. The number of incubators in official institutions in Turkey is about 1850. The average 1-week intensive care for an infant and incubator costs will be roughly 80 million TL (approximately 50 million USD) a year (excluding staff and ventilation costs) (Yurdakök M., 2008).

3.1 Structure of Portable Cardiotocograph

Portable CTG began to develop due to above-mentioned reasons. Portable CTG’s schematic view is shown in figure 1.

Other parts of the device have been completed except for the signal inputs and expert system software. CTG amplifies filters and digitize FHR and UC signals and sends them to central computer via SMS. The software will be developed, will draw graphics from FHR and UC data and will send detected abnormalities to doctor via SMS. The doctor, who is warned about the abnormality, can receive abnormality graphics from the server. If the doctor has a continuously internet connection, doctor will be able to watch the graphics over the web. With the completion of the overall structure of the system will be as shown in figure 2.
3.2 Details of Expert System

Main point in interpretation of FHR and UC charts is detecting the large hills and collapsed areas. The most simple and effective method of determination of collapsed areas and hills on the chart is calculating gradient between consecutive points (Ibrahimy M. I et al., 2003). Change of situation of gradient from positive to negative between consecutive points shows the existence of a hill. In the same way, change of situation of gradient from negative to positive between consecutive points shows the existence of a collapsed area. After the detection of these points, it will be done determination of these points' positions relative to each other in the same time slices.
4. INTERPRETATION OF MEASURED PARAMETERS

4.1 Interpretation of FHR and UC Values Together

Cardiotocography is a test that evaluates well-being of baby based on the relationship between contractions and baby's heart rate. It used for the same purpose during the birth (msxlabs, 201). Heart rate of babies in the womb is between 120-160 per minute normally and in a continuous oscillation. This is referred as short-term and long-term variability. This indicates that the baby's central nervous system in good condition. Symptoms in the graphics are very typical of a healthy fetus without fetal distress: Heartbeat is between 120-160 per-minute. Heart rate oscillates. Graphics are interpreted based on heart rate, size of oscillations, size and duration of decelerations (msxlabs, 2011). Deceleration kinds are shown in Figure 3. Late deceleration indicates that the decrease in the amount of oxygen that delivering to baby. Early deceleration indicates that the baby's head is stuck. Variable deceleration indicates that the baby's umbilical cord is stuck (childbirths, 2011 - Schifrin B., 1993). The above traces are fetal heart rate and below traces are uterine contractions in Figure 3.

![Figure 3. Deceleration kinds. (a) late deceleration, (b) early deceleration, (c) variable deceleration (childbirths, 2011)](image)

Fetal tachycardia and bradicardia are shown in Figure 4. Fetal tachycardia is caused by the following situations: fetal oxygen deficiency, drug treatment, prematurity, maternal stress or anxiety, maternal fever, fetal infection and fetal activity. Fetal bradicardia is caused by the following situations: fetal oxygen deficiency, drug treatment, the synthetic oxytocin to stimulate contractions of the mother, maternal hypertension and umbilical cord stuck (childbirths, 2011 - Schifrin B., 1993).

![Figure 4. (a) fetal tachycardia, (b) fetal bradicardia (childbirths, 2011)](image)
5. CONCLUSIONS

In this study, telemedicine and its methods were examined; some recent prominent studies in telemedicine were reviewed and completed parts of designed portable CTG were explained.

The system will be developed; can be basis for development of content aware medical devices in Turkey. A total solution can be obtained with including content aware devices of different field of medicine without changing overall structure of the system. At this point, there may be a need to develop application layer protocols for communicate in the same language between devices and central computers.

Maternal and infant health will be monitorized more closely and easily with developed postable ECG. The designed expert system based portable CTG devices can have benefits for patients and medical doctors.

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MODULAR SOFTWARE ARCHITECTURE APPROACH FOR A TELEMATIC RESCUE ASSISTANCE SYSTEM

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ABSTRACT
German emergency medical services are in need of new solutions to their care system in order to cope with raising mission numbers and a reduction of available physicians for emergency care. As countermeasure to this development the research project TemRas investigates the introduction of a Telematic Rescue Assistance System. Supported by this system, physicians located in a teleconsultation center advise multiple paramedics teams during their emergency missions. Usage of this system must be unobtrusive for the supported paramedics in order to enable optimal patient care. The proposed software architecture addresses this by enabling a seamless integration of existing medical devices and their communication protocols for real-time data transmission between emergency scene and teleconsultation center. To ease the integration of the resulting heterogeneous application infrastructure in the teleconsultation center, a message bus is introduced which provides a qualified integration point for such environments.

KEYWORDS
Telemedicine, Emergency Medical Services, Software Architecture

1. INTRODUCTION
German Emergency Medical Services (EMS) are experiencing increased mission numbers combined with a shortage of trained EMS physicians especially in rural areas. This development threatens the quality of patient care in the established German two-tiered EMS model where Mobile Intensive Care Units (MICUs) – each consisting of an ambulance vehicle staffed with two paramedics – are supported by EMS physicians if need is indicated (Bey et al., 2008). The German research project Med-on@ix provides a possible solution for this problem by investigating how to support paramedics in patient care while an EMS physician has not yet arrived on the emergency scene (Skorning et al., 2009). The support is given by means of a Telematic Rescue Assistance System (TRAS) enabling skilled EMS physicians located in a teleconsultation center (hereafter called tele-EMS physicians) to be provided with patient vital signals, auscultation data, photos, real-time video and bidirectional voice communication from the emergency scene (Protogerakis et al., 2009).

Research objectives in the project Med-on@ix focused mainly on the following aspects:
- testing medical support capabilities of such a TRAS
- defining requirements for TRAS
- implementing a TRAS prototype for evaluation which enables the support of one MICU by one tele-EMS physician

During the one year evaluation phase at the end of the project Med-on@ix, the supported MICU was accompanied by an additional EMS physician to secure patient care, allowing for the introduction of additional equipment and to reduce requirements on the TRAS concerning application usability. In August 2010 the follow-up research project TemRas started, targeting the following aspects:
- refining the medical support processes
- advancing the developed TRAS in order to enable simultaneous support of multiple MICUs
- preparing system design for a possible commercialization of the TRAS
A field test with the duration of one year will be performed at the end of the project TemRas. During this field test two physicians will be on duty in the teleconsultation center, advising five MICUs – this time without being accompanied by an additional, dedicated EMS physician – in their day to day missions.

The major challenges addressed by the TRAS’ adapted software architecture concern the absence of standards for data exchange or compliance with these standards by existing devices used by MICUs as well as to manage the communication for different applications. The development of the TRAS software architecture presented in this paper is based upon the architecture designed in project Med-on-@ix but follows a new modular approach to cope with these problems. Based on other approaches to TRAS architectures and related considerations, the new approach of the TRAS architecture is presented in this paper.

2. RELATED WORK

This section gives a brief overview of the software architecture designed in the project Med-on-@ix. It also discusses related approaches to the problem of connecting devices located at an emergency scene with a teleconsultation center for remote diagnostics, which is the main focus of most published work addressing TRAS software architectures. A short discussion motivates the new architecture approach presented thereafter.

The software architecture used in Med-on-@ix as described by Protogerakis et al. (2009) is based upon a hybrid middleware combining messaging and streaming transports to connect all system components. The middleware uses Remote Procedure Calls (RPC) implemented with the help of the object oriented framework Internet Communication Engine (ICE) by vendor ZeroC for communication between different peers. A robust Internet Protocol (IP) network, connecting emergency scene and teleconsultation center, is realized by using multiple mobile network links combined with multipath routing (He & Brassil, 2007). This middleware concept facilitates the use of dynamic compression and data prioritization settings depending on mobile network quality. An inherent drawback of this approach is that all client applications have to be adapted to the middleware’s interfaces or adaptors have to be provided to connect a device with the middleware. To avoid this drawback is the major focus of the new, modular architecture approach described in this paper.

Another approach presented by Shaikh et al. (2009) focuses on a service oriented architecture using XML messages and the Simple Object Access Protocol (SOAP) to connect mobile clients to central diagnostic facilities. This design does not cover the transmission of real-time data like video, voice calls or continuous vital signals. Likewise, Lamberti et al. (2003) propose the use of web technologies like XML messages and XSLT transformation to interchange information between mobile clients, in-hospital workstations and storage services. The usage of existing standards for medical data exchange including Vital Signs Information Representation (VITAL, ENV 13734) and Digital Imaging and Communications in Medicine (DICOM, ENV 12052) eases the integration of Hospital Information Systems for information exchange.

Pavlopoulos et al. (1998) proposed and successfully tested a preclinical EMS support system using a single Global System for Mobile Communications (GSM) channel for medical data transmission and a second one for voice communication. Similar to the approach of Protogerakis et al. (2009), client devices were interfaced to enable communication via a specific Transmission Control Protocol (TCP)/IP based application protocol. Connection losses are reported to be a major problem in this setting.

Alesanco and Garcia (2010) address the issue of real-time Electrocardiography (ECG) data transmission over unreliable mobile networks by proposing a new communication protocol on the application layer using User Datagram Protocol (UDP) at the transport layer. They conclude that TCP transports over a 3G mobile network channel are not suited for real-time transmission of ECG waveforms.

Common to the described approaches is the need for client applications and devices to be able to directly communicate with the middleware either by implementing its interfaces or via special adapters understanding both, the client’s and middleware’s interfaces. At this layer, standards as used by Lamberti et al. (2003) play an important role to reduce the need for application and device adaption. RPC mechanisms like SOAP or as used by ICE provide only limited support for the addition of new functionality without the need for major modification of existing applications. Instead, the use of a message bus for such scenarios has been established with the advent of Enterprise Integration Patterns (Hope & Woolf, 2004).
3. MODULAR ARCHITECTURE APPROACH

3.1 Brief Requirements Summary

Protogerakis et al. (2009) presents basic requirements which guided TRAS development in the project Med-on-@ix. To continue the TRAS development, an initial requirements adaption has been performed, following a participative development approach as described by Schneiders et al. (2011). The resulting major improvements which have to be provided by TemRas can be summarized as follows:

- An integrated working environment is required, which automatically connects the applications used by the tele-EMS physician to the devices of the MICU he/she currently supports.
- A highly automated documentation system that gathers as much data from the diagnostic devices as possible and that queries missing information from the tele-EMS physician.
- The MICU’s paramedics cannot be equipped with burdensome additional equipment compared to their usual equipment outside of TRAS implementation: Vital signals measurement unit must be integrated into the defibrillator; communication units providing data and voice connection between the paramedics on-scene and the teleconsultation center must be miniaturized; no tablet computer or comparable notebook can be carried by the paramedics.
- The TRAS should be integrated seamlessly into the MICU’s equipment in order to avoid additional workload for the paramedics by introducing the TRAS.

3.2 Software Architecture

The new architecture addresses the new requirements posed on devices which are used on the emergency scene by facilitating the usage of existing diagnostic devices without requiring their adaption to a common middleware. This differs to existing approaches which require the adaption of devices to communication protocols enforced by the middleware. The following aspects form the modular architecture approach’s core:

- enabling transparent usage of proprietary communication protocols to connect endpoints between the emergency scene and teleconsultation center without the need for adaption to the middleware
- providing an easy integration point for components with the middleware to allow their automatic control for mission management without enforcing the need for integration

All real-time data streams for continuous vital signals transmission, auscultation recordings, video and bidirectional voice communication will bypass the middleware, dissolving the need for handling streaming in the middleware. Quality of Service features, that Protogerakis et al. (2009) intended to be handled by the streaming part of the middleware, will either be performed on the transport layer of the data links between emergency scene and teleconsultation center or directly by the applications if supported.

This reduction of responsibilities for the middleware facilitates the use of existing messaging solutions to handle mission management, mission documentation and application control. A message broker using the Advanced Message Queuing Protocol (AMQP) was chosen as central message bus of the middleware to promote the use of open standards. This provides a simple integration point for software components and likewise 3rd party applications if their integration with the middleware is desired. This concept is depicted in Figure 1.

![Figure 1. Modular architecture approach for transparent connection of 3rd party devices](image)

The robust IP network, which already has proven its practicability in project Med-on-@ix, forms the basis for the transparent usage of proprietary communication protocols. The Mobile Communication Units
establishing the network via multiple mobile data links are undergoing miniaturization and enhancement to enable the simultaneous support of multiple emergency scenes.

Applications used by the tele-EMS physician have to be compatible with the existing communication capabilities of devices used on the emergency scene. In many cases, this requires the usage of proprietary applications which has the advantage of using existing and proven software in the teleconsultation center. A drawback is the missing standardization for the integration of these applications into the tele-EMS physicians’ workplaces to allow the required degree of automation. In the short term, individual solutions for this integration have to be implemented. A standardized component model which allows the embedding of different 3rd party applications into an automation framework would provide a solution for this problem.

4. CONCLUSION

A new approach to TRAS software architecture is presented that facilitates modularity by providing a qualified integration point for optional integration – instead of enforcing the connection of devices and applications to a common middleware. A major advantage of this heterogeneous approach is the simple usage of existing medical devices and applications. The targeted goal to deliver an integrated working environment to tele-EMS physicians currently requires the integration of 3rd party applications by different means. Open standards for the communication with medical devices or a standardized component model for the data displaying applications would diminish this need. The development as well as the establishment of such standards is an important task for future work in this research area.

ACKNOWLEDGEMENT

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REFERENCES


A DOMAIN SPECIFIC CONCEPTUAL MODEL FOR A MEDICAL EXPERT SYSTEM IN PSYCHIATRY, AND A DEVELOPMENT FRAMEWORK

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ABSTRACT

Despite the long pursuit of ways to develop practically useful medical expert systems, it still remains largely an unrealized goal. The difficulties in developing successful medical expert systems can be understood in relation to conceptual, computational and societal aspects of their development.

In this paper we introduce a novel knowledge and reasoning model specific for psychiatry, along with a generic development framework for its design and implementation. Diagnostic reasoning in psychiatry involves eliciting phenomenology based on clinical symptoms and signs, and then diagnoses. The relationship between the severity of individual symptoms, and the degree of confirmation of likely diagnoses and their severity, are modeled using approximated mathematical functions based on expert clinical judgment. Each symptom is assigned a predictive value, and a weight according to its importance in relation to each likely diagnosis. Given a set of symptoms and their severity, the degree of confirmation of a likely diagnosis and its severity are calculated using the corresponding mathematical functions, predictive values and weights. The development framework provides a structured and a step-wise approach to identify and deal with conceptual, computational and societal issues.

Using the development framework, we hope to implement our domain specific conceptual model as a web-based diagnostic and consultation system in psychiatry, and effectively address the issues in relation to computational and social aspects. We also hope that our approach will give insight to develop domain specific conceptual models in other medical subspecialties, and implement them successfully by adopting the development framework.

KEYWORDS


1. INTRODUCTION

Even though there has been a significant advancement in software and hardware technology over the past several decades, effective automated clinical reasoning is still largely an unrealized dream in the medical field, despite significant efforts to achieve automation. Systems such as INTERNIST-I and CADUCEUS, which have taken more than a decade of development, have been failures (Wolfram,D.A., 1995). While some medical Decision Support Systems (DSS), which have clearly improved the quality of health care delivery (Kawamoto, K. et al. 2005), (Hunt, D.L. et al. 1998) are in use, they are relatively simple applications limited to small domains. For example, DSS for diagnosing and prescribing antibiotic treatment (Samore, M.H. et al. 2005), systems to calculate anticoagulant dose (Poller, L. et al. 1998), and DSS for cardiac rehabilitation (Goud,R. et al. 2009). The reasons for this situation can be understood in relation to problems with conceptual, computational and societal aspects.

There are a number of generic conceptual models of medical reasoning, and these include hypothetico-deductive reasoning (Elstein,A.S. et al. 1978), scheme-inductive reasoning (Mandin,H. et al. 1997), pattern recognition (Norman,G.R. et al. 1992), backward and forward reasoning (Hunt,E., 1989), Parsimonious Covering Theory (Reggia,J.A. and Peng,Y., 1987), Information Processing Approach (Wortman, 1972), and process model for diagnostic reasoning (Stausberg, J., and Person, M., 1999). Unfortunately, these models fail to capture the uniqueness, depth and complexity of the knowledge and reasoning in different medical
subspecialties. There is a significant diversity in the nature of knowledge and reasoning strategies used by clinicians across different medical subspecialties, and therefore generic models for reasoning and knowledge representation are unsuitable. Many of the above models also lack the clinical intuitiveness that is required for example in psychiatry, where subjective evaluation and imprecise knowledge and reasoning strategies are employed.

One of the main issues related to computational models is the difficulty in developing and maintaining sufficiently large knowledgebases, which require long-term commitment and a seemingly insurmountable amount of manpower (Kinney, 1987). Development of INTERNIST-I, which is an expert diagnostic system in Internal Medicine, has still not been able to complete its knowledgebase despite taking about 25-30 person-years of effort (Wolfram, D.A., 1995). Importantly, there have been mismatches between the computational models developed and the nature of real world clinical work. In addition, there are a number of important social and organizational issues that have been overlooked by the traditional approaches to development of medical expert systems. Lack of attention to the way the technology is going to affect the organization in which the system is to be embedded is one of the core reasons for failures in medical expert systems (Wears and Berg, 2005). Finally, engaging clinicians and getting them to use medical expert systems can be difficult since clinicians may perceive these systems to represent a threat to their autonomy and professional identity (Das, 2002).

