

Building OBR-based OWL Ontology for Viral Hepatitis

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Abstract

Ontology of Biomedical Reality (OBR) is a recent framework for building biomedical Ontologies to facilitate inferences across the boundaries in anatomy Ontology, pathology Ontology, etc. Liver viruses are the most dangerous cause for liver problems, because they last for a long time and lead to serious complications (liver inflammation, etc.). The viral hepatitis includes a variety of different viruses: hepatitis A, B, C, and D. In this paper, Viral Hepatitis Ontology is developed using OBR framework for the A, B, C and D viruses, which are the most widely spread among males and females. This Ontology is represented in the Web Ontology Language (OWL) that has become recently the standard language for the semantic web. By developing the Viral Hepatitis Ontology, both Intelligent Systems and Physicians can share, reason, and exploit this knowledge in different ways.

Keywords: *Viral Hepatitis, Biomedical Ontology, Ontology of Biomedical Reality, OWL Ontology.*

1. Introduction

Ontology, in Philosophy, is the branch of metaphysics that deals with the nature of being, while it, in Logic, is the set of entities presupposed by a theory [1]. Furthermore, it is a kind of controlled vocabulary of well defined terms with specified relationships between those terms, capable of interpretation by both humans and computers [2]. Ontology of Biomedical Reality (OBR) has been developed to facilitate inferences across the boundaries of domain Ontologies in anatomy, physiology and pathology [3]. Biomedical Ontologies play one of central roles in integrating the information about various model organisms.

Liver is the largest solid organ in the human body, and has been affected by different kinds of diseases [4]. There are many viruses that cause liver diseases (Hepatitis A, B, C, and D). Hepatitis A Virus (HAV) is a significant cause of infectious disease worldwide. According to the World Health Organization (WHO), 1.5 million clinical cases occur worldwide a year [5]. Hepatitis B is a serious liver disease caused by the hepatitis B virus (HBV). This virus can affect people of all ages. This long-term or “chronic” HBV infection can lead to liver cirrhosis, liver cancer and death [6]. Hepatitis C is an infection of the liver caused by the hepatitis C virus (HCV). It is difficult for the human immune system to eliminate this virus from the body, so the infection with HCV usually becomes chronic. HCV is one of the danger viruses in liver [7]. An estimated 180 million people are prevalence of HCV infection in worldwide [8]. Hepatitis D virus (HDV) infection occurs worldwide but incidence and prevalence data are limited in many parts of the world due to inaccurate reporting and delayed detection [9].

In this paper, Viral Hepatitis Ontology is developed using OBR framework for the A, B, C and D viruses. This ontology is represented by the Web Ontology Language (OWL) that has become recently the standard language for the semantic web. By developing the Viral

Hepatitis Ontology in OWL, both Intelligent Systems and Physicians can benefit in many ways by sharing, reasoning, and exploiting this knowledge.

This paper is organized as follows. Section 2 presents the Background and Related work. Section 3 presents the methodology followed in this research to design the Viral Hepatitis (VH) Ontology, while the design methodology phases are described in details in section 4, section 5, and section 6 respectively. Finally, section 7 concludes the most important points in this paper.

2. Background and Related Work

Medical Ontologies are interested in solving problems such as the reusing and sharing of patient data or the transmission of these data and the need of semantic-based criteria for purposive statistical. The unambiguous communication of complex and detailed medical concepts is now a crucial feature of medical information systems [10]. There are medical Ontologies developed to facilitate this purpose. The Open Biomedical Ontology (OBO) is the library of medical Ontologies in different medical domains [11]. The Ontologies in OBO are designed to serve as controlled vocabularies for expressing the results of biological science [12]. NCBO's BioPortal is an open repository of biomedical Ontologies that provides access via Web browsers and Web services to Ontologies [13]. Unified Medical Language System (UMLS) is a set of files and software that brings together many health and biomedical vocabularies and standards to enable interoperability between computer systems [14].

