An ontological framework for knowledge sharing in healthcare

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Abstract

Introduction: The ability to share EHR's (Electronic Health Record) underlying knowledge both internally and externally within healthcare organizations has been accepted as a method to improve the quality and delivery of care but has also raised important questions related to legal and privacy issues. This paper aims to explore the critical factors that impact knowledge sharing in the French healthcare sector. Our main research focus is to answer the question of how to improve Knowledge sharing in the healthcare sector. **Methodology:** An exploratory qualitative study was handled to investigate EHR's underlying knowledge sharing. We conducted non-directive, face-to-face interviews with physicians working in different healthcare institutions. **Results:** Three major issues were identified, namely the need for: a common healthcare terminology, the interoperability among healthcare information systems, and the patient's informed consents before sharing his sensitive data. **Conclusions:** This paper proposes an ontological framework that extends the Systematized Nomenclature of Medicine Clinical Terms with privacy dimension to secure access to sensitive patient's data. This study has limitations that could be addressed by future studies. First, the size of the sample is limited. Further explorations of knowledge sharing among other kinds of workers (e.g. nurse) and other countries would add richness to the phenomena and associations described in this paper.

Keywords: Electronic Health Record (EHR), healthcare systems, knowledge sharing, ontology.

Un marco ontológico para el intercambio de conocimientos en salud

Resumen

Introducción: la posibilidad de compartir el conocimiento subyacente del EHR (Registro Electrónico de Salud) dentro y fuera de las organizaciones de salud se ha aceptado como un método para mejorar la calidad y prestación de asistencia médica, pero también ha planteado cuestiones importantes sobre asuntos legales y de privacidad. Este trabajo tiene como objetivo explorar los factores críticos que inciden en el intercambio de conocimientos en el sector de la salud en Francia. Nuestro principal enfoque de investigación es responder a la pregunta de cómo mejorar el intercambio de conocimientos en el sector de la salud. **Metodología:** se llevó a cabo un estudio exploratorio cualitativo para investigar el intercambio de conocimientos subyacente del EHR. Se realizaron entrevistas en persona y no directivas con médicos que trabajan en diferentes instituciones de salud. **Resultados**: se identificaron tres problemas principales, a saber, la necesidad de: una terminología médica común, la interoperabilidad entre los sistemas de información de salud y los consentimientos informados del paciente antes de compartir sus datos sensibles. **Conclusiones:** este artículo propone un marco ontológico que extiende la Nomenclatura Sistematizada de Términos Clínicos de la Medicina con una dimensión de privacidad para asegurar el acceso a los datos sensibles de los pacientes. Este estudio tiene limitaciones que podrían abordarse en futuros estudios. En primer lugar, el tamaño de la muestra es limitado. Otras exploraciones del intercambio de conocimientos entre otros tipos de trabajadores (por ejemplo, enfermeros) y otros países añadirían riqueza a los fenómenos y las asociaciones descritas en este documento.

Palabras clave: Registro Electrónico de Salud (EHR), sistemas de salud, intercambio de conocimientos, ontología.

Um referencial ontológico para o compartilhamento do conhecimento nos cuidados da saúde

Resumo

Introdução: a habilidade de compartilhar a informação inerente dos PEPs (Prontuário Eletrônico do Paciente) tanto interna como externamente em organizações de cuidados da saúde já foi aceita como um método para melhorar a qualidade e a entrega do cuidado, mas também levantou algumas questões importantes relacionadas com assuntos legais e de privacidade. Este trabalho tem como objetivo explorar os fatores críticos que impactam o compartilhamento do conhecimento no setor francês de cuidados da saúde. Nosso enfoque principal de pesquisa é responder à pergunta de como melhorar o compartilhamento de conhecimento no setor da saúde. **Metodologia:** um estudo qualitativo exploratório foi implementado para pesquisar o compartilhamento da informação inerente dos PEPs. Conduzimos entrevistas não diretivas, cara a cara com médicos que trabalham em diferentes instituições de saúde. **Resultados:** três questões principais foram identificadas, principalmente a necessidade de: terminologia comum à área de saúde, a interoperabilidade entre sistemas de informação da saúde e os consentimentos informados dos pacientes antes de compartilhar seus dados sensíveis. **Conclusões:** este trabalho propõe um referencial ontológico que estende a Nomenclatura Sistematizada de Termos Clínicos Médicos com dimensões de privacidade para proteger o acesso a dados sensíveis do paciente. Este estudo tem limitações que poderiam ser resolvidas com estudos futuros, por exemplo, o tamanho limitado da amostra. Explorações futuras do compartilhamento de conhecimento entre outros tipos de trabalhadores (exemplo, enfermeiras) e outros países enriqueceriam esse fenômeno e as associações descritas neste trabalho.

