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Proposal of an ontology for Mental Health Management in Brazil

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Abstract

Mental illness represent a large part of public health problems worldwide. Additionally, mental health managers need to make decisions based on complex data from dispersed sources with low levels of standardization and integration. This generally hinders knowledge extraction and its use as a reference to provide useful indicators and reports for efficient decision making. In this context, the interoperability between Information Systems is an essential characteristic to establish the capacity of communication, exchange and reuse of information for the generation of knowledge. In order to reduce the data complexity and to assist in the data interpretation, Semantic Web technology can be used. It classifies the stored information with metadata and give them meaning and thematic through the use of ontologies. Therefore, given the importance of mental health and the need for quality data, this article aims to specify and develop an ontology capable of consuming, integrating, analyzing and making available data of a regional mental healthcare network.

Keywords: Mental Health; Information Systems; Semantic Web; Ontology

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1. Introduction

The Semantic Web (SW) is a new model of data structure in the internet that will allow better results for users in general, this technology makes use of ontologies to realize its operation. This model proposes that the documents of a database can be classified according to their thematic, subject and context [1]. Furthermore, it helps computers to interpret the meaning of data to improve: search results, data exchange, machine learning, interoperability and obtaining data meaning. The SW development depends on the implementation of the metadata in the web pages, since it is through them that software agents can relate web pages according to their theme or subject [2].

For a successful implementation of a SW project, the development of ontologies is necessary to define and relate the metadata. These artifacts are conceptual maps that give context and meaning to the data [3]. An ontology is an explicit and formal specification of a set of concepts in a particular field of interest.

Therefore, the objective of this article is to propose an ontology to assist in the management of mental healthcare network in Brazil, in order to allow the integration and interoperability between independent databases and to enable the generation of relevant indicators to mental health, in order to improve decision making. It is part of a larger project whose main objective is to specify and develop a Semantic Web-based Decision Support System (DSS) for a regional mental healthcare network, which will be able to consume, integrate, analyze and make available data obtained from heterogeneous sources.

In the next section, a background related to mental health, ontologies and a contextualization of a mental healthcare network will be presented. The Methods section defines the methodologies used for the construction of the ontology, as well as the declaration of the domain and its subdivisions. The Results and Discussion section focuses on the demonstration of the ontology and its ability to improve the use and integration of health data. Finally, in the Conclusion section it is described in detail how the ontology can help the decision making process through the integration of information from databases of different natures, increasing the efficiency and effectiveness of health management.

2. Background

Currently, mental illness represents one of the greatest problems of our society, with depression being one of the most recurring problems in the world [4]. The World Health Organization (WHO) predicts that by 2020 this disease will be the leading cause of disability on the planet [4]. To improve this situation is necessary the sharing of information and knowledge from biomedical departments around the world. An ontology provides a common understanding of a knowledge domain through highly expressive relationships that can be used to increase the intelligence of a system [5][6].

Furthermore, there is a lack of relevant data, as well as specific reports and indicators in traditional information systems [3]. In addition, there are difficulties in registering, collecting and accessing information from a ‘Psychosocial Care Network’ (‘RAPS’; Portuguese: ‘Rede de Atenção Psicossocial’). The purpose of the RAPS is the creation, expansion, integration and articulation of health actions and healthcare services at different levels of complexity for people with mental disorders and people with needs arising from the use of crack, alcohol and other drugs [7]. The main components of RAPS are: primary care; specialized psychosocial care; urgency and emergency care; transitory residential care; hospital care; deinstitutionalization strategies; and psychosocial rehabilitation [7].

Given this context, specifically in the RAPS of the XIII Regional Health Department (XIII RHD) of the Sao Paulo State, Brazil, a web-based system entitled ‘Mental Health Information System of the XIII RHD’ (‘SISAM-13’; Portuguese: ‘Sistema de Informação em Saúde Mental do XIII Departamento Regional de Saúde do Estado de São Paulo’) was developed to monitor appointments, hospitalization requests, hospitalizations and the movement of patients in this network [8].

