APHRO Ontology for managing patient health records

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Abstract

This paper presents an overview of the Albanian Patient Healthcare Records Ontology with regards to the main medical services in "Mother Teresa" University Hospital Center in Albania, patients demographics, common vital signs of the patient, risk factors, patient visits and several diseases of the cardiovascular diseases, chronic respiratory diseases, diabetes and cancer. APHRO ontology will provide data of different patients and offer the opportunity to integrate patient records within different sectors in the hospital through mapping of ontology concepts to the SNOMED CT.

Keywords 1

Ontology, Healthcare, Integration

1. Introduction

Commonly the different HIS (Hospital Information System) components are designed and implemented by different software developers without explicitly focusing on the interoperability of the different HIS components, resulting into practical problems of interfacing and transferring data to each other [1]. Beside of that, it is not the volume of data that makes medicine significantly challenging, but the challenges arising from extracting useful information from different sectors in medicine [2]. In order to gain knowledge and exchange data from different healthcare providers or components in different Health Information Systems there is a need in interoperability in Healthcare.

According to the report of the Regional Office for Europe of the World Health Organization for the conditions in the primary health care in Albania, it is stated that there is no integrated national information system nor electronic medical records [3].

Ontologies are used as a source of vocabulary standardization and integration, as a computable knowledge extraction by applications [4] and an important facilitator for unambiguous definitions and data exchange [5]. In addition, ontologies provide implicit semantics that enable the derivation of new information from existing ones, a key element to procure interoperability among different systems [6].

In this paper we propose the APHRO (Albanian Patient Healthcare Records Ontology) ontology in Albania in order to keep records of main patient's healthcare data like demographics data, vital signs, risk factors, patient visits, different diseases and the main medical services in University Hospital Center "Mother Teresa", Tirana, Albania. This ontology will provide an approach in offering interoperability of patient's data through the use of Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT).

Also the concepts (when it is possible) will be mapped to the SNOMED CT in order to offer interoperability between different health information systems in the near future. SNOMED CT is the most comprehensive multilingual clinical healthcare terminology

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that it is used in electronic health record systems to facilitate clinical documentation and reporting and to retrieve and analyze clinical data [7].

The paper is organized as follows. In Section 2 are examines some related works focusing on ontologies and interoperability in healthcare domain. Section 3 presents the methodology in creating the ontology in healthcare, while the section 4 describes the APHRO (Albanian Patient Healthcare Records Ontology) Ontology using the main medical services in University Hospital Center "Mother Teresa" and mapping patient's data to SNOMED CT terminology. Finally, conclusions and future steps are present in Section 5.

2. Related Work

Ontologies have been implemented in different sectors of healthcare like primary healthcare, emergency services, public healthcare, diseases healthcare, etc. [8].

The authors in [9] have presented a perspective in integrating SNOMED-CT concepts for clinical data representation in the Health Information System through implementation of standard codes, free-text entry and configurable forms.

The proposed tool in [10] is used for the extraction and integration of medical information from heterogeneous sources using SNOMED-CT terminology and also exports matched data according to the HL7 format. Also in order to ease patient understanding and facilitating the analysis of health data the authors in [11] designed interactive visualization in reporting medical history and symptoms of the patients.

Also the authors in [1] designed the HoPro (Hospital Process Ontology) Ontology in order to describe the business processes and every day functions and different interactions of the hospital.

The Chronic Obstructive Pulmonary Disease ontology [12] designs concepts of the disease, environment, equipment, patient data and treatment.

The research work in [13] presents Do_Care, an ontology reasoning - based healthcare monitoring system that integrates different ontologies like medicine ontologies, sensors ontologies and personal profile ontologies.

Currently in our knowledge there is no an ontology integrating medical services in Albania and the related SNOMED CT terminology, code and concepts for interoperability in healthcare. While in other domains, OntoAL ontology is developed in public E-Government Services domain in Albania [14].

3. Methodology

First of all, we have conducted research in ontologies developed in the Albanian healthcare system and we have found no ontology being used with medical services that are offered in Albania in different sectors and in the same time providing interoperability using SNOMED CT terminology. So beside of that, the APHRO Ontology will also record the patients' data according to their demographics data, risk factors, vital signs, diseases and visit data.