Palavras-chave: compartilhamento de conhecimento, ontologia, Prontuário Eletrônico do Paciente (PEP), sistema de cuidado da saúde.

Introduction

Knowledge sharing plays a major role in improving organizational performance. Organizations are increasingly investing in knowledge sharing systems to effectively and efficiently capture, circulate, and reuse information resources (Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995; Teigland & McLure, 2003). This key process is particularly sensitive in the healthcare sector, where knowledge sharing is critical to patient care efficiency. This situation creates the challenge of finding a balance between knowledge sharing —to ensure value creation— and conservancy/protection of the patient's data. Even though the impact of knowledge sharing on decision making and improvement has been discussed in previous research, there are some controversial factors that reduce the propensity to share within healthcare services and systems. Attitude, culture, and technologies have all been identified as barriers to the knowledge sharing process (Choi, Kang, & Lee, 2008; Witherspoon et al., 2013).

Today, the use of the EHR (Electronic Health Record) leads physicians to share sensitive information. To protect healthcare information and facilitate knowledge sharing processes in this sector, it is critical to define convenient classification principles. However, in France medical data and information do not have different classifications; they are all confidential and protected by medical secrecy. The Touraine Act (Article 47 of the Health Bill) would enable researchers, associations, and private companies to have access to billions of types of medical data. Nonetheless, classification rules create distinct classes of information based on their levels of sensitivity. Likewise, providing access to qualified information demands a strategic value.

This research focuses on understanding the factors that influence knowledge sharing between physicians in the French context and proposes an ontological framework that extends the Systematized Nomenclature of Medicine Clinical Terms with the privacy dimension so as to secure access to sensitive patient's data. Our research questions are the following:

- What are the main barriers to knowledge sharing in the French healthcare context?
- How to improve the current EHR implementation in order to enhance knowledge sharing?

The paper begins by presenting the various researches about knowledge sharing, followed by a focus on the current context of the healthcare domain. Then, we describe the research methodology used to answer our questions and present the obtained results. Later on, we discuss the main findings and propose a conceptual model and an ontological framework for healthcare knowledge sharing. We conclude by underlining the limits of our research while presenting the future research directions.

Background

Knowledge sharing

Knowledge sharing (KS) is defined as "the act of making knowledge available to others within the organization. Knowledge sharing between individuals is the process by which knowledge held by an individual is converted into a form that can be understood, absorbed, and used by other individuals" (Ipe, 2003). It is a volitional action by which knowledge is made known to other people (Cramton, 2001; Davenport & Prusak, 1998). The shared knowledge could be explicit or tacit (Bartol & Strivastava, 2002). KS therefore is an exchanging process of implicit and explicit knowledge allowing the development of a new idea and subsequently the improving of organizational performance (Wang & Noe, 2010). As other activities, knowledge sharing involves both benefits and risks (Constant, Keisler, & Sproull, 1994; Cummings, 2004) and it differs from "knowledge transfer" and "knowledge exchange". "Knowledge transfer" includes both the sharing of knowledge by the knowledge sender and the acquisition and use of knowledge by the receiver. "Knowledge transfer" usually has been used to designate the movement of knowledge. On the other hand, "knowledge exchange", although it has been used interchangeably with knowledge sharing, involves both knowledge sharing, when an agent provides knowledge to others, and knowledge seeking, when an agent searches for knowledge from others (Wang & Noe, 2010). Sharing Knowledge explicitly or tacitly requires effort on the part of the individual doing the sharing. Various factors affect the decisions about the sharing of knowledge among employees and other organizational participants; however, most previous studies have concentrated on the role of attitudes, intentions, and behaviors on knowledge sharing (Wang & Noe, 2010).

