

Application of standardized biomedical terminologies in radiology reporting templates

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Abstract. The Radiological Society of North America (RSNA) has been promoting structured radiology reports by creating “best practices” reporting templates. The RSNA Reporting Template Library has been developed with the goal of integrating reusable knowledge into the clinical reporting process, which has intentionally incorporated standardized biomedical terminologies to reduce communication errors caused by term ambiguity and inconsistency in radiology reporting. To date, only a few studies have evaluated the usage and coverage of biomedical terminologies in radiology reporting. This research addresses the gap with the objectives of assessing how well standardized biomedical terminologies represent radiological knowledge as reflected by the RSNA reporting templates, and of obtaining first-hand information to guide the enhancement of both standard terminologies and RSNA reporting templates from the user’s perspective. We employed the RadMap software and NCBO BioPortal Annotator to identify matching terms from RadLex[®] and SNOMED CT[®] with the terms in the templates. The RadMap mapping results show that a majority of terms in the sample reporting templates were mapped at least partially to terms in the RadLex[®]. The reporting templates analyzed with the BioPortal Annotator yielded 38% to 53% coverage of the standardized terminologies. The findings provide useful estimates of how well the standardized terminologies capture the concepts that appear in reporting templates. The researchers believe that standardized terminologies play an important role in radiology structured reporting, and the incorporation of standardized terminologies into reporting templates will greatly improve the quality of radiology reports.

Keywords: Radiology reports, structured radiology reporting, reporting templates, standardized biomedical terminologies, RadLex[®], SNOMED CT[®], BioPortal Annotator, mapping process, RSNA

1. Introduction

A radiology report documents a radiological procedure and the radiologist’s findings, and delivers the information to physicians and patients. As a communication means, the radiology reports must be accurate, easily understood and appropriately thorough, using understandable, unambiguous language [3]. Although medical imaging and information technologies have developed remarkably, the form and content of radiology reports has changed little in the discipline’s history [9]. Conventional radiology reports present significant disparity in structure, content and terminology. Radiologists may differ in the use of common terms in radiology reports, such as “opacity”, “density” and “consolidation” [10], which creates the risk of misunderstanding, making it difficult to re-use the reporting data for decision support, data mining and integration into electronic medical records.

The utilization of structured reports makes it easier to capture information and knowledge in a consistent way and display it in an organized format. The incorporation of standardized terminologies with structured radiology reports enables the drawing together of reporting data from various sources and using the same terms to represent the same information on all occasions of use. The structured reporting approach may promote report completeness and consistency, enable data extraction and analysis, and allow reporting information to be efficiently retrieved and re-used [11].

As a practical means of knowledge representation for structured radiology reporting, reporting templates incorporate reusable knowledge in the clinical reporting process and make it possible to integrate all of the information collected during the imaging procedure [4]. Since information in a structured reporting template adheres to a consistent format and standardized terminologies, it is easier to merge that information with generalized knowledge-based resources and integrate the structured reporting process with clinical guidelines, learning resources and decision support.

The Radiological Society of North America (RSNA) has been promoting structured radiology reports by creating “best practices” reporting templates with predefined formats and standardized terms. As of July 28, 2013, two hundred and forty-five templates have been created and released on the searchable web site of RSNA Reporting Template Library (<http://www.radreport.org>). Each template, available in both plain text and XML format, contains a set of metadata elements. For example, the reporting template of Chest X-ray includes elements such as *Procedure*, *Clinical information*, *Comparison*, *Findings*, and *Impression*; the sub-level elements under *Clinical information* are: “Cough”, “Fever”, “Shortness of breath”, “Pre-operative exam” and an “Undefined” slot (See Appendix A: Sample reporting template of Chest X-ray). Users can easily browse, search and download these templates online.

To incorporate standardized biomedical terminologies with the RSNA Reporting Template Library, the reporting elements in the templates has been mapped to RadLex[®], Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT[®]) and Logical Observation Identifiers Names and Codes (LOINC[®]) terms. RadLex[®], a RSNA sponsored radiology lexicon, is a unifying source for medical imaging terminology [5] and contains more than 58,000 radiology-related terms (<http://www.radlex.org>). SNOMED CT[®] is the most comprehensive, multilingual clinical healthcare terminology in the world, and contains more than 310,000 terms (<http://www.ihtsdo.org/snomed-ct>). LOINC[®] is a universal code system for identifying laboratory and clinical observations (<http://www.loinc.org>). These biomedical terminologies are available on the National Center for Biomedical Ontology (NCBO) BioPortal (<http://bioportal.bioontology.org>), an open biomedical terminology repository that provides access to biomedical ontologies and terminologies with a broad range of topics [8].

To date, only a small number of studies have evaluated the usage and coverage of biomedical terminologies in radiology reporting [1,2,6]. Our research attempts to bridge the gap by addressing the following questions:

- What role do standardized biomedical terminologies play in radiological knowledge representation and organization with structured reporting?
- How well do RadLex[®] and SNOMED CT[®] represent radiological knowledge in RSNA reporting templates?

