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Abstract. The emerging crucial point of healthcare organizations is to involve patients in autonomous monitoring their own health status by using personal ICT-based systems to manage data, and to ask for an effective cooperation with the doctor, if necessary. Two motivations urge this innovation: the growing costs of healthcare services, and the need to promote patients' education. Therefore, the objective of this paper is to outline a Patient Guidance System (PGS) architecture to allow the patients an ubiquitous and secure management of personal health data and an easy call to the doctor in case of a critical or suspicious health situation. The PGS architecture will support an effective cooperation between the patient and the doctor in such a way to assure to the patient – either at home, or moving and/or being monitored by wearable devices – a clear interaction to get an easily understandable healthcare service.

Keywords: Healthcare network; Patient-to-Doctor interaction; Collaboration

1 Introduction

Almost everywhere in Europe healthcare systems are organized at the regional level, in the form of territorial networks of different types of service centers, including hospitals, local consulting and health status testing centers, and mainly family doctors and specialists. Referring to the Italian organization, the territorial healthcare management unit is the Local Healthcare Agency – LHA (i.e. Agenzia Sanitaria Locale – ASL), which is referred to a territory whose population and whose extension are usually corresponding to a province. All LHAs located in a same region depend on the Regional Government, which coordinates the healthcare services in terms of political plans and attribution of an annual budget.

In any country, unless relevant adjustments will be applied to the healthcare systems, incidence of the care costs is going to become explosive [1,2]. New methods and procedures for the performance evaluation of the services and for controlling their costs are going to be studied and sometimes applied, but a reasonable compromise

between the necessity of reducing costs and the healthcare system scope of assuring to any person a sufficient health status, is far from being found and tested.

Experience of the authors in analyzing the care system of the LHA in the Asti province, North-West Italy, in recent research projects (www.codesnet.polito.it and www.lep.polito.it/prinsalute), shown that a real key of the health care quality is the improvement of the cooperation between the patients and the family doctors: these last ones are the basic stones of the healthcare system, because they operate at the same time as patient's consultant – by acquiring symptoms and selecting therapies – and as "drivers" of patients flows among the LHA service centers. Then, an effective collaborative interaction between a patient and his/her doctor becomes the crucial step for improving the LHA quality of services.

Based on these concepts, the ***Patient Guidance System (PGS) Architecture*** here outlined has two complementary goals. First, to allow the patient an ubiquitous and secure management of his/her personal health data and, in case either of not being able to recognize the health status, or of a critical health situation, to call the doctor for help by supporting an effective cooperation between the patient and the doctor (the two "actors" of the healthcare system).

As it will be shown in the following, the PGS Architecture could also support some innovative collaborative actions. Since the remote patients are persons frequently not expert of the LHA service network operations neither of the devices for self-monitoring their health status, patients and doctors must be equipped with a proper connection with a Data Maintenance and Securitization Centre (usually located at the regional healthcare government centre), managing data and information for the whole PGS Architecture, and equipped with a connection with the Network Maintenance Resources devoted to assure the efficiency of the whole connecting network. Furthermore, Distributed Telemedicine Network, already existing, will make possible to remote or moving patients to activate the connection with their Personal Health Records (PHR) by operating on data and information of various type and nature (monitored, vocal, images).

The described project is currently at a design stage, but a real application to an Italian LHA is under consideration.

2 The PGS Architecture

Based on the above introduced scope of the PGS Architecture, the effective cooperation between the patient and the doctor must be obtained through an IT infrastructure suitable for applying the following actions/controls.

- To enable the patient to contact his/her Personal Health Record (PHR), stored in a secure digital repository, by using a *PHR Consultation Facilitator*, that is a new original communication system assuring the effective interaction between patients and their own PHRs;
- To support the patient in monitoring his/her own PHR by using a Digital Library of simple and comprehensive patient's health status models (ontology) and an original set of patients-dedicated rules to analyze PHR

(semantics), all organized into a *Patient Consultation Support Base* such to be used also by unskilled persons;

- To enable the patient to call a doctor for help, by using a *Patient-To-Doctor (P2D) Interaction Facilitator* which makes as cooperative and as easy as possible the communication between the two actors;
- To facilitate remote or moving patients in activating connection with either their family doctor or any other healthcare service centre through a *Distributed Telemedicine Network (DTN)*, to transfer physiologic data and health information of various type and nature and to ask for immediate and understandable support.

