

# Health Multi-Terminology Portal: a semantic added-value for patient safety

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**Abstract.** Since the mid-90s, several quality-controlled health gateways were developed. In France, CISMeF is the leading health gateway. It indexes Internet resources from the main institutions, using the MeSH thesaurus and the Dublin Core metadata element set. Since 2005, the CISMeF Information System (IS) includes 24 health terminologies, classifications and thesauri for indexing and information retrieval. This work aims at creating a Health Multi-Terminology Portal (HMTP) and connect it to the CISMeF Terminology Database mainly for searching concepts and terms among all the health controlled vocabularies available in French (or in English and translated in French) and browsing it dynamically. To integrate the terminologies in the CISMeF IS, three steps are necessary: (1) designing a meta-model into which each terminology can be integrated, (2) developing a process to include terminologies into the HMTP, (3) building and integrating existing and new inter-terminology mappings into the HMTP. A total of 24 terminologies are included in the HMTP, with 575,300 concepts, 852,000 synonyms, 222,800 definitions and 1,180,000 relations. Heigh-teen of these terminologies are not included yet in the UMLS among them, some from the World Health Organization. Since January 2010, HMTP is daily used by CISMeF librarians to index in multi-terminology mode. A health multi-terminology portal is a valuable tool helping the indexing and the retrieval of resources from a quality-controlled patient safety gateway. It can also be very useful for teaching or performing audits in terminology management.

**Keywords.** Abstracting and indexing; Cataloguing; Controlled Vocabulary; Information Storage and Retrieval; Internet; Subject Headings; Terminology as subject.

## Introduction

The Internet is currently the major source of scientific and health information and knowledge. Several Quality-Controlled Health Gateways (QCHG) have now been developed. In [1], Koch defines quality-controlled subject gateways as Internet services that apply a comprehensive set of quality measures to support systematic resource discovery. Most of QCHG are using a thesaurus to index Internet resources, primarily

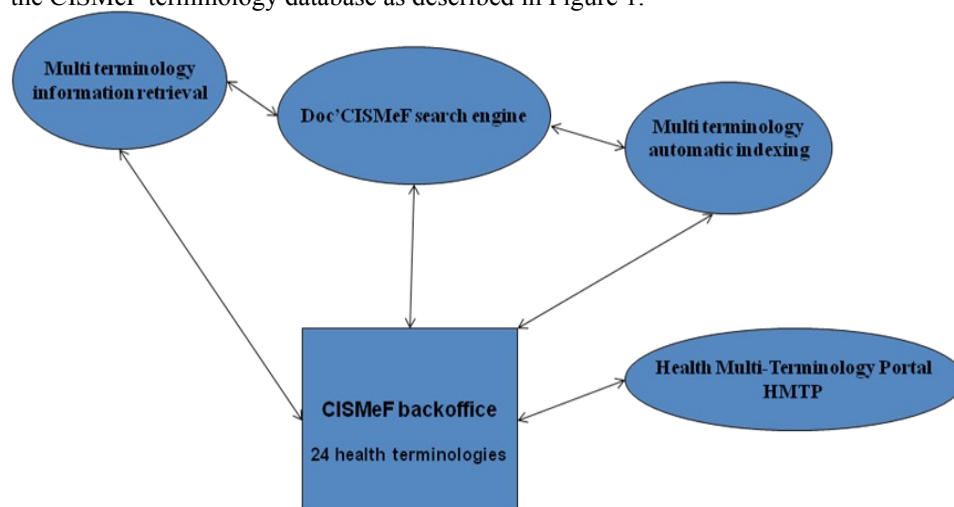
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the Medical Subject Heading (MeSH) thesaurus<sup>2</sup> from the US National Library of Medicine. As far as we know, the oldest QCHG is Diseases, Disorders and Related Topics<sup>3</sup> (DDRT) , developed since 1993 by Tor Alhenius, former Medical Librarian of Karolinska Institute in Stockholm, followed by Catalog and Index of Health Resources in French<sup>4</sup> (CISMeF) [2] created in February 1995, then Health on the Net[3] (HON) developed since September 1995, Intute<sup>5</sup>, originally Organizing Medical Networked Information<sup>6</sup> (OMNI) created in 1996 [4], and later in 2001 Healthinsite-Au<sup>7</sup> [5].