However, the SISAM 13 does not perform data analysis nor generate reports and indicators. Additionally, the current version of SISAM 13 does not support semantic interoperability, in other words, all the inserted data are isolated, hindering their reuse by decision support tools. Thus, an ontology needs be developed to allow the semantic interoperability of SISAM 13 and to improve the knowledge management of the mental healthcare network.

In order to provide an appropriate formality for knowledge reuse and optimization on the World Wide Web (WWW), there is the Basic Formal Ontology (BFO) [9]. It is a upper level ontology, a model that provides a strategy

for digital representation of information using concepts from information and computer science, linguistics, logic and philosophy [10].

The novelty of this article is related to the fact that, currently, there are ontologies in the field of mental health that focus on the description and classification of mental diseases, such as the MFO Mental Disease Ontology (http://www.obofoundry.org/ontology/mfomd.html), however, there are no ontologies that can map the processes of a RAPS with the purpose of generating indicators.

3. Methods

The proposed ontology is based on the concept that an ontology can be considered a software artifact which performs data indexing, building a controlled vocabulary for a specific knowledge domain [11]. The ontology includes the use of SW technologies along with a full understanding of the functioning of a mental healthcare network.

Initially, a literature review was conducted seeking to define the processes and components of mental healthcare networks. Secondly, best practices for ontology construction were handled. Finally, the ontology was developed through the integration of the mental healthcare networks procedures findings with the techniques of building ontologies. The Protégé software (https://protege.stanford.edu/) was adopted for building the ontology, its entities, properties and relationships, this software was selected because it is easy to use, reliable, robust and open source.

The development of the ontology was divided into the following stages: specification, prototyping and development. The first step, consists of specifying the ontology, which involves the collection of functional and non-functional requirements and the production of specification document that contains the domain definition, the purpose of the ontology, the definition of the users, the definition of the tasks and the resources needed. The next two stages, prototyping and development, involve validating the visual and functional characteristics of the ontology and they were conducted through Protégé software.

The BFO meta-ontology was adopted, since it is compatible with other ontologies worldwide and the dissemination, interoperability and reuse of the ontology can be facilitated [9]. With its hierarchical pattern, it is possible to describe the nature of the ontology entities, allowing that machines (software agents) and researchers can understand them. In this architecture, an entity can be classified as a *continuant* or *occurrent*. *Continuant* are entities that continue to exist over time (for example, doctor) and *occurrent* are entities that occur only at a given time, such as an event or process (for example, treatment). In addition, each of these entities have subtypes [12].

4. Results and Discussion

This section presents the developed ontology, which represents the operation of a mental health unit in Brazil. The main purpose of this ontology is to provide a structure for electronic information repositories capable of integrating information, providing a broader picture for the RAPS decision making and supporting the interoperability of different systems among different repositories.

The conceptual basis of the ontology presented here is the management processes of a mental health unit, the 'Psychosocial Care Centre' ('CAPS'; Portuguese: 'Centro de Atenção Psicossocial'), which is a unit belonging to RAPS. Thus, we do not start the development from existing mental health ontologies, such as MFO Mental Disease Ontology, since the existing ontologies map only the field of mental diseases classification and do not care about work processes. However, it can be used to integrate our ontology by incorporating the *disorder_classification* entity.

The main component of this study was the application of semantic indexes in the data related to mental health processes, transforming them into knowledge through the SW. Such knowledge can be used to generate useful indicators for public mental health management in this field, for example, bed occupancy rate, dropout rate, rate of symptom reduction, morbidity rate, patient satisfaction, among others [13]. The developed ontology can also be used to serve as a basis for the development of a DSS and a Health Observatory (HO).

RAPS processes were mapped through an ontology in the BFO model, creating a controlled vocabulary for the domain concepts and structuring their relationships in order to: generate semantic markings that provide dissemination and possibility of reuse of knowledge in other systems; facilitating the integration and the interoperability between information systems; and assisting in the calculation of relevant indicators.

