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HL7 Implementation Guide: Service-Oriented Architecture Implementations of the Context-aware Knowledge Retrieval (Infobutton) Domain, Release 1

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1 Executive Summary

Clinicians face numerous knowledge needs during the course of patient care and the majority of these needs are not met, compromising the quality of care. Likewise, in order to be partners in the decision making process, patients need to be well-informed about their health and health care options. Online health knowledge resources that are capable of solving clinicians' and patients' knowledge needs are now widely available, but a series of barriers hinder a more effective and frequent use of these resources to support decision-making. Context-aware knowledge retrieval into Clinical Information Systems (CIS), such as Electronic Health Record (EHR) and Personal Health Record (PHR) systems, is an increasingly promising approach for delivering relevant clinical knowledge to the point of care as well as patient-tailored educational material to support patient-centered care. These kinds of knowledge retrieval tools have been known as *Infobuttons*.[1]

To support the integration of knowledge resources into CISs, the Clinical Decision Support Work Group (CDS WG) has been developing a set of standard specifications for context-aware knowledge retrieval. The first of these specifications, entitled *Context-Aware Knowledge Retrieval, Knowledge Request Standard*, is a normative ANSI/ISO HL7 standard.[3] This specification provides a standard mechanism for Clinical Information Systems to submit knowledge requests to knowledge resources. In addition, a URL-based implementation guide was developed to specify knowledge request implementations using the HTTP protocol.[4]

The present specification complements the previous ones by enabling the implementation of context-aware knowledge retrieval applications through a Service-Oriented Architecture (SOA) based on the RESTful (*Representational State Transfer*) software architecture style (Section 3).

1.1 Scope of this normative ballot

After a 2-year period as a draft standard of trial use (DSTU), the Clinical Decision Support Work Group proceeds to balloting this specification at the normative level. The DSTU specification was revised based on implementers' feedback. This specification includes:

1. Functional requirements for SOA context-aware knowledge retrieval implementations (Section 2);
2. Specification of a RESTful implementation of context-aware knowledge retrieval (Section 3);
3. Specification of a knowledge response service payload for the RESTful implementation above (Section 4).

1.2 Changes from the previous release

The following changes were implemented in the present specification:

1. SOAP specification was removed.
2. Conformance criteria in Section 3 were refined and tightened.
3. Redesigned extension of the atom.category element (Section 4.2.3.1).
4. Revised the possible values for atom.link and clarified definitions.
5. Knowledge response includes support for JSON and JSON-P (Section 4.4).

2 Functional Requirements

2.1 Scenario – Integration with knowledge resources via Infobutton Manager

The following scenario illustrates the process through which a clinician accesses context-specific knowledge retrieved from multiple resources from within a CIS. A knowledge broker called *Infobutton Manager*[2] mediates the integration between the CIS and the multiple resources as described in the steps below. The resources respond with structured metadata that describe the retrieved knowledge content, a summary of the knowledge content and/or the entire content itself, and links to the complete knowledge content at its source. The structured metadata enable Infobutton Managers to filter, process, and aggregate, retrieved knowledge from multiple resources. It also enables rendering of aggregated content into various user interfaces, depending on application specific requirements. The scenario described below is illustrated in Figure 2.

Dr. Jones is looking at a problem list of a male, 77 year-old patient with Heart Failure. Dr. Jones clicks on an infobutton located next to the Heart Failure problem list entry.

(a) The CIS sends a knowledge request to an Infobutton Manager.
(b) The Infobutton Manager acts as a broker, sending requests for context-specific knowledge to multiple knowledge resources.
(c) Each knowledge resource responds with metadata about the content items that are considered to be relevant based on the CIS context. The knowledge resource response includes the following elements:
    - Knowledge topics (e.g., etiology, treatment, prognosis) that are covered by the resource and that might be relevant given the CIS context;
    - Knowledge metadata (e.g., knowledge author, type of content, last update date);
    - Summary of the retrieved knowledge topics;
    - Complete content represented in one or multiple formats (e.g., HTML, XML, binary) or a pointer to the complete content at its original source.
(d) The Infobutton Manager produces a knowledge response aggregating the responses obtained from the multiple knowledge resources and sends the response back to the CIS.
(e) The CIS renders the knowledge response content and presents it to Dr. Jones for content browsing and navigation. Dr. Jones selects a specific knowledge topic (e.g., diagnosis, therapy) from one particular resource. The resource responds with the complete content, which is then presented to Dr. Jones. Alternatively, if the desired content is not satisfactory then Dr. Jones may return to the aggregate summary select a different topic and/or knowledge resource.

2.2 Scenario – Integration with knowledge resources for personalized patient education handout

The following scenario describes the process in which a healthcare provider creates a personalized patient education handout by selecting pieces of content from one or more resources. The scenario exemplifies a potential rendering approach for the content retrieved and aggregated in the previous scenario and in Figure 2. The scenario is just an illustration of a specific knowledge integration use case and does not entail additional requirements or actors for the standard specification.

Dr. Jones opens up the records of a female, 72 year-old patient with a number of entries on her problem list and medications list. Dr. Jones launches a CIS module called “patient handout builder.”

(a) The patient handout builder receives a request from the CIS to retrieve relevant patient education content to help Dr. Jones build a customized/personalized patient education handout. The CIS sends the patient's entire problem list and medications list as part of the request.
    - Alternatively, Dr. Jones selects a subset of problem and medication list items that should be included in the request.
(b) The patient handout builder requests knowledge from multiple resources as described in Section 2.1 considering the conditions and medications that are present in the patient's record.
(c) The resources respond as in Section 2.1. The patient education builder presents the retrieved patient education topics to Dr. Jones.
(d) Dr. Jones selects the relevant topics for her patient, potentially modifying the content, and adding notes.
(e) Finally, Dr. Jones offers the handout to the patient (e.g., via printed copy, e-mail, personal health record).

2.3 Knowledge Retrieval Interaction

The following interactions refer to the scenarios described in Sections 2.1 and 2.2. The interactions provide a comprehensive view of the process involving the communication between a CIS system and one or multiple knowledge resources. Most knowledge integration implementations follow one of two architecture approaches: 1) direct communication between a CIS and a knowledge resource (Figure 1); 2) communication between a CIS and multiple knowledge resources through a knowledge broker known as Infobutton Manager[2] (Figure 2).