From 1995 to 2005, CISMeF used two standard tools to describe and index the most important and quality-controlled sources of institutional health information in French: (1) the MeSH thesaurus and its French translation by the French Medlars Center (French National Institute of Health), and (2) several metadata element sets, in particular the Dublin Core metadata format [6]. In [7] CISMeF have described the various enhancements of the MeSH thesaurus, that the CISMeF team has developed for adapting this terminology to the broader field of health Internet resources (vs. scientific articles in the Medline bibliographic database where the MeSH thesaurus was originally built for).

Since 2005, the CISMeF team has undergone a major strategic shift: switching from a mono-terminological world to a multi-terminology universe for the overall CISMeF IS, which includes multi-terminology automatic indexing [8], multi-terminology information retrieval [9] and integration of several terminologies (n=24) in the CISMeF terminology database as described in Figure 1.



**Figure 1.** Inter-relationship between CISMeF Terminology Database and the HMTP

There is an increasing amount of interest today not only in developing and maintaining healthcare terminologies but also in making them interoperable within information technology systems delivering services to applications. A “Terminology

<sup>2</sup> <http://www.nlm.nih.gov/mesh>

<sup>3</sup> <http://www.mic.stacken.kth.se/Diseases/>

<sup>4</sup> <http://www.cismef.org>

<sup>5</sup> <http://www.intute.ac.uk>

<sup>6</sup> <http://omni.ac.uk/>

<sup>7</sup> <http://www.healthinsite.gov.au/>

Server” is a tool that manages and gives access to several terminologies [10]. Many terminology servers have already been developed, mostly in English [10-14].

The principal aim of this work is to (A) create a Health Multi-Terminology Portal (HMTP) largely inspired by the most recent advances [15], to (B) connect it to the CISMef terminology database for searching concepts and terms among all the health terminologies available in French (or in English and translated in French), in particular for patient safety included in this portal and to (C) browse it dynamically. The ultimate goal is to use the results of this research: (a) to index resources manually or automatically in the quality-controlled health gateway, such as CISMef or its Drug Information Portal [9]; (b) to permit multi-terminology information retrieval; (c) to evaluate the integrity of terminological data (audit); (d) to provide a new source of education for students.

## 1. Material and Methods

### 1.1. List of Terminologies included in the HMTP

The six terminologies of the PSIP project (Patient Safety through Intelligent Procedures in medication) [16] have been integrated in the HMTP:

- WHO-ICD10 (International Classification of Diseases, 10<sup>th</sup> revision)<sup>8</sup> for diagnoses,
- WHO-ATC (Anatomical Therapeutic Chemical Classification System)<sup>9</sup> for drugs, developed by the Collaborating Centre for Drug Statistics Methodology,
- WHO-ICPS (International Classification for Patient Safety)<sup>10</sup> for patient safety vocabulary,
- IUPAC (International Union of Pure and Applied Chemistry) for chemical sciences and laboratory tests<sup>11</sup>,
- NCCMERP (National Coordinating Council for Medication Error Reporting and Prevention)<sup>12</sup> for adverse drug event (ADE) description
- PSIP Taxonomy<sup>13</sup> for the description of potential dangerous situations in medication.

Overall, twenty four terminologies and classifications have been included in the CISMef terminology database, and therefore in the HMTP. Some of them are issued from the Unified Medical Language System (UMLS) meta-thesaurus (n=8) but not the most (n=18), and in particular:

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<sup>8</sup> <http://www.who.int/classifications/icd/en/index.html>

<sup>9</sup> <http://www.whooc.no/atcddd/>

<sup>10</sup> [http://www.who.int/patientsafety/taxonomy/april\\_2008-response\\_technical\\_expert\\_comments\\_nov08.pdf](http://www.who.int/patientsafety/taxonomy/april_2008-response_technical_expert_comments_nov08.pdf)

<sup>11</sup> <http://www.iupac.org/>

<sup>12</sup> <http://www.nccmerp.org/>

<sup>13</sup> [www.psip-project.eu](http://www.psip-project.eu)

- the MeSH thesaurus, including the MeSH Supplementary Concepts (MeSH SC), the translation in French of 8,300 MeSH SC and the add-on of over 10,000 synonyms to MeSH terms,
- the SNOMED International to describe electronic health records [17],
- two other terminologies developed by the World Health Organization (WHO): WHO-ART (Adverse Reactions Terminology)<sup>14</sup>, for adverse effects and WHO-ICF<sup>15</sup> (International Classification of Functioning, Disability and Health) for handicap,
- Various codes used for drugs and chemical compounds: CAS for chemistry, Brand Names and International Non-proprietary Names (INN) for drugs, CIS, UCD, and CIP for French drugs,
- MedDRA, for adverse effects<sup>16</sup>.
- FMA (Foundational Model of Anatomy) for the human anatomy.

