MECES (www.diagnomx.eu) – An Open Access, Secure, And Multi Language Medical Communication System

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Abstract: **Herein, theory of and practical experiences with the user friendly, Medical Electronic Expert Consultation System (MECES, www.diagnomx.eu) are described.**
Theoretical considerations: The demands of an adequate communication system that acquires and transfers medical information can be fulfilled by use of open access sources and tools.
Development and implementation: MECES uses a common forum framework. Implemented tools include handling of virtual slides, interactive image magnification and navigation, private data protection, creation of medical reports, mobile access, on-line discussions, and automated multi-language translation.
Experiences: The system has been tested for over 100 cases, between developing and developed countries, and private practices. It is a multi functional tool applicable for different medical tasks, and for teaching or continuous education.
Perspectives: At present MECES is a high performance medical communication system. In future it will be expanded with our general medical information systems (ELIAS, Electronic Information Archiving System), with automated measurement system (EAMUSTM), and automated diagnosis assistant system (ADIAS).!

Introduction

Communication is the transfer of information between several vertices which can act as source or receiver or both [1-2]. Electromagnetic signals are transformed into human understandable information, which includes speech and images. Certain boundary conditions form the framework of the network. They are related to the required performance and define the user groups [3-4].

Medical communication is also embedded in a framework of limitations, such as financial conditions, available technology and reliability, human performance, demands of the society, behavior of patients, and access to disease recognition and treatment places [5-9]. Successful telemedicine has to take into account these conditions [10].

What is the theoretical background and which conditions have a successful telemedicine network to meet? These questions will be answered in the following, hopefully to the reader's satisfaction.

Theoretical Considerations

Human communication depends upon interactions between individual knowledge and information "environment" which can be assessed actively or passively [3, 11].

One can try to describe general conditions of successful communication in medicine, and to derive practical rules that permit to:

1. Forecast the development of communication systems;
2. Estimate the mandatory conditions for success;
3. Implement tools that obey or include the proposed regulations;
4. Measure the obtained results.

Any proper medical communication includes a consistent and reliable recognition of the patient's health condition (diagnosis) and therapeutic action "at the patient's place". As direct consequence telemedicine can be only as good as the medical actions on site. This statement is of importance when applying telemedicine in developing countries, especially if it is aimed to improve the medical service.

The second derivative is that both diagnosis and therapy have to be at the "same medical level" if the costs should be minimum. High investment in diagnosis is wasted if the consecutive therapy is not available [5-6, 12-15].

A successful telemedicine should include both speech and vision. In on-line modus speech is the appropriate communication medium [3, 16-17]. Chat could be a replacement of speech transfer, however combined transfer such as video conferencing is preferable [18-19].

Communication requires an understanding between source and receiver, i.e. standards [20-22]. Common standards are language, security keys, picture archiving and communication system (PACS), Digital Imaging and Communication in Medicine (DICOM), Institute of Electrical and Electronics Engineers (IEEE), medical guidelines, and others [13, 20].

Medical communication aims to release of the doctors' work burden which can be obtained by automated measurement systems such as EAMUSTM (www.diagnomx.eu/eamus) [13, 20, 23-24]. Medical information addresses different knowledge at different locations and times.

Open access systems appear to generate a new era in social behavior, so – called social forums (facebook, etc.) or dictionaries and lexica (www.dict.leo.org, www.wikipedia.org).

Implementation of an Open Access Medical Forum (MECES)

The described theoretical framework explains the implemented features, which in MECES combine the following issues (see also Fig. 1):

1. Communication aim {risk <> diagnosis <> therapy <> follow up}
2. Information area {pathology <> radiology <> endoscopy <> …}
3. Information carrier {image <> speech <> table <> function}
4. Information type {primary <> expert <> literature}

These tasks can be fulfilled by internal structures with fixed communication pathways, external information nodes such as Skype, applets, and image measurement systems (EAMUSTM), and that run under different operating systems (Unix, Windows, Android, etc.) [25].

These requirements have been integrated into the Medical Electronic Communication Expert System (MECES) that uses a common forum framework written in php language. The framework permits the creation of medical cases with secured private data. Still images and virtual slides can be uploaded. Connection to specific servers allows information modification, analysis of image quality, and image measurements (EAMUSTM), access to the National Institute of Health (NIH) library, or scientific journals (www.diagnosticpathology .org). Both on-line (chat, videoconferencing) and off-line communication (email, SMS, etc.) are included. Still images are viewed by a specific viewer, VS by the vendors' viewers. Medical reports are created on demand. Automated multi-language translation is in its test phase.

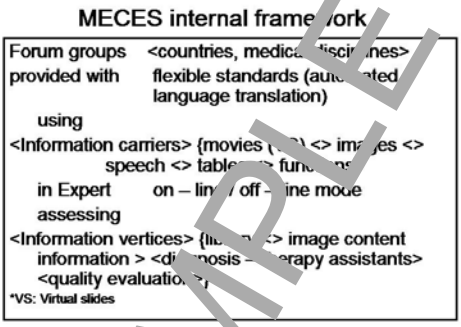

Figure 1

Experiences with an Open Access Communication System (MECES)

The present stage and future expansion of MECES are shown in Fig 2. The system has been tested for tissue – based diagnosis in more than 100

cases. Most of the cases have been acquired in developing countries. Others have been used for board examination.

The performance of the system was judged to be good – very good. No breakdowns or other handicaps have been noted so far.

Implemented and future functions of MECES

MECES contains	country & {medical discipline} related discussion groups
provided with	external communication (notification via email, SMS), language translation, reports, private data encryption
using	movies (VS), images, voice, tables, executable functions
in Expert	discussion, chat, skype, mobile, stationary, off line modes
assessing	external servers providing related (library, journal) information, image quality assurance, image measurements, diagnosis assistants.

*VS: virtual slides

Figure 2

Perspectives

MECES is an internally hierarchic organized distributed dynamic communication network in medicine, and fulfils all demands of innovative communication, data distribution, flexibility and technology development in medicine to our experiences. It can be adjusted to additional business such as medical continuous education or scientific publication. Indeed, an operative connection with the open access scientific journal diagnostic pathology will create new tools accessible for education, and routine work. The basic strategy perches on distributed communication with flexible edges and specialized nodes, in accordance with the communication rule that information increase can be only attained from different (distributed) sources and not from the same source [1]. In other words MECES is a suitable tool to assist both the individual patient and the medical community to improving the patient's health condition and the medical knowledge in general.

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Assistive Tools for Real-Time Optimized Audits of Homes of People with Disabilities or With Loss of Autonomy

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Abstract: **In a context of aging populations, policies supporting home care are becoming major issues. The audit of the living space has become an important preliminary step in the process of compensation and prevention of loss of autonomy. A number of improvements can be identified through the audit such as adequate accessibility of the habitat permitting or facilitating ambulation and daily life activities. However, each evaluator often operates under his own methodology and the main problem arises during the evaluation, due to the lack of information support that could help and guide efficiently in real-time for example on current standards or regulations. Our proposal relies on an interactive "connected" tool integrating real-time assistance databases.**

What is a home audit? For whom? What for?

Ideally, maintaining people at home relies on technological support as well as environmental adjustments. For patients to stay at home adequately it is necessary to assess their needs and those of their relatives. The following criteria are essential: the person's wishes, health and health history, degree of autonomy, social environment (isolation, neighbours...), professional helpers (attending physician, social worker, home help...), type and state of dwelling, financial means and Social Security cover.

Auditing consists in controlling and advising. It is a tool supporting continuous improvement which enables to assess a specific domain by evaluating the premises and producing an inventory of weaknesses and/or nonconformities. Subsequently, appropriate measures can be taken to remedy deviations, as to implement compliance with norms.

If staying at home happens to be manageable, evaluating the premises is part of the process of assessment for persons progressively losing their autonomy. Various factors can account for this loss of autonomy:

- Diseases: degenerative deteriorations of the central nervous system, cerebrovascular condition, psychiatric conditions, arthropathies and after-effects of fractures, eye and ear diseases;…

- Deficiencies: altered or impaired state or function affecting psychology, physiology or bodily structure;
- Impairments: generally restricted faculties which involve deficiency, inaptitude or even handicap;
- Handicaps or disadvantages: restrictions concerning an environment in terms of accessibility, expression, understanding or apprehension.