The following sub-sections will give a detailed presentation of the above listed PGS components.

2.1 The PGS Infrastructure

The basic scheme of the PGS Architecture is the infrastructure illustrated in Figure 1. In schematic terms, it will be obtained by the functional integration of (i) the PHR Intelligent Management System (*PHR-IMS*), devoted to Patient-To-Doctor collaborative communication, (ii) the IT network connecting patients whose health status is continuously monitored by portable devices with their PHR Digital Repository, and (iii) the Communication Support System between the PGS and the coordination centre (usually located at the regional level), to support all users of the PGS Architecture in front of unexpected events, either due to connection problems or due to exceptional situation of the patient's health status.

The basic functionalities of the PGS Architecture will be the following:

- To facilitate the patient in the consultation of his/her Personal Health Record (PHR), such to apply a personal monitoring of the health status as well as of safety alert parameters;
- To facilitate the patients mobility in three forms: *Mobility of a patient inside the area* managed by the Local Healthcare Agency where patient is residing, from his/her family doctor to other doctors, specialists and other health care centres; *Mobility of a patient outside*, i.e. towards sanitary centres of other Territorial Healthcare Agencies; *Mobility of a patient to another country*, with a different language.
- To facilitate the interaction between a patient and the doctor such that the former could receive help in understanding his/her own health status, and should be supported in giving an as clear as possible presentation of his/her symptoms;
- To support on one hand the request of new sanitary information by the doctor to the public (or private) Regional Agency managing healthcare services (also disseminating information on new products, new protocols, etc.), on the other, to help doctors in detecting potential patient mistakes in contacting them or wrong or unwilling choice made by non-expert patients, using P2D.

In addition, assurance of the necessary data security and privacy protection requires that a common management of data, as well maintenance of both data and system effectiveness, must be guaranteed by a Regional Healthcare Agency which

must have at disposal both the complete data base of PHRs, such to make analyses of the population health, and the most recent information on new drugs, new protocols and treatments, and be able to support demands from doctors and also disseminate information, such as to integrate latest available medical knowledge.

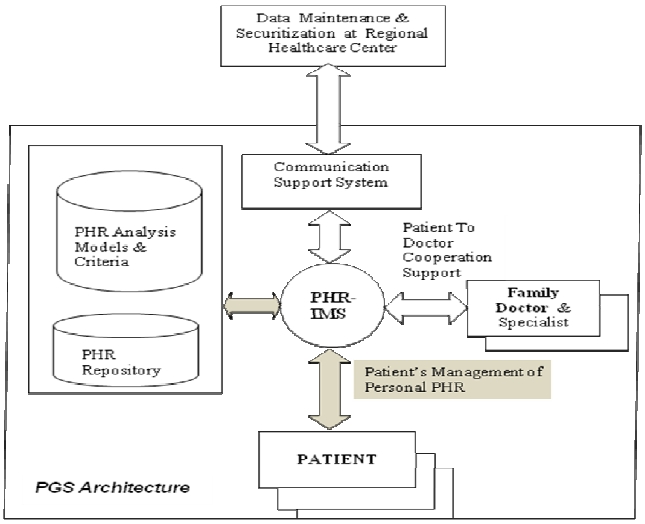

Fig. 1. Scheme of the PGS Architecture

2.2 Conceptual model of the PHR Intelligent Management System

Figure 2 gives a sketch of the Intelligent Management System to be made at disposal of the patient in order to make a consultation of the personal PHR and, in case of critical situations, to ask the doctor for help.

The basic components of the PHR-IMS are described in the following (numbers are referred to the PHR-IMS components and the data/information flows illustrated in the Figure 2).

1. Data generated from the patient monitoring system (portable device, wearable computing, etc.)
2. Data & information from a contact call by the patient (patient's inputting data using a Web form, phone call with a health care centre operator, etc.)
3. Ontology with patient medical and social models as well as rules concerning healthcare services that could be obtained (e.g. administrative norms established for the considered region, country, etc.), generated by formalizing existing and newly defined models, as well as by integrating/extending existing standards, taxonomies, etc.
4. Semantic rules to guide the calling patient to analyze his/her own PHR and making a personal "diagnosis" of the proper health status such as to

recognize if a call to doctor is necessary, owing to unclear vision of the health status or to physical problems;