2. Methodology

Five RSNA reporting templates were selected from common radiology exams as samples for the purpose of investigating the role of the standardized biomedical terminologies in radiological knowledge

representation. The sample data represent a variety of imaging modalities such as computed tomography (CT), diagnostic radiology (DX), magnetic resonance imaging (MR), nuclear medicine (NM), and ultrasound (US) and a variety of body areas and organ systems (brain, chest, hepatobiliary, pelvis, and abdomen, etc). RadLex[®] and SNOMED CT[®] were chosen to assess the usage and coverage of standardized biomedical terminologies in these reporting templates.

Elements from the XML-encoded reporting template documents were extracted using a semi-automated mapping tool called RadMap developed by Dr. Charles Kahn's research group (user account required to access RadMap) [2]. While radiology-specific terms are coded using RadLex[®], general clinical terms are coded using SNOMED CT[®]. Elements from the templates were mapped to RadLex[®] first, and then to SNOMED CT[®] if no match was found in RadLex[®]. For example, in the Chest X-ray Reporting Template (<http://www.radreport.org/explore/0000102>), the element "Pre-operative_exam" has an exact match status with a RadLex[®] concept (ID="RID28815") (<http://bioportal.bioontology.org/ontologies/47447?p=terms&conceptid=RID28815>):

```
<element name="Pre-operative_exam" radlex:id="RID28815" radlex:match="Exact">
```

and the sub-level element "Cough" matches a SNOMED concept (ID "49727002") (<http://bioportal.bioontology.org/ontologies/42789?p=terms&conceptid=49727002>):

```
<element name="Cough" radlex:id="-" radlex:match="-" snomed:id="49727002">
```

A sample XML-encoded reporting template that includes the mapping information of RadLex[®] and SNOMED CT[®] is shown in Fig. 1.

The mapping process is ongoing and has not been completed yet. While the expert radiologists are continuing to create and update more templates, further mapping process is needed with the development of the standardized terminology-based RSNA Reporting Template Library. A subsequent analysis of the mapping results has been conducted to guide enrichment of reporting templates and existing radiology vocabularies.

Since the RadMap software was mainly designed to map elements of reporting templates to specific RadLex[®] terms and is currently for internal use, the NCBO BioPortal Annotator (<http://bioportal.bioontology.org/annotator>) was applied as an additional tool to identify matching terms from the RadLex[®] and SNOMED CT[®] with the terms in the reporting templates, and to further assess how well standardized biomedical terminologies represent radiological knowledge as reflected by the RSNA reporting templates.

The BioPortal Annotator is a tool that processes text submitted by a user, recognizes relevant biomedical terms in the text, and returns the annotations to the user. Annotations are based on syntactic concept recognition using a dictionary compiled with concept names and synonyms from the standardized terminologies [7].

For each reporting template, the BioPortal Annotator was used to annotate the template with matching RadLex[®] and SNOMED CT[®] terms. First, the total number of annotations was counted. Then, the duplicated annotations were removed to obtain the number of unique annotations. Furthermore, the terminology coverage of RadLex[®] and SNOMED CT[®] in the template was tallied. The percentages of matching terms from both RadLex[®] and SNOMED CT[®] were calculated to indicate the coverage.

The Mapping process is shown in the chart (Fig. 2).

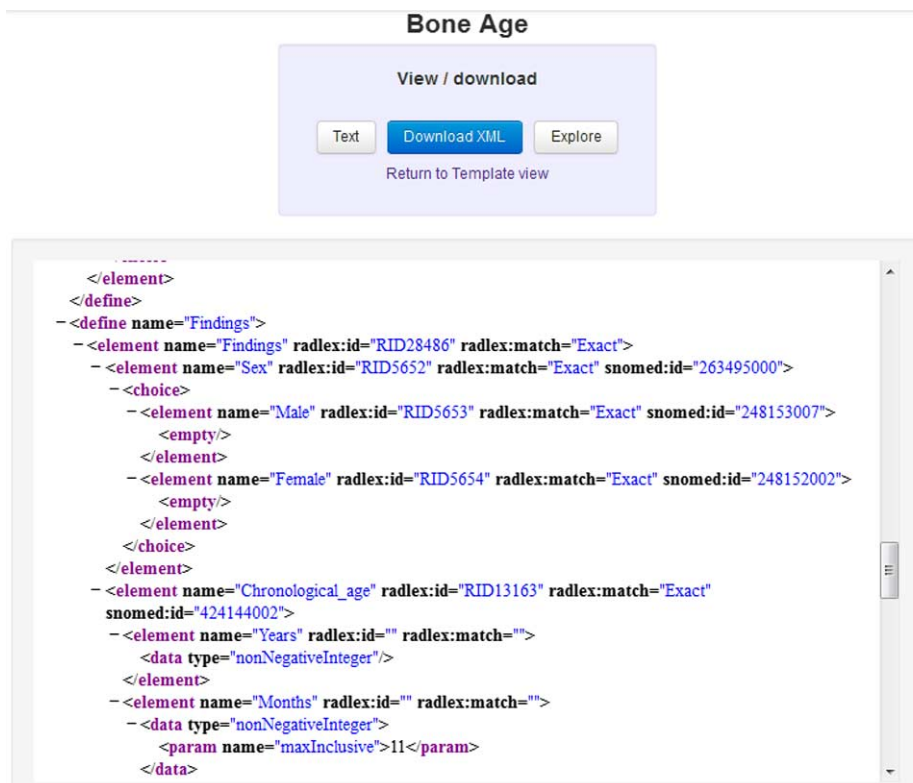


Fig. 1. A sample of XML-encoded reporting template. (Colors are visible in the online version of the article; <http://dx.doi.org/10.3233/ISU-130708>.)