In addition, there are many research works have been achieved to build specific domain Ontologies for different diseases. For example, Vanja Lukovic, et al [15] developed the OBR-Scolio application Ontology for the pathology domain of spine. Also, Abdel-Badeeh Salem, et al [16] have built domain Ontology for lung cancer. Although the viral hepatitis (VH) diseases cause great complications to humans, there is no OWL-based Ontology developed for them. In this paper, a Viral Hepatitis Ontology for Liver is developed using the Web Ontology Language (OWL). In addition, this Ontology is integrated with the Ontology of Biomedical Reality (OBR) framework [3]. OBR is a recent framework for building biomedical Ontologies to facilitate inferences across the boundaries of anatomy Ontology, pathology Ontology, etc.

As we can see from figure 1, the root of Ontology of Biomedical Reality is the universal Biological entity. A distinction is then drawn between two classes: Biological continuant and Biological occurrent, the definitions of both of them are inherited from Basic Formal Ontology (BFO) [17]. The Biological continuant class is divided into two sub-classes: Organismal continuant and Extra-organismal biological continuant. The Organismal continuant class includes entities that range over single organisms and their parts, while the Extra-organismal biological continuant includes entities that range over aggregates of organisms. Also, the Biological occurrent class is divided into two sub-classes: Organismal occurrent and Extra-organismal biological occurrent. The Organismal occurrent includes processes associated with individual organisms and their parts. The Organismal continuant class is divided into two sub-classes: Independent organismal continuant and Dependent organismal continuant. The Independent organismal continuants have mass and material, while Dependent organismal continuants are immaterial and do not have mass.

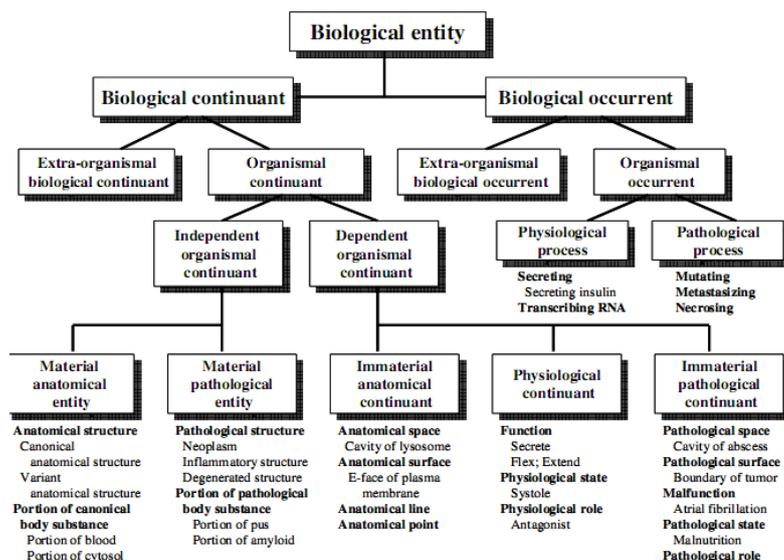


Figure 1: Ontology of Biomedical Reality

3. The VH Ontology Design Methodology

Figure 2 represents the design methodology that we have followed to build the Viral Hepatitis (HV) Ontology in OWL, which is then integrated with OBR. As shown in this figure, the methodology includes three phases: VH Ontology Extraction phase, VH Ontology Validation phase, and VH Ontology Representing in OWL phase. In the following subsections, these phases are explained in details.