We have introduced a novel domain specific conceptual model for an expert system in psychiatry, and a development framework that is aimed to identify and address the conceptual, computational, and societal (including organizational) issues in a structured and stepwise approach by taking a holistic view of the development process.

2. ISSUES IN KNOWLEDGE AND REASONING IN PSYCHIATRY

The core diagnostic knowledge in psychiatry is largely based on phenomenology, which was introduced to psychiatry by the German Psychiatrist and the philosopher Karl Jaspers (Jaspers, K., 1997). Phenomenology describes psychopathology in terms of subjective experiences (i.e. phenomena) related to psychiatric illnesses (Fish, 1967). Typical examples of such phenomenology include delusions and auditory hallucinations in schizophrenia, and obsessions in Obsessive Compulsive Disorder. Inferring a diagnosis is largely based on the presence or absence of these phenomena. This is in contrast to General Medicine, where diagnoses can often be made reliably using quantitative measurements from clinical signs or laboratory results. For example, a patient presenting with chest pain and having ST elevation on EEG and elevated troponine-I, can be diagnosed reliably to have an ischemic cardiac disease (Armstrong, O. et al. 1996). Unfortunately there is no single laboratory investigation (i.e. objective and quantitative measurement) that can be used to diagnose most of the major psychiatric disorders. This situation causes a number of significant problems.

Firstly, reasoning based on subjective data is more difficult and less precise than that based on quantitative measurements. For example, whilst troponin-I level greater than 0.6 ng/mL is known to be diagnostic of myocardial infarction with a sensitivity of 94% and a specificity of 81% (Bever, R. et al. 2000), it is not possible to infer the diagnosis of clinical depression with such certainty since we are not able to reliably quantify the severity of depressed mood using an agreed upon objective measurement.

Secondly, there tends to be a significant degree of inconsistency in diagnostic reasoning based on the subjective interpretation of the symptoms. This can become particularly manifest when more than one clinician is involved, leading to different interpretations of signs and symptoms. There are studies showing diagnostic inconsistencies related to a number of disorders including Major Depressive Disorder (Guze, C. et al. 1992), (Kessing, 2005), and Bipolar Disorder (Haas, K. et al. 2004). These issues have made psychiatry vulnerable to severe criticism, particularly from the anti-psychiatry movement. Critics have questioned the scientific basis of the psychiatry due to the vagueness of diagnostic criteria (Szasz, T.S., 1989).

3. CONCEPTUAL MODEL

In psychiatry, diagnostic knowledge can be viewed as a hierarchy of three entities consisting of diagnostic data items, diagnostic phenomena and diagnoses. A diagnostic phenomenon is indicated by a constellation of
diagnostic data items, which need to be present in order to substantiate the presence of the diagnostic phenomenon. For example, melancholia can be considered as a diagnostic phenomenon related to depression, in which the symptoms of early morning wakening, worsening of depression in the morning, and severe loss of weight, are few examples of diagnostic data items (i.e. symptoms). Diagnostic inference based on this hierarchical knowledge of three levels of entities, involves a two-step process: firstly, inferring diagnostic phenomena based on diagnostic data items, and then inferring diagnoses based on diagnostic phenomena and diagnostic data items. In contrast, diagnostic inference in General Medicine involves a single step, where diagnoses are usually inferred based directly on diagnostic data items. Since diagnostic phenomena are more closely related to diagnoses than individual diagnostic data items, these diagnostic inferences based on diagnostic phenomena should be more accurate than those reached using diagnostic data items alone.

One important aspect of the diagnostic knowledge in psychiatry is its vagueness due to the subjective nature of the diagnostic data items. For example, the diagnostic data item ‘depressed mood’ is difficult to quantify, but can often be expressed as a degree of severity in a scale from 0-10. While the degree of severity can be expressed using the linguistic terms mild, moderate and severe, the resulting vagueness of the knowledge can be modeled using fuzzy logic relations (Zadeh, 1969). For example, the severity of a diagnostic data item can be described using the membership function: 

\[ \mu_q(S) \rightarrow [0,1] \]

which maps the diagnostic data item into a interval between 0-1.

Similarly, the degree of confirmation of a disorder can be described using the membership function: 

\[ \mu_c(D) \rightarrow [0,1] \]

which maps the degree of confirmation into a interval between 0-1.

The relationship between the severity of a diagnostic data item and the degree of confirmation and severity of a likely diagnosis can be expressed using fuzzy logic rule,

\[ \text{IF } \mu_q(S_i) \text{ THEN } \mu_c(D_j) \text{ with } \mu_q(D_j) \]

Severity of each symptom has different relationships with the degree of confirmation of a likely diagnosis and its severity. Using expert clinical judgment, these relationships can be approximated and defined using two sets of mathematical functions, C for the confirmation and Q for the severity. For example, given a symptom, \( S_i \) and its severity, \( \mu_q(S_i) \) the confirmation of a likely diagnosis, \( D_j \) can be expressed as \( \mu_c(D_j) = C_{ij}(\mu_q(S_i)) \). Similarly, the severity of \( D_j \) can be expressed as \( \mu_q(D_j) = Q_{ij}(\mu_q(S_i)) \). These two relationships are described in figure-1.

![Figure 1](image-url)

Figure 1. Relationship between the severity of symptom \( S_i \) and the degree of confirmation of diagnosis \( D_j \).

Since it is often true that more than one diagnostic data item is related to a diagnosis, the above rule can be expanded to include diagnostic data items \( S_1, S_2, ..., S_n \) in the following form,

\[ \text{IF } \mu_q(S_1) \cap \mu_q(S_2) \cap ... \cap \mu_q(S_n) \text{ THEN } \mu_c(D_j) \text{ with } \mu_q(D_j) \]

Given the severity of individual symptoms \( \mu_q(S_1), \mu_q(S_2), ... , \mu_q(S_n) \), the certainty of the diagnosis, \( \mu_c(D_j) \) can be inferred by implementing different techniques. Using fuzzy logic, the composition of the severity of all the symptoms can be inferred using fuzzy intersection (t-norms), which is translated as a
minimum function (i.e., yielding the minimum out of the severity of all symptoms). Since each symptom and phenomenon have different degrees of predictability of a likely diagnosis, a more clinically intuitive approach would be to give a predictive value \( p \) to individual symptoms and phenomena according to their relevance for a particular diagnosis. For example, depressed mood can be considered to have a higher predictability of depression compared to insomnia. Predictive value is similar to the statistical concept of Predictive Value (Bennett, 1975), except that it can be decided by expert clinicians according to their clinical judgment, as a subjective measure rather than an objective conditional probability. Then the diagnostic certainty can be expressed as the average of the product of individual symptom severity and the predictive value as follows:

\[
\mu_c(D_j) = \frac{1}{n} \sum_{i=1}^{n} C_{ji} \left( \mu_q(S_i) \right) p_{ji}
\]

A similar calculation can be applied to determine the severity of a likely diagnosis based on a set of symptoms. The only difference is that, instead of the predictive value, a weight \( w \) is given to each symptom according to its importance. This is because the contribution of each symptom for the overall severity of a likely diagnosis can vary significantly. For example, auditory hallucination indicates more severity compared to insomnia in relation to diagnosis of depression. The severity of the diagnosis \( D_j \) can be calculated as the weighted average of the severity of all symptoms as follows:

\[
\mu_q(D_j) = \frac{1}{n} \sum_{i=1}^{n} Q_{ji} \left( \mu_q(S_i) \right) w_{ji}
\]

The same model can be used for etiological reasoning, in which the relationship between a diagnosis and a set of etiological factors shows a similar pattern.

4. DEVELOPMENT FRAMEWORK

Development of successful medical experts systems requires addressing a range of complex issues related to conceptual, computational and societal aspects. Therefore we have introduced a bottom-up development framework that will guide the development by taking a structured and stepwise approach to identify and address these complex issues. Using the development framework, the development process can be described as a layered approach as shown in figure-2. The layers comprise a conceptual layer, a computational layer and a societal layer from bottom to top, and the successful negotiation of issues at each layer results in the conceptual, the computational and the societal models respectively.

![Figure 2. Layered View of the Development Framework](image)

The Conceptual Layer addresses the unique nature of the knowledge, its structure and organization, and the nature of the reasoning process in a given domain of expertise. As we have previously discussed in relation to the domain of psychiatry, conceptualization of the knowledge structure and organization, and the reasoning process, results in the conceptual model.

The Computational Layer addresses computational issues related to the design implementation of the conceptual model. These include design and implementation of the knowledgebase, inference engine and human computer interface. As we have mentioned earlier, development and maintenance of a sufficiently large knowledgebase presents a significant challenge. The authors believe that it can be addressed by taking
an on-line collaborative approach, in which the knowledgebase is developed and maintained as web ontology through contribution of the online expert community. The success of social software such as Wikis and Weblogs has led to previous proposals of a collaborative approach to building a knowledgebase through online participation of an expert community (Richards, 2009).

Societal aspects related to implementation of medical expert systems have largely been overlooked in the past, and can be implicated as a one of the main reasons for failures. Modern day health care organizations are described as complex sociotechnical systems, in which dynamic interactions routinely occur between the technology and people (Wears and Berg, 2005). Also, some of the key aspects of modern day medical practice involve collaborating and communicating with multiple stakeholders. Therefore it is important to identify the role of an expert system in relation to these dynamic interactions in a workplace, and also, how these interactions can be affected by its use. It is also important that the functionality of expert systems should reflect the nature of the actual work practices in the real world, so that the systems can be seamlessly integrated into work practices. Issues that will also need to be addressed in the Societal layer include engagement of clinicians, who may feel that their professional integrity is threatened by medical expert systems, and ethical aspects in relation to use of medical expert systems. The Societal model encompasses the strategies that are used to address these issues.

5. CONCLUSION

The main reasons for the failure of attempts to develop effective medical expert systems have been explained in relation to a range of important issues in conceptual, computational and societal aspect of the development. Lack of domain specific conceptual and computation models, difficulties in implementing sufficiently large knowledgebases, failure to address the organizational issues, and difficulties in engaging clinicians are some of the significant issues. In this paper, the authors have developed a novel domain-specific conceptual model for psychiatry, an area of medicine that is unique due the highly subjective nature of its knowledgebase and the vagueness in its reasoning process. The authors have proposed an accompanying layered development framework to address conceptual, computational and societal issues by taking a structured and holistic approach. Using this development framework, the authors are expecting to implement the conceptual model described in this paper as a web-based system, underpinned by a sufficiently large knowledgebase that can be developed collaboratively. It is expected that this approach will also be useful in the building of effective medical expert systems in other medical specialties.

REFERENCES


REPRESENTING MEDICAL ALERTS IN A PATIENT SUMMARY THROUGH ISO/EN 13606 ARCHETYPES

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ABSTRACT
In this Project, a Patient Summary was implemented collecting information from three disparate heterogeneous sources: the Primary Care Electronic Health Record (EHR), the Hospital EHR and the data available in the Pharmacy Department software application. Knowing alerts, including allergies, and current treatments or certain conditions could be vital during healthcare contact, consequently one visible and distinct section of the Patient Summary shows now this kind of data. To represent that information, a specific archetype was designed, although, previously we had to define the concept of alert in the context of an EHR. Finally, linking archetypes to terminologies (SNOMED CT and WHO ICPC) provided the semantic interoperability needed for the meaningful exchange of information between those distributed systems.

KEYWORDS
Patient Summary, archetype, medical alert, semantic interoperability, SNOMED CT.

1. INTRODUCTION
A Patient Summary is a concise clinical document that provides an electronic patient health dataset applicable both for unexpected, as well as expected, healthcare contact (epSOS Project 2010). In other words, its aim is to provide healthcare professionals with essential and understandable health information at the point of care. This basic information was collected in this Project from three heterogeneous and geographically distributed resources, the EHRs implemented in the Primary Care and Hospital settings and the information stored in the Pharmacy Department software application.

In line with the content of the Patient Summary described in the epSOS Project, three sections constitute the core clinical information of our Patient Summary: alerts, problem list and medications.

To achieve this Patient Summary from information compiled in various locations and diverse proprietary formats a standardization platform was developed following the ISO/EN 13606 standard. The standard specifies the information architecture required for interoperable communications of EHRs of a single identified patient between EHR systems and a central repository (ISO 2008). The ISO/EN 13606 standard is based on the dual model approach of the EHR, i.e. the separation between information (the data) and knowledge (which may change in the future).

Knowledge is then represented in the ISO/EN 13606 standard by archetypes. An archetype has been defined as an agreed, formal and interoperable specification of the data and their inter-relationship that must or may be logically persisted within an EHR for documenting a particular clinical observation, evaluation, instruction or action (Kalra & Tapuria 2008). An EN13606 archetype represents this specification as a set of constraints, expressed in a standardized form, for instantiating a particular EHR Reference Model.

Therefore, archetypes define a data structure, including optionality and multiplicity, data value constraints, and relevant bindings to natural languages and terminology systems. In an EHR archetypes have prove to be a user friendly means to capture and collect professional consensus on how clinical data should be represented.
2. REPRESENTATION OF MEDICAL ALERTS

In line with other initiatives (Lövström 2009), we decided to start with defining the role and concepts of alerts in the context of an EHR. An alert was then considered any information related to hypersensitivity, conditions or treatments which, in case they are unknown to the healthcare professional, could constitute a serious threat to the life or health of the patient. That is to say, any relevant information of which professionals in a healthcare setting must be aware of is an alert.

Severe hypersensitivity to drugs is a well-known example of a condition that constitutes a risk to life or health; however, many other diagnoses or clinical information may be life threatening as well. Diagnoses such as malignant hyperthermia, porphyria, and bleeding disorders; special treatments like anticoagulants or immunosuppressants; implanted devices and transplanted organs illustrate other information that has to be taken into account in a healthcare contact.

This type of information is actually contained in many of the EHRs in place, although in a non-standardized way that restrains its communication between systems. Therefore, to be able to facilitate the exchange of alerts between systems, and even between organizations at local, regional, national or international level, it is necessary that such information is structured and makes use of terminologies. In our project, a specific archetype was developed for clinical alerts.

Our approach in developing the archetypes for alerts followed the recommendations of initiatives like the SemanticHealth Roadmap Project that identified the use cases to prioritize in an EHR that need most to be captured and shared to improve quality and safety (Stroetmann et al. 2009). The first priority use case for safe shared care identified were new medication prescriptions (requiring comprehensive information on concurrent medication and details of known allergies and conditions) and reminders and prompts.

2.1 The ISO/EN 13606 Standard Archetype Model

ISO 13606 Part 2 defines an archetype model to be used to represent archetypes when communicated between repositories, and between archetype services. It defines an optional serialized representation, which may be used as an exchange format for communicating individual archetypes. Such communication might, for example, be between archetype libraries or between an archetype service and an EHR persistence or validation service (ISO 2008).

Archetypes have been developed to represent clinical information and to be able to communicate that information. The reason for that approach is the complexity of the information contained in an EHR, and hence, the difficulty for its transmission. Much of clinical meaning in an EHR is derived not from individual data values themselves but from the way in which they are linked together as compound clinical concepts, grounded under headings or problems or associated with preceding healthcare events during the act of data entry or data extraction (Kalra 2006). Moreover, the nature of healthcare determines the strictness and unambiguity needed for representing, managing and exchanging clinical information.

This requirement, to preserve the clinical meaning, is in the origin of the dual model approach mentioned earlier for the architecture and communication of EHRs and for the achievement of semantic interoperability. Thus, the dual model approach distinguishes a Reference Model used to represent the generic properties of health record information (part 1 of the standard), and archetypes (conforming to an Archetype Model, part 2). Archetypes are metadata used to define patterns for the specific characteristics of the clinical data that represents the requirements of each particular profession, speciality or service.

In this Project, three archetypes were developed to represent the information of each section of the Patient Summary: alerts, problem list and medication. Bearing in mind two vital characteristics of archetypes, i.e. the involvement and agreement of healthcare professionals in its conception and the subsequent validation (EuroRec 2011), a team of doctors, nurses and pharmacists, along with technical experts adapted the available archetypes.

We adapted the openEHR Foundation archetypes taking into account the works of the epSOS Project, the NEHTA data specification for alerts (NEHTA 2009) and the information models of the local systems (the EHRs implemented in the Hospital and in the Primary Care setting). Our final aim was to develop ISO/EN 13606 archetypes on account of the fact that to support semantic interoperability, archetypes need to be shared and used consistently by EHR system vendors and their users, so that the EHR data they create is consistently organized. In fact, the object model for the representation of archetypes in UML has been
published by the openEHR Foundation and was included as a normative specification in the ISO/EN 13606 standard part 2 (Q-REC, European Quality Labelling and Certification of Electronic Health Record Systems 2008).

As already said, clinical archetypes need to be quality assured, since they will direct the way in which clinical data will be captured, processed and communicated. Therefore, it is important that the design of individual archetypes is an accurate and faithful reflection of good practice for the specific domain.