3. Results

Research findings are presented through three tables. Table 1 shows the RadMap mapping results for RadLex[®] terminology coverage of five sample reporting templates. As shown in Table 1, RadMap extracted 61 elements from the “CT Brain” reporting template, of which 49 matched exactly to RadLex[®] terms, 9 were partial matches, and 3 reporting terms were unmatched to RadLex[®]. The results show that a majority of terms in the sample reporting templates were mapped at least partially to terms in the RadLex[®] vocabulary.

The BioPortal annotation results and terminology coverage of the five sample reporting templates are displayed in Tables 2 and 3. As shown in the Appendix B, the Annotator returns all the concept occurrences of one terminology for each template, including many duplicate terms. The number of concept occurrences is presented as total annotations, while the number of unique annotations of RadLex[®] or SNOMED CT[®] is presented without duplicate terms. The unique annotations represent the distinct concepts from RadLex or SNOMED CT that appear in a single template. For each reporting template, we tallied the number of matching terms of RadLex and SNOMED CT with the unique element extracted from the template.

Table 2 lays out the number of reporting elements, the number of annotations in targeting terminologies, and the total number of annotations for each template. The number of reporting elements indicates the number of predefined terms appearing in the XML-encoded template. Each element may be mapped to zero, one, or more terms in RadLex[®] or SNOMED CT[®]; the total number of annotations is shown

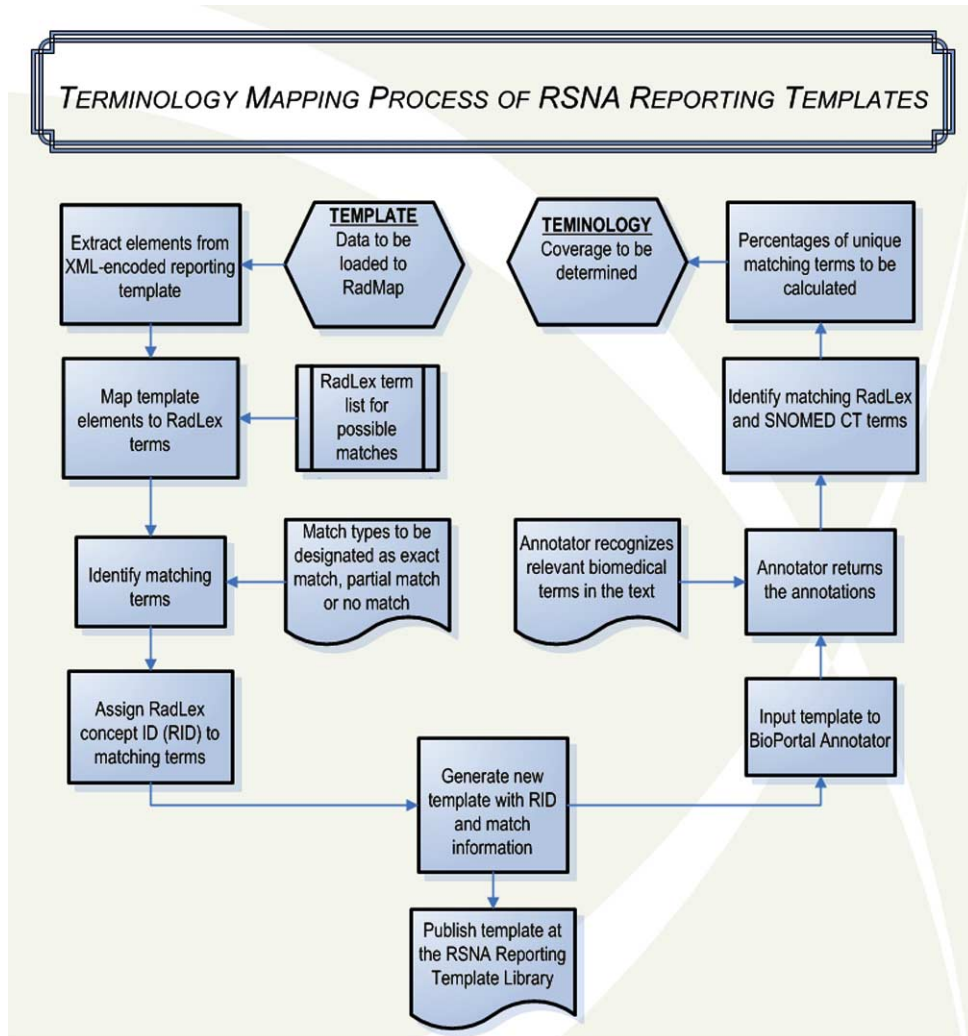


Fig. 2. Overview of the terminology mapping process. (Colors are visible in the online version of the article; <http://dx.doi.org/10.3233/ISU-130708>.)

in the rightmost column. For example, 78 elements of the “MR Abdomen Abscess” reporting template were mapped to 116 annotations, including 43 matching terms from RadLex® and 73 matching terms from SNOMED CT®.