The interaction steps and corresponding service payload components are listed in the tables and figures below. Table 1 and Figure 1 depict a direct interaction between a CIS and a knowledge resource. Table 2 and Figure 2 depict an interaction between a CIS and multiple knowledge resources mediated by Infobutton Manager.

Step	Description	Payload
1	A CIS sends a *knowledgeRequest* with context information to a knowledge resource.	HL7 International *Context-aware Knowledge Retrieval, Knowledge Request* Standard.
2	The knowledge resource sends back a *knowledgeResponse* to the CIS.	Text/html or HL7 International *Context-aware Knowledge Retrieval, Knowledge Response Standard* (described in Section 4 of the present specification).

Table 1 – Context-aware knowledge retrieval interaction without an Infobutton Manager.

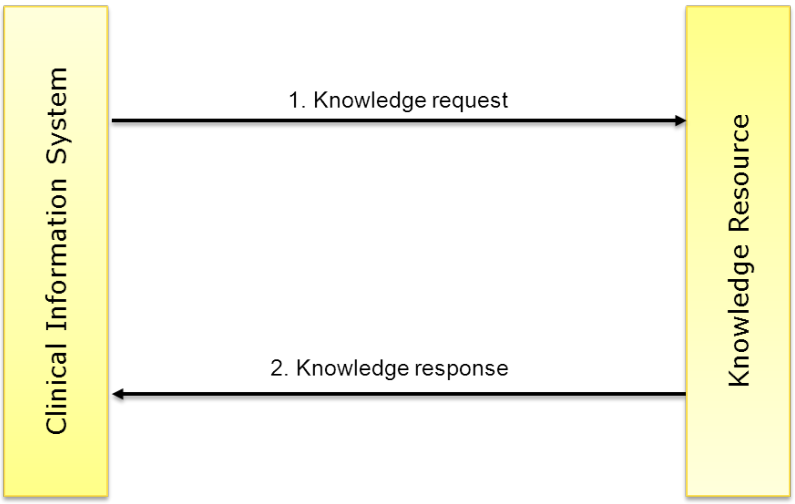

Figure 1 – Context-aware knowledge retrieval interaction without an Infobutton Manager.

Step	Description	Payload
1	A CIS sends a *knowledgeRequest* with context information to an Infobutton Manager.	HL7 International *Context-aware Knowledge Retrieval, Knowledge Request* Standard.
2	The Infobutton Manager sends a *knowledgeRequest* to multiple knowledge resources. Although the payload information model for items (1) and (2) is the same, the Infobutton Manager may refine the contents of the knowledge request based on user input or internal heuristics.	HL7 International *Context-aware Knowledge Retrieval, Knowledge Request* Standard.
3	Each knowledge resource sends back a *knowledgeResponse* to the Infobutton Manager.	Text/html or HL7 International *Context-aware Knowledge Retrieval, Knowledge Response Standard* (knowledge response payload, described in Section 4 of the present specification).
4	The Infobutton Manager sends to the CIS an aggregateKnowledgeResponse, which is composed of an aggregate of knowledge responses from one or more knowledge resources. .	Text/html or HL7 International *Context-aware Knowledge Retrieval, Knowledge Response Standard* (*aggregate knowledge response* payload, described in Section 4 of the present specification). The *aggregate knowledge response* payload information model is composed of one or more *knowledge response* instances wrapped by a single element.

Table 2 – Context-aware knowledge retrieval interaction with an Infobutton Manager.

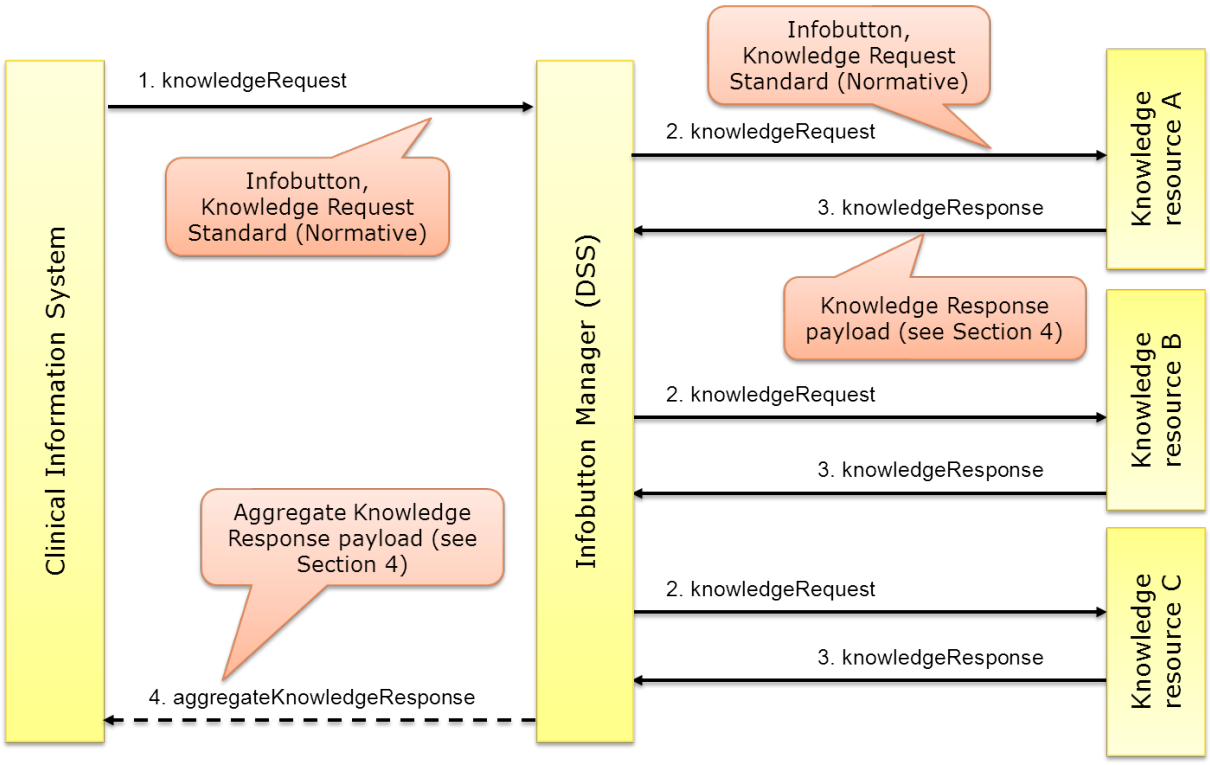

Figure 2 – Context-aware knowledge retrieval interaction with an Infobutton Manager.