5. *Facilitator* of the patient interaction with the system (input), exploiting medical and social models to tailor the PHR monitoring process to the patient's characteristics, attitudes, etc. ("interact to understand"), and *Generator* of a snapshot of patient health status to be stored (by descriptive model based on measured parameters, historical data, models & thresholds), by verifying each time the patient's clinical parameters and adjusting their thresholds to the current conditions of the calling/monitored patient;
6. Patient instance (PHR) in the Digital Repository;
7. Patient profiling (models, thresholds, history, etc., mining literature and analogies), doctor profiling, Patient-To-Doctor matchmaking and guide to read of patient history (e.g. augmented reading, variation in patient health status), description of the rules for diagnosis to the calling patient (reasoning, procedures and prescriptions), update of the Digital Repository with the outcomes of the Patient-To-Doctor cooperation process.

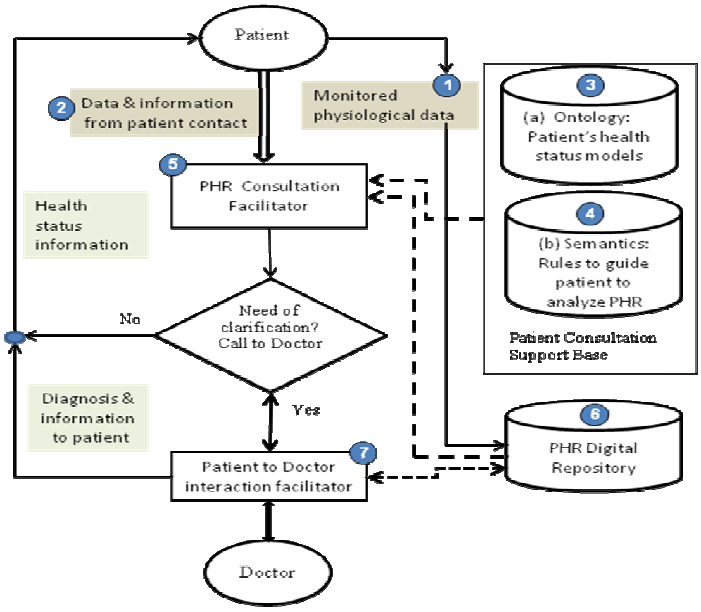

Fig. 2. Model of the PHR Intelligent Management System

It must be remembered indeed that the remote patients are persons frequently not expert of the connecting network operations neither of the devices for monitoring their health status. Then, the two blocks N° 5 and N° 7, that are the PHR Consultation Facilitator and the Patient-to-Doctor Interaction Facilitator must be equipped with a proper connection with the Data Maintenance and Securitization Centre (usually located at the regional healthcare government centre), managing data and information for the whole PGS Architecture, and have also to be equipped with a connection with the Network Maintenance Resources devoted to assure the efficiency

of the whole connecting network. The above mentioned connections play the role of Communication Support System among patient, doctor and the Data Maintenance and Securitization Centre.

3 Short Survey of the State-of-the-Art

In order to evaluate the innovation contained in the proposed PGS Architecture, as well as of its potential application, two types of existing systems in the healthcare sector, with special reference to the patient support and the interactions between patients and doctors have been analysed: (i) systems already in operation, and (ii) recently published results.

Referring to existing systems for PHS analysis already in operation, the following two examples have been analyzed. The Microsoft HealthVault[1] allows for the creation of a personal repository of health information a citizen can "bring" with him/her and access when needed. The HealthVault can be populated by either uploading data from health/fitness devices, by digitizing paper records or by connecting to pharmacies and labs online. Google Health[2] is designed to allow citizen to organize, track, monitor, and act on their health information. Specifically, its users can manage their health history online, set personal health and wellness goals and track and monitor their progress through both embedded and third-party services.

By comparing the two examples with the main features of the on-going PGS Architecture, it can be seen that Microsoft HealthVault and Google Health are strongly oriented to the citizen/patient, with lazy connections with the healthcare system, but they are not specifically designed for collaborative analysis and diagnosis. In general, their functionalities depends on third-party applications developed upon the PHR infrastructure.

Along with the two above products, Dossia[3] is one of the largest PHR deployments in the world, based on Open Source software. The Dossia system enables individuals to gather copies of their own medical data and to create and utilize their own personal, private and portable electronic health records. In practice, Dossia is an information management system. No specific facilitation of the patient-to-doctor interaction is considered.