For example, following the BFO structure, in the developed ontology the patient was classified as an *independent continuant* entity (which does not depend on other entities to exist) and its symptoms were considered as a *specifically dependent continuant* entity (which depends on another entity to exist, as a quality or variable of the first entity). Thus, the treatment of the patient is mapped in this procedure as an *occurrent* entity (an event that exists only at a certain point in time, having a beginning and an end).

The indexing of databases through metadata from ontologies, enables to search for information through its characteristics, such as thematic, area, context, relation with other information [14]. This allows to represent the implicit knowledge of a domain, through the definition and mapping of the *continuants* entities and *occurrents* entities within the health service (Fig. 1).

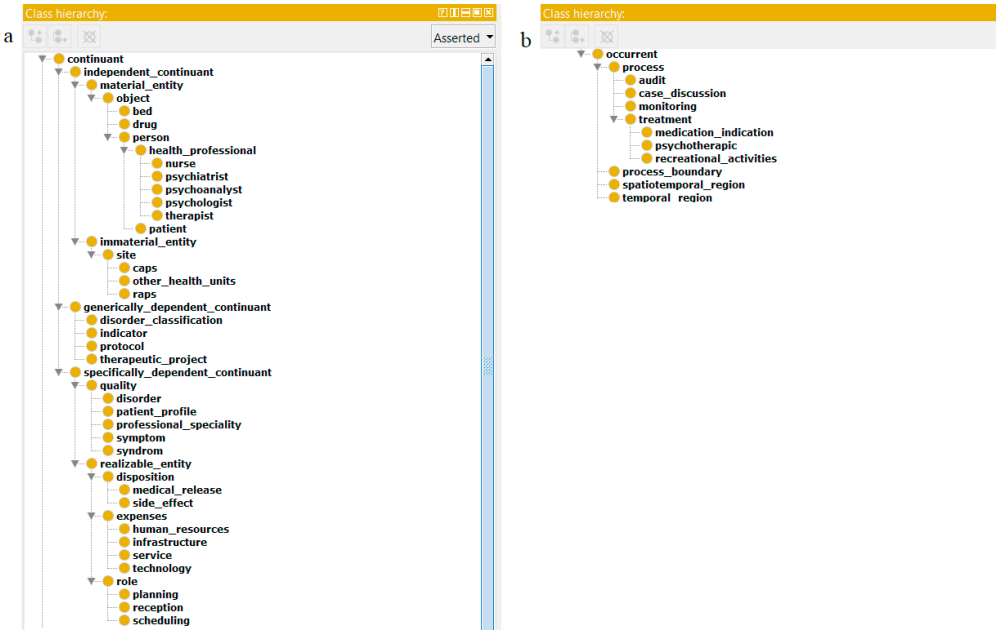

Fig. 1.(a) Continuants Entities to Mental Health Context; (b) Occurrents Entities to Mental Health Context.

In order to understand the organization of the health services, the processes and services were mapped , enabling the explanation of terms, functions and relations inherent to the patient within the RAPS.

As an example that represents the entire process of patient care, from the moment of arrival to the health service, passing through any procedure of discussion of the case and the accomplishment of the necessary activities for the treatment, there is the CAPS. Where the user is accompanied until the final situation in which one can receive medical discharge or return to pre-established activities or if these activities are found to be ineffective, a new discussion is generated about referral to other treatment methods (Fig. 2) [15]. The CAPS is an element included in RAPS, specifically in the specialized psychosocial care, and allow the population's access to psychosocial care through the reception, continuous monitoring and attention to urgencies and emergencies, in order to promote links and guarantee the rights of those who need treatment [7].