Pending issue: The present specification assumes that an Infobutton Manager implementation SHALL wait until it receives for responses (or a request times out) from every resource before it sends a final aggregateKnowledgeResponse back to a CIS client. Yet, we acknowledge that additional desired behaviors may arise during the DSTU period. For example, an Infobutton Manager could send multiple interim aggregate knowledge responses responses back to the CIS client as it receives individual knowledge responses back from each knowledge resource. If desired, these additional behaviors will be assessed and guidance regarding these behaviors will be included in the implementation guide prior to final publication.

3 RESTful Specification

This section describes a RESTful specification for context-aware knowledge retrieval. In this implementation, Infobutton Managers and knowledge resources are considered to be knowledge retrieval service instances that receive a context-aware knowledge request. Knowledge resources respond with a *knowledge response* payload. Infobutton Managers combine the responses from multiple knowledge resources into an *aggregate knowledge response* payload, which is then sent back to the CIS (Figure 2).

1. Clinical information systems SHALL be able to:
    a. Submit knowledge requests according to the *HL7 International URL-Based Implementations of the Context-Aware Knowledge Retrieval Standard*[4] and Section 3.1 below.
    b. Receive knowledge responses submitted by knowledge resources according to the *knowledge response* payload specified in Section 4.
    c. Receive knowledge responses submitted by infobutton managers according to the *aggregate knowledge response* payload specified in Section 4.
    d. Process the transactions above in HTTP GET and/or HTTP POST.
2. Infobutton Managers SHALL be able to:
    a. Receive knowledge requests submitted by CISs according to item 1.a above.
    b. Submit knowledge requests to knowledge resources according to the *HL7 International URL-Based Implementations of the Context-Aware Knowledge Retrieval Standard*[4] and Section 3.1 below.
    c. Receive knowledge responses submitted by knowledge resources according to the *knowledge response* payload specified in Section 4.
    d. Respond to CISs according to the *aggregate knowledge response* payload specified in Section 4.
    e. Process the transactions above in both HTTP GET and HTTP POST.
3. Knowledge resources SHALL be able to:
    a. Receive knowledge requests submitted by CISs and Infobutton Managers according to the *HL7 International URL-Based Implementations of the Context-Aware Knowledge Retrieval Standard*[4] and Section 3.1 below.
    b. Respond to CISs according to the *Knowledge Response* payload specified in Section 4.
    c. Respond to Infobutton Managers according to the *Knowledge Response* payload specified in Section 4.
    d. Process the transactions above in both HTTP GET and HTTP POST.

NOTE: Specific details regarding knowledge retrieval functionality that can be implemented through the mechanisms described above are outside the scope of this specification. Implementers are free to design various types of knowledge retrieval functionality as long as they comply with the conformance criteria defined in this present specification.

3.1 knowledgeResponseType parameter

Knowledge requests SHALL include a *knowledgeResponseType* parameter to specify the format of the response in terms of a MIME type. The values for the *knowledgeResponseType* SHALL be limited to the following:

1. text/xml
2. application/json
3. application/javascript (for a knowledge response in JSON-P). If the value of *knowledgeResponseType* is “application/javascript”, knowledge request submitters SHALL also include a parameter for a call back function named *callback*.

The following conformance criteria apply to the *knowledgeResponseType* values defined above:

1. Clinical information systems SHALL implement one or more of the knowledgeResponseType values defined above.
2. Infobutton Managers SHALL implement all the *knowledgeResponseType* values defined above.
3. Knowledge resources SHALL implement all the knowledgeResponseType values defined above.

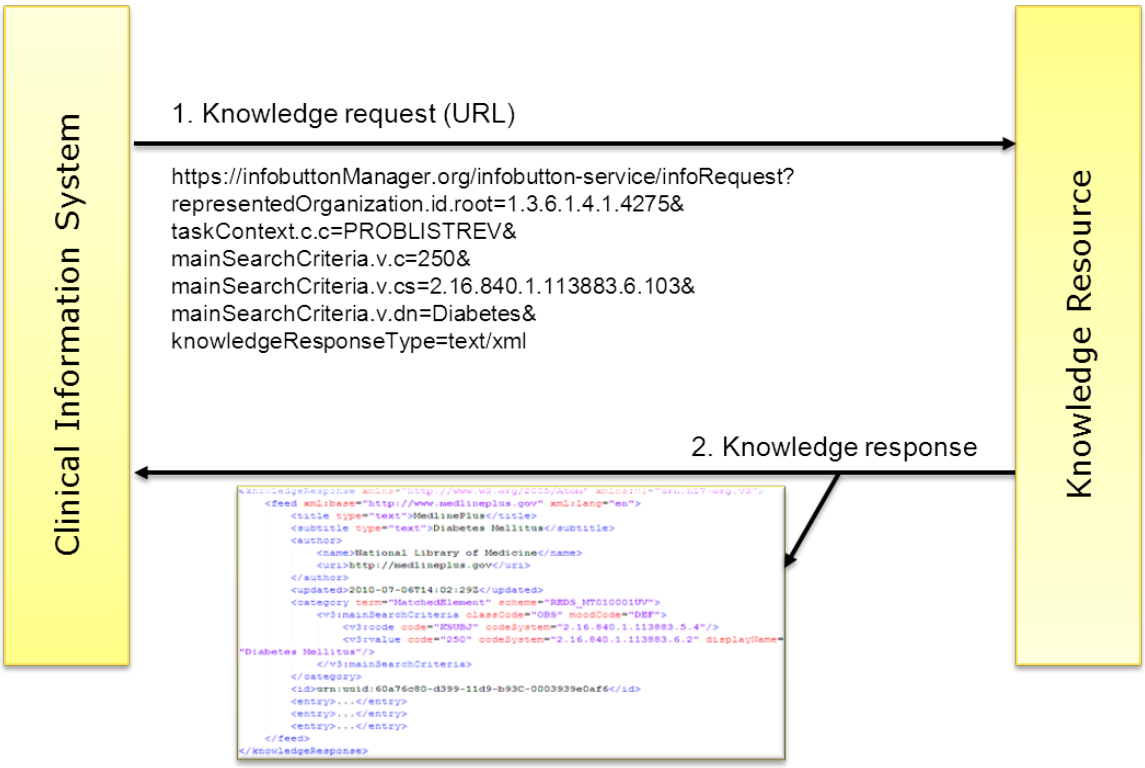

Figure 3 – A RESTful context-aware knowledge retrieval implementation with a URL-based knowledge request and an XML knowledge response.