Obviously, adapting the lodgings cannot remedy all these difficulties, but a number of improvements can be identified thanks to an audit.

- Complying with accessibility standards enables to move around and perform everyday life tasks like preparing meals,
- Preventing falls,
- Improving salubrity and comfort,
- Accessing social and cultural life.

Thus, an audit aims at performing an inventory of all failures so as to establish a list of recommended renovations. The report is to be passed on to fitters and artisans (for estimates) and eventually to social financiers.

Organisation and Actors Involved

In France, like in other countries, the main bodies that perform or request audits are public establishments run by regional councils, hospitals, welfare agencies or, pension funds, associations of social workers and users, private agencies and service providers, social medical institutions. Audits are generally performed by occupational therapists. They aim at assessing the person so as to maintain and increase her independence and autonomy within her usual social and professional environment. They can collaborate with medical professionals (like orthoptists for the visually-impaired), building contractors (plumber, architect…), social sector professionals like case-workers to help set up a file for funding.

Advantages of adopting a digital tool

Depending on the domain, each evaluator uses his own methodology without any standardized guideline. This may result in approximations and discrepancies in complete audit, post-reading and understanding difficulties, no standardized format, long re-keying after evaluation completion. Moreover there is a lack of information that could provide efficient real-time support, for example on current standards or regulations.

The following example relies on a connected interactive tool integrating assistance databases. It can be an IP-enabled touch pad with dedicated software permitting to:

- Standardize file output data , thanks to report templates,
- Evaluate comprehensively through a list of parameters to be checked based on the disabilities of the person and the room being inspected,
- Provide real-time assistance by displaying standards and regulations,
- Access edit and complete a third-party evaluator's audit report,
- Improve readability by displaying selectively the main criteria to be appraised depending on the room and impairment,
- Import patient details (name, address...)
- Compare different evaluations of the same house
- Capture and annotate photos and explanatory sketches on-the-go,
- Generate statistics by sharing information within a single database.

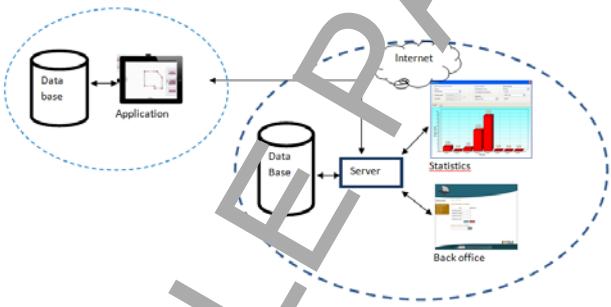

Fig. 1: Application architecture

As shown in figure 1, the example architecture is composed of a database hosted on a web server, a network administration interface, a site enabling to display the shared knowledge base and a client-application on the touch pad. A copy of the data-base is installed on the tablet to provide for a lack or loss of internet connexion. All information is eventually uploaded on the server and secured within the online database.

As shown in figure 2, when creating a new audit report, a general information page is displayed, the different fields have to be filled in, (name, address...). Selecting the type of disability already permits to filter the criteria that need to be assessed in the house. It is then possible to add a room by picking up from the list. The overall criteria for this room are displayed (circulation, lights, flooring...). If the evaluator thinks there is nothing wrong with a criterion, he can validate by ticking the green OK box. Otherwise the criterion can be invalidated (red tick) and a list of sub-criteria is displayed, then following the same validation process. The

Fig. 2: Application Screen Capture

navigation bar on the right can be popped up at any time to display selectively context sensitive help for the current room.

After assessing all the relevant rooms, a summary of the audit is displayed. In case something has been forgotten or a mistake has been detected, it is possible to re-edit the room by clicking the corresponding tab. Otherwise the evaluation is validated and a draft report is issued. The various fields can be filled out to describe the solutions devised to meet the different needs.

When saving the audit at final step, several documents can be attached (blueprints, annotated photos...). Once saved, the information can then be reviewed by a third-party or mutualised for statistical usage.

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Four Years Evolution of a Teleconsultation Service in Minas Gerais, Brazil

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Abstract: **Telehealth has emerged in Brazil as a strategy to support primary care practitioners in small and geographically disadvantaged cities. The Telehealth Network of Minas Gerais provides teleconsultations and tele-electrocardiography for primary care in Minas Gerais province. The objective of this study is to describe the evolution of the teleconsultation service by Telehealth Network of Minas Gerais from 2007 to 2011. The service was initially implemented in 82 municipalities in 2007, and successive expansions have been performed, reaching 658 of the 853 province municipalities in 2011. The mean utilization rate per month has increased from a mean of 5% in 2007 to 60% in 2011. A total of 30,975 teleconsultations were performed, 15,052 in the past year. The increase in the number of teleconsultations has led to the adoption of professionals on duty of different areas, who answered 70% of the teleconsultations. The mean response time is 24 hours. Most health professionals (97%) were satisfied with the service and referrals to distant centers were avoided in 81% of the cases. Cost-effective analysis showed that the service is cost-effective and economically viable. In conclusion, teleconsultation service provided by Telehealth Network of Minas Gerais has been expanding continuously, and has been gradually integrated to primary care assistance in the municipalities.**

Introduction

Minas Gerais is a Brazilian province with 853 municipalities, a population of almost 20 million people and a large territory which represents an obstacle to patient referrals. Additionally, the health system in Brazil cannot meet the demand for specialists. Telehealth has emerged as a strategy to support healthcare practitioners in small and geographically isolated cities, in order to avoid unnecessary referrals and improve service quality.

The Telehealth Network of Minas Gerais has expertise in teleassistance and provides teleconsultations and tele-electrocardiography for primary care in Minas Gerais since 2006 [1]. The system uses low cost technology, which is suitable to poor villages. The objective of this study is to describe the evolution of the teleconsultation service by Telehealth Network of Minas Gerais from 2007 to 2011.

Implementation and Utilization

A methodology for implementation and maintenance of the teleconsultation service was developed in 2007 [2-4]. The service was initially implemented in 82 municipalities and successive expansions have taken place, growing to 149 municipalities in 2008, 421 in 2009, 553 in 2010 and finally 658 of the 853 provincial municipalities in 2011.

The mean teleconsultation utilization rate per month has increased from a mean of 5% in 2007 to 60% of the implemented municipalities in 2011. Nevertheless, the average number of teleconsultations sent by municipalities in 2011 was 2.5 per month, meaning there is still potential for a large increase in the demand (Fig. 1). A total of 33,042 teleconsultations were performed, with 15,052 in the past year (Fig. 2). Of these, 53% were requested by nurses, 36% by physicians and 11% by other healthcare

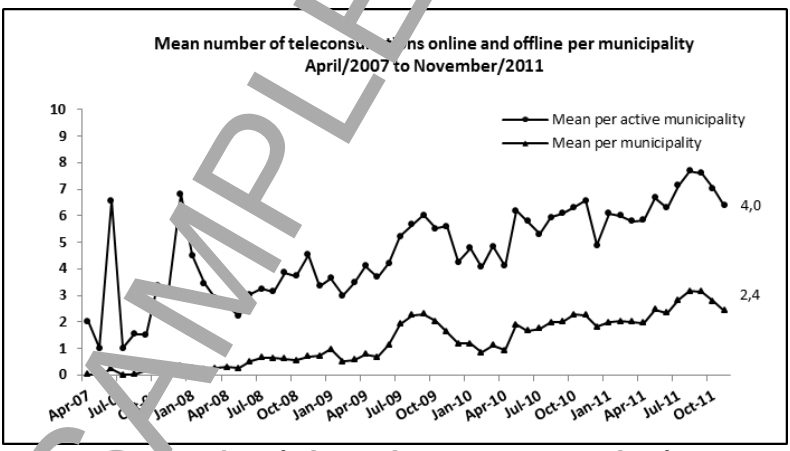

Figure 1. Mean number of teleconsultations per municipality from 2007 to 2011

professionals, including dentists, pharmaceuticals, physiotherapists, psychologists, nutritionists, audiologists, biochemists.