### 2.2 Archetype for Medical Alert Representation

The design of the specific archetype for medical alerts (allergy was the first use case) was agreed by a team of professionals involved in the Project: doctors, nurses and pharmacists assisted by technical experts in ICT research. The LinkEHR Archetype Editor (www.linkehr.com) was used for the definition of archetypes.

Based on the openEHR Foundation archetypes and on the information model of the local systems along with the works of NEHTA, epSOS and the CCR standards of the USA (Continuity of Care Record standard 2011), we developed an archetype for alerts that conforms to the requirements specified in ISO/EN 13606 Part 2.

Previously, a definition of alerts was required in order to be able to develop a meaningful archetype. This approach follows the clinical requirements of EuroRec Q-REC Project as archetypes are expected to specify the precise nature of the clinical entity for which it defines a use pattern. Additionally, we fulfil the requirement of including or reference one or more concepts from an internationally registered terminology system (SNOMED CT and ICPC). The subset for allergic reactions subset of SNOMED CT had already been implemented in the Hospital EHR. The openEHR archetype for alerts (openEHR Foundation 2011) was selected as the starting point for our team discussions. Table 1 shows the contents of the archetype for medical alerts.

<table>
<thead>
<tr>
<th>Structure ‘Archetype for Medical Alert Information’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert type (Categoría)</td>
</tr>
<tr>
<td>Description (Descripción)</td>
</tr>
<tr>
<td>Certainty (Certeza)</td>
</tr>
<tr>
<td>Status (Estado)</td>
</tr>
<tr>
<td>Start of alert (Inicio de la alerta)</td>
</tr>
<tr>
<td>Comment (Comentario)</td>
</tr>
<tr>
<td>Source of the information (Origen)</td>
</tr>
<tr>
<td>Other information: End of alert (Alerta finalizada)</td>
</tr>
</tbody>
</table>

Figure 1 shows the Alerts section of the Patient Summary.
3. CONCLUSION

Knowing medical alert information may be vital when a healthcare professional is treating a patient. Medical alerts include not only hypersensitivity to substances, specially drugs, but also conditions and treatments which should be known to healthcare professionals so patient's health or life is not threatened during routine treatment as well as during an unexpected contact.

In this Project, a Patient Summary comprising three sections (alerts, problem list and medication) was achieved through a standardization platform and using the ISO/EN 13606 standard for the architecture and communication of EHRs. The aim of the Patient Summary was to provide doctors with essential information actually stored in heterogeneous systems; semantic interoperability was achieved through clinical archetypes which represent specific domain entities. These archetypes were developed by a group of domain experts: doctors, nurses and pharmacists, along with ICT researchers.

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REFERENCES


ABSTRACT
Drug expenditure is a relevant factor in profit and loss account of healthcare systems. Hospital management is in charge of optimising drug management in order to reduce inventory costs and maximise the cost-effective use of personnel and resources. This paper presents a conceptual framework to tackle this problem, embodying the starting point for future researches. To this purpose, it describes a representation of physical and information flows related to drugs in a hospital, the variables related to the hospital environment, the management parameters useful to reach the drug system optimisation and the performance indicators to measure efficiency of approaches.

KEYWORDS
Conceptual framework, healthcare management, drug logistics.

1. INTRODUCTION
It is universally recognised that the exponential growth in healthcare expenditure is not only due to the increase in population estimated life and the rise in costs of healthcare services, but also to the considerable amount of wastes in healthcare processes (WHO, 2010). The progressive reduction in public resources – and the subsequent need to restore budgets – makes governments responsible for finding solutions to achieve more operational efficiency in these processes. Drug expenditure, in particular, is a relevant factor in profit and loss account of healthcare systems (EUROSTAT, 2008, Jarrett, 1998). Management of hospital pharmacy has to find techniques to reduce drug inventory costs and maximise the cost-effective use of personnel and resources (Aptel and Pourjalali, 2001; Awaya et al., 2005; Oliveira and Pinto, 2005).

In the industrial setting, numerous studies have tried to detect and correct the wrong management policies with the aim to design efficient inventory systems; nevertheless, the difficulties of transferring directly these techniques to the hospital environment continue nowadays to be reflected in the lack of a thorough understanding of the reengineering of inventory systems in this contest (de Vries, 2010).

Exploring reasons of economic inefficiency, it is conceivable to suppose that the main problem is the existence of hidden stocks in order to avoid stock-outs (de Vries, 2010). The high inventory level is justified by the concern about their lack – if the worst comes to the worst, the cost of lives loss is much higher than the cost of keeping additional inventory (Aptel and Pourjalali, 2001). The problem is that level often seems to be more politically and experience-based driven rather than data-driven (Nicholson et al., 2004).

This paper deals with the definition of a conceptual framework to tackle the issue of drug management optimisation in healthcare systems in a contest highly complex – only similar to a military organisation during a period of conflict (Jarrett, 2006) – and with variables involved that are linked by non-linear dependencies. The purpose of the paper is to represent the starting point for future researches. In the following section, the components of the proposed conceptual framework are described. They are (figure 1): physical and information flow representation; hospital factors; performance indicators; management parameters. The physical and information flow diagram shows the existing relations among stakeholders and between drug supply and consumption in hospital systems. The environment is characterised by variables related to the particular hospital (hospital factors) and can be ruled through many different inventory management decisions. These decisions (using the performance indicators) determine different performance
levels, which can lead to choose the best values of the management parameters that optimise the system (optimisation process).

2. COMPONENTS OF THE CONCEPTUAL FRAMEWORK

2.1 Information and Physical Flow Representation

The first step in hospital drug management optimisation is to analyse needs and constraints of stakeholders, in order to identify the value of the hospital activities for patients and organisations. This lays the foundations of an efficient reengineering of supply chain that reduces healthcare costs without affecting patients (Jarrett, 2006). Regarding to places of drug management and dispensing, it is possible to distinguish between clinical and managerial perspectives. From a clinical point of view, the usefulness of having centralised patient-oriented pharmacy services to deliver professional services to patient (Carroll and Gagnon, 1984) has been recognised. From a managerial perspective, many authors state the possibility to reduce logistics costs using a satellite pharmacy systems (Poley et al., 2004); numerous studies, finally, suggested the benefits of having central inventory control – rather than allowing each department or region to deal with suppliers individually (O’Hagan, 1995 cited in Jarrett, 2006) – particularly in terms of drug waste reduction (Poley et al., 2004). In addition to a centralised point of distribution, however, it is necessary to have a decentralised drug management system to allow nurses to quickly reach stocks in the proximity of places (beds) where services (administration) are delivered to patients. For these reasons, the inventory system is characterised by centralised and decentralised stores (de Vries, 2010), with two type of warehouses: ward and hospital pharmacy. The first one has to deliver drugs to inpatients, the second one is in charge of managing items for inside (to wards) and outside dispensing (to patients).

On the basis of bibliographic analysis and interviews to stakeholders of different hospitals (for dimension and type), we depict the first element of the framework, that is the information and physical flow related to drugs in a hospital. As shown in figure 2, the information flow that leads to drug requirements starts with a patient admission. During this phase, the physician states a diagnostic hypothesis, attributing (with or without a confirmation) a disease to the patient. Depending on resources availability (beds, laboratories capacity, etc.) and urgency, he also assigns a diagnostic and/or therapeutic pathway to the patient. The hospitalisation in a ward can be immediate or delayed according to a queue list (for Inpatient access, Day Hospital, Day Surgery, etc.); in the case a medical prescription (a part of the Patient Medical Record) is made, the patient needs for medicines to be administered during the hospitalisation (by nurses) or at home (in this case, depending on drug typology, drugs are dispensed by the hospital – outside dispensing – or taken from a community pharmacy). Each physical flow corresponds to an information flow that allows medicine traceability (type of drug, expiry date, lot number, etc.), ending with the information storing in the patient medical record. It is important to notice that the use of Information Systems, regardless the drug management policy, can contribute to guarantee patient safety (for example, it can control the match between drug prescribed and administered, avoiding administration errors), to be ready in case of recall and to efficiently manage drug shelf life and expiry date. In figure 2 are also shown the distribution points/warehouses (ward and pharmacy) described previously. Here net requirements calculations are activated: if positives, they determine orders to be released to suppliers (from wards to hospital pharmacy or from hospital pharmacy to external suppliers).
followed by the warehouse upload when stocks arrive (in case of purchasing, this is preceded by Control and Acceptance activities).

Figure 2. Information and physical flow of drugs between/inside ward and hospital pharmacy

2.2 Hospital Factors

Every healthcare system has its catchment area, dimension, capacity to deliver services, layout, etc. Moreover, hospital environment – differently from the manufacturing one – has a strongly variable demand. These characteristics influence the detection of solutions to the drug management optimisation issue because they represent boundaries for the problem. The classification of independent and related dependent variables is proposed in table 1.

Stochasticity and uncertainty of the in/out patients number and the type of diseases are well known in literature (Iannone et al., 2007). Influencing the amount and typology of drugs required to care, they inhibit, at the state of art, the use of efficient techniques of demand forecasts. Moreover, forecast difficulties are strengthened by the drug prescription variability, on equal diseases, due to different clinical condition of patients and professional autonomy of physicians. Finally, drug prescription can be changed during the therapy. Other independent variables are: space restriction in warehouses (that influences the highest quantity of stocked items); drug shelf life (when short, it needs particular attention in the definition of safety stocks – to minimise deterioration costs – and materials handling – to avoid moving expired medicines) and layout (it affects, together with the type of internal means of transport, the time needed to reach wards from hospital pharmacy). Layout is considered as an immutable condition because it is generally defined, in the design phase, on the basis of other parameters, such as position of operating rooms, laboratories, etc.

Table 1. Variables describing hospital environment (hospital factors)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Example of Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients per disease</td>
<td>Drug requirements variability (quantity and type)</td>
</tr>
<tr>
<td>Drug prescription variability per disease</td>
<td>Maximum quantity of drugs stored</td>
</tr>
<tr>
<td>Warehouses capacity storage</td>
<td>Drug wastes</td>
</tr>
<tr>
<td>Drug Shelf life</td>
<td>Transportation time</td>
</tr>
</tbody>
</table>
2.3 Performance Indicators

Performance measurement systems have had great success in healthcare sector, for example with the use of the balanced scorecard (Zelman et al., 2003). They are components of the conceptual framework because they permit to evaluate performances of management policies which are implemented for the inventory system optimisation. The indicators of table 2 may be suitably aggregated (using a hierarchical architecture) and weighted on the basis of the importance attributed by hospital management in order to choose the most performing among different scenarios. Moreover, they may be used to formulate boundaries to the optimisation problem.

Regarding to the hospital pharmacy services, the framework considers only the supply and distribution (logistical) function aspects but not the clinical pharmacy ones (Fowler and Campbell, 2001). Like every service company, also hospital success is related to the service level offered to customers. It is quite easy to understand that quality of medical services is influenced by the availability of medicines for patients therapies (Yurtkuran and Emel, 2008). This availability may seem a very critical aspect of the framework because the objective of inventory management optimisation towards a cost reduction may lead to an overall decrease in inventory levels. Finding a proper balance between quality metrics and costs is one of the main challenges for logistics (de Vries, 2010). Anyway, a distinction between critical and non-critical (for which little delay can be allowed) items can be a starting point to set desired service levels (Nicholson et al. (2004) suggested considering respectively 99% and 90%). In the framework described, service level can be viewed as dependent on the efficient management of the two supply phases, i.e. from pharmacy to ward (service level to patient) and from external suppliers to pharmacy (service level to ward). While in the first case understocking can be solved rapidly in the opening hours of pharmacy, in the second case stockout of pharmacy needs an urgent order for suppliers, which implies time and capital consuming. Another indicator, traditionally used to assess inventory management techniques, is inventory turnover. Economically speaking, it can be seen as the measure of efficiency related to the space occupied by an item. Then there is the combination of inventory levels and incidence of expired drugs. From both cost and quantity point of view, it is the measure of the influence of storage on costs. Finally, the logistic cost related to management policies in terms of personnel and physical resources (inventory costs, transportation resources, etc.) should be calculated.

Table 2. Performance indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Method of evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service level to patient</td>
<td>Ratio of request on supply</td>
</tr>
<tr>
<td>Service level to ward</td>
<td></td>
</tr>
<tr>
<td>Inventory turnover</td>
<td></td>
</tr>
<tr>
<td>Inventory level</td>
<td>Costs and quantity</td>
</tr>
<tr>
<td>Percentage of expired drugs</td>
<td></td>
</tr>
<tr>
<td>Logistics cost</td>
<td>Total drug management cost</td>
</tr>
</tbody>
</table>

2.4 Management Parameters

The conceptual framework describes how physical and information flows of drugs are interrelated and what the characteristics of the environment are. The performance indicators allow to find, in such an environment, the value of the management parameters that are the solution to the drug management optimisation issue. Robustness and reliability of this solution depend on the method used to identify it.

The two fields of intervention which need to be globally optimised are ward supplies and pharmacy supplies. Look-back (for example Re-Order Level, Re-Order Cycle, Just in Time), look-ahead (for instance Material Requirements Planning) or mixed (for example Consignment Stock) approaches can be used. All these approaches can be adopted inside the same healthcare system depending on the item typology (ordering cost, inventory cost, shelf life, demand mean and deviation, etc.). Cluster analysis has to be performed in order to group items that can be similarly managed. For example, galenics may have little or no stock, their components may be managed differently (bill of materials can simplify evaluations).

Look back approach is more popular than the other ones but, notoriously, is characterised by higher inventory levels. Moreover, forecasts on aggregate data about consumptions recorded by pharmacy are
influenced by ward drug management. Look-ahead techniques, instead, need for careful and precise information about requirements forecast. Awaya et al. (2005) state that the first step in this direction is to implement an inventory control tool which links prescription and consumption through an electronic physician order-entry system. Forecast techniques should be used both for requirements of inpatient with a drug therapy (using medical prescription data) and for waiting patient (in a queue) or patient temporarily without a prescription. In these cases, diagnostic hypothesis (expressed through a disease code belonging, for example, to the International Classification of Diseases – ICD or to the Systematised Nomenclature of Medicine – SNOMED) may be the grouping criteria for forecasting of requirements with their variability (using data mining techniques). For Kalmeijer et al. (2003), the extensive use of Information Systems to manage requirements means considering the default medication database as the local stock. Non-stock items are automatically ordered from pharmacy, instead. Another example comes from Dotoli et al. (2010) who consider requirements of patients currently hospitalised as drugs already administered and not present in the pharmacy. They calculate the quantity to be ordered from pharmacy (to wards) on the basis of the average number of drugs that are prescribed for each patient and the number of patients hospitalised in the department.

In table 3 management parameters for both the distribution points are listed. Along with supplying techniques and safety stocks (defined for the drug cluster), there are logistics resources (in terms of personnel and physical resources). Their sizing depends, inter alia, on frequency and quantity of transport from pharmacy to wards, quantity to handle in the central warehouse due to arrivals, characteristics of material handling equipment. All these decisions impact on the resource costs, as pointed out in Section 2.3.

The last parameters are shifts scheduling and opening hours of pharmacy. They can influence internal transport especially in case of look-ahead method. For example, Yurtkuran and Emel (2008) depict a pharmacy unit that operates on a daily basis; during the night shift, pharmacy staff begins to prepare the medication packages.

<table>
<thead>
<tr>
<th>Optimisation fields</th>
<th>Management Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wards management policies</td>
<td>Look-back / look-ahead techniques</td>
</tr>
<tr>
<td></td>
<td>Safety stock level</td>
</tr>
<tr>
<td>Pharmacy management policies</td>
<td>Look-back / look-ahead techniques</td>
</tr>
<tr>
<td></td>
<td>Safety stock level</td>
</tr>
<tr>
<td></td>
<td>Number and type of logistics resources</td>
</tr>
<tr>
<td></td>
<td>Pharmacy shifts and opening hours</td>
</tr>
</tbody>
</table>

3. CONCLUSIONS AND FUTURE PERSPECTIVES

This paper presents a conceptual framework for drug management optimisation in hospitals. To this purpose, it describes a representation of physical and information flows related to drugs in a hospital, the variables related to the hospital environment, the management parameters useful to reach the drug system optimisation and the performance indicators to measure efficiency of approaches.

This study is the starting point for future researches. It makes it possible to test the benefits on hospital system of all optimisation techniques successful in services and manufacturing environments. Topic of discussion can be the effect on global performances of safety stocks centralisation, substituting them in wards with an efficient mechanism of “real-time” replenishment from the pharmacy. Theoretically, this can allow a balance among consumption forecast errors of wards – in similar demand conditions for each ward, the centralised stock is calculated using Maister’s “Square Root Law” (1976). In this way, wards can obtain advantages in terms of releasing spaces occupied by stock and reducing management difficulties related to the control of a high number of items. The concept may be extended from one hospital to others belonging to the same region, shaping a constellation of hospital systems (Falivene et al, 2010). This configuration would be constituted by a central warehouse and a number of decentralised virtual warehouses (hospital pharmacy) able to be, depending on the real consumption, also mutual safety buffers. It would lead to quantity discount benefits and a decrease in inventory costs.