4 Knowledge Response Payload

To identify potential standards that could be leveraged to support the functional and technical requirements of the knowledge response described in the previous sections, a survey of existing Web-based knowledge integration standards was conducted. Due to their wide adoption and ease of use, content syndication standards, such as RSS (Really Simple Syndication) and Atom, were raised as the primary candidates. The following sections compare the different content syndication standards explaining the rationale behind the choice of Atom as the framework for the *Knowledge Response* payload (Section 4.1); provide a brief overview of the Atom standard (Section 4.2); and provide a specification for the *Knowledge Response* payload (Section 4.2) and the Aggregate Knowledge Response payload (Section 4.3.).

4.1 Content Syndication Standards

Web-based content syndication is a form of syndication in which website material is made available to multiple other sites.[1] Most commonly, Web syndication refers to making Web feeds available from a site in order to provide other people with a summary of the Web site's recently added content (for example, the latest news or forum posts). The term can also be used to describe other kinds of licensing Web site content so that other Web sites can use the content. The two main families of Web syndication formats are RSS[6] and Atom.[7]

	RSS 2.0	Atom
Format	XML	XML
Standard organization	Interest group (Harvard)	IETF (Internet Engineering Task Force – Internet Society)
Focus	Simplicity	Robustness
Extensibility	Informal	Formal, via namespaces and extension guidelines
Content structure	Plain text or HTML	Plain text, HTML, XHTML, XML, binary content, content pointer
Full content vs. partial content	No distinction	<summary> and <content> tags
Support for aggregate feeds	No	Yes
Publishing protocol	MetaWeblog, Blogger	Atom publishing protocol
Date published	2003	2005

Table 3 – Comparison between the RSS 2.0 and Atom Web syndication standards.

Through a comparison between RSS 2.0 and Atom, the CDS WG achieved a consensus that Atom has several advantages over RSS 2.0 when considering the requirements of this implementation guide:

- Unlike RSS 2.0, Atom has been developed and maintained by a formal standards development organization (IETF);
- Atom provides multiple mechanisms to enable extensions to its base model;
- Atom allows retrieved knowledge content to be represented in multiple formats, such as HTML, XHTML, XML, and binary.

4.2 Knowledge Response Payload

This section includes a brief overview of the Atom standard as well as extensions and restrictions regarding the use of particular Atom elements for the purpose of the *Knowledge Response* payload. Descriptions of the Atom standard in this Section are provided for convenience. For a complete specification of the Atom standard, implementers should refer to the official IETF Atom specification.[7]

4.2.1 Atom Overall Structure

Atom is organized in two main elements: *Atom:feed* and *Atom:entry*. *Feed* is the root element of an Atom instance. It contains metadata about a specific set of retrieved content, such as the content set title, author, id, and last update time. Table 3 provides a list and a short description of the *Atom:feed* child elements. A feed contains one or more *Atom:entry* elements. Each *Atom:entry* contains metadata about a specific content item, a summary of the content, and optionally the complete content itself. The *Atom:entry* child elements include the *Atom:feed* child elements as well as the elements listed in Table 4.

Figure 4 contains a feed XML instance showing the *Atom:feed* node and its children. Figure 5 shows the entry elements of the feed in Figure 4.

Element	Cardinality	Description
id	1..1	A permanent, stable, and universally unique identifier for the feed. The *id* value SHALL be an URI/IRI[1] (refer to Atom specification for details). The id SHALL 1) be a valid URI/IRI; 2) be globally unique; and 3) never change.
Title	1..1	Human-readable title for the feed. SHALL be used to represent the knowledge resource content collection name to be displayed to end-users (e.g., MedlinePlus).
subtitle	0..1	Human-readable subtitle for the feed. MAY be used to represent the high-level knowledge subject covered by the feed (e.g., Diabetes Mellitus).
updated	1..1	Last time the feed was modified. SHALL be used to indicate when the knowledge response was generated.
author	1..n	Author of the feed. SHALL be used to represent the knowledge resource publisher name (e.g., National Library of Medicine).
Link	0..n	A pointer to a Web document that contains the feed. Includes the following attributes: *href*, *rel*, *hreflang*, *title*, *length.* - *href (1..1):* the link's URI - *type (1..1)*: format of the content pointed by the URI (e.g., text, html, xhtml, xml, binary MIME types) - *rel (1..1)*: the relation between the link content and the feed or entry. Possible values are: *alternate* = a link to an alternative version of the feed or entry (e.g., full-text content, including multiple languages and formats); *related* = a link to other content, which is related to the content represented in a feed or entry (e.g., other relevant documents on a similar topic as the current feed); *self* = identifies a resource equivalent to the containing element (e.g., a permanent link to the feed itself); *via* = identifies a resource that is the source of the information provided in the feed or entry (e.g., bibliographic citations). - *title (1..1)*: a human-readable title for the link - *length (0..1)*: number of characters contained in the complete content represented in a particular feed.

[1] A useful tutorial on unique URIs is available at http://diveintomark.org/archives/2004/05/28/howto-atom-id

Element	Cardinality	Description
category	0..n	Content metadata that reflect the parameters and values in the knowledge request. The present specification provides a domain-specific extension for the *Atom:category* element (see Section 4.2.3.1 for details).
Icon	0..1	An icon to be display associated with the feed. MAY be used to represent an image that knowledge consumers are familiar with, such as a knowledge resource publisher or content collection icon.
Entry	0..n	Contains the content retrieved. Each piece of content (e.g., document, image) retrieved by a knowledge resource in a knowledge response SHALL be represented as a distinct entry element. An entry includes metadata about the content, a link to the content source, a summary of the content, and the complete content itself.

Table 4 – Description of the *Atom:feed* node elements.