Knowledge sharing in the healthcare domain

Scholars have stressed the role of knowledge sharing in the healthcare domain as a way to improve performance by providing qualified services. In that sense, developing information technologies has an extreme effect on the facilitation of knowledge sharing. Expanding these technologies encourages professionals to become more active participants in their domain (Ivanov, Sharman, & Raghav, 2015). Glass et al. (2011), for instance, have discussed how encouraging the attitude to share information about patients leads to greater decision making in healthcare, and subsequently enhances treatment services.

Perera et al. (2011) have done research on patients and found that although the majority of them were interested about computerized healthcare information, the larger part was concerned about privacy issues and did not want to share their record outside healthcare circles. Torabi and Beznosov (2013) state that despite the global acceptance of knowledge sharing, there is still a growing concern about privacy. This leads to an attitude of unwillingness towards sharing. Indeed, health records are personal in nature and involve privacy issues, therefore assuring clients that these privacy issues are essential to the knowledge sharing process. Concerns about privacy are divided into: the type of information stored (e. g., medical, biometric, financial, behavioral, and biographical) and which sector would use the shared information (Smith, Dine, & Xu, 2011). Likewise, technology and the difficulty to apply it on the healthcare domain also appear as controversial issues (Choi, Kang, & Lee, 2008; Witherspoon et al., 2013). Along that path, Borgman (2015) researched how to guard the confidentiality of data: "What a type of data to share and with whom".

Typically, different Healthcare Information Systems (HIS) have been planned to serve knowledge sharing within a healthcare setting. One of these HIS is the implementation of Electronic Health Records. EHRS are considered to offer significant benefits to patients and health providers, as current paper-based records have serious deficiencies. The ISO Technical Report (ISO-TR20514) defines a basic generic EHRS as "a repository of information regarding the health status of a subject of care, in computer processable form." However, since the original idea of electronic health records was focused on data storage and not on data processing, a lot of current implementations do not take full advantage of the opportunities provided by computerization. In order to address the knowledge sharing issues, the healthcare domain is gaining more attentionin the field of Ontology and Semantic Research (Prathima, Parvathy, & Devi, 2011; Yuwen & Yang, 2010). Ontologies provide a common understanding of a domain that can be communicated between people, and of heterogeneous and widely spread application systems. The goal of an ontology is to achieve a common and shared knowledge that can be transmitted among people and application systems. Gruber (1995) defined Ontology as "explicit and formal specification of a shared conceptualization of a domain of interest" (p. 908). Ontology provides the unique representation of knowledge. It enables unambiguous recording of data in a knowledge base. Medical Ontologies such as Medical Language System (UMLS) and SNOMED-CT (Brut et al., 2011) would improve the access to the electronic patient records privacy. That way, ontology allows healthcare knowledge sharing through a semantic access to EHR, i. e. by defining clinical terminologies for precise and shareable expressions in EHR entries. Another advantage of ontology is that its hierarchical structure will result in better control over access and use of personalized medical information.

In addition to the problem of knowledge access, EHR systems raise troubling issues regarding privacy and ethics (Ben-Assuli, 2015). Indeed, the rapid development of data collection and management technologies has led to previously unknown challenges in that medical information is now available on mobile devices, shared networks, and even sensors attached to the human body (Malin, El Emam, & O'Keefe, 2013). These changes in the way information is stored and retrieved have sensitized the public to issues of privacy (e. g. healthcare workers sharing health records of famous people, identity frauds or unintended disclosure of medical information through a stolen mobile device). Caine and Hanania (2013) showed that most patients wanted more control over the use of information stored in their EHR, and none agreed to a complete, comprehensive access to their EHR by practitioners affiliated with their healthcare provider. Powell, Fitton, and Fitton (2006) surveyed British citizens concerning the introduction of the NHS national health records system and inquired whether there were items send details which they preferred not to be shared with the national records system. They found that the items that participants usually wished to keep private were mostly

related to pregnancy, contraception, sexual health, and mental health, which is information considered sensitive, private, and potentially stigmatizing.

