Communication Framework for Emergency Rescue Services Enhanced by Personal Health Monitoring Solutions: Methodological Approach

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Abstract. This work aims to specify and validate a communication framework for healthcare rescue and emergency services enhanced by personal health monitoring solutions. This framework aims at presenting a contribution to the evolution of the actual emergency healthcare services response model toward a national wide communication framework able to enhance emergency services efficiency and effectiveness by the seamlessly integration with personal health monitoring solutions. Following a "participatory action research" methodological approach, this work aims to establish the gap and limitations, verified nowadays, between reactive and proactive emergency frameworks by identifying major risks and misleading needs, leading to the specification and discussion of scenarios where emergency responders benefit from the suggested communicating framework and the value added emerged from it.

This paper focuses on the methodological approach and will describe the most important findings of the first stages: the state of the art, the diagnosis needs and the research model specification.

Keywords: pervasive healthcare, personal health monitoring, emergency services response and communication framework.

1 Introduction

The actual societies are facing growing challenges concerning with healthcare services delivered to their citizens. In on hand, there are financial constraints and budget restrictions inherited by the global financial and economic crisis. In the other hand, citizens have expectations and demands for better and healthcare services. These two forces, considered by some in opposite directions, influence the delivery of healthcare services and shape the design from the next generations.

In the Portuguese society, actual healthcare rescue and emergency services provide and match the expected quality and effectiveness of service. Thought, it is plausible to admit that there is a strong context for changes to happen considering the evolution occurring both on peoples healthcare needs and patterns (e.g. growing life range expectancy, growing number of chronic patient), and on the Information and Communication Technologies (ICT) actual trends (namely in what concerns the empowerment of common citizens with powerful tools for get the knowledge, the new

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modalities of interaction with other people or specialized professionals and the actual possibilities of monitoring our own health status).

Under this context, we believe that these circumstances can shape interesting opportunities to study and rethink actual rescue and emergency healthcare services policies and scenarios, in order to incorporate citizen's new needs and expectations simultaneously with the enhancing possibilities emerged from the ICT value added.

This paper aims to describe the context, problem, hypotheses and research methodological approach for a research project in its early stage of execution. It also aims to establish the starting point for the research plan, providing the opportunity to discuss and reflect on the project activities and tasks.

This paper starts with an overview over the state of the art related with emergency healthcare services, personal health monitoring and ICT in healthcare services. Based on the context provided by the intersection of these fields, a diagnose about needs and tendencies is presented. Then the article focuses on the methodological approach where it describes the research and action plan in order to persecute the aimed objectives. At the final, a section mapping objectives and the findings expected is presented.

2 State of the Art

2.1 Emergency Healthcare Services

In the Portuguese society, the right of healthcare protection of the population is assured by the country national government, namely by the National Heath Service (*Serviço Nacional de Saúde* - SNS). This service, held by the Ministry of Health reached the 30 (thirty) years old in the year of 2009. The SNS is composed by the following entities:

- Hospitals;
- Local Health Unit;
- Health Center;
- Health Center Groupings.

Since 1981, Portugal also has specific entities responsible for the emergency recue and healthcare services – Integrated Health Emergency System (*Sistema Integrado de Emergência Médica* – SIEM [1]). The SIEM mission is "(...) provide assistance to victims of accident or sudden illness. (...)"[1], and it is composed by the following entities: Public Safety Policie (*Polícia de Segurança Pública* – PSP); National Institute of Health Emergency (*Instituto Nacional de Emergência Médica* - INEM); Firefighters; Portuguese Red Cross (*Cruz Vermelha Portuguesa* - CVP); Hospitals e Health centers.

In a simplified description, the health rescue and emergency procedure is based on the following steps: it starts when someone calls the 112 (European Emergency Number). The call is answered by PSP or GNR (*Guarda Nacional Republicana*). When the rescue call is related with health emergency, the call is redirected to the Urgent Patient Orientation Centers (*Centros de Orientação de Doentes Urgentes* - CODU). Whenever the CODU deploys and emergency team for the emergency calls, they try too find the geographically closer team, from the entities representing the SIEM (INEM, *Firefighters* or CVP).

Regarding the public information promoted by the INEM [1], there are three major attitudes that can and may improve the efficiency of an rescue call related with cardiac arrest, namely:

- Ask for help, immediately triggering the Integrated Emergency Medical;
- Start immediately maneuvers of Basic Life Support;
- Access to defibrillation as early as possible but only when indicated.

Bearing in mind these major attitudes and the new possibilities brought by the personal health monitoring technologies evolution, we believe that there is a wide range of changes and scenarios that could benefit from this strategic alliance.