Complexity and stochasticity of variables that describe the issue can be handled with simulation techniques, widely adopted in facility design (emergency departments, operating rooms, etc.), staff planning
and scheduling and bed capacity management. Pharmacy management studies are too few compared to those stated above (Yurtkuran and Emel, 2008). The research can be oriented to reproduce the mechanism of requirements evidence and management. It can be used at first to test ex-ante impact and criticalities of management parameters, then to find their optimised value.

REFERENCES


ATTITUDES AND OPINIONS OF PEOPLE WHO USE MEDICAL SERVICES REGARDING PRIVACY AND CONFIDENTIALITY OF HEALTH INFORMATION IN ELECTRONIC ENVIRONMENT

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ABSTRACT

In health services, it is a necessity to keep records of patients. Although paper-based records are commonly used for this purpose, they are not as convenient as computerized records. Therefore, many health facilities have recently started keeping patient health records in electronic databases. However, questions about confidentiality and privacy of these records have been raised with this new system. This study aims to investigate the opinions and attitudes of people who use the health services of Turkey about the privacy and confidentiality of EHR. The survey method is used in this study, and 596 participants from 64 different cities in six geographical regions of Turkey have participated in the survey. The findings showed that people feel comfortable about computer usage in health-care but they are concerned about the privacy and confidentiality of their information and also they are not sure if their medical records are safe and secure. Moreover, they are mostly unaware of current regulations related to information privacy in Turkey.

KEYWORDS

Privacy, confidentiality, information privacy, EHR, Turkey

1. INTRODUCTION

Before an information system is used, being sure about the fact that the protection of integrity and confidentiality of the patients’ information is essential (Smith and Eloff, 1999). In the early 21st century, ethical concerns for the privacy of the medical records became a controversial issue (Tracy, Dantas and Upshur, 2004), when the information technology and electronic records terms were mentioned, and concerns about the security of them emerged.

There is a myriad of resources about information privacy in the literature. Privacy of health information, of course, is in demand among all types of information (Kalra, 2006). According to a literature review study about medical confidentiality (Sankar, et al., 2003), there were 5746 articles found only in MEDLINE (1966 to March 2001) and BIOETHICSLINE (1980 to March 2000). After an elimination process 110 studies about the patient perspectives of medical confidentiality have remained. However, none of those papers originate from Turkey.

The purpose of this study is to reveal the level of awareness and concern of the people who use medical services of Turkey about their medical records stored in electronic environment. A questionnaire was presented to the people who lived in different parts of Turkey and four research questions were prepared for this purpose. Answers to these questions will clarify the awareness and concern levels of the participants.

The research questions are as follows:
1. What is the level of concern, trust, comfort and tolerance about their health information stored in a computerized environment for people using health services in Turkey?
2. What are the participants’ perceptions and experiences related to electronic health information?
3. Are people aware of the laws and regulations in Turkey about information privacy?
4. Are there any differences in concern levels between genders?

2. METHODS
The study is a descriptive study and its aim is to investigate the attitudes and opinions of the people who use medical services of Turkey about privacy and confidentiality of health information in electronic environment.

2.1 Participants
In order to figure out the opinions and attitudes of the people who live in different geographical regions of Turkey, the questionnaire was delivered to 694 people from six geographical regions and the responses of 596 people (279 women, 317 men) from 64 different cities in six geographical regions of Turkey were included in the analysis process. Data collection was performed with two different methods:

- **Online survey**: The questionnaire was accessed by 594 people via the Internet. Seven of the subjects did not fill any of the questions and 69 of the subjects had too much missing answers so they were eliminated and 518 useful online subjects remained.
- **In-person survey**: 100 paper-based questionnaires were distributed but only 80 of them were returned. Two of the subjects were eliminated; one did not answer too many of the questions and the other participant’s age was not appropriate for the survey (15).

The average age level of the sample is 28.63 (± 9.12). The sample is dominated by undergraduate (67.8%) and graduate (19.5%) levels. Health status of the participants is mostly average and above. The responses for the items about computer ownership and ability show that the sample’s interest in computer is generally high. “Don’t know” (3%) and “Under the average” (3.9%) choices are only a total of 6.9%.

2.2 Instrumentation
A questionnaire was developed specifically for this study. There are 20 questions in the questionnaire and seven of them were inspired from two different surveys; Privacy Survey: What Canadians Think (EKOS Research Associates, 2007) and Medical Privacy and Confidentiality (Princeton Survey Research Associates, 1999).

The language of the instrumentation was chosen in participants’ native language, Turkish. The study instrument has three different sections: Demographic information, Level of concern, Awareness about laws and regulations.

2.3 Data Analysis
In the study, descriptive statistics was given by frequencies with numbers and percentages. Standard deviation was calculated for the only continuous variable (Age) in the study. Chi square test was used to figure out if there were any differences between genders. Reliability analysis, Cronbach’s alpha, was performed in this study to calculate internal consistency of the scale. The results of the analysis should be at least 0.7 or above in order to talk about a consistency (Pallant, 2007). In the study, it is calculated as 0.814.

3. RESULTS AND DISCUSSION
There are three questions related to the patients’ experiences in the instrument. According to the results, there are five participants (0.8%) who have experienced an inappropriate conduct or release of their medical records without their consent. There is a quite big percent of the respondents (12.5%) who avoided being tested in case someone might see the results. Moreover, nine of the participants (1.5%) asked their doctors to write a less embarrassing illness into their medical records instead of the actual condition. There are five
questions in the questionnaire in order to find out the concern levels of the participants about computer usage in healthcare. 66.3% feel comfortable about computer usage in healthcare and the people who feel uncomfortable are 7.2%. Most of the participants (64.4%) are not sure as to whether or not their health information is safe and secure.

Women and men have significantly different views (p=0.001) about if the current health information which exists about them is safe and secure. Unlike women, men do not think that their medical data are safe and secure (See Figure 1).

![Figure 1. Bar graph of the comparison between women and men on their opinions about their medical information’s security](image)

Answers of the question about being concerned with invasion of personal information in Turkey are “Yes” with vast majority (68.5%). “Not concern” choice has only 11.4% and the rest of the participants (20.1%) did not think on this topic. According to the respondents, disclosures by people with authorized and unauthorized access are both equally dangerous for the privacy and confidentiality of electronic health records (61.6%). 28.5% of the participants believe that the second biggest danger is “Disclosure by people without authorized access who break into computer systems”.

There are seven questions about the laws and regulations in Turkey. Questions arise as to whether they are aware of their rights, whether they have any concern about existing circumstances in Turkey and about which kinds of modifications they want to be done so as to reduce their concern. According to the results, a big majority of people chose “Don’t know” choice for all these three items. This means that people are generally unaware about the laws and regulations in Turkey. For detailed answers see the Table 1.

<table>
<thead>
<tr>
<th>Items:</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
<th>Missing values</th>
</tr>
</thead>
<tbody>
<tr>
<td>As far as you know, do you have rights to reach your medical records and to demand modifying or deleting them in Turkey?</td>
<td>47 7.9</td>
<td>151 25.3</td>
<td>398 66.8</td>
<td>-</td>
</tr>
<tr>
<td>As far as you know, are there any laws in Turkey which prevent your medical data from being used without your consent?</td>
<td>76 12.8</td>
<td>97 16.3</td>
<td>423 71</td>
<td>-</td>
</tr>
<tr>
<td>As far as you know, are there any regulations in Turkey which prohibit reaching medical data via internet?</td>
<td>41 6.9</td>
<td>134 22.6</td>
<td>418 70.5</td>
<td>3 41</td>
</tr>
</tbody>
</table>

T.C. ID number is a unique identity number that every Turkish citizen has and it was recently started to be used for medical data storage in Turkey. There were two questions about T.C. identity number usage in the instrument. Of all the participants, 327 (55.1%) of them have concerns about T.C. ID number usage in medical data storage and 370 (62.1%) of the participants prefer a special number for this purpose.
3.1 Discussion

This study presents a large overview on thoughts of people who use medical services in Turkey about computerized medical information’s effects on privacy and confidentiality.

According to the participants’ experiences, very little percentage of people or a member of their families experienced a serious breach of their health information. In the results of the survey in Canada, this percentage is four times more than Turkey (EKOS Research Associates, 2007). Moreover, the percentages of the people, who have asked a doctor not to write down their health problem in their medical records, or have asked the doctor to put a less serious or less embarrassing diagnosis into the record than was actually the condition, in USA are two times more than the percentages in Turkey (Princeton Survey Research Associates, 1999). However, the percentage of the people, who prefer not be tested because of their concern about that others might learn about the results, in Turkey is , very high, six times more than the percentage of the people in the USA (Princeton Survey Research Associates, 1999). Also, for the results of a literature review study, which review lots of papers published about this topic, patients tended to postpone or give up the treatment, or change the inception or the total story of their illness because of the concerns about confidentiality (Sankar, et al., 2003). These results can be interpreted that a lot of people are afraid of breach of their medical records in Turkey as well and even more. Therefore, they choose wrong methods in order to avoid it. To do so, most of the people abstain from being tested. This result is the most alarming finding of the study and it should be taken under control immediately. The attitude “refraining from being tested for the illness” can cause irreparable results such as being late for a fatal illness’s treatment or spreading an incurable illness to more people. Hence, necessary measures should be taken immediately by Turkish Ministry of Health such as serious punishments for invasions of medical data or giving patients the opportunity to hide sensitive medical information.

According to the results of the statistical analysis, a big majority of participants do not feel uncomfortable about computer usage for treatment purposes. In the survey conducted in Canada, 73% of the respondents feel also comfortable with computer usage for medical purposes (EKOS Research Associates, 2007). Similar results show that computer usage in medical area do not disturb people in general.

The participants seem uncertain about whether their health information safe and secure in Turkey. In Canada, a similar question in the shows quite different results (EKOS Research Associates, 2007). More participants in Canada think their health information is safe and secure than in Turkey. However, like the people in the USA, participants of this survey have also concerns about the invasion of their personal information (Princeton Survey Research Associates, 1999). Very little and close percentages of people in both countries have no concern (~10%). In the UK the patients also feel uncomfortable about the confidentiality of electronic health records (Carman & Britten, 1995). To sum up, unlike Canadian people, the participants are not sure about the privacy of their information in Turkey and do not feel comfortable about the privacy of their medical information similar to the participants from the USA and the UK.

American people think the biggest threat to the privacy and confidentiality of personal medical records kept on computer-based systems can more likely be access of unauthorized people (Princeton Survey Research Associates, 1999). On the other hand, people in this survey in Turkey mostly see access of authorized and unauthorized people equally dangerous. This result can be interpreted that a big majority of people do not trust even executive people and this is a very big problem, against which the governments should take immediate measures such as establishing new regulations with serious punishments for people or organizations even for public servants that violate medical privacy or requiring doctors, hospital, and other health facilities to set up security systems on their computer and regular audits of them should be done by the government.

4. CONCLUSION

Today, computerized systems are used almost in every area and especially for public services. Health-care is one of the largest areas of usage. Storage of medical data in electronic databases is widely used in Turkey. Necessarily, opinions of the system users should be asked before these kinds of systems are implemented. However, in the literature, there is no example of such research studies conducted in Turkey. In this manner, this study will contribute a lot to the literature.
The public concerns about the current system and awareness levels about laws and regulations will be understood with the results of the study. These contributions will be valuable for inspiring Turkish Ministry of Health to increase the public awareness about the privacy rights and protections provided. Furthermore, laws and regulations about the privacy protections may be broadened and more vigorously enforced to reduce public concerns. A unique de-identified number for medical data storage may be used to prevent invasions and this will help to reduce people's concerns about their privacy.

4.1 Shortcomings and Future Works

The sample size is large enough for comparing many of the groups but some of them still have small sizes. For example, lower educated, older ages and lack of computer literacy groups occupy small percentages of the participants. The main reason for this is that the questionnaire was conducted via the Internet. Because of the need for computer usage, people who completed the online questionnaire were mostly younger ages, higher educated and not surprisingly have a higher level of computer literacy. Consequently, generalization cannot be made for the Turkish public since the sample profile is not a mirror of the Turkish population. Reaching to the elderly and/or lower educated people was necessary in order to figure out the public opinions and to make comparisons between age and education level groups. However, it was not possible not only because of internet usage but also because of complexity of the questions for them. Many of the questionnaires which were filled by these groups were not completed properly or the answers were generally "Don’t know", "Not sure", etc.

Also, as another limitation, because of the new law changes, even if the new laws did not came into force in that time, it is not easy to be sure which laws they referred in their answers. Therefore, this study should be repeated in a few years’ time.

Future studies should conduct a public research and thus they can identify what the public are thinking about the privacy of their health records, and whether they are aware of the new regulations and legislations.

REFERENCES


Reflection Papers
FRENCH E-HEALTH POLICY

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ABSTRACT
France and health system relies on multiple actors such as health insurance (compulsory & complementary), more than 300,000 professionals including general practitioners, pharmacists and laboratories; 4,000 hospitals representing more than a million of employees. In 2000, the World health Organization considered the French health system as the best worldwide. Still, major gaps remain in terms of access due to social and geographical disparities. With a deficit exceeding Euros 11bn, health expenditures grow faster than national wealth. In 2004, the French Government announced a national healthcare information technology (IT) program, composed of: the Sésam Vitale Smartcard and France's Electronic Health Record (EHR). France is one of the forerunners in the European Union designing a legal framework adapted to the use of eHealth with Denmark, England, Estonia, Finland, Norway, Scotland, Slovak Republic and Sweden. This paper gives an overview of the French e-Health Policy till March 2011 concerning the governance of eHealth (1), the deployment of eHealth applications (2) and of the infrastructures (3).

KEYWORDS
Law, Governance, France, Telemedicine, eHealth, European Union.

1. GOVERNANCE
1.1 A New Global Plan
It seems that the development of this lead market, which the European Union has supported for many years, is gaining momentum. In January 2009, President Sarkozy declared that telemedicine is a national priority. Prime Minister Fillon asked legislator Pierre Lasbordes to make national policy recommendations. In November 2009, the French Representative formulated 15 recommendations in his report to the Ministry of Health on e-Health development. The Hospitals, Patients, Health, territories Law (or Bill Bachelot) is the first stage of the Hospital 2012 Plan, launched by French President Sarkozy, which aims at revamping of the French health care system. The bill aims for guarantee a better and equal access to care for all French people, whatever their geographic location. Article 78 amended the French Public Health Code and confirms telemedicine’s legal basis (Art. L 6316-1 of the Public Health Code). A national telemedicine plan will be adopted by the end of 2011.

Another indication of the strong political commitment at the national policy level is the growing establishment of permanent administrative support structures. National competence centers such as ASIP Santé (Agency for Shared Healthcare Information Systems), in France, (or THL, National Institute for Health and Welfare in Finland; gematik in Germany) are increasingly being created. It follows the insight that without such a coordinating and sometimes also directing agency national or regional implementations will not succeed. ASIP Santé is a new eHealth competent authority established with a comprehensive remit. Set up by decree in September 2009, it works towards: 1/implementing the general health information infrastructure addressing the medical, technical and legal requirements in the field, and encouraging its use; 2/producing and promoting domestic and international guidelines, particularly in the area of interoperability (technical and semantic) and security; and 3/designing and deploying shared healthcare IT systems such as the EHR.

This is a milestone in French health reforms of health information systems governance. The reforms seek to consolidate the public management process and thereby encourage the development of health information systems compatible with telemedicine and electronic health records. ASIP Santé’s function is to develop
health and medico-social information systems, and it has therefore begun developing security provisions (including identification, authentication, signatures and encryption) and promoting public confidence. *ASIP Santé* will also create a national information systems framework in consultation with all healthcare stakeholders.

France is also one of the six EU countries that report on actual assessments of the impact of investments in the eHealth domain. As such analyses are expected to lead to an optimization of resource allocations not only with respect to planned investments, but also for already running activities, one can expect more attention to be paid to such socio-economic and change management aspects in future.

### 1.2 Financial Aspects

In December 2009, the Parliament adopted the Social Security Finance Law for 2010. It allows health professionals to receive remuneration for telemedicine medical procedures and authorizes one exception to the physical presence requirement of both patient and general physician for the consulting to be reimbursed, in the event of an e-Consulting (art. L 162-3 (V) of the Social Security Code).

**Disease Coding**

Cost containment and improved quality of care provide the impetus for the introduction of France's new national disease and cost coding system provides the basis for introducing activity-based funding formulae. This depends on the coding system for its clinical evidence base. The first state hospitals began to implement the new system in 2004. The government also plans to use the coding system in disability benefits reform, where it claims doctors have been too ready to grant disability benefit.

**The telemedicine decree**

A government order gives a list of telemedicine medical procedures, their implementation conditions and financial coverage. It was adopted in compliance with the bill Bachelot. This is a recent example of how to tackle the challenge of reimbursement for a concrete application. This decree specifies the kind of telemedicine services to be made available and how they may be reimbursed. One option is to integrate such services into multi-annual contracts which regional health agencies in France sign with healthcare providers. Alternatively, telemedicine services can become funded through a separate fund set up by the social health insurance in order to improve quality and coordination of healthcare (Decree n° 2010-1229 of 19 October 2010 on telemedicine). These funds are also disbursed through the regional health agencies. Another sign that some countries begin to tackle the issue of reimbursement rules for telehealth services is the UK National framework agreement for telecare, which defines a list of telemedicine items cleared for purchase within NHS England.