Regulatory compliance issues of health data

In European and internal texts (Directives 95/46/CE and the Data Protection Act No. 87-17 respectively), "critical data" is defined as imperious confidential medical data, therefore it can be collected only in certain cases and under legal supervision. Collecting and analyzing these types of data is prohibited. However, in some specific cases, such as the computerized medical record of a hospitalized patient, laws authorize data storage and analysis. Besides this, a patient can restrict the sharing of personal data regarding his treatment in an establishment (articles 38 and 40 of the law of January 6th, 1978, modified in 2004). Moreover, a patient in charge may object to some data processing that could be considered as sensitive data. Additionally, this control is required "to take all necessary precautions, given the nature of the data and the risks presented by the data processing, in order to preserve the data security and, in particular, to prevent them from being deformed, damaged or unauthorized accessibility" (Article 34 of Data Protection Acts).

The medical data contains information that may reveal the pathological state of a given person. This sharing of data allows professionals to improve their management. Information sharing between healthcare professionals also responds to a will of avoiding redundant examinations and limiting useless acts. However, in spite of a legal principle, there are still several concerns. The lack of an international dialogue regarding medical data analysis and a significant growth of technologies makes it almost impossible to legislate on all of the newly created technical systems.

The article L1110-4 al. 3 of the public health codes states that: "two or several healthcare professionals, unless disagreement of the person duly warned, can exchange information concerning the same person being cared for, to assure the continuity of care or determine the best health care possible. When the person is cared for by a healthcare team in a medical system, the information concerned is considered to be confided by the sick person to the entire medical team." The article L1110-4 al. 3 of the public health code encompasses a relatively broad and vague

scope. The purpose of the exchange of data is to provide the most sanitary coverage and to manage the continuation of treatment. These two objectives seem relatively obscure and so broad that they could legitimize numerous exchanges of medical information. This way, the article does not seem to effectively find a balance between the interests of privilege in regards to the exchange of data and respect for one of the fundamental rights of the patient, i.e. respect for the sensitivity of personal information.

The Touraine Bill aims to reform the medical access methods by allowing profit-seeking companies to have access to this kind of personal information. Article 47 of the Bill of Health, as adopted by the National Assembly on December 15th, 2015, plans for the creation of a "National System of Health Data." This system will gather all the medical information collected by the current public institutions once it has been made anonymous. The objective set forth by the government is to make the information more accessible while maintaining and respecting the confidentiality of patients' medical files. This base of information could interest all organizations in the world of health. For public institutions, this new database could allow for a better approach to the health system —to rationalize it and correct its deficiencies. The doctors could have a more global view of the problems connected to health, especially on the national level, while anticipating and improving the care and treatment of certain diseases. For example, it would be possible to anticipate an epidemic of certain diseases or to optimize the treatment of chronic ones.

Methodology

Study setting and data collection

A review of the literature on knowledge sharing in healthcare revealed that the concept of knowledge sharing and privacy were rarely studied jointly. As few studies addressed these two themes in an explicit way, an exploratory qualitative study is useful in this context. We conducted non-directive, face-to-face interviews with physicians working in different healthcare institutions. The interview guide consisted of four themes: 1) use of the Electronic Health Record, 2) information sharing (explicit knowledge), 3) knowledge sharing (tacit/implicit knowledge), and 4) privacy and access. It was tested and refined with a physician (a department head of resuscitation and intensive care) who participated in several

projects involving the EHR implementation. The data analysis was performed by using the qualitative content analysis method (Berelson, 1952) supported by NVivo 10 software.

Sample

Our sample consisted of seven physicians from our personal networks who were requested to participate in the study. These physicians carry out their practice in 7 different healthcare institutions. Their experience ranges between 20 and 30 years and they have varied profiles: general practitioner, anesthetist-resuscitator, specialist in vascular medicine, internal medicine specialist, two oncologists, and a cardiac surgeon. These physicians have participated in the implementation of EHR in healthcare institutions in France.

Pre-Coding

The audio recordings were transcribed into a verbatim transcript. Interviews lasted about 75 minutes. The interviewers labeled transcripts with a date and specialty of each physician, but no name. The senior researcher divided the seven transcripts into 630 text passages (i. e. text fragments or, in other words, independent statements). Each text passage corresponded to a single topic or meaning.