2.2 Personal Health Monitoring

The scientific and technological developments have boosted the introduction of new techniques and tools in various areas of knowledge. Health has been one of the areas that has most benefited from these developments, perhaps because it aims to preserve the essence and most precious thing a human being - the life.

The necessity and intrinsic motivation for research and experimentation of new techniques and devices to improve healthcare has allowed to achieve a dynamic technological evolution, which is difficult to find parallel.

It is expected that healthcare services focus move from treatment to prevention. However, for this adjustment it is necessary to research and experiment new forms of organization of services and their interaction with citizens. The prospect of new scenarios could include, for example [2]:

- Means of non-invasive diagnosis and treatment;
- Health care at home;
- Short periods of confinement in a hospital environment;
- Rehabilitation processes more efficient;
- Citizens more informed and aware of their health status and treatment.

In healthcare, a technique that is widespread is the use sensors (individual sensors) to collect data for different biomarkers (eg heart rate, changes in electrical potential generated by the heart's electrical activity - ECG, etc.).

Personal Health Monitoring (PHM) solutions have evolved in complexity and features. Despite the diversity of sensors that emerge at a rapid pace, with a view to monitoring of various biomarkers, the concept of PHM has evolved in the direction of sensor networks. These networks arise by the necessity and possibility of monitoring a number of different biomarkers, enabling the preparation of a more complete and accurate picture about the health of a patient.

The introduction of sensor networks is only possible through technological developments in different areas of science, including:

- Miniaturization of devices and equipment;
- Significant increase in processing and analyzing information;
- Materials and smart textiles;
- Wireless communications.

The horizons opened by Personal Health Sensor Networks (PHSNs) [3] allow the design of new scenarios where technological PHM solutions do not refer only to data continuously capture. The increased ability to process and analyze information in real time opens doors to scenarios where PHSNs have the capacity to detect patterns and evidences of potential attacks or anomalies in the health of the individual that is being monitored. Such evidences may be used as alerts to the individual causing it to take measures so as to minimize and, ideally, prevent medical emergencies.

2.3 ICT in Healthcare Services

The current era of Information and Communication provided the ideal context for major changes and developments in key areas for the day-to-day individual and societies. The Public Health has been one of the areas where most substantial progress has been achieved.

However, the different dimensions involved in the health of an individual or society, go beyond the Physical and Mental health, with which we can identify more easily, particularly through recognition of diseases, diagnoses, treatments, etc.

In addition to Mental and Physical dimension, the Social dimension of health has been also the target of evolutionary phenomena providing the emerging of new horizons, possible only by widespread access to ICT by the patients / citizens and health professionals.

Whether through technological advances at the electronics and telecommunications, or through the ability, brought by ICT, of shortening the distance of relationship in a group or network, new channels and strategies start to emerge and try to take advantage of these gains in view of modernization and development of health systems. In Portugal, it is possible to highlight some services that use ICT as a key tool in its strategy, for example:

- Consultation to medical information and / or health;
- Electronic personal health record;
- Book appointments online;
- Personal health monitoring.

The spread of ICT allows providing a set of communication channels to use in a formal and informal way. The use of these communication channels allows the patients / citizens to adopt a more participatory and even more responsible role about his state of health. This can be accomplish through the gathering of information, sharing experiences or participating in thematic groups related to specific aspects of health (e.g. a particular disease, given a clinical episode, etc.).

However, the technological evolution cannot, by its own, guarantee the success of these new strategies or policies.

The latest trend in the context of communication networks in health, focuses on technology-mediated scenarios that allow a direct relationship between the individual and the environment in which it moves, as well as the assets that it incorporates (a form of carrying transparent / non-invasive) in its everyday activity.

The ubiquitous nature and emerging "pervasive" technologies in healthcare, can give some perspectives about future trends of research in the context.

In the specific context of Rescue and Emergency Services, which delimit the field of this thesis project, seems essential to study the potential of assistive and pervasive technology in emergency scenarios.

According to Doukas et al [4] assistive environments represent, par excellence, a framework for PHM devices and enhance the creation of new scenarios and interaction models in which these technologies can be combined with public health services, expanding on the possibility of integrating personal contexts with interpersonal and inter-institutional services.

3 Diagnosis Needs

In this work, we intend to investigate and explore possible developments in the process of communication of information among the victims of a health emergency and emergency medical services that will participate in the rescue operation.

It is intended to reflect on new paradigms of interaction and communication that may introduce capital gains in the process, enhanced by the use of digital platforms, and this may improve the effectiveness and efficiency of the rescue operation with a view to saving more lives, or at least, ensuring a better quality of life as a citizen involved in an emergency related to your health.