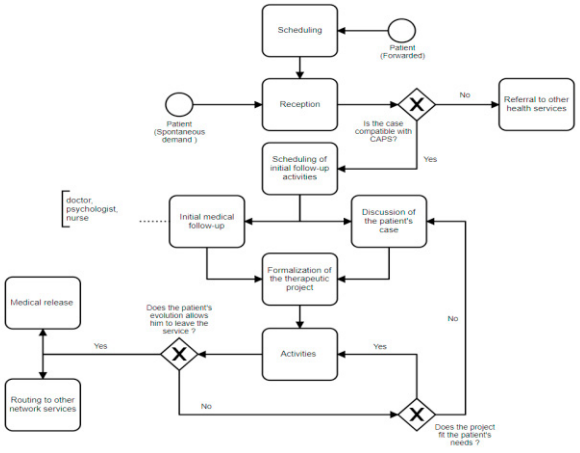

Fig. 2. User Service Flow in CAPS Mapped with BPMN.IO Software.

Therefore, these processes were represented through the ontology (Fig. 3). This ontology can be considered as innovative within the area of mental health management, since it characterizes not only clinical aspects but also administrative processes. However, the ontology does not have in its scope the detailed classification of all mental diseases, we only describe the mental disorder as a dependent entity of the patient. In order for the ontology to be more complete, it is possible to perform an integration with a specific ontology for classification of concepts of diseases of controlled medical vocabulary, such as the Disease Ontology (http://disease-ontology.org/), which has the classification of all mental diseases according to ICD-10 (International Classification of Diseases 10th Revision).

In the case of using the developed ontology in a DSS, it is necessary to index the raw data according to the semantic markings generated by the ontology, enabling the creation of information. For example, if a manager wants to know how many people had schizophrenia in the city of São Paulo in the year of 2017, he needs to look for this information in several systems of several hospitals in the city that work independently. With the application of an ontology, it is possible to index their databases so that a DSS works to obtain all the desired information coming from these different information systems directly. The main challenges faced in this case may be related to the incompatibility between different versions of Protégé and different BFO standards, to reuse an ontology, it is necessary to consider the BFO version.

For the case of using this ontology in a health observatory, the sources of input and output of data should be indexed and offered as the basis for a generation of knowledge and consequently of health intelligence [16]. Primary data comes from health information systems as well as administrative systems, supporting improved results, generating indicators of public accounts, quality management, payments and hiring. In addition supporting the production of epidemiological and demographic statistics [16][17].

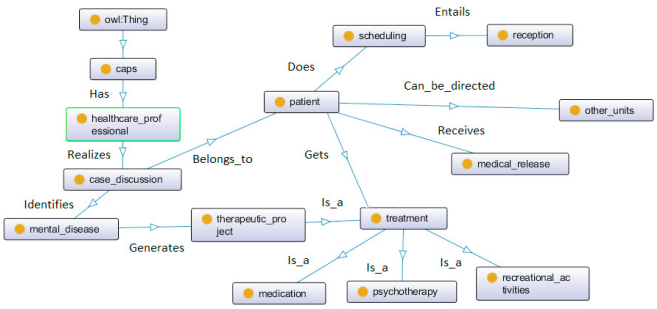

Fig. 3. Reduced Ontology showing only Process

5. Conclusion and future work

In conclusion, the proposed ontology has the power to integrate databases of different natures within the RAPS, allowing the semantic marking in the raw data and thus transforming them into information, knowledge, and in a later moment, in intelligence. Therefore, knowledge can be more easily disseminated, reused and subject to contributions and changes if necessary.

Furthermore, the ontology provides improvements to the RAPS decision-making and also to the creation of public health policies by providing the manager with information from various systems that work independently.

Before the advent of SW technologies, this type of panoramic analysis was very complex because it required an exhaustive search of information that was in information systems that used different standards. As future work we can mention the use of this type of ontology to serve as a basis for decision support information systems, besides the possibility of building semantic observatories in health, providing benefits for health managers, allowing greater efficiency in services, increase the quality of service and better allocation of resources. This directly brings benefits to every society that will improve performance and effectiveness in the public health sector.

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