Open coding

To familiarize themselves with the interview content and the coding framework, three of the authors who were trained in the content analysis methodology worked independently to determinate the enablers (positive factors) or inhibitors (negative factors) of knowledge sharing. They used open coding to cluster practitioner statements into themes (nodes). Then, they compared and discussed their results with the senior researcher. Two other researchers who were not involved in this study started from scratch working independently to code the passages using NVivo10 software. The coders agreed on 90% of the passages, demonstrating inter-coder reliability. Coders discussed and resolved their disagreements. The senior researcher reviewed the results. The quotes of physicians were then translated into English and validated by a native English speaker.

Results

This section presents an analysis of the transcriptions in the light of studied objectives.

According to the first physician, certain information must not be shared or distributed:

> It is not very easy to put up protection barriers for data security. How to implement them? According to the profile of each one? It is almost impossible to control medical staff, who comes for a long time or a temporary moment, and setting privacy rules is complicated.

He explained the complexity of sharing sensitive information: "...people were affected by HIV; accessing their file was impossible. For these types of patients, stricter accessibility rules have to be defined for other physicians, moreover, which physicians can access the file should be based on the patient's agreement."

For the second physician, the decision about classification of medical data returns to the patient, which is the proprietor of his data: "It is the patient who must choose what is available to the general public and what is not." On that note, he explained:

> Even when you have security systems with access controls, generally the passwords are hung on the wall, like everywhere. If you want the hospital is the place of '3*8' (shifting work time), there is always a team which comes after the previous one; it is a place where there are temporary employees.

The third physician defined non-shareable information and the people who can share it: "This information relates to personal patient life, psychic elements... sometimes we don't have time to ask a patient to choose which information is confidential and which one is private. Sometimes we are involved in a massive flood of information, and don't know how it should be shared." The choice of sharing information is difficult given the legal obligations. He explains that "we are a little flooded by the sum of information that we have to give, and we always have a legal constraint."

The fourth physician explained that medical staff may have access to very private and highly confidential information, and should respect professional secrecy. Sometimes, he hides some elements: "I don't want to note the name of disease at all because it is so private. Some patients ask me not to note it on their

file. I'll give you some examples, a voluntary interruption of pregnancy, or this can be sexual assault..." He noted that the patient's file sometimes contains information that is not useful or relevant to ensuring the consistency of care.

The fifth physician considers that the patient has to know his record in its entirety and that it comes down to him to manage it and get empowered. So, he notices: "for me it is the patient who has to manage these data and all information about his health." He explained the complexity of sharing: "there are always questions about which knowledge and information should be shared and in which way it should be done? Daily, we are very confused."

The sixth physician explains that some information must be kept discretely or anonymously. He notes that "for HIV, it is noted in blood results, but it is not re-reported roughly in red 'PATIENT AFFECTED BY the HIV'... Certain physicians who did not want to put it in EHRs, particular in the cases of AIDS".

Finally, the seventh physician interviewed acknowledges that sharing information in the medical domain stays a vague theme, especially regarding the information that can be shared: "We share information if it is relevant to the care of the patient...Thus, everybody is entitled to the respect for its private life. It is can be psychiatric diseases, sexually transmitted disease…"

Discussion and contributions

The interviewed physicians found that the current EHR structure does not allow an effective and secure knowledge sharing. Although this electronic record has been built to solve sharing issues and to improve collaborative work, there is a business gap between theoretical expectations and its current use in Health Information Systems. More precisely, our qualitative analysis has revealed that knowledge sharing within EHR systems raises three main issues: 1) the need for a global standard terminology for semantic access to EHRs, 2) the need for semantic interoperability among healthcare information systems, and 3) the need for managing privacy issues within EHR systems. These issues are especially more challenging within the healthcare big data context.

In order to move to an efficient and secure use of EHR, we propose a preliminary core ontological framework that covers the aforementioned main issues. This framework encompasses three main ontological facets: a domain facet, an informational facet, and a privacy facet.