Some terminologies and ontologies will be integrated in the coming months, in particular LOINC (Logical Observation Identifiers Names and Codes) for laboratory tests identification, SNOMED CT, US National Cancer Institute Terminology and Metathesaurus.

### *1.2. Integration of the Terminologies*

To integrate the terminologies in the CISMef database (Oracle 11.1g database), three steps are necessary: (1) the design of a meta-model into which each terminology can be integrated; (2) the design of a process that integrates the terminologies into the HMTP; (3) the construction and integration of inter-terminology mappings into the HMTP. Two inter-terminology mappings were performed: one exploiting UMLS concepts and one using NLP tools developed by the CISMef team [18].

The meta-model designed for the database in order to fit all the terminologies into one global structure is described in Figure 2. A model of each terminology was designed as a specialization of the meta-model. The purpose of the meta-model is to factor out the artefacts (i.e. classes, relationships and attributes) that are common to all the terminologies, thus facilitating integration of multiple terminologies within a single platform. Some artefacts, although specific to certain terminologies, must nevertheless be represented in order to avoid losing information. This meta-model is generic enough to be applied to: semantic mediation, hierarchical and graphic navigation, automatic indexing, and information retrieval.

Consequently, a cut-off has to be selected in order to faithfully represent a terminology with no loss of information while removing artefacts shared by terminologies in order, subsequently, to offer independent shared services related to a given terminology. A distinction is therefore made between the unified meta-model (namely UMV2) and the extensions specific to each terminology (namely UMV1 x, where x denotes a particular terminology), as illustrated in Figure 3.

<sup>14</sup> <http://www.umc-products.com/DynPage.aspx?id=4918>

<sup>15</sup> <http://www.who.int/classifications/icf/en/>

<sup>16</sup> <http://www.meddrasso.com/MSSOWeb/index.htm>

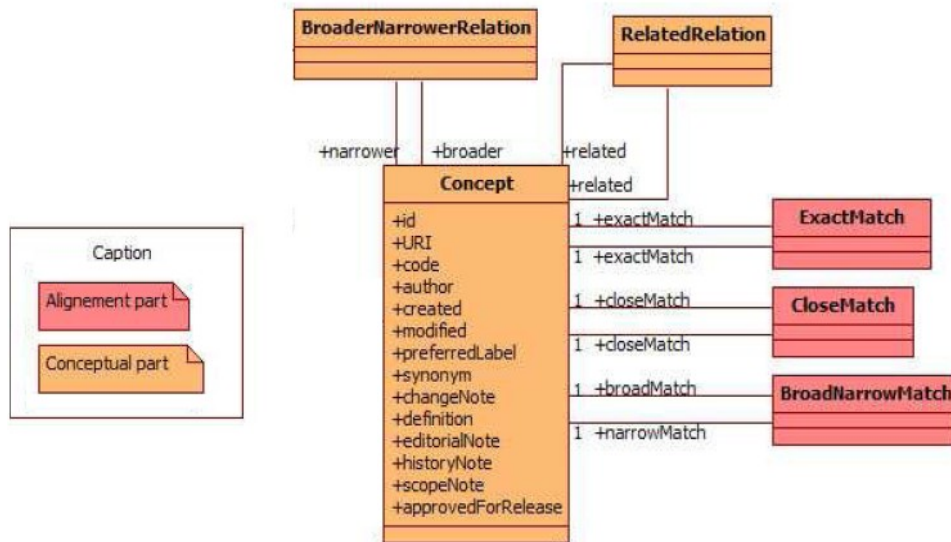


Figure 2. The CISMeF Terminology Database conceptual structure.

