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Towards improving usage and management of supplies in healthcare: An ontology-based solution for sharing knowledge

N. Lasierra [a,*], F. Roldán [b], A. Alesanco [a], J. García [a]

[a] Communications Technologies Group (GTC), Aragón Institute of Engineering Research (I3A), University of Zaragoza, Spain
[b] Hospital Management Research Unit, University of Zaragoza, Spain

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ABSTRACT

The goal of this work is to contribute to an improvement in the management and usage of medical items in hospitals by developing an ontology-driven solution that organizes and describes clearly related knowledge. Experts in the purchasing and management of hospital supplies (administrative and clinical) were invited to participate at different stages of the ontology-based system development. As a result of the first stage, the *HealthCatalog* ontology was developed. This ontology models generic items included in a health catalog and their management. Secondly, a further refinement of the ontology was conducted by specifically studying the case of gloves. Twenty-seven references of different glove types were modeled and included in the ontology during the stage two. A prototype was then developed as a proof of concept and for the evaluation of the ontology. Finally, a usability evaluation was planned to improve the ontology and obtain feedback from experts after testing the system. Experts involved in the evaluation stressed its potential use in a real clinical environment and the benefits it would bring in terms of cost and sharing knowledge among clinical personnel. Our proposed ontology-based system provides an understandable and organized solution to capture knowledge regarding item management and usage. It addresses the integration challenge of health catalogs while providing a framework for collaborative sharing and knowledge acquisition among clinicians.

1. Introduction

The rising cost of healthcare is a major concern for governments today. Motivated by demographic changes, e.g. the increase of the aging population with chronic conditions and disabilities in western countries (ECDA, 2010), different methods need to be studied for reducing the cost of providing health care services while ensuring that they continue to be accessible to all citizens (Heinrich et al., 2008; Wickstrøm, Serup-Hansen, & Kristiansen, 2002). The development of telemedicine systems (Monteagudo & Moreno, 2007) and reducing unnecessary diagnostic tests (Vegting et al., 2012) have both been studied with the aim of improving the effectiveness of health care delivery. Effective use of medical products, intelligent purchasing and new management strategies can also positively contribute to reducing cost while maintaining the welfare state (Songthung et al., 2012). Carrying out these tasks efficiently requires effective management of a key element within a health system organization: the health catalog.

Professionals from different disciplines (clinical, informatics, administrative) using a wide range of products, equipment and services, generate the core of daily activity in hospitals and medical centres. All these centres are managed by means of an ERP (Enterprise Resource Planning). This software application integrates a set of management actions and policies that operates over a structured database containing a list of items. The ERP together with this database are used to manage the available resources of the hospital. This list of available items in the previous database is known as the health catalog. The item forms the basic unit of a health catalog, an item being any type of product (e.g. needles, syringes, gloves or bandages), equipment (e.g. ultrasound scanner) or service (e.g. cataract surgery) used in a hospital. This is a big and complex structure that may include around 20,000 references (there is one reference for each type of item and for each available size of that item). Purchasing procedures, stock management, services provision or the authorization for using the items are examples of procedures done according the health catalog. Nowadays, as stated before, these health catalogs are implemented in big databases. These include information about each item regarding

* Corresponding author. Address: Communications Technologies Group, Aragón Institute of Engineering Research (I3A), University of Zaragoza, C/María de Luna Ed. Ada Byron, 50018 Zaragoza, Spain. Tel./fax: +34 976762698.

E-mail addresses: nelia.lasierra@unizar.es (N. Lasierra), fernando.roldan.h@gmail.com (F. Roldán), alesanco@unizar.es (A. Alesanco), jogarmo@unizar.es (J. García).

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purchasing information (e.g. cost), classification within each family product, item movements (e.g. stock in warehouses or consumption) and basic descriptive text information. Currently, health catalogs are used in hospitals by technicians (management personnel) in charge of purchasing and control of materials.

Two years ago, the situation in Spain was that multiple health catalogs were used in different public health organizations even in each area of one single region of the country. This model enhanced the autonomy of each individual centre that comprised a health area. However, other limitations emerged such as poor product management in terms of costs and usage. While knowledge in terms of cost-efficiency remains in a single area of the health structure, all the costs were assumed by the public health system. As a consequence, motivated also by the global economic crisis, current efforts in hospital management now focus on the centralization of the health catalog and consequently its management. Nowadays, there is no single standard or universal health catalog. Current trends aim to align items from different hospitals in an area (corresponding to a local authority) using as a reference the catalog of the main hospitals. Furthermore, there is an increasing interest in centralizing pharmacy purchases.