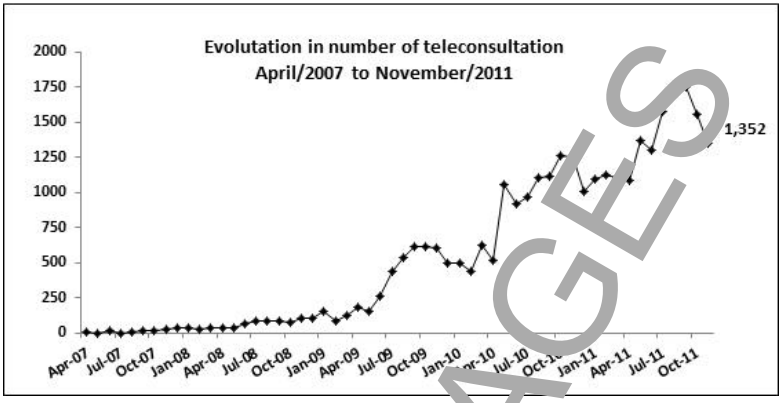

Figure 2 Evolution in number of teleconsultations from 2007 to 2011

Professionals on duty and response time

The increase in number of teleconsultations has led to modifications in the service, with adoption of professionals on duty, who perform all clinical activities supported by a network of specialists. When these professionals judge it necessary, they can ask for additional information from a subspecialist. From September to December 2011, professionals on duty answered 90% of the teleconsultations and forwarded the remaining 10% to the subspecialists. Regarding the teleconsultations performed in 2011, 29% were answered by general practitioners, 19% by dermatologists, 12% by nurses, 11% by gynecologists and 6% by pediatricians. The success of the professionals on duty contributes to the rapid responses and cost-effectiveness of the service.

System efficiency is measured by teleconsultation response time, and it strongly impacts user satisfaction. In 2011 the average response time was 22.3 hours, being 18.7 hours for professionals on duty and 41.6 hours for subspecialists. Demand on weekends and holidays correspond to 8%, and 17% of the teleconsultations are nocturnal, although primary care functions only in working hours, indicating that healthcare practitioners sometimes use their free time to perform teleconsultations.

Satisfaction survey

The satisfaction survey given to the 1,284 users from January to October 2011 has shown that most health professionals (97%) were satisfied with

the service, and referrals to distant centers were avoided in 81% of the cases.

Cost analysis

Cost-effective analysis showed that the service is cost-effective and economically viable. The main economical benefit of using telehealth is to reduce costs by reducing the number of referrals. Considering that the system is able to reduce 80% of them we have a cost/benefit ratio of 1/3,43. Considering the total investment since 2006, the Return on Investment (ROI) is 2,75.

Conclusion

In conclusion, teleconsultation service provided by Telehealth Network of Minas Gerais has been expanding continuously and has been gradually integrated to primary care assistance in those municipalities, improving quality of care, providing continuing education, reducing isolation of primary care professionals, referrals to distant reference centers and costs.

Acknowledgment

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Home Telemonitoring of Respiratory Function in Cystic Fibrosis Patients: Economic Evaluation and Quality of Life

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Abstract: **We attempted to quantify the real economic impact of Telemonitoring on NHS balance.**

Introduction

In chronic lung disease, the continuous monitoring of clinical status, the detection and early treatment of respiratory complications are currently the main criteria guiding the treatment [1]. Early initiation of antibiotic therapy can prevent the development of serious complications perhaps using less invasive antibiotic therapy [2].

In The Center for Cystic Fibrosis (CF) of Bambino Gesù Pediatric Hospital of Rome since 2001 the telehomecare (THC) has been activated in the follow-up of patients at home.

In a previous study [3] we have investigated the possible role of THC in the follow-up of a group of patients with CF in detecting early stages of infectious pulmonary exacerbations. The study included 17 subjects (11 f, 6 m) with CF followed at home with THC in addition to conventional treatment, for a period of 29.6 months ± 13.5. The age of entry in THC was 15.74 years ± 5.8. As controls were enrolled 28 patients with CF (13 f, 15 m, age 14.77 ± 5.22). The results indicate, in subjects with THC, a statistically significant reduction of hospital admissions and a tendency over time to the stability of lung function.

In the present study we have attempted to quantify the real economic significance of using the monitoring of respiratory function on the scale of economic NHS, in order to find a balance between spending on health and health needs.

Materials and Methods

In our CF center, the activity of THC was initially performed using Oxitel equipment and since 2005 using Spirotel equipment supplied as “Home Vivitel Control Service” (www.vivisol.it). Patients included in the program were followed and treated in the Day Hospital with the usual protocols of follow-up [4].

The calculation of the budget statement was made by examining the costs of medical equipment, medications used, the cost of housing of a day hospital and of an outpatient visit. We considered as revenue the fees relating to admissions avoided through early detection of acute events and therefore to remaining free beds that the hospital could use for other patients.

Simultaneously we administered to patients a questionnaire (sent via e-mail) with multiple answers, partly open, to confirm the level of satisfaction with this method and related matters. We used 3 categories of subjects, homogeneous for age and all chronic diseases: 1) CF patients who used the telemonitoring, 2) CF patients who did not use the remote home monitoring and 3) 28 chronic non-CF patients who did not use the remote home monitoring. We tried to evaluate some parameters to which a market value does not match such as anxiety, pain, the expectation of well-being, using the method of individual "willingness to pay" (W.T.P.) [5].

Results

We recognized 136 pulmonary relapse episodes: 99 were treated at home by oral or i.v. antibiotic therapy (€ 379.833) and 37 by hospitalization (€ 150.405), with a total cost induced of € 530.238. Considering that, in absence of THC, all episodes would involve hospitalization; we compared the total cost of THC patients with the cost of 136 in-patients acutely hospitalized in the same period for chronic pathologies with similar DRG (€ 552.840). On the other hand, in THC treated patients, the 99 avoided hospitalizations needed the structure to perform as many admissions, with an income of € 422.916 that we considered a saving (€ 530.238 – € 422.916 = € 107.321,88). The balance (€ 552.840 - € 107.321) shows a total saving of € 445.519 (€ 89.103/year, € 5241/patient/year considering a 5 years period).

The results of the questionnaire are presented in graphical form in Figures 1-6 (our elaboration).

Discussion

The annual savings achieved through home telemedicine in the management of patients with CF is not very relevant, especially in view of the national average expenditure per patient. It should however be noted

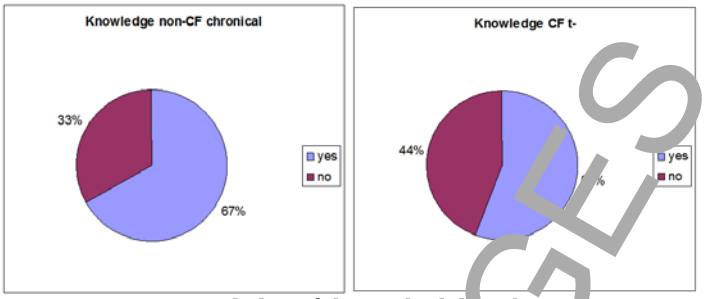

Figure1. Knowledge of the methodology by patients

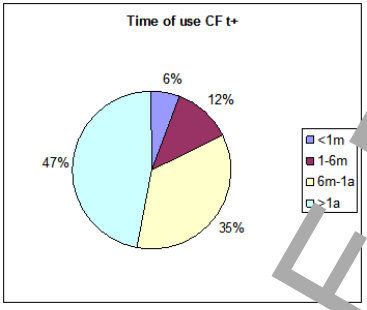

Figure 2. Percentage distribution of CF patients based on time of use of home care telemedicine

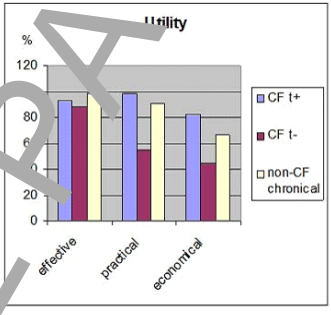

Figure 3: Opinion of patients on the utility of telemedicine: % of positive responses about its usefulness

that these savings are obtained in front of improved levels of care and satisfaction levels of the subjects.