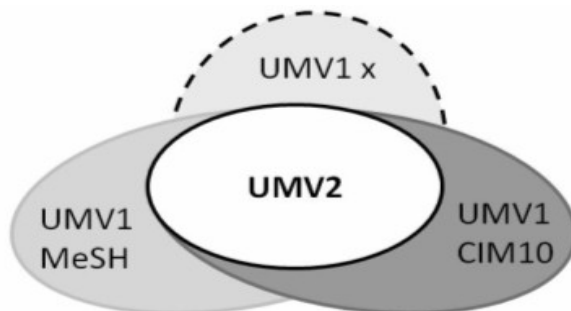
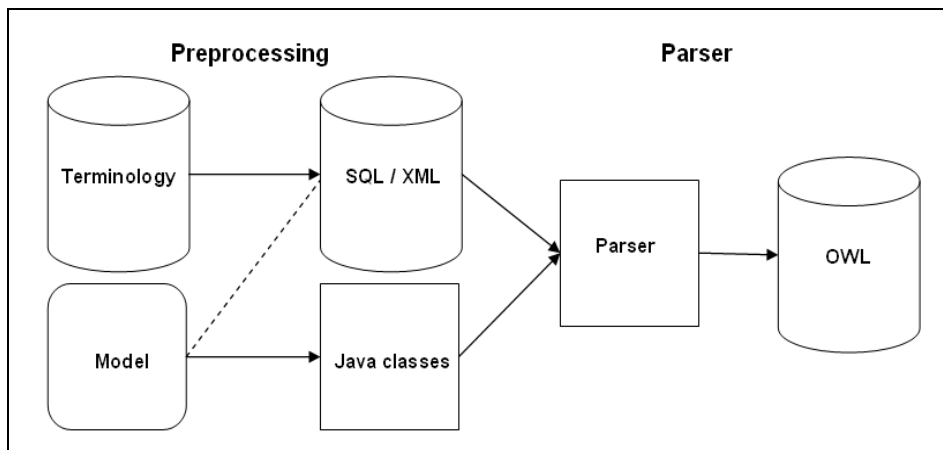


Figure 3. Representation of the unified meta-model (UMV2) and the specific extensions of each terminology (UMV1 x)

### 1.2.1. The CISMeF Terminology Database

This system was established around the "Descriptor" which is the central concept of the terminologies (or "keyword"). Each descriptor is labelled and may be defined, linked to other descriptors (such as Related-Term relation) and involved in a hierarchy (BT-NT for Broader Term – Narrower Term). A descriptor may also contain specific attributes, synonyms, abbreviations, etc.

It was also necessary to work on the terminologies modelling in order to fit it into the global database structure and to standardize the data in a well known and shared format. That is why the Resource Description Framework (RDF) syntax was chosen with the Ontology Web Language (OWL), standards recommended by the W3C. The workflow of terminology integration is described in Figure 4.



**Figure 4.** Process for formatting a terminology into OWL

#### 1.2.2. *OWL Models*

The first part consists in creating a meta-model in OWL that can include all the terminologies. The Unified Model for Vocabularies has been specified for this requirements. The next stage consists in creating one model for each terminology. Thus, the original data was collected and the native structure of each terminology needed to be well understood.

#### 1.2.3. *OWL Data Files*

The second part of the work consists in developing a parser for each terminology. The input is the original data (or normalized original data) and the output is a representation of the terminology in OWL. As data could be in different shapes and structures, in some cases additional processes were performed (temporary databases, files in several formats, etc).

#### 1.2.4. *Database Integration*

The final stage is the integration of the OWL files into the CISMeF Information System (IS). A generic parser was developed to directly insert each terminology into the database. A special model was designed to represent each terminology in a "CISMeF Terminology Database view". The parser can use this model as an input to recognize descriptor classes, definitions, synonyms, relations in order to insert it very easily into the database.

### 1.3. *Creation of the HMTP*

The HMTP was designed as a graphic interface of a Web Service, entirely dedicated to information retrieval and semantic relations between terms of several terminologies. Thus, the main objective was to dissociate the substance from the form, in particular the interface.