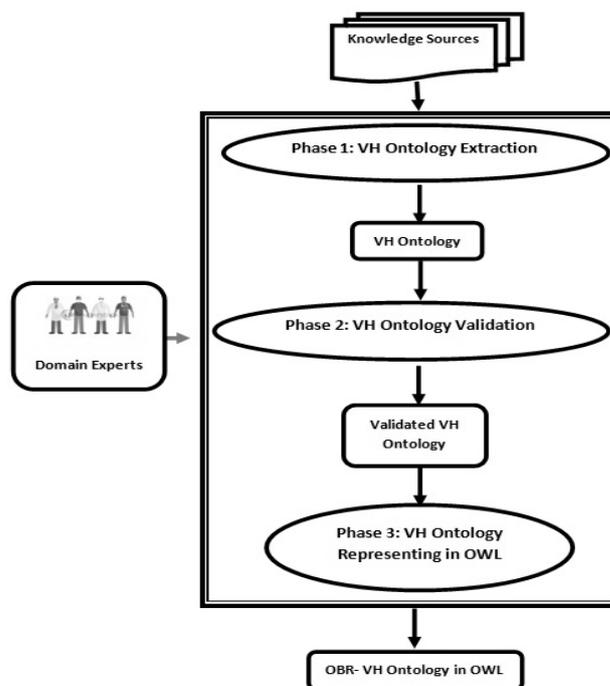


Figure 2: The VH Ontology building methodology

4. The VH Ontology Extraction Phase

In this phase, we have extracted the needed knowledge from several medical sources such as Domain Experts, a Medical Book [18], and set of Trusted Medical Webs [19, 20 and 21]. The bottom-up approach has been followed in this research to build the VH Ontology, so after extracted the needed knowledge, we have studied the Viral Hepatitis diseases (A, B, C and D) to determine the symptoms, signs, and laboratory-findings caused by these diseases. We have found that there are 18 distinct symptoms and 15 distinct signs caused by the Viral Hepatitis diseases (A, B, C and D). Also, there are 16 laboratory-findings can be used to differentiate between those Viral Hepatitis diseases. This phase had been passed through two steps: Mapping between the VH Diseases and their symptoms/signs/laboratory-findings, and classifying the VH Diseases and symptoms/signs/laboratory-findings.

• **Step 1: Mapping between the VH Diseases and their symptoms/signs/laboratory-findings**

In this step, we have mapped each Viral Hepatitis disease to its corresponding symptoms, signs, and laboratory-findings. Table 1 represents the mapping between the Viral Hepatitis diseases (A, B, C and D) and their symptoms. For example, the HAV causes 9 symptoms: Diarrhea, Fatigue, etc. Table 2 represents the mapping between the Viral Hepatitis diseases (A, B, C and D) and their signs. For example, the HAV causes 5 signs: Depression, Low Grade Fever, etc. Finally, table 3 shows the mapping between the Viral Hepatitis diseases (A, B, C and D) and their corresponding laboratory-findings

Table 1: VH Diseases versus Symptoms

Symptom	HAV	HBV	HCV	HDV
Diarrhea	✓	✓	✓	✓
Fatigue	✓	✓	✓	✓
Headache	✓	✓	✓	✓
Loss of Appetite	✓	✓	✓	✓
Nausea	✓	✓	✓	✓
Pain in area of liver		✓	✓	
Sore Muscle	✓	✓	✓	✓
Vomiting	✓	✓	✓	✓
Jaundice	✓	✓	✓	✓
Abdominal Pain	✓	✓	✓	
Itching		✓	✓	
Joint aches		✓	✓	
Malaise		✓	✓	
Aching Limbs			✓	
Sore Bones			✓	
Sore Joint			✓	
Excessive Tiredness				✓
Sore Throat				✓

Table 2: VH Diseases versus Signs

Sign	HAV	HBV	HCV	HDV
Depression	✓	✓	✓	✓
Low Grade Fever	✓	✓	✓	✓
Rash	✓	✓	✓	✓
Urine is Dark	✓	✓	✓	✓
Weight Loss	✓	✓	✓	✓
confusion		✓	✓	
Dehydration		✓	✓	
Difficulty Concentrating		✓	✓	
Grade or Clay Colored Stools		✓	✓	
Irritability		✓	✓	
Alcohol intolerance			✓	
Chills			✓	
Cirrhosis			✓	
Dry eyes			✓	
Sickness			✓	