### 2. DEPLOYMENT OF E-HEALTH APPLICATIONS

#### 2.1 Electronic Health Record

The centre-piece of the French healthcare IT program is its national web-based electronic health record program. The French EHR will deliver patient care and patient safety benefits & cut fraud and save the state Euros 2-3bn per year. According to the forecasting institute OPECST, the cost of rolling out the EHR throughout all French hospitals and general practice surgeries may actually exceed Euros 10bn. The EHR is administered by *ASIP Santé*, responsible for planning the program, selecting vendors and supplier management. The EHR is also overseen by the National Council for Information and Liberty, a government body concerned with civil liberties and data protection. The phase of piloting and testing of concepts has largely passed and the system is being rolled-out since December 2010 like in the Netherlands, where the general practitioners’ record is already in use regionally, but a national federation of data is still pending.

The second component in the French national healthcare IT program is the patient-held *Sésam Vitale-2* smartcard. It will contain a photograph of the user, vital medical details, and a secure patient identifier. Critically, the Vitale-2 will allow patient control over clinical access to patient records, as it will be required to unlock access to the central EHR system, the DMP. The Sésam Vitale-2 card is complemented by the clinician’s professional card. This is the health professional’s security smartcard.
Regarding patient rights & confidentiality, the Medical Privacy Act of March 4, 2002 details the ownership rights of the patient to his or her data. The transmission of personal information is authorized only between health professionals treating the same patient, and only with patient’s prior consent (art. L 1110-4 of the Public Health Code). The EHR has been the subject of controversy in France, with an appeal to the Council of State to declare it unconstitutional. The Council rejected the claim, but the government has instituted greater safeguards subsequently. Clinicians cannot access a patient’s overall medical record. Each health professional is only authorized to view areas strictly relevant to their professional interests. This authorization is contained in the clinician’s professional card, which must match the authorization levels and codes held in central security servers. Implementation of a regional EHR, accessible through Web services, will be the responsibility of the regional health agencies.

### 2.2 The Pharmaceutical Record

This professional tool is developed on the basis of the EHR by the National Council of Pharmacists (art. L 161-36-4-2 of the Public Health Code). It aims at centralizing data on all medicines dispensed to each patient, and, subject to strict confidentiality conditions, to make it accessible from any pharmacy. The Pharmaceutical record will allow pharmacists to fight drug induced accidents and redundant healthcare.

The introduction of electronic pharmaceutical services usually requires that specific legislation be passed. In France the law n° 2007-12772 introduced a pharmaceutical record for every beneficiary of social health insurance. Contrary to the nation-wide electronic health record, which is opt-out based; the pharmaceutical record is optional and is thus opt-in based. The patient has the right to refuse the update of the record with specific drug information, refuse access to it, and close it.

### 2.3 E-Prescription

In France, the Health-care Insurance Act allows prescription by email only after the healthcare professional has performed a prior clinical examination (Healthcare Insurance Act n°2004/810).

### 3. E-HEALTH INFRASTRUCTURES

#### 3.1 Professional e-Card

The interest to use eCards as a token for professional ID and as access means to eHealth systems has increased considerably in recent times, from only 7 countries reporting such activities in 2007 to 18 in 2010. The healthcare professional card in France is currently shifting from being based on an older numéro ADELI (Automatisation Des Listes), a 9 digit identifier for all healthcare professionals including social workers and psychologists - which is composed from administrative data and stored currently on the healthcare professional card (CPS) - towards a system where the ID is provided through a recently installed “Distributed repository of healthcare professional data” (RPPS). The distribution of the new eCard for healthcare professionals, which provides higher ID security through electronic access to the RPPS, has already begun for certain groups of healthcare professionals such as hospital doctors. ASIP Santé plans to distribute 800 000 new cards to health professionals (including pharmacists and midwives). The health professional shared directory ensures the reliability of personal data contained on the cards.

#### 3.2 Standards

A key driver of developments in this field is the global International Health Terminology Standards Development Organisation, IHTSDO (SNOMED CT - systematic nomenclature of medicine, clinical terms). France is one of the few countries that have translations of older versions of SNOMED (like Hungary and Germany) and is discussing possibilities for transition to present SNOMED CT.
3.3 Storage

Three storage types of EHR systems may coexist: centralized, decentralized or host-based. France is the best example of a country that went with this third option: a host-based EHR system. French users are free to choose a data-host for their health record. As prescribed by the French Decrees on Data Hosts (Decree on Data-hosts dealing with health related data, 4 January 2006) and Confidentiality (Decree on Confidentiality, 15 May 2007), data hosts can only deal with health data after having obtained certification.

4. CONCLUDING REMARKS

Numerous new eHealth applications are developed but only a few are perpetuated, partly due to legal uncertainty (European Commission, Internet of the things – An action plan for Europe, 2009). Some of the legal barriers identified towards the predictive health market are: the application of personal data protection legislation, liability issues (i.e. civil liability for defective goods or products, but also for medical services and advices), intellectual property rights and jurisdictional uncertainty. Another objective will be to clarify the general legal framework since legal certainty is a pre-requisite for businesses to invest in innovation and for providers and users to take up new products and services. Legal issues that remain unresolved will constitute potential impediments to eHealth services uptake.

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DATA QUALITY ANALYSIS FOR E-HEALTH MONITORING APPLICATIONS

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ABSTRACT
Nowadays, technological improvement has been a motivation to develop new healthcare programs and approaches to better assist chronic patients. E-Health monitoring refers to a continuous observation of patient’s condition (physiological and physical) traditionally performed by one or several body sensors. Data coming from such sensors are then transferred to a server, then monitored, processed and accessed by medical experts. In this kind of applications, very important actions and decisions are based on sensed data (as remote diagnosis, consultations, emergency intervention, hospitalization, etc.) and thus a high level quality of data is essential to manage healthcare effectively. Data quality in this domain is an important issue that has to be addressed. Data Quality, being important part of information management, helps to ensure the correct processing of collected data as well as the appropriate interpretation and intervention of medical services. In this paper we explore the issues that define data quality in e-health applications.

KEYWORDS
Data quality, e-Health applications, medical monitoring, health informatics

1. INTRODUCTION

In medical domain, the improvement of ICT (Information and Communication Technologies) strongly helps to provide better quality of healthcare, using for example, high-technology sensors (i.e. pulse, body temperature, ECG, etc.), wired and wireless communications technologies, real-time data processing, interactive interfaces, etc. This improvement introduces “e-Health” which is considered actually as a primary engine to assist patients and which combines the use of electronic communication and information technology with the use of digital data transmitted, stored and retrieved electronically, both locally and at distance.

The monitoring of patients’ condition with chronic diseases is now possible by continuously recording and processing their vital signs or activity every day. Traditionally, data coming from patients sensors are transferred (at real or differed time) via wired or wireless communication to a server and being analyzed, monitored and managed by medical professionals. This kind of applications enables to capture precisely atypical symptoms or activities at any time, and providing accessibility of the healthcare independently of geographic location. Patients can be monitored at their natural environment (Varshney, 2007).

However, the management of data in this kind of systems is becoming increasingly complex. Sometimes decision makers (medical experts or professionals, users…) are confronted with inaccurate, incomplete or too much information. As a result, more and more questions concerning data quality, security and privacy in this domain arise. Ensuring the quality of data in healthcare domain remains a critical aspect, if data quality is ignored, collected information may have a considerably negative impact on the achievement of the application and decision making. For e-Health monitoring applications, the problem is particularly more difficult to avoid due to the criticality of the domain. In this paper, we claim that data quality concerning patients’ monitoring and assistance cannot be neglected. We introduce an analysis of data quality issues in this particular domain. This analysis is associated within a project, grouping industrial and academic research teams, users and manufacturers.
2. E-HEALTH MONITORING SCENARIO

In order to better integrate healthcare systems between patients and medical services, more and more patient-centric approaches are exploiting pervasive and ubiquitous infrastructures allowing patients to be an active part of their own healthcare (i.e. Medic4you, Health Guide, Medmobile...). We base our analysis of data quality on a current research project which proposes a monitoring for patients with chronic pathologies requiring continuous surveillance and medical assistance (Figure 1). This project proposes to integrate a secure medical monitoring (using IMDs – Implant Medical Device) with wireless transmission allowing a complete mobility of a patient (i.e. using a Smartphone) and being continuously monitored by medical experts. Also it is associated to the development of a data hub (i.e. MicroSD card) and to dedicated Human Machine Interfaces (HIMs) opening new perspectives for e-Health monitoring applications.

![Figure 1. e-Health monitoring application](image)

The scenario that we explore in this paper is the monitoring of patients with cardiac problems and equipped by with a cardiac IMD. First it is necessary to establish a communication between the IMD and the external programmer at medical center (hospital or clinic) during the IMD implantation. This communication is essential in order to setup the device and prepare it to follow-up data (FU – data collection). In fact, during the implantation the parameters of the IMD are fixed allowing monitoring the device. Next, in this use case, two patients monitoring are considered: one in real-time which can be continuous, triggered or on-demand and a second one in differed-time (at FU for instance). In both cases, the sensed data can be pre-stored and pre-processed at implant side, several warnings and pre-diagnosis can be programmed at this point. Collected data is then transferred via 3G/GSM/GPRS (en real-time or a posteriori) to a back-end server for much complex analysis and processing. Moreover, some consultations over the year are scheduled with the patient. These consultations (routine, triggered by warnings or on-demand) are principally oriented to follow-up data, control the implant and verify patient’s condition. Regarding traditional healthcare applications, these consultations can be performed remotely and a constant monitoring can be also associated. Nevertheless, the introduction of IMDs, mobile devices, wireless communication and others comes with some quality, security and privacy issues. More and more medical experts are confronted to a lot of information, sometimes inaccurate or incomplete. If data quality is ignored, acquired information may have a considerably negative impact on the achievement of the application and decision making.

3. DATA QUALITY IN E-HEALTH MONITORING APPLICATIONS

In the last years, technological improvement opens new possibilities to healthcare and practice medicine, but carries some inherit risks and leaves decision makers with numerous unanswered questions about quality, security, privacy, ethics, risk management and other important matters. Some surveys and approaches have showed the importance of data quality for end-users, in particular, in healthcare domain (Shaw et al. 2009). Many quality criteria have been proposed without a general consensus; in fact each domain has its specific vision of data quality as well as the solutions to solve the quality problems (Wang et al., 1996). Data quality is often considered as "fitness-for-use", it is based on the specific use of data and the requirements to be satisfied.
To tackle this issue, based on existing quality modeling approaches (Wang et al. 1996), (Naumann et al., 2000), (AHIMA, 1998), we propose to analyze the e-health monitoring systems according to appropriate quality criteria. Such strategy aims to manage data quality at every point along its transition minimizing poor data quality spread.

3.1 Impacting Data Quality

To correctly identify data quality issues, we have firstly to identify the source of the quality problems, analyze its impact and, where possible, propose a solution. In our particular application domain, there are many contextual reasons why it is difficult to maintain a good quality of data. Some difficulties are related to technology (i.e. equipment, QoS (Quality of Service), to human intervention (input errors, misunderstanding...), or to process of data transformation (i.e. optimal analysis and processing). Consequently, we study the characteristics of e-Health monitoring applications according to data flow (from data source until destination) and we try to determine where, when and how an impact over data quality happen. For this, we define three main levels of data management and processing over the system (Figure 2), defined as: Data collection (sensor data collection, pre-processing and transfer), Data processing (data processing, storage and delivery) and Data discovery (data access, enhancement and discovery).

![Figure 2: Data management and processing levels](image)

We believe that the context in which data are collected (Data Collection level) is a crucial aspect to be considered for data quality assessment. At this level, the quality of data can be impacted by the rate of data collection (too fast, too slow...), the correct performance of body sensors (battery, sensors life time, setting...), the quantity of data to be pre-processed and transferred (i.e. respecting data quote) as well as the quality of communication (broadband, frequency...). We claim that at this level it is necessary to implement a quality procedure in order to validate or qualify data and its context, before they arrive to back-end servers or before they are discovered by the users. For example, if several warnings are triggered from a critical pre-diagnosis at patients’ side, we have to ensure as accurate as possible the data transmitted to medical services or the patient itself. In this kind of applications, patient can be also allowed to monitor himself in real-time and thus any information with poor quality can impact its behavior.

Data processing level refers to all the processes responsible to transform and store sensed data. Thus, at this level more analysis and data enhancement can be performed. As we show in figure 2, the processes are executed at back-end server which is also considered as a data repository. Sensed data are then integrated with more heterogeneous data as EPRs (Electronic Patient Records), medical images, videos, etc. which are normally provided by external sources as medical services or others. In such a case, we are confronted with more information often provided manually and with inaccurate or incomplete information. It is also important to guarantee the data accessibility and the respect of privacy constraints. Data has to be as available and freshness as possible in order to provide a performing monitoring, also only allowed persons has totally or partially access to certain information. We think that current quality approaches at the domain of DIS (Data Integration Systems) or DW (DataWarehousing) can be adapted to evaluate and control data quality at this level. Finally, at data discovery level, the system has to guarantee a good decision making based on reliable and secure data. We estimate important to control the quantity of data communicated to the users as well as the quality of the representation (i.e. consistency, understanding, etc.). Users (not always experts) can be confused with too much information and by the way as information is represented and communicated.
3.2 Towards Data Quality Criteria

We observe that in medical domain the big picture of data quality is generally illustrated by the accuracy and reliability of data. The more accurate and reliable data is, more confident and relevant decisions will be taken by the actors (patients, medical experts, medical services). However, we estimate that on our context other complementary perceptions of quality are also necessary. Data availability, completeness, freshness and others are also important to certify the accuracy and reliability of data. Our perception of data quality is related to a set of quality dimensions referring the characteristics of data processing and management levels over the system, associated to several quality criteria and to a quality evaluation procedure. Thus, in order to define the optimal quality criteria, we decide to analyze, at first place, the pertinence and usefulness (or applicability) of the basic and most used quality criteria (i.e. (AHIMA, 1998)) as: Accuracy, Precision, Accessibility, Currency or Freshness, Consistency, Relevancy, Comprehensiveness. Comparing the specificities of e-Health monitoring applications and the goal of each quality criteria, we found some important correlations. In this paper, we focus specially on underlying the quality criteria principles over data collection.

Considering accuracy for example, it is necessary to specify how valid and error free are data coming from body sensors, particularly to ensure integrity, validity and reliability of all the collected data. Together, precision contributes to complete data validation. Data can be not accurate but precise enough to ensure data reliability. Thus, some ranges and categories describing data precision have to be defined. Besides, these collected data (after a pre-processing) must be available as necessary. Thus, accessibility must ensure to provide legal access as well as the required amount of data according to users description, goals, etc. Currency guarantees data up-dating. Definitions for currency or freshness for each type of obtained data must be determined (i.e. data are up-date within 2 seconds, 2 hours, 2 days). Also, regarding the characteristics of sensed data (raw and pre-processed), we have to ensure their consistency to data specifications and goals.

4. CONCLUSION

This paper describes an ongoing research dedicated to analyze data quality issues in a critical domain as e-Health monitoring. We note that this is a first attempt to analyze and define data quality in this kind of applications, and naturally this aspect requires further investigation from the research community. For example, modeling users and system requirements and associate them to quality evaluation methods, algorithms and procedures. Also, we note that the quality criteria presented previously are the core of data quality approaches but they are not exhaustive. Since the most part of quality criteria depends on the specificities of the environment and the user requirements, we plan to adequate other perspectives of quality as Quality of Service (QoS), especially on data collection level.

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PROVIDING TECHNICAL AND SEMANTIC INTEROPERABILITY FOR INTEGRATED HEALTHCARE USING AN IHE-COMPLIANT SYSTEM

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ABSTRACT
Integrated, round-the-clock patient care is becoming one of the key topics for IT applications in eHealth. This paper discusses how to achieve technical as well as semantic interoperability for integrated healthcare. Integrating the Healthcare Enterprise (IHE) plays an important role. The worldwide initiative IHE aims to optimize the interoperability of IT Systems in medicine and healthcare, using international standards. Documents, based on the Health Level Seven Clinical Document Architecture (HL7 CDA) standard, which can be electronically exchanged between healthcare systems, represent an integral part in a comprehensive solution. Since uniform semantic standards are only used rudimentarily in these documents it is seldom possible to directly compare, check (on plausibility, correctness and completeness) or integrate document content. Such integration is only possible in consideration of semantics and domain specific differences. An example for efficient data exchange using an IHE-compliant system is presented.