Figure 1 shows the answers to the question about knowledge of the methodology. As you can see, in spite of telemedicine in Italy has not yet been adequately spread, a large number of patients, however, know the existence of it.

Figure 2 shows how long our CF patients are using telemedicine.

Figure 3 reports the opinion of patients on utility of telemedicine in terms of efficiency, convenience and economy. It is evident that all three groups of patients have no doubts about its efficacy and practicality.

Figure 4 reports the opinion whether telemedicine may change the doctor-patient relationship. According to our CF patients, telemedicine cannot replace the doctor, and can help you to better follow the course of the disease.

Figure 5 - answers if the telemedicine do save time in the daily management of therapy. As seen above, the responses of CF patients in telemedicine appear more homogeneous than the group not in telemedicine.

The results on Figure 6 reveal the willingness to pay (WTP). CF patients in telemonitoring gave a report very close to reality. CF patients not in telemedicine, have an expectation on the method so they would be willing to pay more than twice in the first group. Patients in the third group are positioned in a central location. They probably do not have a direct interest in the technique, but as chronic patients, however, have similar expectations on innovative technologies to patients in the second group.

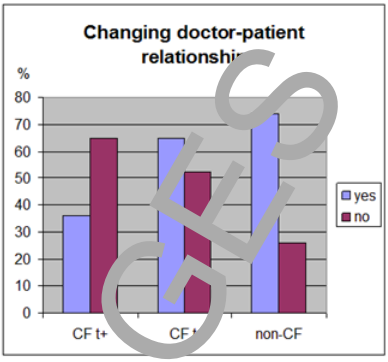

Figure 4 Opinion of patients on the change of doctor-patient relationship from the use of telehomecare: percentage of positive responses.

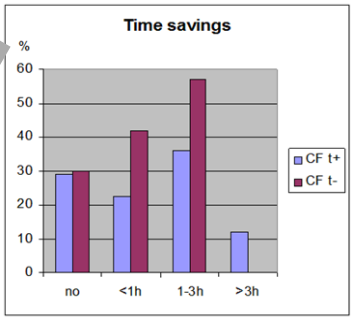

Figure 5 Opinion of patients on the time savings from the use of telehomecare: percentage of positive responses.

Conclusions

The use of telemedicine highlights several advantages that will surely become even more evident when its use will spread more. Being able to monitor patients at home is certainly a turning point for the "quality of life" of people with chronic conditions that, with the progress of medical knowledge, will in time more and more numerous.

The reduction in hospital accesses is a goal of considerable magnitude in the long-term management of chronic diseases. Telemonitoring in the follow up provides a further guarantee of better survey on exacerbations often cause of the gradual decay of the general conditions.

From the economic point of view, we pass through a historical phase in which health is increasingly considered a right for all. In front of

increasingly limited economic resources, it still shows a steady increase in health expenditure, which is now a substantial part of the National Gross Domestic Product. At this economic stage, telemedicine can be a rare source of savings. The hope is that new studies confirm our initial data to begin with conviction the phase of the development of telemedicine in Health.

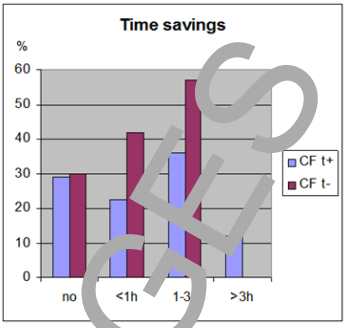

Figure 6 Patients' willingness to pay for a home telemedicine service, expressed in Euro per month.

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Social Networks and Telehealth: Enlarging Access to Health Promotion. Telehealth UERJ-Brazil's Experience in Preventing Childhood Obesity at Schools

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Abstract: Introduction and aims: Telehealth at Schools is a project developed through the integration of health professionals, school staff, students and UERJ's Telehealth Center team intending to provide educational materials and interactive games for children. In this project, in view of the seriousness of the epidemic of childhood obesity in the world, a site was developed for remote access. The objective of this work is to present the importance of social networks as an effective and rapid dissemination of this site information. Methodology: On August 2011, the site was launched as "Coloring the plate and moving the Shoe" [http://www.telessaudeuerj.br/colorindo-e-movendo/]. Since then, a social networking was implemented and a customized tool was developed for analyzing the website access. Results: During the period of observation 31,551 hits were carried out to the site, with an average of 5.3 minutes of connection. Conclusion: social networks have proven effective in the rapid dissemination of the site, facilitating the diffusion of its content.

Introduction

Telehealth at Schools is a project developed through the integration of health professionals, school staff, students and UERJ's Telehealth Center[1] team. Its main goal is promoting the use of internet as a means to share educational materials for schools' staffs and families and offer interactive games for children. It also provides a monthly interactive teleconference by health professionals to remote communities. In this project, in view of the seriousness of the epidemic of childhood obesity around the world, a site was developed for remote access. The objective of this work is to present the importance of social networks as an effective and rapid dissemination of this site information.

Methodology

On August 2011, the site [2] was launched as "Coloring the plate and moving the Shoe" (Figure 1). Since then, a social network was implemented and a customized tool was developed for analyzing the website access. This project was funded by the Research Foundation of the State of Rio de Janeiro (FAPERJ) [3] and is part of the activities of the Brazilian Telehealth Networks Program [4].

Figure 1. The website "Coloring the plate and moving the Shoe" [2]

Results

During the period of observation, 31,551 hits to the site were carried out, with an average of 5.3 minutes of connection. The teleconferences disclosure started one week prior the event date, and is increasing progressively since then. The users are making questions and sending comments about the discussions related to childhood obesity prevention.

Conclusion

Social networks have proven to be one of the most powerful and effective tools for the rapid dissemination of the site facilitating the diffusion of its content and activities.

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Deploying Innovative Mobile-based Telemedicine Systems using Open Source tools in Resource-poor Areas of the Philippines

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Introduction

The healthcare situation in the rural areas of the Philippines has remained unchanged over the past five years. There is a continued lack of doctors and hospitals to serve the 50 million Filipinos living in the rural areas of the country [1]. There have been previous projects that attempted to address this situation using available Information Communication Technologies, the primary technology being the use of Short Message Service (SMS) based systems for the transmitting of information [2]. The shortcoming of SMS based systems is the very limited amount of information (160 characters per message) that can be sent through the system.

Since then, there have been advances in technology such as Android based cell phones. These phones allow intuitive, user-friendly applications to be built, that can capture detailed patient information and store the data on the phone. These records are then transmitted to a central Electronic Medical Record system, through various methods of transmission.

With these new technologies available, doctors can now receive detailed information to make a more accurate diagnosis, and can service many more patients since the technology extends their reach remotely.

System Outline

The Sana Mobile Telemedicine System is a standard-focused open-source system that allows for the creation of highly customizable workflows that are loaded onto the phone (Android application), connects to a back-end electronic Medical Record System (OpenMRS), and allows for reliable operation on unreliable networks through its synchronization, packetization and multi-modal transfer abilities [3].

The Sana Mobile Telemedicine system has the following features [4]:

- It interfaces with point-of-care diagnostic tools through the attachment of portable medical devices to the mobile phone;

- It allows guidelines, checklists, medical procedures and protocols to be saved on the phone, bringing evidence based Medicine into the hands of a health worker or nurse at a clinic;
- It streamlines triage and referral system which includes initial assessment, initiation of diagnostic procedures, appropriate physical examination, and documentation;
- It facilitates coordination of care, care standardization and quality monitoring through the use of Electronic Medical Records.

Fig. 1 Components of Sana

Components of Sana

There are four components of Sana. These are: the Sana Android Phone client, the Mobile Dispatch Server, the SMS Server, and the Electronic Medical Record System [5].