The domain facet

With the fast-growing clinical terminologies and changing needs of the physicians in different hospitals, a common reference terminology needs to be adopted to ensure a high quality in information retrieval. The existing medical Ontologies such as Unified Medical Language System (UMLS), GuideLine Interchange Format (GLIF), Generalized Architecture for Languages (GALEN), International classification of Diseases (ICD), and Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), could be used as a means to standardize medical concepts within EHRs. SNOMED CT is proven to be the most efficient and robust classification.

Our idea is to exploit these taxonomies in order to get access to EHRs in a standardized way, e.g. using the diseases classification, in which a certain concept such as "diabetes" will be the gateway for all the information classified based on it. Figure 1 depicts an excerpt of the SNOMED CT concept hierarchy.
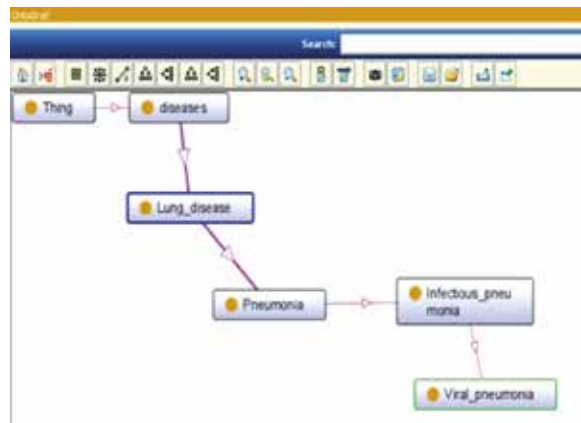

Figure 1. The SNOMED CT concept hierarchy. Compiled by the authors

The informational facet

In order to deal with the issue of interoperability, multiple efforts for standardizing EHRs structure have been proposed —such as HL7 and open EHR. However, no general solution has been adopted for the moment. In France, an EHR is organized into eight areas that organize health data of a patient:

- Synthesis of the patient medical status and general medical data.
- The treatments and healthcare associated documents (e.g., prescriptions).
- The reports (e.g., medical consultation or hospitalization reports).
- Medical imaging (e.g., latest magnetic resonance imaging results).
- Laboratory analysis results (e.g., blood analysis).
- Prevention data (e.g., vaccine reminders).
- Certificates or statements (e.g., certificate for a sport practicing).
- Personal space, which contains documents that the patient considers as important to inform his doctors (medical images or digital documents provided by a health professional).

A standard representation for an EHR structure allows defining one record with fine-grained information that will hold any type of health-related data item for the entire lifetime of a person (figure 2). Although various EHR systems exist within healthcare organizations, the unified EHR structure simplifies inter-organizational data exchange and sharing in order to increase the quality of service to patients.
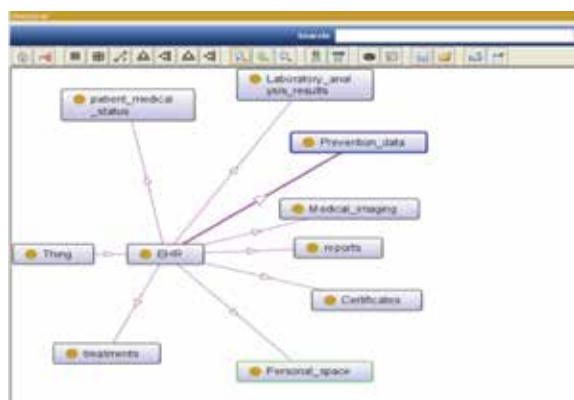

Figure 2. EHR information ontology. Compiled by the authors

The privacy facet

Access control is a central problem in privacy management. The interviews revealed that the responsibilities in healthcare organizations are widely shared and that healthcare professionals may generally be non-compliant with privacy guidelines. A common practice in controlling access to sensitive data is Role-Based Access Control (RBAC). But RBAC is limited as it does take into account the patient consent for accessing personal and sensitive data. According to the ISO 27002 standard, the privacy dimension needs to

> Ensure an appropriate level of protection to information. It is appropriate to classify the information to indicate the need, priorities and desired degree of protection when handling them. The information may have varying degrees of sensitivity and criticality. Some information may require a special level of protection or special handling. It should develop an information classification plan for prioritizing protection levels and inform stakeholders of the need for special handling (International Organization for Standardization, 2013, p. 22).