KEYWORDS
Integrating the Healthcare Enterprise, technical interoperability, semantic interoperability

1. THE CHALLENGE OF INTEGRATED HEALTHCARE

The global population faces a rapid demographic change. Countries in the European Union (EU) will be especially affected by population aging (Tivig et al. 2008). This leads to demographic and cultural challenges for Europe (Kühne 2006). However, aging is not only framed as a challenge. The World Health Organization (WHO) views aging as a success story enabled by medical advances but also as a potentially missed opportunity. Thus, integrated, round-the-clock patient care is becoming one of the key topics for IT applications in eHealth (Kurschl et al 2011). In the course of caretaking, care dependent people are often being passed between different care systems: from homecare – sometimes with support of mobile nursing services – to the hospital and, often with a different amount of care required, back home or to a nursing home. They are surrounded by a complex system of a huge number of organizations which are involved in the care process (see Figure 1; Mayr and Lehner 2009). To guarantee integrated care, it is inevitable to provide clearly defined data exchange interfaces for all health service providers to allow effective interdisciplinary collaboration.

Figure 1. Large number of stakeholders involved in care process

Another challenge is the successful combination of models and technologies in integrated healthcare. Thus, the worldwide initiative Integrating the Healthcare Enterprise (IHE) aims to optimize the
interoperability of IT Systems healthcare, using international standards (IHE 2010). Standardized documents, which can be electronically exchanged between healthcare systems, represent an integral part in a comprehensive solution. Current projects like epSOS (epSOS 2010), ELGA (ELGA 2010) and e-Care (Franz et al. 2009a) boost the use of fully structured or at least semi-structured healthcare documents in form of HL7 CDA. But as long as there are no strict requirements for system providers to provide their data in highly granular structures, loads of unstructured data will always exist which cannot be interpreted unambiguously (Wozak et al. 2008).

2. TECHNICAL AND SEMANTIC INTEROPERABILITY

National as well as international initiatives for information integration in healthcare aim at the increase of interoperability of information systems and at minimizing integration efforts. The term interoperability denotes the ability of systems for collaboration. Technical interoperability indicates the interaction of technical components and systems. Semantic interoperability, on the contrary, denotes the interpretation of data, while preserving the intended meaning. It can be achieved using common information models and uniform terminology, thus enabling cross-community interpretation, processing and storage.

Conformance to IHE integration profiles and adherence to suggested standards are preconditions for smooth integration. Three of the most important integration profiles are: (i) Patient Identifier Cross-Referencing (PIX), which supports the unique identification of patients with different patient identities in several domains; for this purpose, patient data are sent from a source to a PIX Manager (IHE 2010); (ii) Patient Demographic Query (PDQ), which defines a central patient register that allows distributed applications to query demographic and case-related patient information (IHE 2010); (iii) Cross Enterprise Document Sharing (XDS), which supports the patient care of several healthcare providers by allowing registration, distribution and access of any documents referring to one patient.

The most important suggested IT standards, besides Digital Imaging and Communications in Medicine (DICOM) for the exchange of images, are Health Level Seven (HL7) with Version (V) 2 and 3 as well as Clinical Document Architecture (CDA). HL7 V2 is primarily used in hospitals for message exchange between well-established systems (HL7 2010). HL7 V3, which is based on the Reference Information Model (RIM) and on the Extensible Markup Language (XML), is used for cross-community message exchange in the entire health sector. CDA as part of HL7 V3 defines the structure and content of medical documents and is used as the preferred document format in the above mentioned projects.

In the health sector, different coding systems are used, which provide a uniform definition of terminology. Examples for such coding systems are ICD, LOINC, SNOMED-CT, among others. Since such coding systems are not always used and fully structured information can therefore rarely be provided, unstructured and only partly structured (semi-structured) information have to be taken into account. Therefore, the various types of information have to be connected to provide semantic interoperability, which is necessary for comparing and checking structured as well as semi-structured data. Current research (cf., e.g., Kilic and Dogac 2009) only consider finely structured CDA data, whereas other work in this research area like (Spat et al. 2007) is limited to fully unstructured free text documents. Also, the comparison of models in one domain has already been successful, as described in (Franz et al. 2009b). But preserving semantic interoperability is required not only in one domain, but across several domains.

3. PROVIDING INTEROPERABILITY USING HEALTH SERVICE ENVIRONMENT MODELS

The approach presented in this paper can be used for structured data as well as free text and semi-structured information stored in form of CDA documents in several XDS domains. Using the structure of CDA documents based on the RIM and document metadata (especially XDS metadata) provided by the IHE-conformant system, health service domain models for structured, non-structured and semi-structured data are derived from a meta model (possibly in connection with further documents). Derived domain models build the foundation for a technical mapping between different models and for the cross-domain integration of healthcare data. These domain models may be compared, checked and completed, where applicable. The results can then in turn be applied to the CDA documents. To support interoperability concerning health data
processing as well as the interdisciplinary exchange of these data among institutions, adequate Health Service Environment (HSE) models can be used (see Figure 2).

A transfer of knowledge over institutional borders as well as among different healthcare services demands a clearly structured language. Therefore, it is necessary to develop a semantic model based on different data models. For nursing care, it could for example describe the content of the care summary, its semantics and interpretation to guarantee semantic interoperability. This requires standardized structures for documents and a common language between the mentioned healthcare service levels.

If a document is based on the data model and the healthcare model is known, it is easily possible to map the document or data to another healthcare model. Thus, it also enables a sound interpretation of the content, to compare different data, find contradictory or incomplete data, and complete or correct the data. The models can also be used to check the plausibility of various values if the model supports similarity values (Franz et al. 2009b). Through IHE compliance, the models provide interoperability across healthcare enterprises. Healthcare data can be exchanged electronically through the data model, and the data can efficiently be combined/integrated and interpreted in context. Furthermore, these models allow the easy integration of further systems and services. Using additional patient information over a long period of time, a personalized health model can be derived. This personalized health model allows the simulation of the medical treatment course.

4. EXAMPLES FOR EFFICIENT EXCHANGE OF PATIENT CARE DATA USING IHE-COMPLIANT SYSTEMS

Currently, several projects are conducted which all focus on the efficient exchange of patient care data based on IHE: (i) The national project Elektronische Gesundheitsakte (ELGA, German for electronic health record) is a project from the Austrian health agency. Its goals are the strengthening of patient rights through better accessibility and availability of medical data by building a uniform infrastructure for eHealth applications. The main target is the creation of a national health information system for people and health service providers. (ii) The European project Smart Open Services for European Patients (epSOS) was started in July 2008 by 12 members of the EU. Its goal is to enable access to patient data over national borders. (iii) The regional project e-Care was started in 2008 by the Upper Austria University of Applied Sciences in cooperation with the IT company x-tention IT GmbH and several hospitals, mobile nursing services, and nursing homes. The development process took two years, in which the findings of described projects and initiatives were considered. Since the transfer of care documentation between the institutions was frequently solely paper-based, an electronic care summary as well as an IT infrastructure for the exchange of documents had to be developed.

5. RESULTS

To achieve our goal of technical interoperability in our project e-Care, we established an XDS affinity domain to allow a group of healthcare enterprises, mobile nursing services, nursing homes and hospitals to collaborate. They now have the possibility to use a common set of policies and share a common infrastructure which enables importing and exporting care-relevant data to specific nursing care documentation systems. As the system is based on IHE technical interoperability with ELGA and epSOS is also possible. The system architecture integrates the analysed systems and assures efficient and secure data
export as well as easy access of stored care summaries (Franz et al. 2009a). If a patient is admitted to the hospital, the caretaker in the nursing home presses a button and the system automatically generates and stores the care summary. The caretaker in the hospital can easily access the stored document using a standard browser. In conformance with the IHE Patient Care Coordination profile (PCC), the care summary was implemented as a HL7 CDA document. Due to the use of different nursing models in care facilities, it was difficult to build a mutual basis of exchanged data. To guarantee semantic interoperability, the document content is based on the analysis of different care documentation systems and defined definitions and categorizations are used.

6. CONCLUSION

The presented example enables healthcare providers to exchange care data in a space- and time-independent way within an affinity domain as well as across domains. If an integrated system is IHE-compliant, it is easy for healthcare organizations to join the affinity domain or to connect another affinity domain like ELGA and allow the same benefits for their clients. Systems like e-Care result in better nursing care for elderly people who require additional care, since they ensure better communication. Patients benefit from the optimized information flow, because nurses are better informed about the patients’ current nursing care status and, thus can be properly treated from the beginning. Through better access to information, reduction of paperwork, and appropriate usability of such systems, a major step towards integrated home healthcare can be achieved. A next step might be to adapt the models so that they improve and refine themselves in a self-learning way using new documents for a patient. Thus, the interaction with domain experts during the transformation process could be reduced.

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A TELEMEDICINE ENVIRONMENT FOR BALKANS

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ABSTRACT

The health situation in Western Balkan countries, especially Albania, is poor and yet improving, as the rest of the Balkan area. The ‘Welfare and Health Cooperation in the Balkans’ project is focused on the health care area in order to optimise resources and increase the quality of Public Health Service.

The system we are developing consists of a communication environment based on state-of-the-art communication technologies and networks for shared management of knowledge. As a result, a network will be created to exchange best practices, and promote innovative learning and training programmes.

KEYWORDS

Telemedicine, web 2.0, groupware, document repository, open document format

1. INTRODUCTION

In the last few years, Albania has undergone a profound transformation, characterised by economic growth and the typical epidemiological changes that accompany any transition phase.

Such economic progress resulted in an inadequate health care system, as the latter also had to adjust to many changes, namely the increasing age of population as well as changes in their lifestyle and, consequently, an increase in chronic diseases and a decrease in infectious diseases.

Through the Lisbon Strategy, the European Union and its member states planned several actions to deal with low productivity and poor social conditions in both European and neighbouring territories. Some actions focus on economic development, whilst some other on welfare and health care.

2. THE PROJECT

The ‘Welfare and Health Cooperation in the Balkans’ project, a part of a European strategic intervention in Western Balkans, is aimed at providing institutional support and technical assistance to improve Albanian Health Services. The project is divided into multiple sub-technical units defined as work-packages.

Public and private Italian partners, such as regional governments and non-governmental organisations, participate in specific work-packages of the project. The National Research Council – Institute of Biomedicine and Molecular Immunology "Alberto Monroy" is partner in the no. 2 work-package, which is titled ‘Health/social planning and Need assessment’. The Institute of Biomedicine and Molecular Immunology – was involved in the project as the implementing partner on behalf of the Sicily Region, and received funding from the Budget of the Sicily Region – namely, Amministrazione presidenza rubrica dipartimento della programmazione, Capitolo di spesa nr. 100328 (Presidency Administration, Heading – Department of planning, Category of expenditure No. 100328).

The availability of cheap computer equipment and modern telecommunication technologies enabled us to implement large-scale telemedicine systems in this area where a new health care approach is developing. Telemedicine is the practice of health care through the support of Information Technology tools, health care professionals and innovative techniques of communication between patient and physician. The Catholic
University of Campobasso carried out an epidemiological analysis choosing the population of Shkoder. Similarly, an epidemiological analysis was made of a sample of Albanian population to identify its main problems in health care provision, and the most evident lack of training in its health care staff. To this purpose, the town of Shkoder and two nearby small towns – about 15 km away from downtown – were chosen as our geographical target. Currently, the country’s communication infrastructure is underdeveloped and not up-to-date. Hence, the choice to include two rural towns was made to facilitate communication between these places and the city, which is still considered as the reference point in health care when it comes to severe conditions.

This choice allowed us to design a solution that can be easily developed in any metropolitan area, be this either equivalent to a province or a large city.

One of the objectives of the work-package is to create an environment for communication, by means of state-of-the-art communication and networking technologies for shared management of knowledge. As a result, a network to exchange knowledge and best practices will be set up.

During the preliminary phase of the project, questionnaires were administered to health care staff from the countryside. More specifically, the questionnaires were administered to a group of 30 general practitioners and nurses in the age bracket 27-65, geographically distributed between urban and rural areas. Results of questionnaires showed that both groups of health care professionals had specific learning needs in several medical subjects. Moreover, they generally require to refer to a specialist consultation if they have to examine a patient with a particular disease. According to the results obtained from the questionnaires, the system developed was specifically focused on topics such as diabetes, cardiology and urology.

The platform enables effective cooperation between distant project participants, besides laying the foundation to establish a specialised knowledge base on which training courses and/or continuing medical education can also be provided.

Key features of the system are:

- Easy data entry by operators;
- Categorization of data entered by tagging;
- Consistency of search results with respect to the parameters;
- Establishment of a groupware between users;
- Creation a public web site where to publish information of public interest.

Knowledge Base is one of the system components that allows users to add useful content for staff training. Moreover, this section contains web pages that patients may browse to find information to treat diseases and guidelines about healthy lifestyles.

Wiki is another section where operators can keep an archive of best practices on various medical subjects.

3. TECHNOLOGIES USED

A system of resource management allows operators from peripheral health centres to reserve resources, i.e. diagnostic and therapeutic equipment, which are usually available only in hospitals located in urban areas.

The communication environment that uses Web 2.0 technologies to access the database is also available for access by ‘mobile’ devices, such as PDAs and smartphones.

Health care facilities in rural municipalities were provided with multimedia workstations equipped with a printer so as to give each health care centre the opportunity to access the software. Facilities in Shkoder had already been equipped with workstations to access the Intranet. Furthermore, to ensure mobile access, we provided two HTC 7 Mozart smartphones equipped with Windows Mobile 7 operating system. These devices provide access to the Intranet via Wi-Fi connection, available in all health care facilities, and available in almost all the surrounding areas through UMTS / GPRS.

Moreover, the availability of broadband access, such as Wi-Fi, UMTS or 4G, made it possible to have a fast connection to the server.

The system was created by using an open source software. The server was equipped with the Linux operating system Debian 5.0, Apache 2 web server with support for PHP5, and the MySQL 5.0 database server. ‘KnowledgeTree - Community version’ was used as a document repository.

The latter allows users to store documents by making them immutable as required by law. It is also useful for producing documents thanks to a workflow system that helps engage multiple users in document editing.
The collaboration system between health care members is based on the eGroupWare software, which is available in a GPL version too. In order to make useful content for the staff immediately accessible, eGroupWare has been customized from his production version. It provides a shared address book, bookmarks that record a lot of institutional sites, and a resource management system to reserve and coordinate the use of resources such as medical equipment. Moreover, a website accessible to all Internet users was also set up, which contains information about treatment and diagnosis of diabetes. Along with tobacco smoking and heart complications, this disease is one of the main health issues for the Albanian population.

4. CONCLUSIONS

After a six month trial period, the system’s impact of use will be evaluated through the administration of questionnaires. Results will be compared with the previous ones obtained.

During the design phase of the project, it was envisaged to implement the same or similar systems in other countries. Hence, many planning choices were taken with the aim of making the system scalable both in terms of users and geographic distribution.

REFERENCES

Posters
AN APPROACH FOR SLEEP ASSESSMENT USING BODY MOVEMENT

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ABSTRACT
In recent years, it is known that children’s behavioral disorders are related to sleep disorders. Thus it is important to assess the children’s sleep. It is said that there is a tight relationship between sleep stage and body movements. This study focused on the relationship to assess the sleep quality. Hence, we investigated the body movement measurement technique using video analysis. We can measure the body movements in noninvasive and noncontact way by using this technique. We applied this technique for assessment of Obstructive Sleep Apnea Syndrome (OSAS) therapeutic efficacy. We calculated the amount of body movement by video analysis. And we compared the sum of body movement before OSAS treatment and after. As the result, the sum of body movement decreased significantly after OSAS treatment in patients whom OSAS was completely cured. However, the sum of body movement did not decrease after OSAS treatment in patients whom OSAS was not cured. This findings show the possibility that children’s sleep could be assessed by this technique.

KEYWORDS
Sleep assessment, Body movement during sleep, Video analysis, OSAS (Sleep Apnea Syndrome)

1. INTRODUCTION
Recently, the number of children with sleep problems has increased but children do not usually complain of sleep (Sheldon, 2005). Therefore it is important to develop tools to assess the quality of children’s sleep. A polysomnogram (PSG) is generally used for evaluating sleep. PSG has high accuracy and it is useful for clinical tests; however, it requires costly equipment. In addition, several electrodes are attached to patients during PSG testing, therefore PSG test is not most appropriate way to assess children's sleep in cases such as home use. To solve these problems, a method for sleep assessment in a non-restrictive and non-contact manner is desirable. This study focused on a strong relationship between sleep stage and body movement during sleep (Kohyama, 2000, Giganti, 2008) and we investigated a body movement measurement technique using video analysis (K.Nakajima, Y. Matsumoto and T. Tamura, 2001). This technique is non-invasive, non-contact and inexpensive. We applied this technique for assessment of Obstructive Sleep Apnea Syndrome (OSAS) therapeutic efficacy.

2. METHOD
Video analysis was carried out using difference processing techniques. The concentration value of each point in a video image changes with the movements of the subject. The change in the concentration value is detected by the difference between two adjacent frames. The video images were transformed to still images, the movements of the subject were captured continuously, and an application to detect changes in movements was developed. The size of the converted still images was 340 pixels (width) × 240 pixels (height). The still images were read successively, and the region of interest (ROI) was specified for high-speed processing. After ROI processing, the image was converted to gray scale, and changes in gray values between frames were detected using image difference processing.
In difference image processing, the centre coordinate before the movement shows a decrease and increase in its concentration value. Thus, we first determine the pixels that show an increase and those that show a decrease in their concentration values. We then calculate the average coordinate positions \((px, py)\) of all the pixels that show an increase in their concentration values. And the average coordinate positions \((nx, ny)\) of all the pixels also show a decrease in their concentration values.