Element	Cardinality	Description
id	1..1	A permanent, universally unique identifier for the entry. The *id* value SHALL be an URI/IRI (refer to Atom specification for details). Updated versions of the same entry SHALL have the same *entry.id*, with a different *entry:updated* element.
title	1..1	Human-readable title for the entry. SHALL be used to convey a title (e.g., document title) that can be displayed to the end-user (e.g., as a hyperlink label).
updated	1..1	Last time the entry was modified. SHALL use to indicate when the entry was generated.
author	0..n	Author of the content associated with the entry. MAY use the name of the knowledge resource publisher (e.g., National Library of Medicine, American College of Physicians), a committee/group in charge of content creation, or the name of one or more individuals in charge of content creation.
link	1..n	A pointer to a Web document that contains the content associated with the entry. See Table 4 for a complete description.
category	0..n	Content metadata that apply to each specific entry. For example, an entry may refer to content on *contraindications* of a medication, while another entry in the same feed may provide *dosing information* on the same medication.
summary	0..1	A short summary of the content associated with the entry. The content MAY be represented in text, html, or xhtml.
content	0..1	The complete content associated with entry. The content MAY be represented in text, html, or xhtml.

Table 5 – Description of the *Atom:entry* node elements.

```
<feed xmlns="http://www.w3.org/2005/Atom"
          xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
          xml:lang="en">
   <title type="text">MedlinePlus Connect</title>
   <subtitle type="text">MedlinePlus Connect results for ICD-9-CM 493.22</subtitle>
   <author>
     <name>U.S. National Library of Medicine</name>
     <uri>http://www.nlm.nih.gov</uri>
   </author>
```

```
   <updated>2013-02-20T10:02:53Z</updated>
   <category scheme="mainSearchCriteria.v.c" term="493.22"/>
   <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.103"/>
   <category scheme="mainSearchCriteria.v.dn" term="Chronic obstructive asthma with (acute)
exacerbation"/>
   <category scheme="informationRecipient" term="PAT"/>
         <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
         <entry>...</entry>
         <entry>...</entry>
         <entry>...</entry>
</feed>
```

Figure 4 – A feed fragment that contains multiple entries on Asthma. In this example, the *Atom:category* element indicates that the overall feed subject is "Asthma." The *Atom:entry* elements are collapsed in this fragment, but expanded in Figure 5.

```
<entry>
         <title>Asthma</title>
         <link href="http://www.nlm.nih.gov/medlineplus/asthma.html" rel="alternate"/>
         <id>tag: nlm.nih.gov, 2013-20-02:/medlineplus/asthma.html</id>
         <updated>2013-02-20T10:02:53Z</updated>
         <summary type="html">&lt;p&gt;Asthma is a chronic disease that affects your airways.
Your airways are tubes that carry air in and out of your lungs. If you have asthma, the inside walls
of your airways become sore and swollen. That makes them very sensitive, and they may react
strongly to things that you are &lt;a
href="http://www.nlm.nih.gov/medlineplus/allergy.html"&gt;allergic&lt;/a&gt; to or find irritating.
When your airways react, they get narrower and your lungs get less air.&lt;/p&gt;</summary>
</entry>

<entry>
         <title>Chronic Bronchitis</title>
         <link href="http://www.nlm.nih.gov/medlineplus/chronicbronchitis.html" rel="alternate"/>
         <id>tag: nlm.nih.gov, 2013-20-02:/medlineplus/chronicbronchitis.html</id>
         <updated>2013-02-20T10:02:53Z</updated>
         <category scheme="mainSearchCriteria.v.c" term="491"/>
         <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.103"/>
         <category scheme="mainSearchCriteria.v.dn" term="Chronic bronchitis"/>
         <category scheme="informationRecipient" term="PAT"/>
         <summary type="html">&lt;p&gt;Bronchitis is an inflammation of the bronchial tubes, the
airways that carry air to your lungs. It causes a cough that often brings up mucus, as well as
shortness of breath, wheezing, and chest tightness. </summary>
</entry>
```

Figure 5 – Two *Atom:entry* nodes from the feed depicted in Figure 4. Each entry contains an *summary* and a *link* to the complete source content.

4.2.2 Atom and the Knowledge Response Payload

When preparing or parsing a knowledge response payload, knowledge response implementers SHALL comply with the specifications provided in Table 4 and Table 5 and the following specifications:

1. The root element of the knowledge response payload SHALL be the Atom:feed element.
2. A knowledge response SHALL contain one and no more than one *Atom:feed* element.
3. Each individual piece of content (e.g., document, image) retrieved by a knowledge resource SHALL be represented as a distinct *Atom:entry* element.

4. If a knowledge resource has no content that matches a specific knowledge request, the knowledge response SHALL produce a knowledge response payload with one *Atom:feed* and no *Atom:entry* elements.
5. The retrieved content MAY be classified using the *Atom:category* element according to the *Atom:category* domain-specific extension described below in Section 4.2.3.1.
6. Feed content SHALL contain metadata describing the human language of the feed in general, segments of the feed, and links within the feed. Language representation SHALL follow a restriction over the Atom specification specified below in Section 4.2.3.2.
7. Knowledge resources SHALL include at least one *Atom:link* element per *Atom:entry*.

4.2.3 Atom Domain-Specific Extensions

An important feature of Atom is the ability to define domain-specific extensions via namespaces and extension guidelines. Most of the Atom elements allow the addition of domain-specific children that are imported from external schemas. In addition, values used in Atom instances can be drawn from standard domain-specific taxonomies.

For the knowledge response payload, the Atom *category* element is extended to enable retrieved content to be categorized in terms of elements of the *HL7 Context-aware Knowledge Retrieval, Knowledge Request Standard* information model. Figure 4 shows the fragment of a knowledge response payload in which the feed provides content that meets the need of a knowledge request in which the *mainSearchCriteria* is “Asthma.”

4.2.3.1 *Atom:category* domain-specific extension

This Section specifies a domain-specific extension of the *Atom:category* element for the *knowledge response* payload. The domain-specific extension enables feed content to be classified according to parameter names specified in the *HL7 Context-aware Knowledge Retrieval, URL-Based Implementation Guide*.