### *1.3.1. The HMTP Web Service*

This Web Service was the most important part of the task: retrieve information and major schemes to allow the fullest display in the HMTP interface. The HMTP Web Service has been developed to respect Web Services Standards with Simple Object Access Protocol (SOAP) and Web Service Description Language (WSDL) signatures. It presents some methods to search terms by a concept or by a database unique identifier: in all terminologies/ontologies, concepts are unique Ids. A specific assessment of SQL queries on the database has been performed to obtain the best response time. This program queries a special version of the CISMef IS with extended tables. Another important point of this Web Service is the security management. Axis2 (Apache) is used to deploy Web Services and its module Rampart, which deals with security to authenticate users that want to access the signatures of the HMTP Web Service. Finally, the Jena API was used to generate the final Simple Knowledge Organization System (SKOS) file to be sent by the Web Service as a response. Consequently, this file is well formed and deals with W3C standards.

### *1.3.2. The HMTP Website*

As the HMTP exploits a SKOS file, the graphic interface that renders the final HTML was built based on Java ServerPages (JSP) files including eXtensible Stylesheet Language (XSL) functions. Additional Cascading Style Sheets (CSS) and JavaScript functions are implemented to offer a better website design. The final HTML rendering is processed by the client navigator. This method is a major positive factor for the web application because it works with a minimum of effort. The website has been developed for Firefox 3.x but also works on Internet Explorer 6 and later, Google Chrome and Safari. The final output (XHTML) deals with W3C standards.

For optimal performance, special Asynchronous JavaScript And XML (AJAX) methods are implemented. Since the whole SKOS file data is not directly displayed on the navigator screen, it is useless to transform the entire document in XHTML with the XSL. Therefore, with JavaScript methods, it is possible to re-transform specific portions of the SKOS file immediately (e.g. semantic relations, hierarchies, results of search by terminology). This technology is a very powerful way to increase load speed and to reduce the XSLT processor load for the client navigator. It is also very interesting because usually AJAX utilisation means a direct server request. With the combination of a Web Service, XSLT and AJAX, this step is not necessary (it also reduces the server load and the transformation speed).

### *1.3.3. Hardware, Software and Standards*

The HMTP Web Service responds in SKOS language and deals with Web Services Standards such as WSDL and SOAP. It is written in Java (J2EE on jre 1.6). The HMTP is composed of several servlets that query the different WSDL signatures of the Web Service. The graphic interface is a set of JSP containing XSL functions and templates. Advanced JavaScript methods and CSS are used to finalize characteristics and the client functionalities of the final XHTML webpage. The HMTP has been mainly developed for Firefox 3.x web browsers.

## 2. Results

This terminology portal is available online with a restricted access<sup>17</sup>. To perform mappings between PSIP terminologies (terms alignments), it was necessary to use CISMef semantic tools because 5 out of 6 PSIP terminologies were not included in the UMLS. Therefore, it was not possible to use concept mappings based on UMLS. Table 1 provides the mapping square matrix between the six PSIP terminologies.

Due to various optimizations, the average response time for one concurrent user takes less than 500 milliseconds. HMTF is daily used by CISMef librarians to index health resources in multi-terminology mode for the CISMef catalogue and the Drug Information Portal.

Among the 38,237 CISMef resources which are manually indexed, 32,970 (86.22%) are indexed with only one thesaurus (the MeSH, which is the CISMef main terminology since 1995). A total of 3,866 (10.11%) are indexed with two terminologies, 1,397 (3.65%) with three terminologies and 4 with four terminologies.

All the CISMef resources are manually indexed with at least one MeSH term, even though the perfect term does not yet exist. For example, in the case of a resource where the main subject is the “*Rokitansky syndrome*”, there is no MeSH term for this rare disease. The CISMef indexer used two MeSH terms *vagina/abnormalities* and *uterus/abnormalities*, and have added one SNOMED term *Rokitansky sequence*.

Among the 34,679 CISMef resources which are automatically indexed, 33,935 (97.85%) are indexed with MeSH and 25,568 (73.72%) with SNOMED. Only 1,051 CISMef resources are automatically indexed with one terminology (3,137 with two, 5,379 with three, 5,997 with four and 13,514 with more than four terminologies). Besides MeSH, two terminologies are in constant use: the CCAM is used if possible in the case of technology evaluation of procedures mainly by the French Health Authority (equivalent to the US AHRQ) and the WHO-ATC to index resources about drugs [9, 19].