Table 3: VH Diseases versus Laboratory-findings

Lab Result	HAV	HBV	HCV	HDV
Anti HAV IgG	✓			
Anti HAV IgM	✓			
HBsAg		✓		
Anti HBV IgG		✓		
Anti HBV IgM		✓		
Anti HDV IgM				✓
Anti HDV IgG				✓
Anti HCV			✓	
Hepatitis c RNA			✓	
Alb	✓	✓		
ALT	✓	✓		
AST	✓	✓		
ALP	✓	✓		
TBIL	✓	✓		
Direct bilirubin	✓	✓		
GGT	✓	✓		

• Step 2: Classifying the VH Diseases and symptoms/signs/laboratory-findings

As shown in figure 3, we have classified the Viral Hepatitis Results into three classes: Symptom, Sign and Lab Result. After that, we have classified the symptoms, signs, and laboratory-findings according to the Viral Hepatitis Disease causing them. Therefore, the Symptom class includes three subclasses: “HCV Symptom”, “HDV Symptom”, and “HCV, HBV, HAV, HDV Symptom”. The “HCV Symptom” contains the symptoms caused by the HCV disease only. Also, the “HDV Symptom” contains the symptoms caused by the HDV disease only.

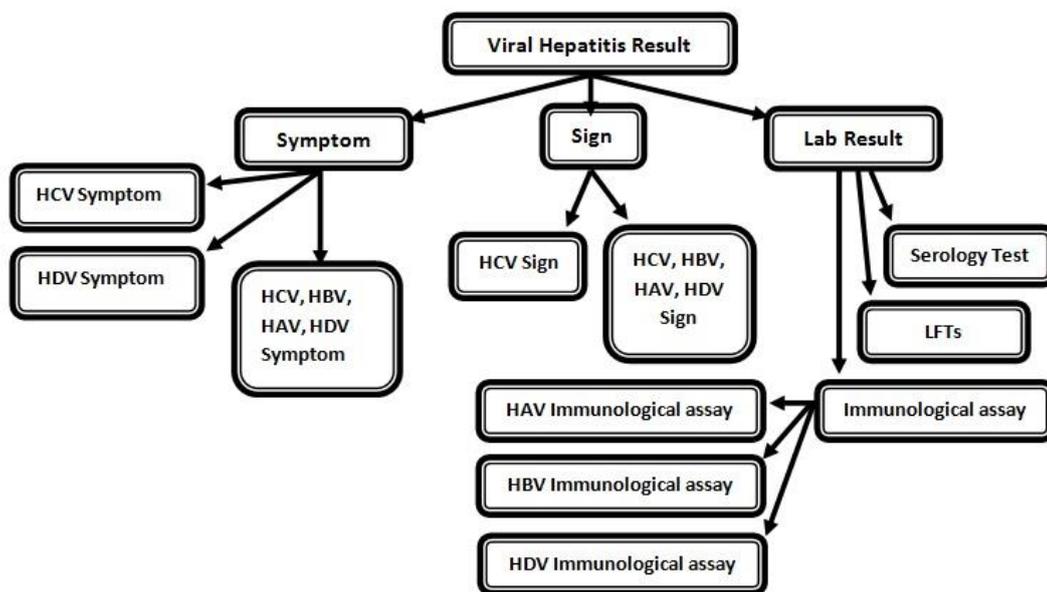


Figure 3: The Viral Hepatitis Result Classification Tree

On the other hand, the "HCV, HBV, HAV, HDV Symptom" contains the common symptoms caused by the HAV, HBV, HCV and HDV diseases. In the same way, the Sign Class includes two subclasses: "HCV Sign", and "HCV, HBV, HAV, HDV Sign". The "HCV Sign" contains the signs caused by the HCV disease only, while the "HCV, HBV, HAV, HDV Sign" contains the common signs caused by the HAV, HBV, HCV and HDV diseases. On the other hand, the Lab Result class includes three subclasses: the "Serology Test", "LFTs", and "Immunological assay". The "Serology Test" class includes the lab results of the HCV disease ("Anti HCV" and "Hepatitis C RNA"). The "Immunological assay" class includes three subclasses: "HAV Immunological assay", "HBV Immunological assay", and "HDV Immunological assay". The "HAV Immunological assay" subclass includes the lab results of the HAV disease ("Anti HAV IgM", "Anti HAV IgG" and "HBsAg") and the "HBV Immunological assay" subclass includes the lab results of the HBV disease ("Anti HBV IgM" and "Anti HBV IgG"). The "HDV Immunological assay" subclass includes the lab results of the HDV disease ("Anti HDV IgM" and "Anti HDV IgG"). Furthermore, the Viral Hepatitis Diseases have been classified into four subclasses: HAV, HBV, HCV and HDV. Figure 4 shows the Viral Hepatitis Diseases classification tree.