An atom:category element has two attributes: *scheme* and *term.* Implementers should use these two attributes to represent feed and entry metadata following an attribute-value pair structure. The following conformance criteria apply:

1. A *category* element SHALL have one *scheme* attribute and one *term* attribute.
2. The value of the *scheme* attribute of an *atom:category* element SHOULD be:
    - One of the knowledge request parameter names specified in the *HL7 URL-Based Implementations of the Context-Aware Knowledge Retrieval Standard; or*
    - *relevanceScore*: a number between 0 and 1 that indicates how relevant the entry content is to the knowledge request; or
    - *strengthOfRecommedation*: a classification that describes the strength of the evidence supporting the content according to an evidence grading scheme.
3. An *atom:feed* MAY have one or more *feed:category* elements. Category instances at the *atom:feed* level SHALL reflect the parameters of the *knowledge request*.
4. An *atom:entry* MAY have one or more *entry:category* elements. Category instances at the *atom:entry* level SHALL reflect the specific characteristics of the entry and may or may not be the same as the parameters provided in the knowledge request.

Figure 6 shows a feed that illustrates the use of atom:category both at the feed and entry level.

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
        xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
        xml:lang="en">
        <title type="text">MedlinePlus Connect</title>
        <subtitle type="text">MedlinePlus Connect results for ICD-9-CM 250</subtitle>
        <author>
```

```
                <name>U.S. National Library of Medicine</name>
                <uri>http://www.nlm.nih.gov</uri>
        </author>
        <updated>2013-02-20T10:02:53Z</updated>
        <category scheme="mainSearchCriteria.v.c" term="250"/>
        <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.2"/>
        <category scheme="mainSearchCriteria.v.dn" term="Diabetes Mellitus"/>
        <category scheme="informationRecipient" term="PAT"/>
        <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
        <entry>
                <title>Diabetic diet</title>
                <link href="/diabeticdiet.html" rel="alternate" type="html" hreflang="en"/>
                <link href="/spanish/diabeticdiet.html" rel="alternate" type="html" hreflang="es"/>
                <id>tag:nlm.nih.gov,2011-15-02:/medlineplus/diabeticdiet.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
                <summary type="html">If you have diabetes, your body cannot make or properly
use insulin.  This leads to high blood glucose, or sugar, levels in your blood. Healthy eating helps
to reduce your blood sugar.  It is a critical part of managing your diabetes, because controlling
your blood sugar can prevent the &lt;
href="http://www.nlm.nih.gov/medlineplus/diabetescomplications.html">complications of diabetes
&lt;/a>.</summary>
                <category scheme="mainSearchCriteria.v.c" term="250"/>
                <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.2"/>
                <category scheme="mainSearchCriteria.v.dn" term="Diabetes Mellitus"/>
                <category scheme="informationRecipient" term="PAT"/>
                <category scheme="relevanceScore" term="0.7"/>
        </entry>
        <entry>
                <title>Diabetic foot</title>
                <link href="/diabeticfoot.html" rel="alternate" type="html" hreflang="en"/>
                <link href="/spanish/diabeticfoot.html" rel="alternate" type="html" hreflang="es"/>
                <id>tag:nlm.nih.gov,2011-02-11:/medlineplus/diabeticfoot.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
                <summary>If you have &lt;a
href="http://www.nlm.nih.gov/medlineplus/diabetes.html">diabetes&lt;/a>, your blood sugar levels
are too high.  Over time, this can damage your nerves or blood vessels.  Nerve damage from
diabetes can cause you to lose feeling in your feet.</summary>
                <category scheme="mainSearchCriteria.v.c" term="250.7"/>
                <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.2"/>
                <category scheme="mainSearchCriteria.v.dn" term="Diabetes with peripheral
circulatory disorders"/>
                <category scheme="informationRecipient" term="PAT"/>
                <category scheme="relevanceScore" term="0.5"/>
        </entry>
</feed>
```

Figure 6 – Fragment of a knowledge response for a patient with *diabetes mellitus* who needs patient education content. The response includes a feed with a *feed:category* element indicating that the feed is a response to a request that includes a "diabetes mellitus" code as the *mainSearcchCriteria* and "PAT" as the *informationRecipient*.. The feed also includes one *atom:entry* element that covers the specific subject "diabetes with peripheral circulatory disorders." Each entry also has a *relevanceScore*.

4.2.3.2 Restrictions in the use of *xml:lang* and *hreflang* attributes

According to the Atom specification, any text-based Atom element (e.g., title, summary, content) may use the xml:lang attribute to specify the human language in which the text is written.

Likewise, *link* instances may use the *hreflang* attribute to specify the human language of the content pointed by the *link* href attribute. As a result, content language may be specified at various levels, increasing flexibility but creating unnecessary complexity for implementations, which need to account for all possible variations.

To limit unnecessary flexibility, the following certification criteria apply::

> Language SHALL be specified at all the following levels: 1) *xml:lang* at the root *Atom:feed* element level; 2) *xml:lang* at the *Atom:entry* element level; and 3) *hreflang* at the level of each *entry.link* element. Other feed elements SHALL NOT contain a language attribute. (Figure 7, Figure 8, Figure 9).

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
        xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
        xml:lang="en">
        <title type="text">MedlinePlus Connect</title>
        <subtitle type="text">MedlinePlus Connect results for ICD-9-CM 250</subtitle>
        <author>
                <name>U.S. National Library of Medicine</name>
                <uri>http://www.nlm.nih.gov</uri>
        </author>
        <updated>2013-02-20T10:02:53Z</updated>
        <category scheme="mainSearchCriteria.v.c" term="250"/>
        <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.2"/>
        <category scheme="mainSearchCriteria.v.dn" term="Diabetes Mellitus"/>
        <category scheme="informationRecipient" term="PAT"/>
        <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
        <entry xml:lang="en">
                <title>Diabetic diet</title>
                <link href="/diabeticdiet.html" rel="alternate" type="html" hreflang="en"/>
                <id>tag:nlm.nih.gov,2011-15-02:/medlineplus/diabeticdiet.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
                <summary type="html">If you have diabetes, your body cannot make or properly
use insulin.  This leads to high blood glucose, or sugar, levels in your blood. Healthy eating helps
to reduce your blood sugar.  It is a critical part of managing your diabetes, because controlling
your blood sugar can prevent the &lt;
href="http://www.nlm.nih.gov/medlineplus/diabetescomplications.html">complications of diabetes
&lt;/a>.</summary>
        </entry>
</feed>
```