In the process of designing the Albanian Patient Healthcare Records Ontology we have followed the tasks according to [15]. In this regard we have:

1. Specified the domain of the Patient Healthcare Records Ontology;
2. Identified the key terms, concepts, and their relations in the Albanian Patient Healthcare Records Ontology;
3. Established the rules and axioms according to the structural properties of the domain in our ontology;
4. Represented the APHRO ontology by using representation languages which support the ontology such as RDF, RDFS or OWL;
5. Combined the constructed ontologies with existing ontologies like SNOMED CT;
6. Evaluated the constructed ontologies by using generic and specific evaluation metrics [15].

In order to offer the interoperability of the patient records we will use SNOMEC CT, because it is very important to map the concepts from different components of the Health Information System to the SNOMED CT. For example, from the proposed system in [16] for recording patient data in the Radiology Service Department at Mother Teresa Hospital in

Tirana, Albania we will construct the ontology with the patient data and in order to offer interoperability we will map some of the patient data to the relevant SNOMED CT concepts and code.

The following figure illustrates the mapping process from the concepts used in [16] to SNOMED CT concepts and codes using sameAs axiom in Protégé.

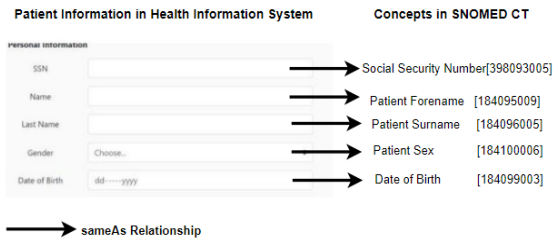

Figure 1: Mapping Concept from HIS to SNOMED CT

Also, the APHRO ontology will include some of the concepts from HL7 FHIR (FHIR is the standard for exchanging health care data, published by HL7 [17]) in accordance with the domain of the APHRO ontology.

Risk factors, common diseases, medical services and Vital Signs of the patients are the main classes in the APHRO Ontology in order to offer scientifically rigorous, consistent and extensible controlled vocabulary to facilitate data exchange and annotation in applications where a reference of their terms are required [18].

4. Proposed Ontology

The ontology is designed using the Protégé tool [19]. Protégé is one of the most popular ontology tools that is capable of defining classes and hierarchies, attribute relationships and attribute-value constraints, and the relationships between classes and attributes [20].

The main concepts of the APHRO (Albanian Patient Healthcare Records Ontology) are Person (Patient/Doctor), HealthCare Provider, Medical Services, Diseases, Common Vital Signs, Patient Visit, Risk Factors and Visit Types.

The main classes of the APHRO ontology, are illustrated in the Figure 2 while other classes, object properties, individuals, data properties, rules, axioms, etc. are detailed in the following paragraphs.

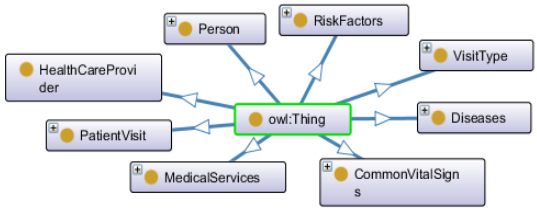

Figure 2: Overview of the main classes of the APHCDO Ontology

In order to offer interoperability between the health care systems the Demographics Data of the Patients, diseases and vital signs will have their relevant prefLabel, altLabel and code (URI) according to SNOMED CT that can be accessed on [21] or [22]. The demographics data of the patient are designed at the ontology using data properties with their relevant Patient Demographics Domain and their relevant Range according to the patient information. In the table below are illustrated some of the patient demographics data and their relevant code in SNOMED CT [21].

Table 1
Patient Demographics

Patient Data	SNOMED CT
SSN	398093005
First Name	184095009
Last Name	184096005
Gender	184100006
Date of Birth	184099003
Address	184097001
City	433178008

The Medical Services in University Hospital Center "Mother Teresa" are designed in the ontology according to [23] in 5 main sectors:

- Medical Activity Sector (13 services);
- Diagnostic Activity Sector (6 services);
- Neuro-Psychiatric Activity Sector (4 services);
- Pediatrics Activity Sector (8 services);
- Surgical Activity Sector (11 services).