The centre coordinate of the moving subject is determined by calculating the centre coordinates of \((px, py)\) and \((nx, ny)\).

For body movement, we calculate \(G(t)\) as the value corresponding to the distance moved by the body within the image, on the basis of the change in the centre coordinate \((x, y)\) of the moving subject at time \(t\). \(G(t)\) indicates the amount of body movement.

\[
G(t) = \sqrt{(x(t+1) - x(t))^2 + (y(t+1) - y(t))^2} \quad (1)
\]

Four children aged 3-6 years (three boys and one girl) were investigated. These children were admitted with sleep problems, and were diagnosed with obstructive sleep apnea syndrome (OSAS) on the first PSG test. All subjects underwent adenoid-tonsillectomy as the medical treatment and a second PSG was performed in order to confirm the therapeutic efficacy. In all subjects, the second PSG revealed a reduction in the apnea-hypopnea index (AHI) and obstructive AHI. The PSG and video images were recorded simultaneously for each subject before and after treatment. The amount of body movement was calculated through video analysis.

3. RESULT AND DISCUSSION

The amount of movement in each sleep stage for the four subjects is shown in Figure 1. The body movement after treatment in subject A showed a remarkable decrease at every sleep stage compared with body movement before treatment. The body movement after treatment in subject B also showed a reduction in stages 2 and 3 comparing with body movement before treatment; however, there was little decline in stage 4. The body movement after treatment in subject C showed a small reduction at the REM stage; however, the body movement after treatment showed an increase in all the other stages. As for the result of subject D, the body movement did not show any obvious trend before or after medical treatment. The results of subject A and B showed a clear reduction in the amount of body movement in all sleep stage. However, the results of subject C showed a significant increase in body movement after the treatment, especially in stages 2, 3 and 4. He had a severe form of the disease. His AHI indices were 50.8 and 28.3 before and after medical treatment, respectively. This subject was, therefore, not considered to have been sufficiently cured after medical treatment. For subject D, there was no significant reduction in the body movement. This can be explained by the factor: A mild form of the disease (the AHI was only 2.2 before medical treatment).

4. CONCLUSION

We investigated the body movement measurement technique using video analysis to assess the children’s sleep. And we applied this technique for assessment of OSAS therapeutic efficacy. As the result, we confirmed that it could be possible to assess the therapeutic efficacy of OSAS by using body movement measurement technique. However, more cases need to be assessed in order to provide a more definite conclusion.
Figure 1. The amounts of body movement in each sleep stage for all subjects

REFERENCES

INVESTIGATE THE DIFFERENCE BETWEEN ECG PATTERNS DURING SLEEP IN THE SEATED POSITION AND IN THE SUPINE POSITION

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ABSTRACT
The goal of this study is to investigate the difference between ECG (Electrocardiogram) patterns during sleep in the seated position and in the supine position. ECG during sleep was measured under both the conditions. Lorenz plot was used for ECG analysis. Results showed that there was a difference in the heart rates and heart rate variability in the two conditions. Before the subjects fell asleep, heart rates showed the same value in both the conditions, but after the sleep onset, heart rates in the supine position were higher than the HR (heart rate) values in the seated position. Fluctuation was found out to be large in the supine position. These results could be applied for the detection of sleep onset estimation especially in seated position sleep.

KEYWORDS
Seated position, supine position, ECG, Lorenz plot, sleep onset estimation

1. INTRODUCTION
In the current vehicle-oriented society, cars have become one of the most necessary modes of transportation. However, the car accidents are also increasing. Especially, in recent years, there has been a remarkable increase in accidents due to irresponsible driving such as drowsy driving etc. Therefore, it is desired to monitor the arousal state of the driver while driving. It is said that the arousal level, which is used to assess the arousal state can be estimated from the Electrocardiogram (ECG). The cardiovascular system is under control of the autonomic nerve system and it is possible to infer the sleep level by analyzing the heart rate fluctuations. Hence, measuring the heart rate variability during driving and using the results to estimate the driver’s arousal level is useful to prevent accidents due to drowsy driving.

Currently, the researchers have developed the arousal level estimation method using ECG mainly focus upon in the supine position. However, in case of the sleep that occurs during driving, the driver is in a seated position. That is, sleep that occurs in the supine position is in a different condition and can have different sleep onset tendencies as compared to the sleep in the seated position. Hence, the method used in previous studies to estimate sleep level in the supine position is difficult to apply in the seated position. Even if it could be applied, it is possible that we get a low accuracy in determining the sleep onset. Therefore, it is necessary to reveal the characteristics of sleep onset in the seated position. Hence, in this research, we investigate the differences between sleep onset tendencies in the supine and seated positions.

2. METHOD
2.1 Variables Measured
The locations of the disposable electrodes used for ECG measurement were set according to the ECG lead system on the right collarbone and left rib. RR Interval (RRI) and Lorenz plot was calculated by ECG data.
In this research, as a reference of the arousal level, wakefulness was measured from the Electroencephalogram (EEG) and Electrooculogram (EOG). In measuring the EEG, the electrodes were placed at C4 and O2 according to the International 10-20 system. To reduce the effect due to activation of the reference electrode, left earlobe A1 was set as the reference electrode. The system reference and biological ground were set near Fpz. The locations of electrodes for EOG measurement were set as: 1 cm outside the right eye, 1 cm below it and 1 cm outside the left eye, 1 cm above it. These 2 electrodes were attached to the electrode at the left earlobe A1 according to the monopolar lead method. EEG and EOG data were used for Polysomnography (PSG).

2.2 Experimental Method

The supine position sleep experiments were conducted on 5 male subjects (23.6 ± 0.9 years). Measurements were taken for 2 hours in the rested supine position. The subjects were instructed to remain smoke, caffeine and alcohol-free on the day of the experiment.

The seated position sleep experiments were conducted on 5 male subjects (21.8 ± 0.4 years) on a chair in the laboratory. Measurements were taken for 2 hours in the rested seating position. To replicate drowsy driving state, the subjects were put into a sleep deprived state by making them stay up the night before sleep experiments day. Subjects were instructed to remain smoke, caffeine and alcohol-free on the day.

2.3 Lorenz Plot (LP)

RR Interval is the time elapsed between two consecutive R waves. Lorenz Plot is the previous RR Interval (RRIn) was taken as the x-axis and Combined RR Interval (RRIn+1) was taken as the y-axis. It is one of the applications for Holter ECG monitor and has been used for qualitative examinations like checking the frequency of arrhythmia etc. A difference has been seen in the distribution of LP according to age, and the expanse and inflation of the distribution changes greatly as the age increases. In case of a healthy person, almost all points on the LP are congested on the line with a slope of 45° but in case of patients with atrial fibrillation, the LP distribution is very discrete.

3. RESULTS

Fig. 1 shows the RRI in the supine position and in the seated position that were calculated from results of measurement ECG waveform for one subject. Before the subjects fell asleep, RRI showed values near 880 ms in both the conditions, but after sleep onset, RRI stabilized near 900 ms in the seated position as compared to the supine position, which stabilized near 1200 ms (fig. 1). Therefore, the RRI in the supine position sleep are higher than the RRI in the seated position sleep. Furthermore, the heart rate fluctuations in the supine position sleep are larger than the heart rate variability in the seated position sleep. These tendencies could be confirmed in all subjects.

![Figure 1. Comparison of RRI between the supine position sleep and seated position sleep. a) RRI of the supine position sleep, b) RRI of the supine position sleep](image)

Fig. 2 shows the Lorenz plot in the supine position and in the seated position calculated from the results of ECG waveform measurement for one subject. In both the conditions, almost all points on the Lorenz plot are concentrated on the upper right side as time passes (fig. 2). Furthermore, heart rate fluctuations in the
supine position are large, if the RRI become high. In the seated position, almost all points on the Lorenz plot keep on the line with a slope of 45°, if the RRI become low.

![Lorenz plot comparison between supine position sleep and seated position sleep](image)

**Figure 2.** Comparison of Lorenz plot between supine position sleep and in the seated position sleep. a) Lorenz plot of the supine position sleep, b) Lorenz plot of the seated position sleep

4. **DISCUSSION**

Before the subjects fell asleep, heart rates showed the same value in both the conditions, but after the sleep onset, heart rates in the supine position were higher than the HR values in the seated position. Therefore, it can be understood that the heart rate variability is small in the seated position sleep compared to the supine position sleep. It has been known that when a load is exerted on the cardiovascular system, such as during exercise, the heart rate increases and fluctuations disappear. It can be inferred that a load is exerted on the cardiovascular system in order to maintain the seated position, hence decreasing the fluctuations in the heart rate. Also, the heart rate fluctuations during sleep in the seated position are smaller according to the Lorenz plot. Therefore, it can be inferred that there is a difference between RRI and heart rate variability during sleep in the seated position and in the supine position.

5. **CONCLUSION**

In this research, we investigated the differences between ECG patterns during sleep in the seated position and in the supine position. The results showed that there were differences between ECG patterns during sleep in the seated position and in the supine position, particularly in the RRI and heart rate variability. Hence, the method used in previous studies to estimate the sleep level in the supine position is difficult to apply in the seated position. If we attempt to detect drowsy driving, it is necessary to develop a sleep onset estimation method, especially in the seated position. As future research, we plan to develop a system that prevents traffic accidents caused due to falling asleep at the wheel, by monitoring the heart rate and detecting sleep onset while driving a car.

**REFERENCES**

CONTROL OF THE FINGER MOTION BY SELECTIVE ELECTRICAL STIMULATION WITH SURFACE ELECTRODES

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ABSTRACT

Electrical stimulation using surface electrodes is not applicable to the precise FES (Functional Electrical Stimulation) because of the problem such as not to stimulate the inner muscle. In this study a forearm FES system using surface electrodes has been developed. We enable selective stimulation for inner muscle by this system. Eight surface electrodes were attached around the forearm at regular intervals. Finger motion was evoked by the electrical current through one electrode to another electrode. The combination of two different electrical current in the selection of pair electrodes allowed selective inner muscle stimulation. This new system was evaluated by the finger motion when inner muscle was given the selective electrical stimulation. One healthy subject participated in this evaluation experiment. As the results, finger motions were divided into six kinds of actions; the thumb’s flexion, its extension, its radial abduction, flexion of the fingers except thumb, their extension and ulnar deviation of the hand. Furthermore, muscle position mapping was estimated by confirming the relationship between the electrode combination and observed actions of a hand and fingers. These results suggest that the proposed system enables FES using surface electrodes to stimulate the inner muscle selectively.

KEYWORDS

surface electrode, FES, forearm, finger motion

1. INTRODUCTION

In recent years, the technology to rebuild the lost bodily function is attracting attention. FES is a technique that uses electrical current to restore motor function in people with paralyzed extremities. FES system using surface electrodes is less invasive than implanted electrodes. However, electrical stimulation using surface electrodes is difficult to stimulate the inner muscle. In this study a forearm FES system using multi surface electrodes has been developed to solve this problem.

This paper describes the new-developed system for forearm electrical stimulation by using surface electrodes.

2. METHOD

2.1 Selective Electrical Stimulation System

The system is composed of PC, the voltage amplifier and eight surface electrodes. PC controls current waveforms. The voltage amplifier adjusts their current value. Eight surface electrodes (M-00-S, METS) which are disposable are attached around the forearm at regular intervals.

Fig 1 shows the proposed system of selective electrical stimulation. Finger motion was evoked by the electrical current through one electrode to another electrode. The current value of single stimulation is set not to evoke finger motion. The combination of two different electrical current in the selection of pair electrodes allowed selective inner muscle stimulation. The waveform of two electrical currents is same.
2.2 Evaluation Experiment

One healthy subject participated in this evaluation experiment. Subject’s right forearm was experimental object. Forearm rested on table during this evaluation experiment. Two evaluation experiments, single electrical stimulation experiment and selective electrical stimulation experiment, were conducted. At the first, single electrical stimulation experiment was conducted to adjust the optimal current value. At the second, selective electrical stimulation experiment was conducted to confirm the reaction of fingers. The system was evaluated by the finger motion when inner muscle was given the selective stimulation. In particular, we focused on the thumb’s motion because the muscles associated with thumb’s motion were located in the depth of forearm. The experiment was recorded in video and finger motion was judged visually.

3. RESULTS AND DISCUSSION

Table 1 shows the results of single electrical stimulation. The thumb motions weren’t observed at all with single electrical stimulation.

Table 1. Result of single electrical stimulation.

<table>
<thead>
<tr>
<th>input – output electrodes</th>
<th>current value [mA]</th>
<th>reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 5</td>
<td>± 2.8</td>
<td>radial flexion</td>
</tr>
<tr>
<td>4 - 6</td>
<td>± 2.4</td>
<td>ulnar deviation, extension of the metacarpophalangeal joint and flexion of the proximal interphalangeal joint of fingers except thumb</td>
</tr>
<tr>
<td>7 - 3</td>
<td>± 2.2</td>
<td>ulnar deviation, flexion of the metacarpophalangeal joint of fifth finger</td>
</tr>
</tbody>
</table>

Fig 2 and 3 are the results which selective electrical stimulation was conducted. Fig 2 shows the reaction in the selection of pair electrodes; 1-5 and 7-3. The flexion of thumb’s metacarpophalangeal(MP) joint was seen. Fig 3 shows the reaction in the selection of pair electrodes; 1-5 and 4-6. The extension of thumb’s MP joint was seen.

a) estimated current pathway  b) observed reaction

Figure 2. Result in 1-5 and 7-3.
The observed motions were divided into six kinds of actions; the thumb’s flexion, the thumb’s extension, the thumb’s radial abduction, flexion of the fingers except thumb, extension of the fingers except thumb and ulnar deviation of the hand. Muscle position mapping was estimated by confirming the relationship between the electrode combination and observed actions of a hand and fingers. Fig 4 shows the muscle position map. The left shows estimated muscle positions and the right shows the forearm’s cross-section as a target for comparison. Compared the estimated muscle position map with the forearm’s cross-section, muscle positions are similar. Therefore, we could confirm the system has possibilities to stimulate the inner muscle selectively.

**4. CONCLUSION**

This paper introduces selective electrical stimulation system for forearm FES devices. The thumb motion was observed with selective electrical stimulation. Furthermore, we could have confirmed the relationship between the electrode combination and observed actions of a hand and fingers was revealed. Therefore, the proposed system enables FES using surface electrodes to stimulate the inner muscle selectively. In the next step, it is necessary to subdivide the finger motions more correctly.

**REFERENCES**


DICOM TECHNOLOGY IN E-HEALTH SYSTEM

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ABSTRACT
In the past couple of years digital technology came into new fields of the medical area of the large number of producer these equipments have been improved, and the needs for a standard to storing and transferring the medical images have been increased. Digital imaging and Communication in Medicine (DICOM) creates an easier way to transfer medical images and separate them from image`s equipment In addition to imaging data, DICOM file format keeps some other contents (information) that are important to inform the image. With this property, we can use DICOM with an effortless manner, and it becomes faster and secures to exchange the data, but it is feasible until keep away from multiple files in one research. This paper provides an overview of DICOM and trying to explain a puzzling number of image formats that are usually used (found) in the medical symptomatic (diagnostic) imaging and cure applications. And useful properties of different types of image files to be studied and a range of free Web-based resources to help showing an operation of digital images will be checked.

KEYWORDS
Digital Imaging and Communications in Medicine (DICOM), Picture Archiving and Communication Systems (PACS), Medical Imaging

1. INTRODUCTION

During the final part of the last century there has been a great improvement of digital technology. Computers came into most part of our lives, so obviously they get an essential part of the medical applications (get an increasingly importance in medical applications). Nowadays lots of medical imaging techniques that are used generally rely on computer processing. However computers are used to store or show images, but it can create images or 3D models from input sequence of data. Data are achieved from imaging devices which use sophisticated methods, for example: CT\(^1\), MRI\(^2\), PET\(^3\), etc. As a result of these numerous ways in development of medical imaging equipment, that was extremely significant to make a standard for connection and information exchange between different medical devices.

Digital Imaging and Communications in Medicine (DICOM) is a standard that defines (determines) a non-proprietary information exchange protocol. Recent version (3.0) of this protocol is released by NEMA (National Electrical Manufacturers Association) in 1993. Each year this standard develops by the committees that have focused on all of medical branches [1].

2. DICOM IMAGES

Image displaying in DICOM standard does not describe how images are shown or explained. In addition to imaging data, DICOM includes data structures that are significant to the image. The structures in the header that includes the object explanation, patient`s information, name of the organization and other information such methods do or have been reported. Information Object Definitions (IODs) are important parts of data structures. IODs are tables of qualifications that define data objects. Information objects are abstract models of objects in the real world versions, for example, "patient" is information that an object has

\(^{1}\) Computed Tomography
\(^{2}\) Magnetic Resonance Imaging(MRI)
\(^{3}\) Positron Emission Tomography(PET)
"Patient Name" and "Patient Number" as attributes. DICOM standard supports various types of medical images for various programs. Because they often have multiple images with high resolution, large files tend to DICOM [for example, 35MB for pre and post-contrast computed tomography (CT) images of the brain] often before storage and transport, they must be compacted.