Legally, there is no typology for classifying privacy levels of medical data. Nevertheless, it is possible to distinguish between public, private, and confidential data. Public data encompasses all of the data that should be kept at the disposal of the public. It is produced or collected by public authorities within the framework of their activities. In France, the law enforces exceptions to the general obligation of opening access to public data for certain information relevant to private life. Private data, on the other hand, does not seem to be able to be defined, and only the already defined personal data has a real existence, particularly from a legal point of view. Lastly, confidential data could be defined as data protected by a confidentiality determined by law. Confidential data does not only exist in the medical material. Confidential data can exist regarding taxes for example. However, the etymology of the word confidentiality indicates the importance of maintaining the secrecy of this data. The word confidentiality derives from the Latin word "fides" meaning the confidence/the fidelity. The confidential information contains a certain degree of security that we place in the heart of the information.

We propose to extend the RBAC model with the aforementioned data privacy levels. This enables the preservation of the patient's privacy by exposing only the public personal data. The confidential and the private data will only be used for providing the patient with the best medical care, for example in the case of an emergency situation. Figure 3 depicts the privacy ontology.

With this proposal, ontological EHRs could be accessed through a semantic annotation based on SNOMED-IC ontology for representing patient diseases, on informational ontology for representing fine-grained standardized EHR sections, and on privacy

ontology for representing role access restriction as well as privacy dimension on patient's data. Figure 4 depicts a semantic annotation example.
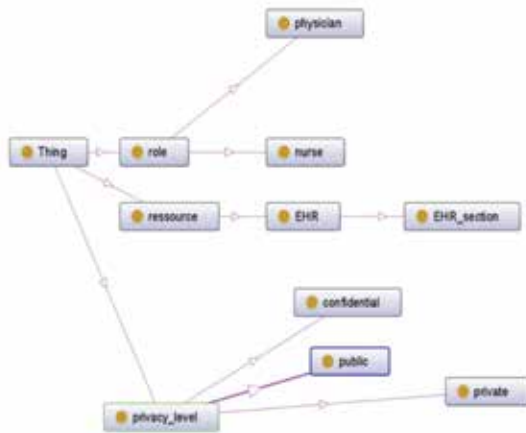

Figure 3. Class hierarchy of the privacy ontology. Compiled by the authors

Figure 4. Ontology-based electronic patient record annotation. Compiled by the authors

Conclusions

This paper's objective consisted in exploring the mechanisms allowing the improvement of knowledge sharing in the healthcare sector. Our study underlines the role of classification in knowledge sharing. However, security concerns represent a predicament in determining what should be shared and what should be private. Decisions about shareable data are determined by the patients. Currently, there are no principles to classify information as confidential or sensitive, and this causes physicians to block access; consequently, it blocks sharing too. Furthermore, information technology does not propose qualified solutions for considering both privacy issues and shareability processes in the healthcare system. This is because in certain cases

there is no clear rule to describe which knowledge is shareable and which is not.

In order to move to an efficient and secure use of EHR, we propose a preliminary core ontological framework that covers the aforementioned main issues. Ontology can contribute to improving knowledge sharing by making the medical knowledge understandable and accessibles. Experimental research focusing on our proposition would shed further light on its scientific utility. However, this study has limitations that could be addressed by future studies. First, the size of the sample is limited. Further explorations of knowledge sharing among other kinds of workers (e. g., nurse) and other countries would add richness to the phenomena and associations described here. On the other hand, this study used interviews and content analysis to examine the phenomena-of-interest. Additional research based on other methods, for instance field observations, survey instruments, and action research, might yield new insights about the proposed framework.

Nowadays, smartphones, social networks, sensors, smart meters, Internet of things (IOT), Cloud computing, among others, are all new technologies that might collect a maximum of data about the patients in order to conceive services fully adapted to their needs. Massive data is, therefore, being produced at exponential rate worldwide. All these elements motivate the use of comprehensive ontologies and semantic technologies to address these new challenges on data privacy.

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