The unique annotation results of the templates and terminology coverage are shown in Table 3. For each template, the table indicates the number of unique elements and their associated unique annotations and concepts. The “Coverage” indicates the percentage of matching terms appearing in the template that match the concepts of RadLex® and SNOMED CT®.

As shown in Table 3, the 55 unique elements of the “Chest Xray – TB screening” reporting template resulted in 28 unique annotations of RadLex® and 33 unique annotations of SNOMED CT®, of which 29 (53%) exactly matched the elements that appear in the reporting template. This finding suggests that at least more than one third of terms in the reporting templates matched the concepts of RadLex® and SNOMED CT®.

Table 1
RadLex® coverage in sample reporting templates

Templates	Elements	Type of match		
		Exact	Partial	No match
Chest Xray – TB screening	83	71	6	6
CT Brain	61	49	9	3
MR Abdomen Abscess	72	50	3	19
NM Hepatobiliary	67	45	8	14
US Pelvis	68	59	4	5

Table 2
Total annotations for each of sample reporting templates

Template name	Template ID	No. of reporting elements	No. of total annotation – RadLex	No. of total annotation – SNOMED	Total No. of annotations
Chest Xray – TB screening	0000144	83	60	73	133
CT Brain	0000004	61	43	58	101
MR Abdomen Abscess	0000039	78	43	73	116
NM Hepatobiliary	0000080	67	56	125	181
US Pelvis	0000092	68	44	73	117

Table 3
Unique annotations for each of sample reporting templates

Template name	No. of unique elements	No. of unique annotation – RadLex	No. of unique annotation – SNOMED	No. of unique matching term	Coverage (%)
Chest Xray – TB screening	55	28	33	29	53
CT Brain	49	29	31	23	47
MR Abdomen Abscess	63	34	53	31	49
NM Hepatobiliary	45	22	46	17	38
US Pelvis	44	24	28	21	48

4. Discussion

The study reveals the potential benefits of integrating the biomedical terminologies into radiology reporting templates. These include standardizing the vocabulary used in radiology reports, reducing variation, and enhancing clarity of radiology reports. As an approach to enforce consistency, the standardized terminologies may facilitate machine processing of reporting information, support quality enhancement, diminish errors, and improve communication.

Mapping the elements in the templates to the terms in RadLex® and SNOMED CT® is essential for organizing radiological knowledge and verifying applicability of the standard terminology in structured reporting. Currently only a portion of the elements in the RSNA reporting templates have been mapped to these terms. A comprehensive study of all templates can be conducted using the same methodology.

The annotation results showed that the RSNA reporting templates accounted for 38–53% coverage of the standardized terminologies in the sample templates. Considering that the templates only include a small number of meaningful specific terms and only exact matching terms were counted for terminology coverage, the percentage of matching terms is relatively significant.

This study had several limitations. First, we only examined a few sample reporting templates with two terminologies, which might reflect individual biases. Second, the BioPortal Annotator often identified multiple concepts for a specific term. For example, the reporting element “Pleural effusion” was mapped to annotations for “Pleural effusion”, “Pleural” and “effusion”. Such redundancy may artificially increase the number of annotations. Third, only exactly matched terms were counted for the terminology coverage with the BioPortal Annotator, which might result in smaller percentage of the matching concepts due to missing of the partially matched terms.

Despite these limitations, we believe that our findings provide useful estimates of how well the standardized terminologies capture the concepts that appear in reporting templates. It could be helpful in determining the appropriate complexity of radiology reporting templates and in identifying the concepts that should be considered for inclusion in the templates.

5. Conclusion

The study found that the standard terminologies RadLex[®] and SNOMED CT[®] have covered a significant number of terms used in the radiology reporting templates. It is obvious that standardized terminologies play an important role in structured radiology reporting. The researchers believe that incorporating standardized terminologies into structured reporting templates will improve the consistency and quality of radiology reports. In a broader picture, the use of uniform terminology for reporting across institutions will enable aggregation and mining of radiology reporting data for knowledge representation and sharing.

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Appendix A. Sample reporting template of Chest X-ray (<http://www.radreport.org/xml/0000102>)

```
<?xml version="1.0" encoding="UTF-8" ?>
- <!--
=====
* Chest Xray
* http://www.radreport.org/template/0000102

This file is part of the "RSNA Radiology Reporting Templates."

The RSNA Radiology Reporting Templates are licensed without charge under
the RSNA's license agreement (the "License"); you may not use this file
except in compliance with the License (http://www.radreport.org/license.pdf).

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WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
```