Phone Client – Android Phone

The Sana phone client is an application written for the Android phone. This phone client allows multiple procedures to be stored onto the phone. Examples of procedures are: Hypertension questionnaire, Shortness of Breath Evaluation. The Health care worker Opens the Sana phone clients, selects a procedure and follows the workflow hard coded into the procedure when interviewing the patient. The Sana application guides the Health Care worker through the step-by-step questionnaire [5].

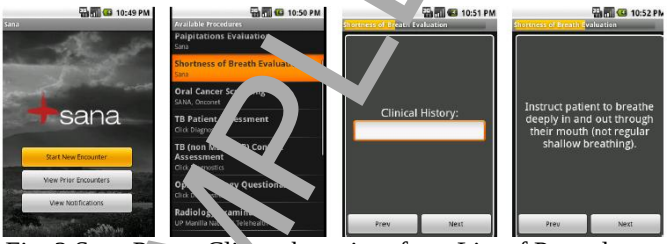

Fig. 2 Sana Phone Client phone interface, List of Procedures, Selected procedure

Once the health care worker completes the form for a patient, information is stored on the phone and then uploaded to the Electronic Medical Record System through multi-modal transfers: data is transferred using multiple

interfaces, including GPRS, 3G, WiFi, SMS and USB cable depending on the size and quality of data [3].

Mobile Dispatch Server

The Sana Mobile Dispatch Server gives the Sana system the capabilities of synchronization, and packetization. These are two very important capabilities as the system is meant to be used in remote areas where there might be little or no mobile telephone network connection. The Mobile Dispatch Server also sends notifications from the Electronic Medical Record System, back to the phone via SMS, through the SMS server. The Mobile Dispatch Server is the bridge that connects the Android phone client to the OpenMRS, Electronic Medical Record System [5].

Electronic Medical Record System - OpenMRS

OpenMRS is an Open Source Electronic Medical Record System that is based on the idea of a concept dictionary, and has the following features, among others [7]:

- Supports open standards for medical data exchange including HL7;
- Central concept dictionary: Definitions of all data (both questions and answers) are defined in a centralized dictionary, allowing for robust, coded data;
- Patient workflows: An embedded patient workflow service allows patient to be put into programs and tracked through various states;
- Support for complex data: Radiology images, sound files, etc. can be stored as "complex" observations.

Results and Discussion

Multi-Organization partnership

The pilot implementation of the Sana Mobile Telemedicine System in the Philippines is a multi-organization partnership that is grouped into three areas: The Implementation and Operations Partners, the Social Partners, and the Medical Partners [8].

Implementation & Operations Partners: **Asia Pacific College (APC)** – Academic Partner to provide research and development resources for the Sana project. **Integrated Open Source Solutions (IOSS)** – I.T. Solutions provider to manage the project, and provide maintenance and support. **CS Foundation, Inc.** – Funding source to pay for the project pilot. Social Partners: **Center for Community Transformation (CCT)** – Manila based Non-government Organization with a nationwide membership of over one hundred thousand. **Negros Women For Tomorrow Foundation (NWTF)** – Bacolod based NGO that helps women achieve self-sufficiency and self-

reliance. Medical Partners: The Doctors that participated in the pilot implementations were the in-house doctors of each of the NGO's.

Actual Pilot Implementation

At the start of the project, the hypertension procedure was agreed upon by the two organizations as the procedure that would be used for the pilot. IOSS was able to customize the hypertension procedure according to the requirements of the two partner NGO's. The hypertension procedure was piloted with the members of each of the two NGO's, and the results of the pilot were discussed after the pilot was completed. Based on interviews of the participants in the project, the Community Health Workers adapted quickly to the Mobile Application (within one or two days). Major complaints were with regards to delays in transmission and receipt of data due to lack of a cell phone signal in some pilot areas [9].

A key component to the success of the pilot was the iterative process used in refining the Hypertension Procedure based on constant feedback from the users. Each organization is now preparing for full implementations of Sana and integration as part of their strategy for delivery of medical services to their members.

Hardware Costs	Unit Cost (€)	Quantity	Total Cost
Android Smart Phone (10 units)	107	10	1,072
USB GSM Modem (1 unit)	18	1	18
SMS Server (1 unit)	268	1	268
Monthly Recurring Costs			
Virtual Private Server	15	12	182
Monthly SMS cost	16	12	193
I.T. Maintenance Support	536	12	6,430
Software License Cost			
Open Source Software	0		0
Total Costs			8,162

Table 1- Costs of Implementation based on the deployment of Ten Android Phones for one year, within each organization (CCT, NWTF)

Conclusion

Based on the Five (5) Elements of Telemedicine [10], the Sana Mobile Telemedicine project is able to address each element. The use of an Open Source Software development platform allows various specialized groups to collaborate and build on top of each group's expertise. This is so well characterized in the Sana Mobile Telemedicine project, which makes use of several Open Source technologies to come up with an effective, working, low-cost solution to provide Remote Medical Diagnosis in low resource areas not only in the Philippines, but for the rest of the world.

Acknowledgment

My sincerest thanks go to Merlin Teodosia Suarez for being my mentor and guide in writing this paper. Thanks also go to CS Foundation Inc., and Integrated Open Source Solutions for the continued development and implementation of the project. Finally, to Asia Pacific College for the support given with regards to the time spent working on this project.

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Measurement of Blood-Glucose via Near Field Communication (NFC)

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Abstract: **A newly designed blood-glucose measurement device wirelessly transfers the measurement data to a NFC enabled smart phone and, at the same time, uses the 13.56 MHz magnetic field provided by a NFC-interface to gain the required electric energy for supplying all electronic components of the device. With this concept the size of the device can be reduced, e.g., to the size of a credit card, because no battery, display and data storage is needed in the device. For measurement the new device is simply placed over the NFC-interface of a smart phone. The NFC interface powers the device and all relevant data about the device status and finally the result of the measurement is transferred to the smart phone. The measurement result and all other relevant information are shown on the display of the smart phone. The values of the blood glucose measurements are saved on the smart phone and can be further processed there if required, or can be transferred to any other place via internet.**

Introduction

Near Field Communication (NFC) is an emerging standard in wireless radio communication. It is a simple data transfer standard applicable over a distance of some centimeters. In some medical devices, NFC is already used for transferring of various patient or measurement data.

The main goal of the development of a new NFC-blood-glucose-meter is the application of NFC for transferring the measurement data and the energy for the measurement by the NFC-interface. With this configuration, the size of the glucose-meter can be reduced radically. There is no display, no battery and no storage for the measurement data needed anymore, the size of the glucose-meter can be reduced to the size of a credit card.

Prototyping

At the beginning of the development of the NFC-glucose-meter it had to be made sure, that the NFC-interface can provide enough power for supplying the measurement. For this purpose a conventional glucose-meter

was purchased for measuring the power consumption during the measurement. Most of the glucose-meters are supplied by a conventional 3V-coin-cell. The measurement of the electric current by application of a measurement resistor showed a current of 1,8 mA during the measurement. When the data of previous measurements was read out of the storage, the current was lower than 0.01 mA. So a power of 5.4 mW has to be gained from the NFC-interface.

The voltage of the 3V-coin-cell is not constant over the whole lifetime. So there is a useable range of supply voltage for the glucose-meter. Measurements showed that the investigated glucose-meter can perform the measurement in a range of 2.3 V – 3.8 V. The power supply by the NFC-interface needs to prepare a voltage in this range while a current of 1,8 mA is flowing. For investigations of the power supply, the glucose-meter was simulated by a resistor of 1500 Ohm (= 2 mA at 3 V) and the voltage on the resistor was measured.