Vital signs from FHIR [24] will be used in the Albanian Patient Healthcare Records Ontology to describe the common vital signs of

the patient. Each of the classes of the Vital Signs have the preferred Label, alternative Labels and the SNOMED CT code according to the SNOMED CT that can be accessed on [21] [22]. The above figure illustrates the FHIR vital signs used in the APHRO ontology.

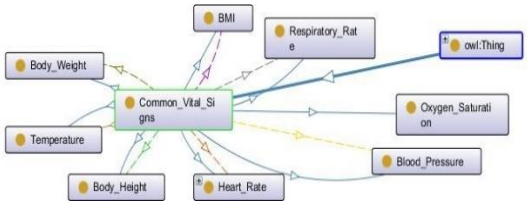

Figure 3: Vital Signs

The APHRO ontology has four common diseases like Cardiovascular diseases, Cancers, Chronic Respiratory Diseases and Diabetes, their relevant risk factors according to [25], and the Modifiable Risk factors for Diabetes according to [26]. In Protégé according to [25] are designed instances of diseases for example, Heart attacks, Heart Failure, Cerebrovascular Disease, etc. are Cardiovascular diseases. Each of the diseases will have prefLabel, altLabel and SNOMED CT URI accessed on [21] or in the BioPortal [22]. In the figure below are shown some of the Risk Factors in APHRO Ontology.

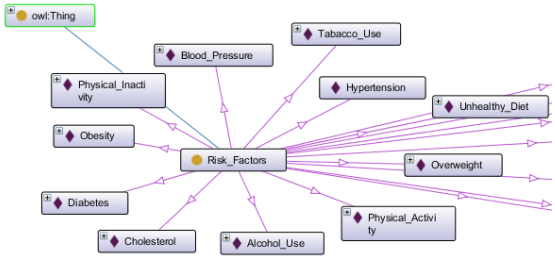

Figure 4: Risk Factors

It is very important that each of the diseases could be related with the relevant risk factors. Meanwhile, we can save information about the risk factors according to the patient data and analyze the possible diseases and situation of the patient. Having information of social history and risk factors would give better information about the status of the patient and provide better health care for the patient while the patient has a visit in the hospital.

The diseases are related to the Risk Factor according to [25], using has_Risk object property. The Domain of has_Risk property is the class Diseases and the Range is the class RiskFactors. The Domain and Range are defined for all the object properties like has_Sign, has_Visit and has_Type. Specifying these axioms is relevant for the reasoner in order to discover new inferences in our ontology. In the following figure are illustrated some of the risk factors related to Heart Attacks (Cardiovascular Disease).

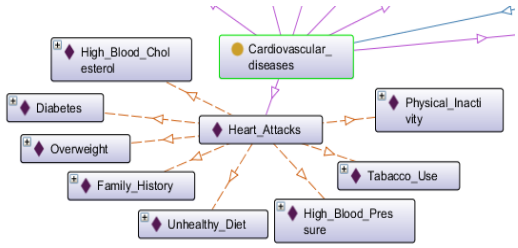

Figure 5: Risk factors related to Heart Attacks

The patient's records can be inserted in the ontology according to the patient demographics, type of visit of the patient, the healthcare provider, etc.

The overall APHRO Ontology metrics according to Protégé is described in the Table 2.

Table 2
Ontology Metrics

Metrics	No.
Axiom	537
Logical axiom Count	227
Declaration axioms No.	156
Class count	74
Object property count	12
Data property count	26
Individual count	43
Annotation Prop. Count	5
SubClassOf	66

5. Conclusions and Future Work

In this paper is designed the Albanian Patient Healthcare Records Ontology, which includes the patient records, vital signs, risk factors, several diseases, patient visits and some of the medical services in "Mother Teresa" University Hospital Center in Tirana, Albania. Also, when it is possible the term in APHRO will have its relevant code, concepts in SNOMED CT.

This ontology can be used in order to gain knowledge, keep information of the patient records and their visits in different medical sectors. Also, APHRO provides the opportunity to enable interoperability between different services, healthcare providers and patient visits in order to facilitate the process of the exchanging health data within them.

In the near future we will integrate additional concepts in the ontology such as family history, services, roles, diseases, diagnoses, tests/scans according to the healthcare providers.

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