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ALL RIGHTS RESERVED

```

-->
- <grammar ns="http://www.radreport.org/" xmlns="http://relaxng.org/ns/structure/1.0"
  xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0" xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:radlex="http://www.radlex.org/" xmlns:snomed="http://www.ihtsdo.org/" xmlns:loinc="http://www.loinc.org/"
  datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">
  <dc:title>Chest Xray</dc:title>
  <dc:identifier>http://www.radreport.org/template/0000102</dc:identifier>
  <dc:type>Reporting template</dc:type>
  <dc:language>en</dc:language>
  <dc:publisher>Radiological Society of North America (RSNA)</dc:publisher>
  <dc:rights>May be used gratis, subject to license agreement</dc:rights>
  <dc:license>http://www.radreport.org/license.pdf</dc:license>
  <dc:date>2012-03-28</dc:date>
  <dc:creator>Kahn CE Jr</dc:creator>
  <dc:contributor>Kahn CE Jr [editor]</dc:contributor>
  <dc:contributor>Medical College of Wisconsin (MCW)</dc:contributor>

- <start>
- <element name="Report" radlex:id="RID28487" radlex:match="Exact">
- <attribute name="template">
  <value>http://www.radreport.org/template/0000102</value>
  </attribute>
+ <interleave>
  </element>
</start>
- <define name="Procedure">
- <element name="Procedure" radlex:id="RID1559" radlex:match="Exact">
- <element name="View" radlex:id="RID12243" radlex:match="Exact">
- <optional>
- <element name="PA" radlex:id="RID28625" radlex:match="Exact">
  <empty />
</element>
</optional>
- <optional>
- <element name="AP" radlex:id="RID28784" radlex:match="Exact">
  <empty />
</element>
</optional>
- <optional>
- <element name="Lateral" radlex:id="RID5821" radlex:match="Exact">
  <empty />
</element>
</optional>
  <text />
</element>
  <text />
</element>
</define>
- <define name="Clinical_information">
- <element name="Clinical_information" radlex:id="RID13166" radlex:match="Exact">
- <optional>
- <element name="Cough" radlex:id="" radlex:match="" snomed:id="49727002">
  <text />
</element>
</optional>
- <optional>
- <element name="Fever" radlex:id="" radlex:match="" snomed:id="386661006">
  <text />
</element>
</optional>
- <optional>
- <element name="Shortness_of_breath">
  <text />
</element>
</optional>
- <optional>
- <element name="Pre-operative_exam" radlex:id="RID28815" radlex:match="Exact">

```



```

        <text />
      </element>
    </optional>
  <text />
</element>
</define>
- <define name="Comparison">
- <element name="Comparison" radlex:id="RID28483" radlex:match="Exact">
- <choice>
- <element name="None" radlex:id="RID28454" radlex:match="Exact">
  <text />
  </element>
  <text />
</choice>
</element>
</define>
- <define name="Findings">
- <element name="Findings" radlex:id="RID28486" radlex:match="Exact">
- <element name="Heart" radlex:id="RID1385" radlex:match="Exact">
  <ref name="Normal_or_text" />
  </element>
- <element name="Lungs" radlex:id="RID13437" radlex:match="Exact">
- <choice>
- <element name="Normal" radlex:id="RID13173" radlex:match="Exact">
  <text />
  </element>
- <element name="No_acute_disease">
  <text />
  </element>
</choice>
</element>
- <element name="Bones" radlex:id="RID28569" radlex:match="Exact">
- <choice>
- <element name="Normal" radlex:id="RID13173" radlex:match="Exact">
  <text />
  </element>
- <element name="Degenerative_changes">
  <text />
  </element>
</choice>
</element>
</define>
- <define name="Impression">
- <element name="Impression" radlex:id="RID13170" radlex:match="Exact">
- <choice>
- <element name="Normal" radlex:id="RID13173" radlex:match="Exact">
  <text />
  </element>
- <element name="No_acute_disease">
  <text />
  </element>
</choice>
</element>
</define>
- <define name="Normal_or_text">
- <choice>
- <element name="Normal" radlex:id="RID13173" radlex:match="Exact">
  <text />
  </element>
</choice>
</define>
</grammar>