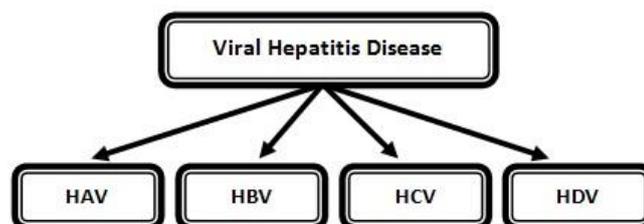


Figure 4: The Viral Hepatitis Diseases Classification Tree

5. The VH Ontology Validation Phase

In this phase, the domain experts have been consulted to review the results of both VH Diseases and Symptoms/Signs/Laboratory-findings Mapping step and VH Disease and Symptoms/Signs/Laboratory-findings Classification step. The domain experts have validated the classification trees generated from those steps by editing some of terminologies, and by rephrasing some of the classes' names. Also, they have added other classes to those classification trees to be fit in the OBR framework. As shown in figure 5, the Viral Hepatitis Result Classification tree has been merged into the OBR framework under the "Immaterial Pathological Continuant" class. In addition, the experts have merged the Viral Hepatitis Diseases Classification tree into the OBR framework by adding many classes. As shown in figure 6, this tree is has been added under a class called "Infectious Liver Disease", which is a sub-class to a class called "Liver", which is a sub-component to the "Pathological Hepatobiliary System" class, which is a sub-system from the "Pathological Organ System" class, which is inherited from the "Pathological Structure" class, which is one of the Material pathological entity subclasses in the OBR hierarchy.