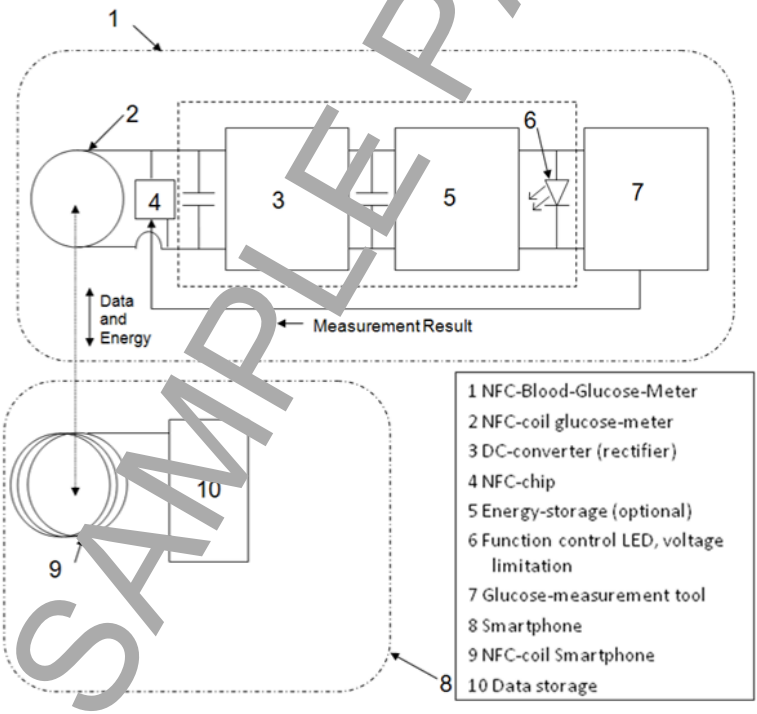

Figure 1. Block diagram of the concept of the NFC-blood-glucose-meter

To realize this concept the transfer of data and energy has to occur parallel at the same time over the same NFC-interface. The coil of the glucose-meter receives the 13.56 MHz NFC-signal and transforms it to a direct current voltage for powering the measurement. Parallel to the coil the NFC-chip is placed, which receives the measurement result by an analog input and is read out by the NFC-interface.

Figure 2. Prototype of the blood-glucose-measurement powered by the NFC-interface

In Figure 1, the block diagram of the concept of the NFC-blood-glucose-meter is shown. If it is required, the direct current gained from the NFC-interface can load an energy-storage device (e.g. capacitor). A LED is applied for signaling the operability of the glucose-meter and limiting the DC-voltage. The measurement data is transferred to the NFC-chip, which is read out by the NFC-interface on the smartphone. The measured data can be stored on the smartphone or in any other accessible data storage.

In Figure 2, the actual prototype of the NFC-glucose-meter is shown. In Figure 2 the glowing of the blue LEDs and the display illustrate, that the system is ready to measure the blood-glucose level.

Further Development

At the actual development stage of the prototype, no single NFC-chip is available, which can transfer the measurement results to the smart-phone by the NFC-interface. Therefore, for the prototype a simple Mifare-NFC-chip is applied, where data only can be written in and read out by the NFC-interface. Semiconductor manufacturers provided the information, that an adequate NFC-chip with analog inputs for transferring the measurement result will be available in the near future.

Summary

The implementation of the NFC-blood-glucose-meter instead of conventional devices causes the following advantages:

- The size of the glucose-meter can be reduced radically to the size of a credit card and a thickness of some millimeters, storing in the wallet or integration in a smartphone-cover is possible;

- Measurement data can be saved on a smartphone or in any other accessible data storage;
- By using the display of the smartphone better display of measurement values, graphs or instructions is given;
- No battery needed for the measurement, therefore this is closer to green technology;
- Compatibility to many different NFC-smart-phones,

Concerning the measurement of blood-glucose with NFC an Austrian patent applications has been submitted in 2011. The Patent Application number is A1603/2011, “Blutzuckermessung mit Hilfe von NFC”, submitted on 31.10.2011.

Stefan Cecil, born 1976 in Eisenstadt, received his M.S. degree in electrical engineering from the Vienna University of Technology in 2003. Since 2004 he is scientist in the Seibersdorf Laboratories in the business field EMC&Optics. There he is working in several projects on problems of electromagnetic compatibility and dosimetry. His research is in the area of numerical simulations of electromagnetic fields with different simulation tools and development of various NFC applying devices.

Achieving Behaviour Change among Pregnant Mothers Using Mobile Phones

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Abstract: **Mobile technologies offer great potential in overcoming health challenges in developing countries by supporting acquisition, transfer, storage, processing, and securing data to deliver meaningful results. AKDN eHealth Resource Centre (eHRC) supports the use of mobile technologies for behaviour change communication among expectant mothers to enhance the use of health facilities for antenatal care and deliveries. The project was implemented in Mardan district in Khyber Pakhtoonkhwa province of Pakistan.**

Lady Health Workers (LHWs) were provided JAVA-enabled Cell phones, and trained in using cell-phones for data entry using a simple template in the local language. LHWs registered all pregnant mothers in the intervention area. The sample size in the intervention area reached 433; while the sample size in control group was 375 mothers. Data was transferred to the server using 'FrontlineSMS' software. The same software was used to generate health promotion and personalized health messages to the mothers. The data was integrated with an Electronic Medical Record solution, 'OpenMRS' to create a medical record for each registered mother.

The study showed a moderate increase in contact between the pregnant mothers and the LHWs. The intervention also significantly increased the number of mothers having four or more antenatal visits at the health facility during pregnancy from 43% to 65%.

The focus group discussions with LHWs, doctors, pregnant women, and their husbands in the communities for their experience of using mHealth solution for safe motherhood revealed that all these groups praised the experience and wanted to continue this intervention.

This mHealth initiative demonstrates a scalable and replicable low cost solution, which can be used for applications other than safe motherhood. The integration of SMS-solution with the community-based medical record system shows an innovation with huge impact on improving health behaviour of individuals and the community.

Introduction

There were an estimated 5.3 billion mobile subscriptions worldwide in 2010, with more subscriptions than people in developed countries and rates of 68% in developing countries [1]. The same report indicates that the total number of text messages sent globally increased threefold from 2007 to 2010, up to a current level of 6.1 trillion messages per year, or 200,000 messages per second. Mobile technologies offer a great potential in overcoming health challenges in developing countries supporting acquisition, transfer, storage, processing, and securing the raw and processed data to deliver meaningful results [2].

Main objective of this initiative was to use low cost mobile Health (mHealth) solutions for behavior change communication among pregnant women to improve their utilization of health facilities for antenatal care and deliveries. The project was implemented in Mardan district of Khyber Pakhtoonkhwa province of Pakistan having a population of 1.9 million [3]. The project started from Jan 1st, 2010 and ended in March 31st, 2011.

Activities

The project used community-based quasi-experimental design, starting with situational analysis, discussions with community, formatting and customization of the software, trainings of the selected health staff, i.e. lady health workers (LHWs) and field surveys. This was followed by creating short messages covering major aspects of maternal health such as antenatal visits, vaccination, pregnancy care, and health promotion and translating into the local language (Pushto). The messages were sent regularly to expectant mothers and the frontline health workers using an interactive SMS solution called 'FrontlineSMS'.

Community-based open source software called OpenMRS was used for maintaining medical records of the patients. OpenMRS is an enterprise electronic medical record system platform to support the delivery of healthcare in developing countries and is also accessible via mobile phones making it appropriate for data retrieval even with limited internet connectivity. Save motherhood project (SMP) is integrated with patient medical record for data management. Registration forms were installed in mobile phones given to each LHWs with proper training to register and enter the data of a pregnant community woman and submitting these registrations forms to the OpenMRS server.

Results

In one year nearly 347 mothers were registered in this project, out of which 97.7% received awareness messages on regular basis. The messages content was focused on baby development, pregnancy problem and

associated risk with delivery. The study showed that this project reduced ratio of delivery and pregnancy related misconceptions in the community. The project helped increase the rate of deliveries at health facilities from 35% to 55%

- *Increase in community contact with health providers*

Pregnant women were shown to have more contacts with the healthcare providers in each trimester, compared to the baseline and the control group. The average number of contacts with LHWS in the case group increased from 4.1 per trimester to 4.7, whereas the same number increased from 4.1 to 4.2 in the control group (p=0.07). Similarly, the average number of contacts with the doctors in the case group increased from 1.2 per trimester to 2.2, whereas the same number increased from 1.2 to 1.4 in the control group (p<0.001).

