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Interoperable Infrastructure and Implementation of a Health Data Model for Remote Monitoring of Chronic Diseases with Comorbidities

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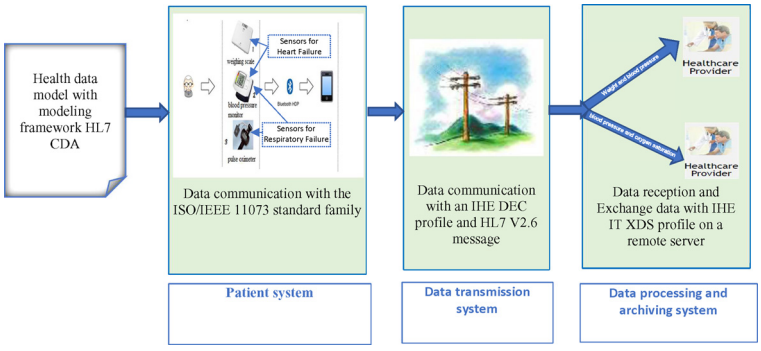
Highlights

- To adopt a common health data model compatible with chronic diseases and their comorbidities.
- To implement an interoperable telemedicine platform.
- Data structure of our health data model based on HL7 CDA (Clinical Document Architecture).
- Context-aware generic model suitable for most acquisition devices.

Graphical abstract



Abstract

Background: The future increase of chronic diseases justifies the development of telemedicine for following up patients outside of the hospital. However, current telemedicine applications are disease-specific whereas chronic diseases are often associated with comorbidities.
Methods: We show that the use of interoperability standards for telemedicine systems makes it possible to build a telemedicine platform (with several medical devices) that can be shared between several diseases workflows. To remotely follow up the patient's vital signs, health professionals need to access to the context description and the relevant background information. The implementation of a health data model that meets the needs of practitioners seems to be an appropriate solution to this problem.
Results: To validate our architecture model of telemedicine application, we conducted various communication tests of vital signs to prove the interoperability of the patient system. The second experiment, we have developed one HL7 CDA document which collects several vital signs to a medical data exchange system among healthcare providers. This led us to propose a telemedicine application model, which is not only in conformity with the Health Information Systems Interoperability Framework (HIS-IF) of the "Agence des Systèmes d'Information Partagés de Santé" (ASIP), but also constitutes a proposed extension of this framework to the patient's home.

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Conclusion: For the remote monitoring of patients with multiple chronic conditions, we developed a generic architecture that allows different telemedicine applications associated with specific diseases to share a common technical platform. This work was to propose at first, a health data model for the patient's vital signs, and, on the other hand second, a study of communication standards to achieve an interoperable system.

Keywords: Telemedicine; Interoperability; Health data model

1. Introduction

The ageing of the population is associated with the development of chronic diseases [1], which were responsible for 36 of the 57 million deaths worldwide in 2008 [2]. The United Nations estimated that this category is expected to reach 406 million by 2050 [3]. The aging of the population will result in an increase of the number of chronic diseases with comorbidity factors [4]. For example, compared with people who do not have diabetes, the diabetic patients have a higher risk of cardiovascular morbidity. Type 2 diabetes is associated with a two-fold to fourfold increased risk of coronary artery disease, and a two-fold to eight-fold increased risk of heart failure [5]. Chronic diseases typically require regular follow-up and are therefore expected to have a strong impact on the medical organization of care and on the cost for society. This is further exacerbated by co-morbidities. The use of telemedicine facilitates patient follow-up outside of the hospital. Telemedicine applications can contribute to reduce healthcare costs by reducing the number of hospital consultations and transports. However, most existing telemedicine projects focus on a single chronic disease and few actors. In such cases, comorbidities are usually not explicitly considered. In fact, taking comorbidities into account requires the ability to share medical data among health care information systems. For having access to care anywhere and anytime with telemedicine, it is necessary to create a fully interoperable infrastructure [6]. The expected benefits of such an architecture are two-fold: first, avoid the redundancy of medical information systems as isolated islands, and second, enable chronic disease telemedicine applications to take into account parameters from the comorbidities. After reviewing communication standards, it also seemed important to define the contents of patient data to share with the medical personnel in order to ensure that the provided information is sufficient for clinical diagnosis.

The aim of our project is to devise an interoperable telemedicine system suitable for monitoring article consists in identifying a model of data structure that meets the medical needs of remote monitoring for several chronic diseases with various medical devices. This led us to propose in a second part a new implementation of interoperable telemedicine systems which allows healthcare professionals to share patient information.

2. Materials and method

To analyze patient's data, health professionals need to access the context description (e.g. information about the type of examination), the important background information (e.g. the type of collected measurements from medical devices and the date and the time of the measurements) and the acquisition context (e.g. sensor characteristics). Furthermore, if exchanged information is limited to raw data captured by patients, it is not possible to interpret it meaningfully. Patient's data are context-dependent [7], and measurement results (weigh, blood pressure, oxygen saturation oxygen, etc.) have different meanings depending on the time of measurement [7]. They cannot be properly interpreted by a remote medical staff without specific contextual information. In this case, we define a health data model available for different chronic diseases and containing the necessary information for the vital signs analyzed. Our health data model must be able to provide the medical needs for several chronic diseases. To improve our health data model, an environment should be implemented to share and exchange patient's data in order to facilitate cooperation between healthcare professionals. As HL7 Clinical Document Architecture (CDA) [8] is the appropriate standard for sharing medical documents, we decided to use its structure to build our health data model. To achieve our goal, we must communicate all data of our health data model from patient's data to the remote computer system. In this case, the telemedicine systems must be fully interoperable from the technical (between two different technology systems), syntactic (between two different communication systems) and semantic points of view.

In order to address the challenges of fully interoperable system for information sharing and sufficient context information for remote diagnosis, we propose the use of standard data exchange formats, interoperable services and standard transport protocols to send structured data to a remote location addresses. To verify our system modeling, we perform the mapping between data of our health data model and the data models from the communication standards used. Laboratory experimentations have enabled to validate our modeling system for the following sensors: a blood pressure monitor, a pulse oximeter and a weighing scale. These three sensors allow us to obtain all possible configurations of our health data model. In fact, the weighing scale DIM model has only one numeric object, whereas the blood pressure monitor DIM model and the pulse oximeter DIM model have two numeric objects. A laboratory trial gave us the opportunity to demonstrate interoperability between the sensors and the smartphone, based on the ISO/IEEE 11073 family of standards [9]. To test the medical data exchange, we have specified a HL7 CDA compliant document structure for collecting several vital signs. We

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