Despite the developments that have been seen on the technological characteristics, the expectations of society and its citizens has also evolved. An indicator that shows just that is the average of life expectancy of an individual, born in Portugal, currently located in 79 years [5][6] This number has evolved positively over the last decades: 1990 - 74 years, 2000 - 77 years and in 2007 - 79 years.

The average life expectancy is only one challenge we are facing today. Changing lifestyles, the need for policies and shoved to contain costs in providing health care and the need to improve the quality of health care, represent some of the challenges for which it is expected that technologies and new opportunities communication and interaction can help with clues for the design of possible future scenarios.

Within the scope of research to be conducted around this issue there are several clues that should be considered:

- Integrity Solutions (textiles, sensors, energy and communications);
- Market entry of monitoring solutions for different biomarkers;
- Validation of devices / medical solutions according to the extensive and stringent laws and regulations apply to health technologies;
- Property rights and privacy of information;
- High cost of new solutions and technologies;
- Sustainable business models for new service models to provide health care;
- Social and ethical issues associated with the communication of clinical information.

Finally, and perhaps most important:

- Education and acceptance by citizens of the new models for providing health care for citizens.

This is, indeed, the most relevant element in the entire area. It is not primarily a technological issue, but the reaction and acceptance that consumers / citizens that will demonstrate the new possibilities opened up by technological developments and will determine the future tendecies and policies in health rescue and emergency responde.

4 Methodological Approach

This research project results from the convergence between three main concepts (Healthcare Rescue and Emergency services - HREs; Personal Healthcare Monitoring solutions - PHMs; and Information and Communication Framework - ICF) and is oriented by the following research question: How can the Personal Healthcare Monitoring solutions enhance Healthcare Rescue and Emergency services?

From this question, the main hypothesis is: Personal healthcare monitoring solutions may support and enhance healthcare rescue and emergency services based on an information and communication framework able to combine the specificities from the rescue and emergency environment with the new technological possibilities available.

The proposed research project has well-defined geographic and time boundaries. For the time reference the project use the year 2011 as the actual moment. Meaning as time window of opportunity, the project points to the period from 2011 to 2016, accordingly the National Health Plan 2011-2016 [7]. From the geographic perspective, the proposed project is oriented to the Portuguese reality, mainly because of the specificity of the National Heath Service (Serviço Nacional de Saúde). Nonetheless, for the state of the art and for the measures and new scenarios proposed, the project aims to embed and get inspiration from lessons and conclusions retrieved from other countries that already have done hard work and progress in this field of action.

4.1 Scientific Areas and Context

The scientific context of this work has it main roots in the scientific field of "Communication Sciences and Technologies". Besides this principal context, there are other auxiliary disciplines that bring value to the project, like: Information Science, by the fundamental role played by the information circulating and resulting from the communication processes; Computation Sciences, by the enlightenment in the state of the art and evolution tendencies on personal healthcare monitoring solutions and devices; Communication in Healthcare, providing de context and specificity where user needs and technology can come together bridging to new horizons.

4.2 Purpose and Goals

This research project has two main purposes: promote the adoption of personal healthcare monitoring solutions in rescue and healthcare emergency scenarios; and propose a good practice roadmap for the implementation of a new communication framework that keeps in perspective the evolution of the actual rescue and healthcare emergency scenarios based on personal healthcare monitoring solutions.

From these two purposes, and considering the research question mentioned above, the main goals, for the proposed research project, are:

a) Understand the actual communication framework in the rescue and healthcare emergency services;
b) Specify a communication framework, in the rescue and healthcare emergency services, enhanced by personal healthcare monitoring solutions;
c) Determine the major advantages and value added introduced by the proposed communication framework;
d) Validate the sustainability of the proposed communication framework for rescue and healthcare emergency services;
e) Design a good practice plan for the communication framework implementation.

4.3 Analysis Model

The presented analysis model has been designed based on Quivy e Campenhoudt [9] and aims to identify and specify the concepts, dimensions, components and measures proposed as organizations structures of the research activities in the project.

The following tables present each one of the three mandatory concepts for the proposed research project.

The first concept specified is Healthcare Rescue and Emergency services.

Table 1. Analysis model - Healthcare Rescue and Emergency services (HREs)

Dimensions	Components	Measures
Healthcare; Rescue and Emergency in healthcare; Intelligent emergency management; Healthcare network;	- Type of service; - Admission requirements; - Emergency nature: - Reactive, preventive or proactive; - Services - Policies; - Project;	- Admission levels; - Availability; - Admission cost; - Answer time; - Recovery cost; - Actual scenarios; - Actual bottlenecks; - Maturity; - Availability; - Citizen know about;

The second concept specified is Personal Healthcare Monitoring solutions (PHMs).