- *Increase in antenatal visits*

The frequency of antenatal visits to health facilities was significantly increased in the intervention group compared to the control group. Percentage of mothers making four or more antenatal visits went up from 43% to 66%, compared to control group where antenatal visits went down from 66% to 57% (p<0.05).

- *Qualitative Data*

The project team also conducted focus group discussions with LHWs, doctor at the facility, pregnant women, and their husbands in the communities about their experience of using mHealth solution for safe motherhood. All these groups praised the experience and want to continue this intervention. LHWs thought of eHealth as a tool to comfort their work load.

"By using this mHealth solution, my work became easier than before. I can now consult to doctors when I find myself in problem. Now I don't need to go the health facility to submit the data of a month, I can send data of pregnant women on daily basis. It has saved my time a lot. I make lesser mistakes now."

Doctors also considered this initiative as a means to decrease communication barrier among health care providers. According to one Doctor: "Communication between all LHWs and health facility is easier now. It has helped in educating the community women and LHWs as well. By getting the daily based data, the data is managed very well in health facility."

The pregnant mothers included in the study found it beneficial for their maternal health. One mother explained regarding her experience as "Safe Motherhood Program has made us aware about our own health especially during pregnancy. Through these messages now we are facing less health

problems. It is really good to get advices on what to do and what not to during pregnancy. We often forget about our pregnancy but this system reminds us daily. It has educated us on birth spacing. Now we think before our delivery where to go and what to do."

Not only mothers, but also their husbands appreciated this initiative. As one man praised: "This program has removed our misconceptions about woman's health during pregnancy. We can now understand that antenatal care and postnatal care is very important for the life of a woman and her child as well. Now we can make proper arrangements before delivery of our wives."

Conclusion

The mHealth initiative discussed above demonstrates a scalable and replicable low-cost solution, which can be used for improving maternal and child health, and other similar applications. The integration of SMS-solution with the community-based medical record system shows an innovation with huge impact on improving health behavior of individuals and the community.

Acknowledgment

International Development Research Centre, Cananda, and PAN Asian Collaboration for Evidence-based e-Health Adoption and Application (PANACeA)

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Shariq Khoja is a physician, with PhD in eHealth from Global eHealth Research and Training Program, University of Calgary. Dr. Khoja has extensive background and interest in using eHealth technologies to facilitate healthcare services and education. His research interests focus on creating evidence and policies to guide the implementation of eHealth in developing countries. Dr. Khoja is leading the 'PAN Asian Collaboration for evidence-based e-Health Adoption and Application (PANACeA)', which supports researchers in 17 Asian countries to create evidence for e-health implementation. Dr. Khoja has contributed extensively to literature, especially through the development and validation of eHealth Readiness assessment tools for healthcare institutions. Dr. Khoja holds Adjunct faculty position at the University of Calgary.

Portable Telemedical System with an Intelligent Expert System for Doctor Decision Making Support in Emergency Situations

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Introduction

In Russia more than twenty thousand people die in road accidents annually. A significant percentage of these deaths as well as the impact of injuries are potentially avoidable with proper timely intervention and response in the critical first hour or so after the accident. According to the golden hour rule survival chances are greatest if aid is received within the first sixty minutes after the accident. In the next hour the number of victims will increase by 30% and if no medical aid was received within the first three hours, the number of victims will increase by 60%. Russian team of engineers at T-smart LLC has found a solution that brings effective medical assistance during the first critical hour.

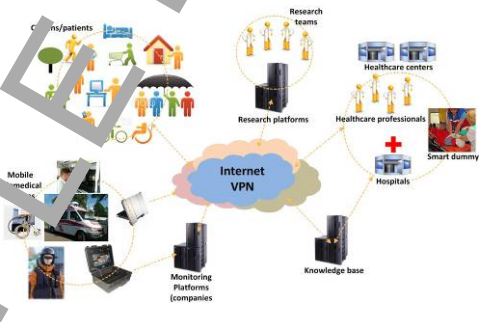

Fig. 1: System Structure

In this paper we are introducing the newest solution in the line of portable telemedical systems – ARNEGA™ Expert – a portable telemedical system with an inbuilt intelligent expert system for doctor decision-making support in emergency situations. This new solution weighs about five kilograms and yet includes an entire clinic of qualified medical specialists.

System Structure

Such structure (Fig. 1-4) allows the user/operator attending a patient to get in touch with a remote expert/consultant who has access to special medical knowledge bases (for reference information) and a smart medical

dummy (for demonstration of correct procedures that should be performed on a patient) and thus receive a qualified consultation and even visual instructions on what to do with the patient onsite.

This new portable solution allows rescue forces and medical staff to reach the farthest corners on Earth to save lives. Technically speaking this is achieved by positioning a mobile telemedical system along with satellite terminals in a safe place with access to communication channels and at the same time dispatching medical staff/rescuers equipped only with an interactive helmet and a vest into dangerous and hard to reach spots, where no vehicle can pass and where any additional equipment will be too cumbersome.

The system consists of a user wearable set of autonomous equipment with software and hardware parts and infrastructural components for organizing a remote telemedical center of expertise. It is implied that the user is a medical worker located in a remote area and is attending a patient.

Wearable equipment consists of both hardware and software components.

Hardware includes:

- A specialized computer with a set of interfaces for connecting medical devices and sensors;
- A set of medical devices and diagnostic sensors;
- An interactive helmet or video glasses with inbuilt cameras and audio and video communication systems, a visualization system with augmented reality support;
- Communication module for contacting a remote medical center;
- Autonomous power supply.

Software includes:

- Visualization module and data processing module;
- Local reference medical knowledge base;
- Local expert module for doctor decision making support;
- Videoconferencing system;
- Augmented reality module.

Figure 2. Interactive helmet & its communication systems

Infrastructural Components: Model of a Telemedicine Center

Hardware includes:

- Supercomputers for data storage, processing and generating an expert's report;

- Smart medical dummy;
- Videoconferencing equipment.

Figure 3. Computer in a rugged case with interfaces

Software includes:

- An automated expert system of doctor decision making support that is based on:
  - The analysis of medical knowledge bases and incoming medical image processing and classification results
  - The analysis of simulated responses received from smart medical dummies when certain procedures are performed on them (mathematical models of physical processes inbuilt into smart dummies are built).
- A videoconferencing module for active interaction between an expert consultant and a remote medical worker;
- A module of automatic generation of an expert report and its further transmission to a remote medical worker (in case a live expert consultant is unavailable).

Figure 4. Medical devices and diagnostic sensors

Technologies

This portable telemedical system involves a number of important innovative technologies, including:

- Newest development in the area of neural network algorithms and their application/adaptation to solve the task of processing images received from medical devices and then classifying them. This will save doctor's time and help make a better decision (diagnosis).
- Expert systems and knowledge base building technologies;
- Object visualization technologies that support and include augmented reality solutions using HPC and GPU-intensive computing resources;
- Application of smart dummy technologies, where a remotely located medical worker learns how to treat a particular patient from

watching a videoconference where remotely located experts perform certain procedures on a smart medical dummy.

Competitive Advantage

The project's advantage is in the innovative solutions used that have no analogues.

In order to solve complex diagnostic tasks effective neural network algorithms will be applied in processing the data received from medical devices. This means that the data has to be carefully and correctly read from the medical devices and gathered in the form of special archives and then all data must be verified by a group of qualified medical experts. When developing neural network algorithms, development team has relied on the experience accumulated by the Russian Scientific School in the field of neutral network technologies and their applications.

In the project course mathematical models of physical processes inbuilt into smart medical dummies will be built with further integration into the doctor's decision support system.