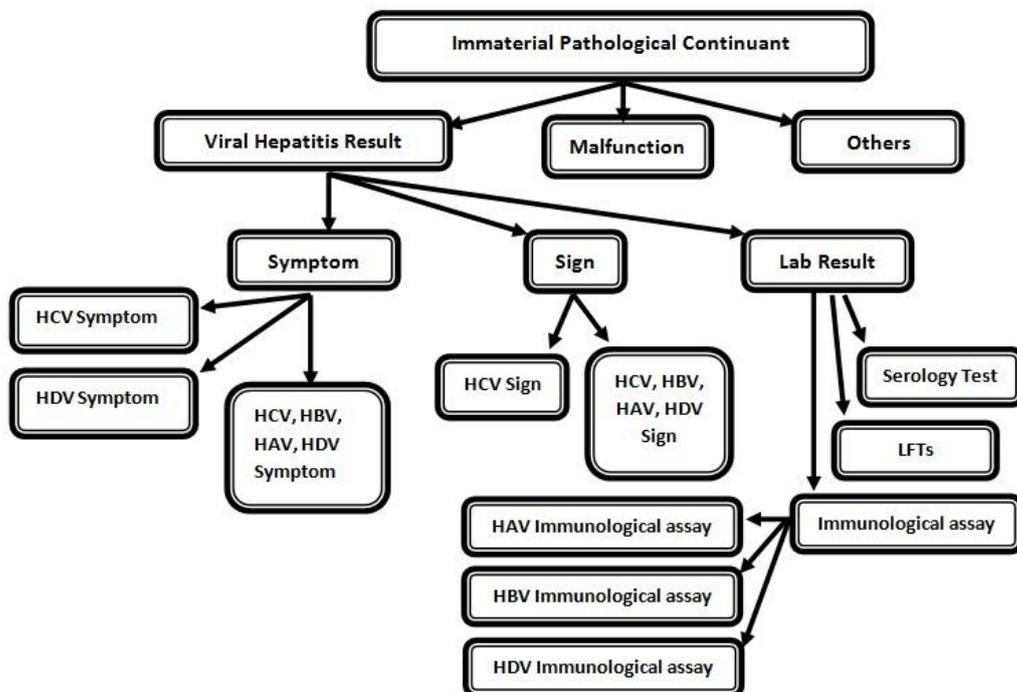


Figure 5: Merging the Viral Hepatitis Result Classification Tree into OBR framework

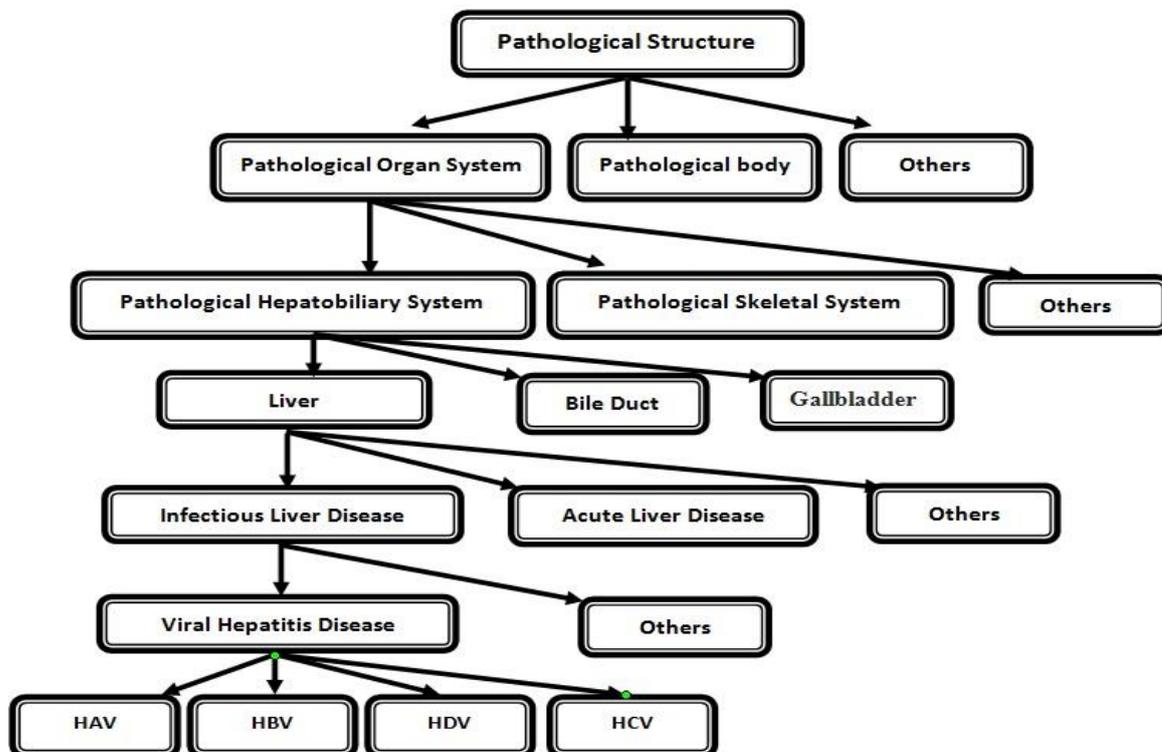


Figure 6: Merging the Viral Hepatitis Diseases Classification Tree into OBR framework

6. The VH Ontology Representing in OWL Phase

To represent the Viral Hepatitis Ontology in OWL, two steps have been followed: representing the classes and relations of the Viral Hepatitis Result Classification Tree in OWL, and representing the classes and relations of the merged Viral Hepatitis Diseases Classification tree with OBR in OWL. The protégé-OWL editor has been exploited to implement this phase. Figure 7 shows the complete OWL classes of the Viral Hepatitis Diseases Classification Tree with OBR, while figure 8 illustrates the OWL classes of the Viral Hepatitis Result Classification Tree with OBR framework.