For X-ray imaging, concentration images are used, though for some applications of CT images are often used colors. DICOM maintains multi-dimensional images multiframe. Compression-based data compression standard is widely used as photos shared Experts Group (JPEG), JPEG Lossless, JPEG 2000, and moving picture experts group (MPEG - 2) for multiple images (video) series [6, 7]. Different applications require different levels of medical image quality. Mammography images need high resolution, so that compression is used mainly Lossless because small details should be preserved. That is the cause why mammography [2] of image files even if big is grayscale images.

![Figure 1](image1.png)

**Figure 1** (a) mammography image of the whole situation (b) part of the uncompressed image, (c) part of the picture is 25:1 JPEG compression.

### 3. DICOM-VIEWING SOFTWARE

All of the image file types explained above can simply be opened and viewed on different workstations or a standard personal computer (PC) with a current operating system such as Windows XP with no need for any particular software. But DICOM images need extra software to be installed before they can be opened and viewed. DICOM-viewing software falls under two major categories: Proprietary viewers, which are provided with imaging systems such as CT or MRI machines; and third-party DICOM-viewing software, moreover in the shape of PACS or as a stand-alone viewer for single PCs.

#### 3.1 Proprietary DICOM Viewers

Proprietary DICOM viewers incline to be written by the producers of and provided with medical imaging hardware. These devoted workstations allocate dynamic passing through masses of images and lots of higher functions, like Windowing and three-dimensional volume rendering. There is usually the power to send out images to portable storage media (for example, CD-R) or to move images to other networked workstations. Exported files are generally transformed by the proprietary software to smaller files (for instance, JPEG or PNG) that can then observe on a PC without any particular software. one time the DICOM images have been changed to other file formats the capability to view successive images from a sequence, as an interactive stack is misplaced. The danger is that workstations are frequently in stable use in radiology departments, mainly in those that still do not install PACS and little time is accessible to use these for image manipulation uses or for apply in teaching. The beneficiary of third-party DICOM-viewing software can improve this difficulty.

#### 3.2 Third-party Software

In current years many several, third-party, DICOM viewers and also Plug-ins for image processing software, like Adobe Photoshop, have been developed. Thought for admitting reinforcement in image
viewers is to make achievable for patients to view DICOM images at home with no require to send the images with an allocation viewer on a CD-ROM or other media type. There are lists of stand-alone DICOM-viewing packets that are commercially accessible. A number of the most well-liked non-proprietary viewers presented for free download are: DICOMWorks, Osiris and Unviewer as the popular all-format image viewer. Osiris is a full DICOM image workstation and it is not a freeware, but it permits other progressed features also only image and header exhibiting a comparison of the primary features of these example software products is left in Table1.

Table1. Comparative features of some DICOM viewing Software

<table>
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<tr>
<th>Features</th>
<th>Softwares</th>
<th>DicomWorks</th>
<th>Osiris</th>
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4. CONCLUSION

The DICOM is one of the most challenging medical image standards. It is produced to create image data standardized and uncomplicated for sharing among the equipment from different producers. Many workgroups that are collected to extend the standard are separated in a mode so that each workgroup develops only a little specified component of the standard. This organization configuration is very effective, because each workgroup is responsible for different regions with as little aliasing between them as feasible. DICOM standard is developed to make possible an additional enlargement and comfortable improve of some parts that continuously develop. That is a very significant option, because these days imaging standards expand very quickly as well as the medical imaging tools. Even still there are some clear weaknesses, for instance in the case of determining needed data in the headers of images, DICOM has showed to be a very comprehensive and, most of all, useful standard for medical imaging archiving and interchanging. The beginning of the DICOM file format has been a most important action forward in clinical radiology by permitting digital images to be simply stored and transferred by electronic means.

REFERENCES


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ABSTRACT

Hospital information systems (HIS) have begun to be used in inpatient therapy institutions since 1990s in Turkey and showed a very fast development after 2003. Goal of this study is to examine any applications on administrative processes of these existing hospital information systems at hospitals bound to the Turkish Ministry of Health, evaluate the current condition and develop any relevant suggestions for the future. It is a descriptive scanning model and a field study. Any inpatient therapy institutions bound to the Turkish Ministry of Health constitute a phase of this study. In this study, sampling is not selected and all phases are included in the scope of the study. This study is implemented by means of the questionnaires on hospital information systems at hospitals bound to the Turkish Ministry of Health conducted between July and October in 2004, 2006 and 2008.

As a result of this study, it is noted that there are an insufficient number of personnel, HIS directors and operators trained in area of informatics at hospitals. Hospitals should be supported with respect to qualified technical labor trained in area of informatics, and teams must be established immediately to provide hospital directors with any consulting services on technical matters.

KEYWORDS

Turkey, Hospital, Hospital Information Systems,

1. INTRODUCTION

While computer technologies have been used in hospitals, especially with the aim of management and finance since 1940, clinical information systems appear to have emerged in the 1960-1970s (Yazar, 2005, 3)

Nowadays the information technologies are used for effective, quality and low cost service delivery in hospitals and health establishments (Yıldırım, Arıöz, 2005, 153). In recent years, health establishments have accelerated automation studies. Previously, studies which have only started to accelerate and improve the paperwork, in the days that followed they make progress to keep and process electronic medical records including the patients’ clinical information with in the success of using technological developments in health sector (Şenel ve Kaya, 2003:35).

Using the information technologies actively in business brings with it many new systems, applications, new responsibilities and job definitions. Even though HIS initially have been only used for the need of accurate billing software, in the process of time it turns into the process which contains all hospital operations like patient identification, registration records of examination, making appointments, preparing prescriptions and report, transfer the laboratory results, electronic patient records, stock follow-up, management reports and examining the quality of data. At this point, using the common language and code substrutures between hospitals and departments come into prominence.(Rodoplù, 2008, 409,438)

There are several hospital organizational structures in Turkey. Some hospitals are training and research hospitals, some are special hospitals while some are hospitals serving to rural areas. Since the reimbursement between the Social Security Institution and the hospitals are carried out electronically, the focus is on billing. Because of the project of the Ministry of Health on central and individual electronic health record focuses on
medical records. HISs are at different levels and structures in hospitals. Besides the complex HIS structure in Turkey, the Ministry of Health Hospitals are administrated by physicians and their responsibilities are not only medical services but also administrative and technical.

The aim of this study is to evaluate the current condition and develop any relevant suggestions for the future for hospitals bound to the Turkish Ministry of Health by examining any applications on administrative processes of these existing hospital data systems at hospitals bound to the Turkish Ministry of Health.

It is a descriptive scanning model and a field study. Any inpatient therapy institutions bound to the Turkish Ministry of Health constitute a phase of this study. In this study, sampling is not selected and all phases are included in the scope of the study. This study is conducted between July and October in 2004, 2006 and 2008. In the questionnaire full automation system is defined as an integrated automation system consisting of medical records and administrative and financial records. Partial automation system is defined as billing. A few small software are defined as executing human resources, accounting, inventory control etc. Directors, who are responsible for management of HIS, accessed online to the questionnaire at the website of the Ministry of Health by a user code and a password designated to them, and answered the questions. Figures and percentages are used in evaluation descriptive statistics.

2. RESULTS

According to the definitions given in the questionnaire, the distributions of current conditions are given in Figure 1.

Figures and percentages are used in evaluation descriptive statistics.

Percentage of HIS use at hospitals is determined as 30.60% in 2004, 76.99% in 2006 and 87.17% in 2008.

It is determined that 65.0% of hospitals had a HIS Directors in 2004, and this ratio reached up to 96.18% in 2006 and 100% in 2008.

It is questioned that whether there is a technical staff responsible for HIS. It is determined that 37.0% of hospitals has a HIS Technical Officer in 2004, and this ratio raised up to 66.01% in 2006 and 100% in 2008.

The distribution of conditions of Hospital information system in hospitals according to years

Figure 1. The distribution of conditions of Hospital information system in hospitals according to years

Figure 2. The distribution of conditions of having Hospital information system directors in hospitals according to years

Figure 3. The distribution of conditions of having Hospital information system technical officer in hospitals according to years

Figure 4. The distribution of conditions of having Hospital information system directors in hospitals according to their titles
In the questionnaire the titles of HIS directors in these hospitals are tried to determine. It is stated that 82.1% of HIS Directors consisted of hospital physicians, hospital managers and deputy managers in 2004, and this ratio felt down 79.86 in 2006 and 74.41% in 2008.

3. CONCLUSION

Information technology and health information systems have an important role in resolving the problems in the health sector. Hospital executives tend to store electronically all data in the hospitals instead of paper since electronically submitted data could be converted to the desired information anytime. (Ömürbek, Altın, 2009, 211) In order to be set and used successfully HISs which include various components such as hardware, software, operation, technical support and maintenance, development and updating it must be met support to executives at all levels. Hospital executives should clearly express their commitment and support of the information systems (Tsay 1991:357). In the studies which analyzed the administrative processes, the percentage of technical officers consisted of 14.30% in 2008 and 16.85% in 2009 (Ülgü et al, 2008,2009).

As a result, it was experienced a rapid increase in the installation and use of HIS in the Ministry of Health hospitals between 2004 and 2008 in Turkey. Compared with similar studies performed earlier, according to the result of this research hospital executives have showed positive developments in this field by trying to required effort to meet the needs of administrative and technical staff in the field of procurement, installation, operation and management of information technology in hospitals, but it has been drawn attention that hospitals still could not fully resolved the lack of trained staff in the field of information and the lack of technical information in the manager and user staff of HIS. Hospitals should be supported for skilled technical workforce trained in the field of information technology and it should be established payrolls/ positions which will advice to hospital executives on technical issues as soon as possible.

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Book

Journal

Conference paper or contributed volume
AN AUTOMATED MULTI-SENSOR MONITORING SYSTEM OF ELDERLY HOMECARE CLIENT'S ACTIVITY PATTERNS

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ABSTRACT

There is an increasing need to provide home care support to the growing elderly population who want to live independently in their homes as they age. In Canada, homecare expenditure is the second fastest growing segment of the publicly funded healthcare system (after medication expenditures), and demographic trends suggest these costs will escalate significantly over the next two decades. A large percentage of homecare clients live alone and are visited only a few times per week by health providers. This isolation poses unique challenges for health service delivery, including the coordination of information and communication among providers, as well as monitoring of patient status and safety between visits. The purpose of this poster is to present an automated activity monitoring system of home care clients as they go about their daily lives. The focus is on the technological development and challenges based on a multi-disciplinary research project and pilot test. The method involves a unique combination of two technologies: a Bed Pressure Sensitive Mat (BPSM) installed in the bedroom, and a Global Positioning System (GPS) receiver plus 3-axis accelerometer worn by patients during waking hours (embedded in a BlackBerry). This poster will demonstrate how these combined technologies provide a comprehensive 24-hour automated and wireless monitoring of patient's in-bed, in-home, and out-of-home active and sedentary activities. Our recommendation based on focus group discussion with clinicians is to seamlessly present this information as a 24 hour time line or “diary” of events, or as graphically summaries of time spent in various activity types over given day, week or longer. We recommend that this information be presented as part of a graphical user interface on a mobile computer to support a point-of-care decision support system for home health care providers. We expect that the homecare environment of the future would be well served by monitoring technologies that are as passive as possible and do not overload patients or their home with multiple devices.

KEYWORDS

Elderly, remote monitoring, daily activities, sleep, decision support.

1. INTRODUCTION

There are two compelling trends that must be addressed in healthcare planning; one related to the impact of demographics on homecare, and the other to emerging health care technologies. Firstly, there is increasing concern in the health care community about the need to provide ways to support older adults who want to live independently in their homes as they age. A large percentage of clients receiving home care support are elderly and live alone (Lang and Edwards 2006). We know the home is an unpredictable environment for care because the healthcare provider visits each home for relatively short periods and only a few times per week (Madigan and Fortinsky 1999). We also know that the home health providers are relatively isolated in their work. This context of relative isolation for providers and clients poses unique challenges for health service delivery, particularly with respect to issues of coordination and communication. Compounding these challenges, we know that the rate of increase of homecare expenditures in Canada is more rapid than all other areas of the publicly funded healthcare system, with the exception of medication (Coyte and McKeever 2001). The demographics in Canada suggest that the costs will escalate significantly over the next two decades. Under the current delivery model this increase would require a substantial number of additional homecare nurses. Clearly we need cost effective solutions to manage the spiraling costs and to address the
social challenges of providing care to older adults at home. Secondly, technology is providing opportunities specific to healthcare issues and costs. It is imperative to move ahead with addressing the options pertinent to homecare through reliable research that will support proven technologies.

The overall purpose of the study presented in this poster is to investigate the user interface design and data fusion strategies for integrating bio-physiological information about home care clients as they go about their daily lives with a point-of-care (POC) decision support system for health care providers. This poster specifically presents an automated wireless 24-hour non-intrusive activity monitoring system of home care client’s in-bed, in-home, and out-of-home active and sedentary activities, along with a prototype web-based software application that displays the patient data in a format amendable to homecare clinicians’ environment and preferences. The focus is on the technological development and pilot test that was recently completed by a multi-disciplinary research team of health scientists, geographers, and engineers.

1.1 Previous Work

A recent study investigated patient safety concerns found that 13% of all homecare clients had experienced an adverse event (Madigan and Fortinsky 1999; Masotti et al. 2007) including unexpected death, urinary tract infection, fall or accident at home, wound deterioration, unexpected nursing home admission, increase in the number of pressure ulcers, improper medication administration or side effects, and hypo/hyper-glycemia. Clients who experienced such events were generally older. E-Health interventions have the potential to address a number of these concerns through technological tools that will improve patient monitoring and remote patient data entry (Bakken and Hripcsak 2004).

There is considerable evidence that regular physical activity is effective in the prevention of many chronic diseases, cardiovascular disease and diabetes in particular (Warburton et al. 2006). The reduction in risk of death from any cause for those who are active is typically greater than 50%. A monitoring of physical activity has been shown to assist patients in self-management of their respective diseases, and to provide more detailed feedback to physicians for adjusting medication and refining care regimes (e.g. Nathan et al. 2005). Providing tools that can automatically monitor patients’ daily activities, especially physical activity, mobility, sleep, and sedentary activity, could further enhance opportunities for diagnosis, education, promotion of self-care, and recovery from traumatic events (surgery, stroke, etc.).

Modern Global Positioning System (GPS)-enabled smartphones and advances in Geomatics offer substantial opportunities to move towards such an automated monitoring system. These technologies are capable of wirelessly transmitting a person’s location to a central server to provide a highly accurate trace of personal movements over long periods of time under real-world conditions (Doherty et al. 2001; Rainham et al. 2008). When viewed on a map, a wide range of activity types/intensities and their location become clearly evident to the naked eye, including driving, parking, walking, entering buildings, stationary activities, etc. The challenge is the development of algorithms for automatically detecting these activities and their attributes. Other non-intrusive monitoring techniques tailored to seniors include information collected from simple binary sensors (such motion detectors), simple analog sensors (such as temperature sensors), or complex sensor systems (such as pressure-sensitive mats). The integration of this information can accurately estimate vital signs, respiration rate, movements (Chen et al. 2005) and sleeping patterns (Harada et al. 2002). These sensor systems hold considerable promise for enhancing the efficiency and safety of care for vulnerable older homecare clients; however, their integration into mainstream homecare has yet to be tested.

2. MONITORING SYSTEM

Two key technological contributions are presented in this poster: 1) an automated wireless 24-hour non-intrusive activity monitoring system of home care client’s in-bed, in-home, and out-of-home active and sedentary activities, pilot tested with three clients and 2) a prototype web-based software application that displays the patient data in a format amendable to homecare clinicians’ preferences as assessed through focus group and one-on-one interviews.

Key to the monitoring system is custom software on a smartphone (BlackBerry) that automatically acquires, compresses and securely transmits data from the on-board GPS/accelerometer and Bed Mat Pressure Sensors (BPSM) to a central server. The BPSM is installed in the bedroom, whereas the GPS
receiver and 3-axis accelerometer are embedded in the smartphone worn by patients during waking hours. During the day, second-by-second GPS location and 3-axis accelerometer readings (25 per second) are recorded. At night, bed mat pressure sensor readings are recorded. Data processing algorithms are then used to automatically detect a wide range of patient activities including sleep duration, bed exits, out-of-home activities, exercise, trips/falls, and in-home movement patterns. Patient activity patterns are then displayed graphically in a web-browser meant to serve as a decision support tool. The poster provides a much more detailed schematic of the system.

3. CONCLUSION

Our recommendation is to seamlessly present this information as a 24 hour time line or "diary" of events, or as graphically summaries of time spent in various activity types over given day, week or longer (as shown in the poster). We recommend that this information be presented as part of a graphical user interface on a mobile computer to support a point-of-care decision support system for home health care providers. We expect that the homecare environment of the future would be well served by monitoring technologies that are as passive as possible and do not overload patients or their home with multiple devices.

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