Figure 7 – Fragment of a knowledge response payload instance in which the entire content is written in English.

```
<feed xmlns="http://www.w3.org/2005/Atom"
        xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
        xml:lang="en">
...
        <entry xml:lang="en">
                <title>Diabetic diet</title>
                <link href="/diabeticdiet.html" rel="alternate" type="html" hreflang="en"/>
                <link href="/spanish/diabeticdiet.html" rel="alternate" type="html" hreflang="es"/>
                <id>tag:nlm.nih.gov,2011-15-02:/medlineplus/diabeticdiet.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
```

```
                <summary type="html">If you have diabetes, your body cannot make or properly
use insulin.  This leads to high blood glucose, or sugar, levels in your blood. Healthy eating helps
to reduce your blood sugar.  It is a critical part of managing your diabetes, because controlling
your blood sugar can prevent the &lt;
href="http://www.nlm.nih.gov/medlineplus/diabetescomplications.html">complications of diabetes
&lt;/a>.</summary>
        </entry>
</feed>
```

Figure 8 – Fragment of a knowledge response payload instance in which the content is written in English, but links to source content are provided in both English and Spanish as defined by the *hreflang* attribute set at the level of each *Atom:link*.

```
 <?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
        xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
        xml:lang="en">
        <title type="text">MedlinePlus Connect</title>
        <subtitle type="text">MedlinePlus Connect results for ICD-9-CM 250</subtitle>
        <author>
                <name>U.S. National Library of Medicine</name>
                <uri>http://www.nlm.nih.gov</uri>
        </author>
        <updated>2013-02-20T10:02:53Z</updated>
        <category scheme="mainSearchCriteria.v.c" term="250"/>
        <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.2"/>
        <category scheme="mainSearchCriteria.v.dn" term="Diabetes Mellitus"/>
        <category scheme="informationRecipient" term="PAT"/>
        <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
        <entry xml:lang="en">
                <title>Diabetic diet</title>
                <link href="/diabeticdiet.html" rel="alternate" type="html" hreflang="en"/>
                <id>tag:nlm.nih.gov,2011-15-02:/medlineplus/diabeticdiet.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
                <summary type="html">If you have diabetes, your body cannot make or properly
use insulin.  This leads to high blood glucose, or sugar, levels in your blood.</summary>
        </entry>
        <entry xml:lang="es">
                <title>Dieta para diabéticos</title>
                <link href="/spanish/diabeticfoot.html" rel="alternate" type="html" hreflang="es"/>
                <id>tag:nlm.nih.gov,2011-02-11:/medlineplus/diabeticfoot.html</id>
                <updated>2013-02-20T10:02:53Z</updated>
                <summary>Si tiene diabetes, su cuerpo no puede producir o utilizar la insulina
adecuadamente. Esto conduce a una elevación del nivel de glucose (azúcar) en el
sangre.</summary>
        </entry>
</feed>
```

Figure 9 – Fragment of a knowledge response payload instance that has one entry in English and one entry in Spanish as defined by the *xml:lang* attribute at the level of each *Atom:entry* element.

4.3 Aggregate Knowledge Response Payload

The *Aggregate Knowledge Response* payload is identical to the *Knowledge Response* payload defined in Section 4.2, except for the following:

1. The root element of the knowledge response payload SHALL be called *aggregateKnowledgeResponse*.
2. An *aggregate knowledge response* instance SHALL contain at least one *Atom:feed* element that is a child of the root *aggregateKnowledgeResponse* element. For example, an Infobutton Manager may create a knowledge response with one *Atom:feed* element per knowledge resource.

4.4 JSON and JSON-P representation

As described in Section 3, a *knowledge response* and *aggregate knowledge response* can also be represented in JSON and JSON-P. To simplify implementation, the JSON format for these payloads follows the XML format very closely. The JSON representation is described relative to the XML representation and according to the following general principles.

- The names for the JSON object members are the same as the names of the elements and attributes in the Atom XML format. JSON does not have a notion of attributes versus elements, so attributes are represented as JSON object members. NOTE: Some XML to JSON conversion tools add a prefix to XML attribute names and a #text property for XML elements that may contain text value. In the present specification, prefixes and #text property SHALL NOT be added.
- There are no namespaces in the JSON representation
- Order is not significant in the JSON representation.
- JSON has a notation for arrays, which are used to represent repeating elements even if they do not repeat in the actual instance.

4.4.1 XML element and attributes & JSON objects

The following conformance criteria apply:

1. Atom XML elements SHALL be represented as JSON objects.
2. Atom XML attributes SHALL be represented as properties of JSON objects.
3. The names for the JSON object properties SHALL be the same as the names of the elements and attributes in Atom XML.
4. Atom XML elements with values SHALL be represented as a JSON object with a property named "_value".
5. The value of Atom XML *text type* elements SHALL be represented in JSON as plain text. If the value *type* is HTML or XHTML, the value SHALL be represented in JSON as plain text with escaped JSON (i.e., '<' as \u003c; '>' as \u003e; '=' as \u003d; and double quote character as \"). XHTML content SHALL NOT be represented in JSON as objects.
6. Atom XML elements and attributes that have namespaces (e.g., xml:lang) SHALL NOT have a namespace in JSON.

For example,

```
<entry xml:lang="en"/>
```

is represented in JSON as:

```
{
   "entry": {
      "lang": "en"
   }
}
```

```
<title type="text">MedlinePlus Connect</title>
```

is represented in JSON as:

```
  "title": {
    "type": "text",
    "_value": "MedlinePlus Connect"
  }
```

4.4.2 Repeating elements

The following conformance criteria apply:

1. Repeating elements SHALL be rendered within a JSON array with the name of the element. This applies even when the repeating element has only one instance.

For example, the following fragment:

```
<feed xmlns="http://www.w3.org/2005/Atom"
        xml:base="http://apps.nlm.nih.gov/medlineplus/services/"
        xml:lang="en">
  <title type="text">MedlinePlus Connect</title>
  <subtitle type="text">MedlinePlus Connect results for ICD-9-CM 493.22</subtitle>
  <author>
    <name>U.S. National Library of Medicine</name>
    <uri>http://www.nlm.nih.gov</uri>
  </author>
  <updated>2013-02-20T10:02:53Z</updated>
  <category scheme="mainSearchCriteria.v.c" term="493.22"/>
  <category scheme="mainSearchCriteria.v.cs" term="2.16.840.1.113883.6.103"/>
  <category scheme="mainSearchCriteria.v.dn" term="Chronic obstructive asthma with (acute)
exacerbation"/>
  <category scheme="informationRecipient" term="PAT"/>
        <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
        <entry>...</entry>
        <entry>...</entry>
        <entry>...</entry>
</feed>
```