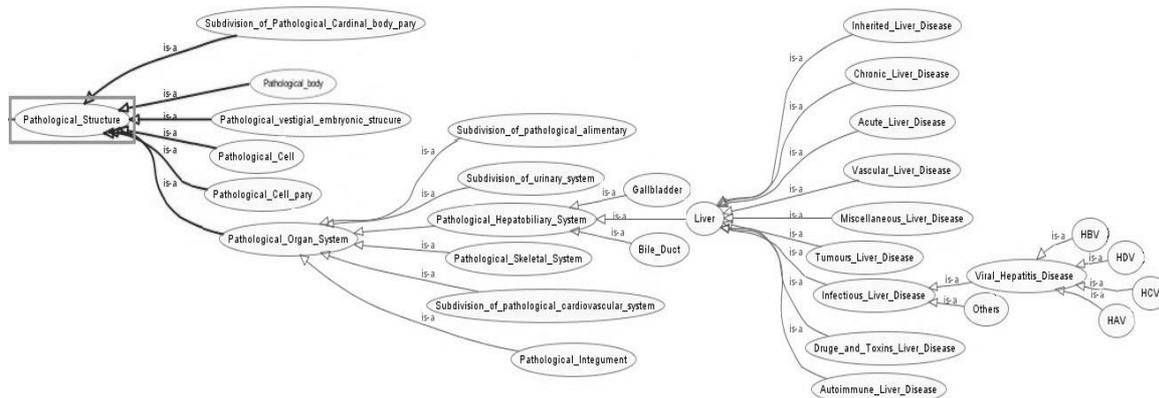


Figure7: The OBR Viral Hepatitis Diseases Ontology

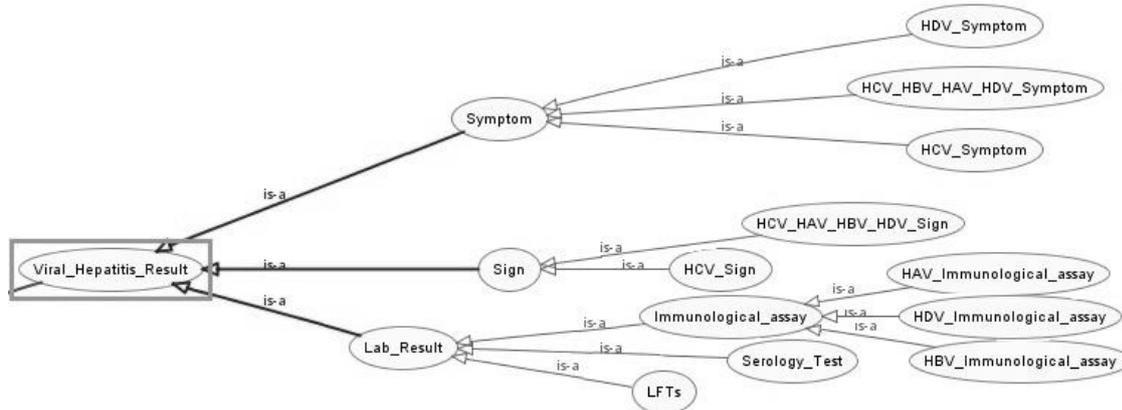


Figure8: The OBR Viral Hepatitis symptoms/signs/laboratory-findings Ontology

7. Conclusion

In this paper, OBR-based OWL Ontology for Viral Hepatitis (A, B, C and D) was developed. The bottom-up approach has been exploited in designing this Ontology. Because the Viral Hepatitis A, B, C and D viruses are the most widely spread among males and females, this Ontology can be shared, and exploited in different ways by both Intelligent Systems and Physicians. The Ontology is represented in Web Ontology Language (OWL) that has become recently the standard language for the semantic web. The protégé-OWL editor was used to implement the Ontology.

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