```

Appendix B. Annotations of SNOMED CT in CT brain template

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	leftward shift rightward shift] * Cerebellum: [normal*]*	Shift
Systematized Nomenclature of Medicine–Clinical Terms	direct	shift: [none* leftward shift rightward shift]*	Shift
Systematized Nomenclature of Medicine–Clinical Terms	direct	gliosis; hemorrhage]* Midline shift : [none* leftward shift	Shift
Systematized Nomenclature of Medicine–Clinical Terms	direct	dizziness trauma] Imaging Technique * Time of	Imaging
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*; non-depressed fracture; depressed fracture ; osteolysis; sclerosis]* Vascular	Fracture
Systematized Nomenclature of Medicine–Clinical Terms	direct	acquisition parameters, such as device settings, patient positioning, interventions	Device
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*; non-depressed fracture; depressed fracture ; osteolysis; sclerosis]* Vascular	Fracture
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Ventricular system: [normal in size and morphology	Normal
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Reason for exam, including medical necessity: [headache	Including
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal* enlarged small]* Cerebral parenchyma: [normal*;	Small
Systematized Nomenclature of Medicine–Clinical Terms	direct	trauma] Imaging Technique * Time of image acquisition *	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	list of key observations, including any recommendations	Including
Systematized Nomenclature of Medicine–Clinical Terms	direct	age* enlarged small]* Basal cisterns: [normal*	Small
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Calvarium: [normal*; non-depressed fracture ; depressed fracture; osteolysis; sclerosis]	Fracture
Systematized Nomenclature of Medicine–Clinical Terms	direct	name, dose, route, and time of administration)* Radiation	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	of image acquisition * Imaging device [MR, CT]*	Imaging
Systematized Nomenclature of Medicine–Clinical Terms	direct	age* widened]* Hemorrhage : [none*; subdural;	Hemorrhage
Systematized Nomenclature of Medicine–Clinical Terms	direct	Extra axial spaces: [normal in size and morphology	Normal
Systematized Nomenclature of Medicine–Clinical Terms	direct	axial spaces: [normal in size and morphology for the	Size
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history * Risk factors	Medical
Systematized Nomenclature of Medicine–Clinical Terms	direct	osteolysis; sclerosis]* Vascular system : [normal* vascular calcifications	System
Systematized Nomenclature of Medicine–Clinical Terms	direct	Basal cisterns: [normal* enlarged small]* Cerebral	Enlarged
Systematized Nomenclature of Medicine–Clinical Terms	direct	image acquisition * Imaging device [MR, CT]* Image	Device
Systematized Nomenclature of Medicine–Clinical Terms	direct	changes; infarction; encephalomalacia; gliosis; hemorrhage]* Midline shift: [none*	Hemorrhage
Systematized Nomenclature of Medicine–Clinical Terms	direct	intraventricular, parenchymal]* Ventricular system : [normal in size and	System

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	Reason for exam, including medical necessity: [headache stroke	Medical
Systematized Nomenclature of Medicine–Clinical Terms	direct	Ventricular system: [normal in size and morphology for the	Size
Systematized Nomenclature of Medicine–Clinical Terms	direct	trauma] Imaging Technique * Time of image acquisition *	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	trauma] Imaging Technique * Time of image acquisition *	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	the patient's age* enlarged small]* Basal	Enlarged
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Calvarium: [normal*; non-depressed fracture ; depressed fracture; osteolysis; sclerosis]	Fracture
Systematized Nomenclature of Medicine–Clinical Terms	direct	name, dose, route, and time of administration)* Radiation	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	name, dose, route, and time of administration)* Radiation	Time
Systematized Nomenclature of Medicine–Clinical Terms	direct	age* enlarged small]* Basal cisterns: [normal*	Minor
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history * Risk factors *	History of
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal* enlarged small]* Cerebral parenchyma: [normal*;	Minor
Systematized Nomenclature of Medicine–Clinical Terms	direct	of administration)* Radiation dose Comparison * Date and	Unit dose
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal in size and morphology for the patient's age*	Associated morphology
Systematized Nomenclature of Medicine–Clinical Terms	direct	fracture; osteolysis; sclerosis]* Vascular system: [normal* vascular	Fibrovascular
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Calvarium: [normal*; non-depressed fracture ; depressed fracture; osteolysis; sclerosis]	Fracture of bone
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal in size and morphology for the patient's age*	Associated morphology
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history *	History of (present illness)
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*; non-depressed fracture; depressed fracture ; osteolysis; sclerosis]* Vascular	Fracture of bone
Systematized Nomenclature of Medicine–Clinical Terms	direct	medications administered (including name, dose , route, and time of	Unit dose
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history *	History of
Systematized Nomenclature of Medicine–Clinical Terms	direct	Vascular system: [normal* vascular calcifications (CT) appropriate	Fibrovascular
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history * Risk factors *	History of (present illness)
Systematized Nomenclature of Medicine–Clinical Terms	direct	Orbits: [normal*]* Visualized upper cervical spine: [normal*]*	Upper
Systematized Nomenclature of Medicine–Clinical Terms	direct	non-depressed fracture; depressed fracture; osteolysis ; sclerosis]* Vascular system:	Osteolysis
Systematized Nomenclature of Medicine–Clinical Terms	direct	Allergies, if relevant * Reason for exam, including medical necessity:	Reason for
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Cerebral parenchyma: [normal*; microvascular changes; infarction; encephalomalacia; gliosis;	Microvascular