Table 2. Analysis model - Personal Healthcare Monitoring solutions (PHMs)

Dimensions	**Components**	**Measures**
User needs; State of the Art; Capture and data transmission; Health data analysis and processing; Health data usage;	- Assisted living environment; -Pervasive healthcare technologies; - Electronic and computational perspective; - Healthcare perspective; - Healthcare impact (physically and mentally);	- Maturity; - Availability; - Access cost; - Number of users / adopters;

The third and last concept specified is Information and Communication Framework (ICF).

Table 3. Analysis model - Information and Communication Framework (ICF)

Dimensions	Components	Measures
Human components;	- Specification; - Validations;	- Stakeholders - Actors
Technical components;	- Solved bottlenecks;	- Instruments; - Techniques; - Channels
Workflows, relations and interactions;		- Workflows; - Procedures
Health information data provenience		- Credibility; - Certifications; - Responsibility;
Health information data accuracy	- Prototyping; - Focus Groups;	- Acceptance level; - Viability; - Value added;
Implementation good practices	- Change management; - Risk management; - Actors involvement;	- Phases; - Methodology;

4.4 Research Method

For the accomplishment of the proposed research project, a "participatory action research" methodological approach is suggested. Regarding Rapoport [9], "Action research aims to contribute to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework". The proposed research project requires an empiric approach of the research problem as well a field action plan close to the agents and environment that origin the identified research question. Due to these characteristics, it seems that the "participatory action research" approach is better suited to the nature of the proposed project, instead of other approaches like: historic, comparative, descriptive, relational, experimental or evaluative.

Following the "participatory action research" methodological approach, this work intends to support research activities by:

- Real time and field investigation, by contrast with controlled or laboratory environment;
- Specificity of situations that the project intend to improve, by contrast with abstracting the problem;
- Incorporate changes or evolution to processes and measure consequences in an iterative and flexible context.

For that matter, the presented methodological plan consists in an iterative set of phases that reflect the "participatory action research" approach intended for the research project.

Table 4. Detailed Action Research Model (adapted from [10])

Task	Description
Diagnosing	Identification and problem delimitation
Action Plan	Design action measures and alternatives
Taking action	Implement and experiment action measures;
Evaluating	Studying the consequences of the actions
Learning	Identifying general and major findings

4.5 Research Operation Plan

Table 5. Research Phases: Goals and Tasks

Phase	Objectives	Tasks
1ª Phase	a) Understand the actual communication framework in the rescue and healthcare emergency services;	1. Diagnosis needs
2ª Phase	b) Specify a communication framework, in the rescue and healthcare emergency services, enhanced by personal healthcare monitoring solutions; c) Determine the major advantages and value added introduced by the proposed communication framework; d) Validate the sustainability of the proposed communication framework for rescue and healthcare emergency services;	2. Framework specification (v1); 3. Framework discussion; 4. Framework specification refinement (V2) 5. Framework validation
3ª Phase	e) Design a good practice plan for the communication framework implementation.	6. Implementation roadmap design; 7. Implementation roadmap discussion; 8. Implementation roadmap refinement;

4.6 Data Gathering

The treatment of collected data will be based on the methodological procedures associated with qualitative and quantitative analysis.

Qualitative Analysis: there is the perspective that most data will be gathered from the focus group sessions, as well from reflections and discussions on the topics under research. Due to the subjective and unstructure essence of the data gathered, this work proposes a qualitative analysis to undestand and get conclusions from the data.

Quantitative Analysis: for the procedures based on systematic data collection techniques, as the case of a questionnaire survey, we intend to apply quantitative analysis.

Based on this combination of methods this research project intend to develop a strategy of triangulation of data that allow the enrichment of the research topics and make sustainable inferences.

5 Final Considerations

Underlying the proposals for this research project, there is a set of goals and predictable results we expect to achieve. Firstly, this project aims to promote the adoption of personal healthcare monitoring solutions in rescue and healthcare emergency scenarios and, to achieve this goal, a communication framework for health rescue and emergency scenarios supported by personal health monitoring tecnologies will be proposed. Secondly, we will propose a good practice roadmap for the implementation of the communication framework which aims the adaptation and evolution of the current health rescue and emergency scenarios.

We expect that the methodological approach of the project, described in this paper, proves to be suitable to accomplish these two main goals, in order to create an ajustable scenario to develop the full potentialities of this research.

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