By the MHO – Management Health Online system[4], a healthcare organization can have a complete informatics system, reliable and adapted to the needs with a reasonable cost of ownership. MHO connects patients and the sanitary structure in a town or a province or a region, through a unique internet-based system, thus managing the patient history and current information in terms of hospitalization, analysis, pharmacy, and make statistics and reports. However, MHO operates as a data base management system with multiple users, the patients; no specific module

1 http://www.healthvault.com/personal/index.aspx.

2 https://www.google.com/accounts/ServiceLogin?service=health&nui=1&continue=https://health.google.com/health/p/&followup=https://health.google.com/health/p/&rm=hide

3 www.dossia.org.

4 www.mhc.com.ar

will support the patients in their understanding of the personal PHR, and no module is providing a cooperative integration of patients with doctors, till now.

Recent years revealed a wide diffusion of papers and, sometime, also books, on the aspects of healthcare when the patient-centered approach is considered. Research and analysis efforts have been developed mainly in the medical area with attention to the potential use of new ICTs, according to two lines.

On one hand, some authors and research centers move to analyze the potentiality of wireless body area sensors, to be used as basic connecting elements in a patient-to-service interaction system. This is the case of [3], where the idea is that a number of tiny wireless sensors, strategically placed on the human body, create a wireless body area network that can monitor various vital signs, providing real-time feedback to the user and medical personnel. In a recent paper with similar approach [4], the authors discuss and map the main findings resulting from the development of a series of four Wireless Sensor Network (WSN) health monitoring prototypes, under the generic name of MoteCare. It devised a generic framework that can be adapted for healthcare monitoring, both at a patient's home or in a care facility is proposed. Other works dealing real-time and mobile physiological data analysis can be found in [5,6].

Whereas the first generation of patient-centred e-health studies have been focused largely on discussing how to assure a good tracking of patients, in a recent paper [7] it is proposed that the next generation of e-health research begin to better address the questions of why, how, and for whom the e-health interventions across a variety of health domains could work. This paper discusses some design and analytic approaches for determining what components of e-health programming work, how they work, and for whom. Intuitively, this paper has the ambition of being normative. It gave interesting suggestions for the PGS Architecture here outlined.

One of the most diffused book [8] on the patient-centred healthcare approaches shows how the adoption of a user-centered design (UCD) focus has immensely enriched the health industry, because the application of UCD concepts are key to successful development of e-services, including e-health. Then, it confirms that Patient-Centered E-Health presents the perspective of a distinct form of e-health that is patient-focused, patient-aware, patient-empowered, and patient-active. These same concepts have been considered the basic ones for the PGS Architecture.

4 Application in Living Laboratories

The Local Healthcare Agency of the Province of Asti (ASL-AT) is a typical public institution to manage, control and financing the healthcare service units located in the province territory and the hospitals located in the towns of Asti and Nizza Monferrato. The ASL-AT operations consist of the organization of all territorial services, and a special attention is dedicated to the dissemination of healthcare service opportunities over the territory, directly to patients at their home, to avoid spare time and costs for patients and sanitary operators in the healthcare centres. To perform such operations and to monitor the services supplied to patients, the ASL-AT collects detailed information on the patients' calls as well as on the doctors' contacts. A very large data base, ranging over the last four years, has been made at disposal for

analyzing the patient's needs of both information on their own personal healthcare status (that means, the patient history stored in the PHR), and the actual patients' utilizations of the healthcare centres even in case of no real necessity (then, when the use of a remote facilitated connection with a PHR repository could satisfy this type of information need) [9]. The contribution of ASL-AT to the present on-going research will allow to give a complete evaluation of the potentials of the proposed PGS Architecture in a region where the actual healthcare service is centred on the doctor and the patient is still considered a "client" of the service network. Indeed, the evolution of any healthcare organization must be towards a patient-centred system: this is the expected evolution also of the new Italian Minister of Health for the ASLs innovated operations. Then, the on-going evolution of the PGS research line will move along the following two directions. On one hand, to complete the definition of the health status models, the ontology and the semantics by analyzing actual healthcare prescriptions and devising their translation into easy/usual language. On the other, to analyze the actual patients' needs, by using the ASL-AT data base with about 8.7 million prescriptions per year, for about 215.000 persons, among which 48% contact doctors and/or healthcare service centres for a number of times ranging from 20 (healthy person) to 350 (with chronic disease) per year, all registered in the ASL data base, and with about 200 doctors providing sanitary services.

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