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	sinuses: [clear* scattered mild inflammatory mucosal thickening]*	Mild
Systematized Nomenclature of Medicine–Clinical Terms	direct	enlarged small]* Basal cisterns: [normal* enlarged	Basal
Systematized Nomenclature of Medicine–Clinical Terms	direct	microvascular changes; infarction; encephalomalacia; gliosis ; hemorrhage]* Midline shift:	Gliosis
Systematized Nomenclature of Medicine–Clinical Terms	direct	sella left/right mastoid air cell fluid] Summary (or	Air
Systematized Nomenclature of Medicine–Clinical Terms	direct	appropriate arterial and dural sinus flow voids (MR)]*	Dural sinus
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*; microvascular changes; infarction; encephalomalacia ; gliosis; hemorrhage]* Midline	Encephalomalacia
Systematized Nomenclature of Medicine–Clinical Terms	direct	as device settings, patient positioning , interventions (e.g., Valsalva maneuver)	Positioning
Systematized Nomenclature of Medicine–Clinical Terms	direct	time of administration)* Radiation dose Comparison * Date	Radiation
Systematized Nomenclature of Medicine–Clinical Terms	direct	[headache stroke dizziness trauma] Imaging Technique	Dizziness
Systematized Nomenclature of Medicine–Clinical Terms	direct	[clear* scattered mild inflammatory mucosal thickening]* Visualized	Inflammatory
Systematized Nomenclature of Medicine–Clinical Terms	direct	empty sella left/ right mastoid air cell fluid]	Right
Systematized Nomenclature of Medicine–Clinical Terms	direct	dizziness trauma] Imaging Technique * Time of image	Technique
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*]* Visualized upper cervical spine: [normal*]* Sella	Cervical
Systematized Nomenclature of Medicine–Clinical Terms	direct	scattered mild inflammatory mucosal thickening]* Visualized Orbits:	Mucosal
Systematized Nomenclature of Medicine–Clinical Terms	direct	appropriate arterial and dural sinus flow voids (MR)]*	Sinus
Systematized Nomenclature of Medicine–Clinical Terms	direct	non-depressed fracture; depressed fracture; osteolysis ; sclerosis]* Vascular system:	Osteolysis
Systematized Nomenclature of Medicine–Clinical Terms	direct	encephalomalacia; gliosis; hemorrhage]* Midline shift: [none* leftward	Midline
Systematized Nomenclature of Medicine–Clinical Terms	direct	Radiation dose Comparison * Date and type of previous	Date
Systematized Nomenclature of Medicine–Clinical Terms	direct	Allergies, if relevant * Reason for exam, including medical necessity:	Reason for
Systematized Nomenclature of Medicine–Clinical Terms	direct	administered (including name, dose, route , and time of administration)	Route
Systematized Nomenclature of Medicine–Clinical Terms	direct	such as device settings, patient positioning, interventions (e.g., Valsalva	Patient
Systematized Nomenclature of Medicine–Clinical Terms	direct	time of administration)* Radiation dose Comparison * Date	Radiation
Systematized Nomenclature of Medicine–Clinical Terms	direct	Date and type of previous exams reviewed, if applicable	Previous
Systematized Nomenclature of Medicine–Clinical Terms	direct	subdural; subarachnoid; epidural, intraventricular , parenchymal]* Ventricular system:	Intraventricular
Systematized Nomenclature of Medicine–Clinical Terms	direct	Radiation dose Comparison * Date and type of previous	Date
Systematized Nomenclature of Medicine–Clinical Terms	direct	fracture; depressed fracture; osteolysis; sclerosis]* Vascular system: [normal*	Sclerosis

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	partially empty sella left/right mastoid air cell fluid]	Left
Systematized Nomenclature of Medicine–Clinical Terms	direct	Clinical History * Medical history	Clinical
Systematized Nomenclature of Medicine–Clinical Terms	direct	Valsalva maneuver)* Contrast materials and other medications administered	Materials
Systematized Nomenclature of Medicine–Clinical Terms	direct	; subdural; subarachnoid; epidural , intraventricular, parenchymal]* Ventricular	Epidural
Systematized Nomenclature of Medicine–Clinical Terms	direct	Radiation dose Comparison * Date and type of previous	Date
Systematized Nomenclature of Medicine–Clinical Terms	direct	sella left/right mastoid air cell fluid] Summary (or	Air
Systematized Nomenclature of Medicine–Clinical Terms	direct	Comparison * Date and type of previous exams reviewed,	Type
Systematized Nomenclature of Medicine–Clinical Terms	direct	left/right mastoid air cell fluid] Summary (or Impression)*	Fluid
Systematized Nomenclature of Medicine–Clinical Terms	direct	including medical necessity: [headache stroke dizziness	Headache
Systematized Nomenclature of Medicine–Clinical Terms	direct	calcifications (CT) appropriate arterial and dural sinus flow	Arterial
Systematized Nomenclature of Medicine–Clinical Terms	direct	including medical necessity: [headache stroke dizziness	Headache
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Sella and skull base : [normal* partially empty	Base
Systematized Nomenclature of Medicine–Clinical Terms	direct	[clear* scattered mild inflammatory mucosal thickening]* Visualized	Inflammatory
Systematized Nomenclature of Medicine–Clinical Terms	direct	applicable Observations * Extra axial spaces: [normal in size	Axial
Systematized Nomenclature of Medicine–Clinical Terms	direct	[headache stroke dizziness trauma] Imaging Technique	Dizziness
Systematized Nomenclature of Medicine–Clinical Terms	direct	sinuses: [clear* scattered mild inflammatory mucosal thickening]*	Mild
Systematized Nomenclature of Medicine–Clinical Terms	direct	Paranasal sinuses: [clear* scattered mild inflammatory mucosal thickening]	Scattered
Systematized Nomenclature of Medicine–Clinical Terms	direct	Comparison * Date and type of previous exams reviewed,	Type
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture ; osteolysis; sclerosis]* Vascular	Depressed fracture
Systematized Nomenclature of Medicine–Clinical Terms	direct	medical necessity: [headache stroke dizziness trauma]	Cerebrovascular accident
Systematized Nomenclature of Medicine–Clinical Terms	direct	Comparison * Date and type of previous exams reviewed,	Type–attribute
Systematized Nomenclature of Medicine–Clinical Terms	direct	Brainstem: [normal*] Other: * Calvarium : [normal*; non-depressed fracture; depressed	Structure of vault of skull
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	Depressive disorder
Systematized Nomenclature of Medicine–Clinical Terms	direct	CT]* Image acquisition parameters , such as device settings,	Observation parameter
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Visualized upper cervical spine : [normal*]* Sella and	Entire vertebral column
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*]* Sella and skull base: [normal* partially	Bone structure of cranium