The health catalog includes a wide diversity of each type of item. An example is medical gloves. The use of gloves has dramatically increased in medical practice to prevent the spread of bloodborne pathogens (WHO 1, 2006). Choosing the appropriate medical glove is critical for effective protection against infections and hazardous materials (Stoessel, 2008). As pointed out by the WHO (World Health Organization), both patient and clinician safety depends on the appropriate usage of gloves (WHO 2, 2009). The classic examination glove is the latex glove. It is elastic, comfortable and has a high degree of sensitivity. Latex gloves are appropriate for techniques that require some precision such as cures and they are appreciated due to the perceived superior durability of the material (Kerr et al., 2004). However, other alternatives are available for allergic people. One example is the nitrile glove which is less elastic than the latex glove, or the vinyl glove which is more elastic but easy to break. The last alternative is the surgical glove which is mainly made of neoprene, is resistant and provides good sensitivity. However, the cost of surgical gloves is considerable higher than the other gloves. The eligibility criterion is then conditioned by tactile sensitivity, elasticity, allergies, price, suitability for the task in question and especially barrier integrity protection (e.g. strength and permeability) (Moore, Dunnill, Peter, & Wilson, 2013). Furthermore, the characteristics of medical gloves usually vary from one manufacturer to another. Thus, around 40 references to gloves can be included in a health catalog.

As a consequence of the wide diversity of items that can be included in a health catalog and also their availability in health centres, it is the experience of the personnel in charge of supply management (administrative and clinical staff) that professionals from different organizations may use different items for the same medical practice. It is clear, therefore, that only one of them is using the best option for a specific technique in terms of cost-efficiency and safety. In fact, this is basically a safety problem. Being aware and properly informed is crucial for reducing risks e.g. of infections. The adequacy of each item for a specific technique is learned and reported through experience over time. Hence, an interesting idea would be to collect this knowledge and share it in a clear manner to take advantage colleagues' experiences. In this paper we present an ontology-based solution in order to contribute to the sharing of expert knowledge and also to unify health catalogs. Our purpose was to develop an ontology-based system to gather and formalize knowledge regarding available items in health catalogs, their usage and their management. This tool could be used as a complement to current ERP systems. Not only are the items included in the health catalog formalized, but also their relation with management tasks that belong to the ERP.

Ontologies are a recognized vehicle for knowledge representation and proven technology for solving problems of understanding. On the one hand, we propose the use of ontologies to represent each item included in a health catalog. Providing a clear description of items will help to align different health catalogs while making clear their content and management. On the other hand, we propose that the health catalog-tool should also be used by clinical staff as a means of sharing knowledge and learning. Our idea is to contribute to a dynamic environment managed by clinical staff where information regarding items included in the ontology-based system may be updated in the light of clinicians' experience and knowledge. This represents an innovation in hospital supply management given that such information is not available in current management systems. This paper reports the main components of the ontology and the methodology followed to study its usage and evaluation. It was not our purpose to address the size and full complexity of the health catalog, but simply to establish the basis for an ontology-based solution and its feasibility. This is an innovative solution towards improving medical supply management and usage in medical centres.

The remainder of the paper is structured as follows. Section 2 provides the background and information on related work. Section 3 describes the materials and methods involved in each stage of the methodology. The results are presented in Section 4. The main advantages and drawbacks of the proposed solution are discussed in Section 5. Finally conclusions are summarized in Section 6.

2. Background and related work

Ontologies have been successfully used in recent decades in the world of computer science and particularly in the semantic web domain for the purpose of achieving a comprehensive and common machine-readable understanding (Berners-Lee, Hendler, & Lassila, 2001). An ontology is an abstract model that provides a controlled vocabulary for the description of concepts, each with an explicitly defined semantics in machine-readable language. Ontologies aim to capture consensual knowledge by a group of people and may be reused across different applications (Corcho, Fernández-López, & Gómez-Pérez, 2003; Studer, Benjamins, & Fensel, 1998). By means of rules it is possible to merge knowledge from them. Also, their usage is popular for the implementation of decision support tools applied in many areas (Bouamrane, Rector, & Hurrell, 2009; Saa, Garcia, Gomez, Carretero, & Garcia-Carballeira, 2012).

Ontologies have proven to be useful tools in many areas including the healthcare and management domain (Becker, Heine, Herrler, & Krempels, 2003; Campana, Moreno, Riaño, & Varga, 2008; Jara et al., 2010; Lasierra, Alesanco, Guillén, & García, 2013; Valls, Gibert, Sánchez, & Batet, 2010). See, for example, Valls et al. (2010) where an ontology is used to describe organizational knowledge in a health care institution as the base to support its management in terms of actors, services and actions. This ontology was part of the European project K4Care (Campana et al., 2008). This project, which focused on personalized home care assistance, included a set of ontologies to capture and integrate knowledge and experience from different centres and professionals. As another example, see the OntHoS domain ontology which gathers a set of terms and definitions for modeling scenarios of hospital logistics (Becker et al., 2003). An interesting application of a knowledge-based system dealing with pharmaceutical products is presented in Jara et al. (2010). This work proposes the combination of the Internet of Things (IoT) and an ontology-based system to detect and assess patients regarding adverse drugs reactions.