Acknowledgment

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TelMedHome - Fast and Cheap Home Care Monitoring of the Patients with Cardiac Diseases

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Abstract: **The aim of the project was to investigate the usefulness of home care telemonitoring of the patients using selected diagnostic tools. We have used advanced numerical analysis of biomedical data such as ECG records, pulse wave, etc. to allow us obtain more detailed information about the patient state. The project was monitored continuously in 21 patients with congenital aortic valve, 35 patients underwent implantation of coronary artery bypass graft CABG and 5 patients diagnosed with aortic aneurysm. Taken as a group study 50 healthy subjects to determine the fundamental norms and standards for selected parameters, the results of advanced analysis of heart rate and ECG. HSR-PW (high signal resolution pulse wave) and NURSE-ECG (numerical resolution signal enhancement ECG) method are based on a special computer programs, which increase the resolution of the pulse wave signals and electrocardiography signals and set the parameter values that inform about the state of the circulatory system. Thanks to this method, it becomes possible to show the details of the pulse wave and electrical activities of the heart parts, which are invisible in standard records. The pulse waves were recorded using a standard wireless electronic pulsoximeter CMS-50E, and electrocardiography signals were recorded by standard digital ECG device. The input data, which come from standard pulse oximeter and ECG devices, were collected from patients staying at home through a system of telemedicine network MONTE (TelMedHome). During the monitoring recorded the number of incidents related to arrhythmia, the oxygenation deterioration, with the work of a pacemaker was detected. By monitoring cardiologists could take the appropriate medical intervention. The telemedical system TelMedHome provides better care for patients discharged from the hospital and improves control of patients staying at home.**

Introduction

The aim of the paper was to investigate the usefulness of home monitoring telemedicine patients scheduled for cardiosurgery using selected diagnostic tools to optimize health care program in the Poznan, Poland. In addition to the planned development of new methods of medical telemonitoring we have used advanced numerical analysis of biomedical

data such as ECG records, pulse wave, etc. to allow obtaining more detailed information about the patient state.

Materials and Methods

Monitoring of the patients staying at hospital and at home was carried out in accordance with the system MONTE (**www.monte.net.pl**). We monitored records of pulse oximetry, blood pressure, temperature and body weight, glucose levels, rate well-being, occasionally, ECG, and once a week, patients were requested to submit a survey in which spoke about his health. These data were automatically transmitted via the Internet to the Department of Cardiac Surgery, University of Medical Sciences, where they were collected and monitored. The pulse waves were recorded using a standard wireless electronic pulsoximeter CMS-50E, which allows measurement of oxygen saturation in the range of 35%-99% with a resolution 1 % for SPO2.To interpret the obtained results, the ultrasound examination and other biochemical patients data were compared to high signal resolution pulse wave (HSR-PW) parameters of the same subjects. The resolution of pulse wave signal was enhanced by special software using the method of linear transformation based on Fourier analysis and deconvolution of original pulse wave [1-4] (Fig.1). Thanks to this method, it becomes possible to show the details of the pulse wave, which are invisible in standard record (Fig.2). Based on the analysis of individual peaks, computer calculates values of some parameters defining the state of the cardiovascular system.

Results and Discussion

The project was monitored continuously in 21 patients with congenital aortic valve, 35 patients underwent implantation of coronary artery bypass graft CABG and 5 patients diagnosed with aortic aneurysm. Taken as a group study 50 healthy subjects to determine the fundamental norms and standards for tested parameters, the results of advanced analysis of heart rate and ECG. HSR-PW (high signal resolution pulse wave) and NURSE-ECG (numerical resolution signal enhancement ECG) method are based on special computer programs, which increase the resolution of the pulse wave signals and electrocardiography signals and set the parameter values that inform about the state of the circulatory system. Thanks to this method, it becomes possible to show the details of the pulse wave and electrical activities of the heart parts, which are invisible in standard records. The pulse waves were recorded using a standard wireless electronic pulsoximeter CMS-50E, and electrocardiography signals were recorded by standard digital ECG device. The input data, which come from standard

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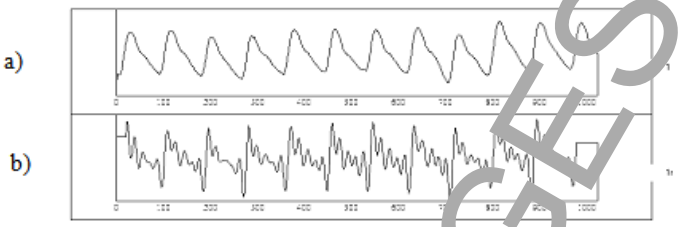

Fig.1. Pulse wave before a) and after b) high signal resolution processing

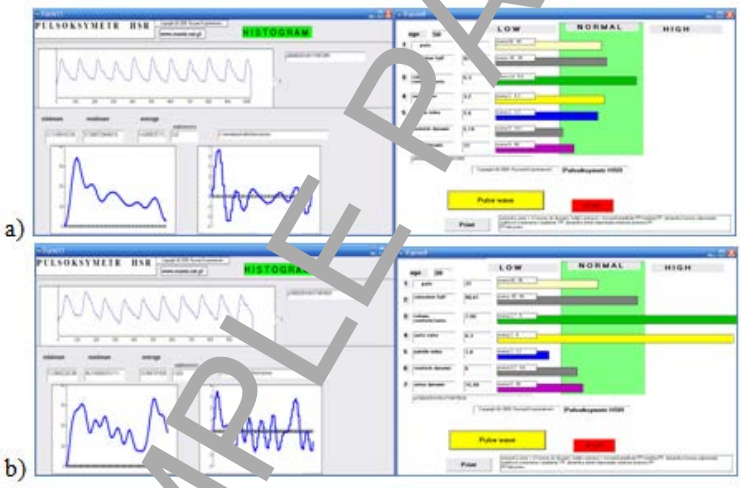

Fig.2. Pulse wave analysis result of HSR (numerically increased) a healthy person a), not qualified for a heart transplant b). Standard pulse wave looks like the same in both cases

In healthy people, in the averaged HSR pulse wave recording, the amplitude of the first peak is clearly higher than the second peak amplitude (Fig.2a).

In people with heart disease such as valve problems, it is observed the reverse situation - the amplitude of the first peak is lower than the amplitude of the second peak (ratio of amplitudes is <1). These changes represents

also volume ratio of the left ventricle to the volume of the aorta > 6 (Fig.2 b).

The HSR –PW shows very well changes of the pulse parameters after heart transplantation (Fig.3). We can observe how, after heart transplantation and other cardiac operations, some of the parameters of the circulatory system are normalized.

During the monitoring recorded the number of incidents related to arrhythmia, the oxygenation deteriorated, with the work of a pacemaker was detected. By monitoring cardiologists could take the appropriate medical intervention. The telemedical system TelMedHome provides better care for patients discharged from the hospital and improves control of patients staying at home.

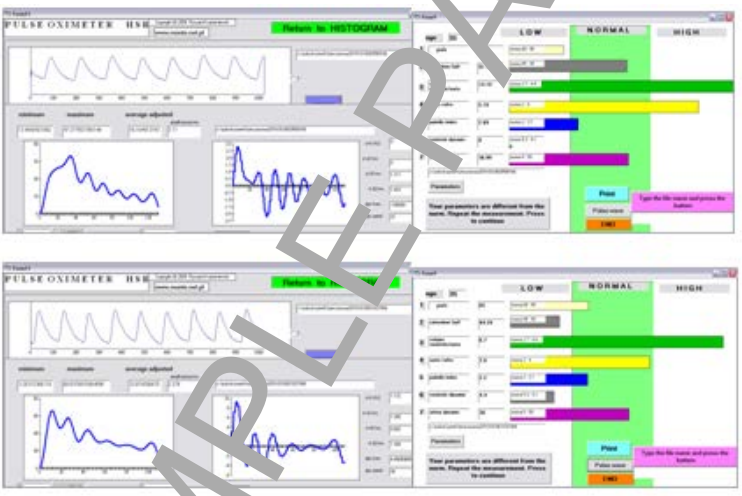

Fig. 3 HSR pulse wave recording a patient with aortic valve defect before the operation a) and after implantation of artificial valve b). Standard pulse wave looks like the same in both cases.

Conclusions

The High Signal Resolution Pulse Wave allows fast, inexpensive and non-invasive diagnostic of cardiovascular system diseases, for example: heart ventricle disorders etc. The telemedical system Monte provides better care for patients discharged from the hospital and improves control of patients staying at home.

Acknowledgment

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