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	(Depressed (and symptom)) or (unhappy)
Systematized Nomenclature of Medicine–Clinical Terms	direct	encephalomalacia; gliosis; hemorrhage]* Midline shift: [none* leftward	Median
Systematized Nomenclature of Medicine–Clinical Terms	direct	rightward shift]* Cerebellum : [normal*]* Brainstem: [normal*]	Cerebellar structure
Systematized Nomenclature of Medicine–Clinical Terms	direct	Allergies, if relevant * Reason for exam, including medical necessity:	Indication for
Systematized Nomenclature of Medicine–Clinical Terms	direct	appropriate arterial and dural sinus flow voids (MR)]*	(Septic spots) or (sinus) or (infected skin: [insect bite] or [ulcer] or [dermatitis] or [local infection skin/subcutaneous tissue NOS])
Systematized Nomenclature of Medicine–Clinical Terms	direct	; subdural; subarachnoid; epidural , intraventricular, parenchymal]* Ventricular	Epidural route
Systematized Nomenclature of Medicine–Clinical Terms	direct	stroke dizziness trauma] Imaging Technique * Time	Traumatic abnormality
Systematized Nomenclature of Medicine–Clinical Terms	direct	left/right mastoid air cell fluid] Summary (or Impression)*	Liquid substance
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	(Depressed) or (C/O feeling: [depressed] or [unhappy])
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Visualized upper cervical spine : [normal*]* Sella and	Entire spine
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*]* Visualized upper cervical spine : [normal*]* Sella and	Bone structure of cervical vertebra
Systematized Nomenclature of Medicine–Clinical Terms	direct	including medical necessity: [headache stroke dizziness	Headache (and [C/O])
Systematized Nomenclature of Medicine–Clinical Terms	direct	parenchyma: [normal*; microvascular changes; infarction ; encephalomalacia; gliosis; hemorrhage]*	Infarct
Systematized Nomenclature of Medicine–Clinical Terms	direct	stroke dizziness trauma] Imaging Technique * Time	Injury
Systematized Nomenclature of Medicine–Clinical Terms	direct	encephalomalacia; gliosis; hemorrhage]* Midline shift: [none* leftward	Medial
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Sella and skull base : [normal* partially empty	Base–unit of product usage
Systematized Nomenclature of Medicine–Clinical Terms	direct	left/right mastoid air cell fluid] Summary (or Impression)	Cell structure
Systematized Nomenclature of Medicine–Clinical Terms	direct	empty sella left/right mastoid air cell fluid] Summary	Entire mastoid
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Sella and skull base : [normal* partially empty	Alkali
Systematized Nomenclature of Medicine–Clinical Terms	direct	Orbits: [normal*]* Visualized upper cervical spine: [normal*]*	Superior
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*]* Visualized upper cervical spine : [normal*]* Sella and	Cervical spine structure
Systematized Nomenclature of Medicine–Clinical Terms	direct	stroke dizziness trauma] Imaging Technique * Time	Traumatic injury

Ontology	Type	Context	Matched term
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	Depressed mood
Systematized Nomenclature of Medicine–Clinical Terms	direct	sella left/right mastoid air cell fluid] Summary (or	Medical air
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	(Depressed (and symptom)) or (unhappy)
Systematized Nomenclature of Medicine–Clinical Terms	direct	scattered mild inflammatory mucosal thickening]* Visualized Orbits: [normal*]	Increased thickness
Systematized Nomenclature of Medicine–Clinical Terms	direct	* Cerebellum: [normal*]* Brainstem : [normal*] Other: * Calvarium:	Entire brainstem
Systematized Nomenclature of Medicine–Clinical Terms	direct	Calvarium: [normal*; non-depressed fracture; depressed fracture; osteolysis; sclerosis]*	Depression
Systematized Nomenclature of Medicine–Clinical Terms	direct	[normal*]* Visualized upper cervical spine : [normal*]* Sella and	Entire cervical spine
Systematized Nomenclature of Medicine–Clinical Terms	direct	left/right mastoid air cell fluid] Summary (or Impression)	Entire cell
Systematized Nomenclature of Medicine–Clinical Terms	direct	rightward shift]* Cerebellum : [normal*]* Brainstem: [normal*]	Entire cerebellum
Systematized Nomenclature of Medicine–Clinical Terms	direct	as device settings, patient positioning , interventions (e.g., Valsalva maneuver)	Positioning patient
Systematized Nomenclature of Medicine–Clinical Terms	direct	medical necessity: [headache stroke dizziness trauma]	Cerebrovascular accident

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