HMTF is also used by various CISMef academic partners in different French and European projects:

- InterSTIS<sup>18</sup> project (ANR-07-TECSAN-010<sup>19</sup>);
- ALADIN<sup>20</sup> project (ANR-08-TECS-001);
- L3IM<sup>21</sup> project (ANR-08-TECS-00); ;
- PlaIR<sup>22</sup> project, funded by FEDER;

	ATC	ICD-10	IUPAC	NCCMERP	PSIP Taxonomy	WHO- ICPS	TOTAL
ATC		256	62	24	3	9	354
ICD-10	256		27			16	299

<sup>17</sup> <http://pts.chu-rouen.fr/> (click on “Log in”; id=cismef ; password=demo10)

<sup>18</sup> <http://www.interstis.org/>

<sup>19</sup> ANR is a French acronym for National Research Agency

<sup>20</sup> <http://www.aladin-project.eu/>

<sup>21</sup> <http://projet4-limbio.smbh.univ-paris13.fr/>

<sup>22</sup> <http://www.plair.org>



<b>IUPAC</b>	62	27		4	4	19	116
<b>NCCMERP</b>	24		4		123	200	351
<b>PSIP taxonomy</b>	3		4	123		43	173
<b>WHO-ICPS</b>	9	16	19	200	43		287

**Table 1:** Numbers of mappings between all the PSIP terminologies

### 3. Discussion

The Health Multi-Terminology Portal is daily used by several partners, in particular to maintain the PSIP taxonomy and to access the other ones included in the project. More generally, the main HMTP users are the health students to learn how to manipulate health terminologies (e.g. about rare disease with Orphanet thesaurus or anatomy with the FMA ontology) and to extract knowledge from it, in particular from hierarchies and relations (e.g. various siblings of a rare disease, symptoms of this rare disease or to obtain all the muscles of the forearm in one click). The HMTP has been evaluated by some medical student groups and gave 58% satisfaction for its user interface and 76% for its functionalities and content.

The validation of the HMTP has been performed by the CISMef librarians and indexing professionals (pharmacologists, physicians, ...). These days, about 65 people are daily working with the HMTP with a final objective of 10,000 users per month from February 2011 (in fact, the HMTP is going to replace the "Terminologie" tool of CISMef<sup>23</sup> that allows to access the MeSH thesaurus and which is visited by an average of 9,816 unique users per month in 2010).

Many conceptual and technical issues has been encountered, specially in the model creation for several terminologies (MedDRA model, FMA ontology to terminology). It was necessary to understand the whole structure and the functional purpose of each terminology to propose a good representation for human. Another problem is the space complexity when data is very large (e.g. SNOMED international with more than 80,000 terms and 62,000 relations). We always have to adapt our tools to allow integration in short time while keeping a control on data. For every new terminology integrated in the CISMef Terminology Database, we learnt more and more about structure and data to be able to integrate all kinds of terminology in our system. Other portals propose to search and navigate through ontologies (e.g. FMA) such as NCBO Bioportal [20] and the EBI Ontology Lookup Service [21-22]. Those tools are also very friendly but do not allow users to navigate through terms or search among synonyms in different languages. They are also not adapted to a daily use to index or to present the FMA to medical students.

Via its Web services, the HMTP may also be used by several interactive applications. The targeted users include the entire range of medical information technology players (e.g. institutions, hospitals, software publishers, information portals) and, through them, all those involved in the healthcare sector, in particular healthcare professionals and patients.

The HMTP presented here has the main functionalities of any terminology server, except the extensive management of terminologies (e.g. adding a new hierarchy). To the best of our knowledge, the HMTP is the first of its kind. The main added value of

<sup>23</sup> <http://terminologiecismef.chu-rouen.fr/>.

HMTP when compared to any UMLS browser [23-24] is the possibility to access the main health terminologies or the multi-lingual terminologies and classification coming from WHO, which are not (yet) included in the UMLS (e.g. ATC for drugs or ICPS for patient safety). Currently, the HMTP is a necessary basic tool to index any document in a multi-terminology mode.

Even if the HMTP web service does not deal with the HL7/CTS specification, it could be an interesting perspective to implement it in order to be compliant with other terminological providers. It would be also convenient to get responses from other similar portals such as NCBO Bioportal, UMLS browser or EBI Ontology Lookup Service to enhance our results and to provide the best possible service to users.

#### 4. Conclusion

A health multi-terminology portal is a valuable tool to help to index and retrieve resources from a quality-controlled health gateway. It can also be very useful for teaching or performing audits in terminology management.

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