is represented in JSON as:

```
{
  "lang": "en",
  "title": {
    "type": "text",
    "_value": "MedlinePlus Connect"
  },
  "subtitle": {
    "type": "text",
    "_value": "MedlinePlus Connect results for ICD-9-CM 493.22"
  },
  "author": {
    "name": {
```



```
      "_value": "U.S. National Library of Medicine"
    },
    "uri": {
      "_value": "http://www.nlm.nih.gov"
    }
  },
  "updated": {
    "_value": "2013-02-20T10:02:53Z"
  },
  "category": [
    {
      "scheme": "mainSearchCriteria.v.c",
      "term": "493.22"
    },
    {
      "scheme": "mainSearchCriteria.v.cs",
      "term": "2.16.840.1.113883.6.103"
    },
    {
      "scheme": "mainSearchCriteria.v.dn",
      "term": "Chronic obstructive asthma with (acute) exacerbation"
    },
    {
      "scheme": "informationRecipient",
      "term": "PAT"
    }
  ],
  "id": {
    "_value": "urn:uuid60a76c80-d399-11d9-b93C-0003939e0af6"
  },
  "entry": [
    {...},
    {...},
    {...}
  ]
}
```


5 Examples

The following examples illustrate hypothetical knowledge integration scenarios. Each example contains a narrative description and references to an XML knowledge request payload and an XML knowledge response payload. XML payload instances and XML schemas are available in the zip file that contains this specification.

5.1 Example 1

Knowledge Request: A registered nurse, English speaker, reviewing a problem list of a male, 45 years old patient, who has diabetes mellitus type 2. The nurse wishes to wants retrieve patient-specific education material to be given to the patient.

Knowledge request URL:

```
representedOrganization.id.root=[OID of the organization submitting the
request]&taskContext.c.c=PROBLISTREV&mainSearchCriteria.v.c=E11&mainSea
rchCriteria.v.cs=2.16.840.1.113883.6.90&mainSearchCriteria.v.dn=Type+2+
Diabetes+Mellitus&mainSearchCriteria.v.ot=diabetes+type+2&patientPerson
.administrativeGenderCode.c=M&age.v.v=45&age.v.u=a&informationRecipient
=PAT&performer=PROV&performer.languageCode.c=en&performer.healthCarePro
vider.c.c=163W00000X&knowledgeResponseType=text/XML
```

Knowledge Response (KnowledgeResponsePayload_example1.xml): A knowledge resource (MedlinePlus) specialized in consumer health information retrieves a knowledge response with two potentially relevant entries: “diabetic diet“ and “diabetic foot.“ The overall language of the response is English (see *feed.xml:lang* attribute), which is the language of the knowledge request performer. However, since the knowledge request did not specify the information recipient’s language, each response entry also contains an alternate link to content in Spanish (see *link.hreflang* attributes).

The overall feed is tagged with a category element that conveys “patient education“ content on “Diabetes Mellitus“ (ICD10 code E11). In addition, the diabetic foot entry is tagged with a category element that conveys “Diabetes with peripheral circulatory disorders“ (ICD10 code 250.7).

The *entry.summary* elements provide a short snapshot of the available content for quick preview.

XML Knowledge response:

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
      xml:base="http://www.ncbi.nlm.nih.gov/medlineplus/"
      xml:lang="en">
      <title type="text">MedlinePlus</title>
      <subtitle type="text">Diabetes Mellitus</subtitle>
      <author>
            <name>National Library of Medicine</name>
            <uri>http://medlineplus.gov</uri>
      </author>
      <updated>2010-07-06T14:02:29Z</updated>
      <category scheme="taskContext.c.c" term="PROBLISTREV"/>
      <category scheme="mainSearchCriteria.v.c" term="E11"/>
      <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.90"/>
```



```
      <category scheme="mainSearchCriteria.v.dn" term="Type 2 Diabetes
Mellitus"/>
      <category scheme="mainSearchCriteria.v.ot" term="Diabetes Type
2"/>
      <category scheme="informationRecipient" term="PAT"/>
      <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
      <entry xml:lang="en">
            <title>Diabetic diet</title>
            <link href="/diabeticdiet.html" rel="alternate" type="html"
hreflang="en" title="Diabetic Diet"/>
            <link href="/spanish/diabeticdiet.html" rel="alternate"
type="html" hreflang="es" title="Dieta para diabeticos"/>
            <id>tag:nlm.nih.gov,2011-15-
02:/medlineplus/diabeticdiet.html</id>
            <updated>2011-02-15T00:00:00Z</updated>
            <summary type="html">If you have diabetes, your body cannot
make or properly use insulin.  This leads to high blood glucose, or
sugar, levels in your blood. Healthy eating helps to reduce your blood
sugar.  It is a critical part of managing your diabetes, because
controlling your blood sugar can prevent the &lt;
href="http://www.nlm.nih.gov/medlineplus/diabetescomplications.html">co
mplications of diabetes &lt;/a>.</summary>
            <category scheme="mainSearchCriteria.v.c" term="E11"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.90"/>
            <category scheme="mainSearchCriteria.v.dn" term="Type 2
Diabetes Mellitus"/>
            <category scheme="mainSearchCriteria.v.c" term="D003927"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.177"/>
            <category scheme="mainSearchCriteria.v.dn" term="Diet"/>
            <category scheme="informationRecipient" term="PAT"/>
      </entry>
      <entry xml:lang="es">
            <title>Diabetic foot</title>
            <link href="/diabeticfoot.html" rel="alternate" type="html"
hreflang="en" title="Diabetic Foot"/>
            <link href="/spanish/diabeticfoot.html" rel="alternate"
type="html" hreflang="es" title="Pie diabetico"/>
            <id>tag:nlm.nih.gov,2011-02-
11:/medlineplus/diabeticfoot.html</id>
            <updated>2011-02-11T00:00:00Z</updated>
            <summary>If you have &lt;a
href="http://www.nlm.nih.gov/medlineplus/diabetes.html">diabetes&lt;/a>
, your blood sugar levels are too high.  Over time, this can damage
your nerves or blood vessels.  Nerve damage from diabetes can cause you
to lose feeling in your feet.</summary>
            <category scheme="mainSearchCriteria.v.c" term="E11.621"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.90"/>
            <category scheme="mainSearchCriteria.v.c" term="Type 2
diabetes mellitus with foot ulcer"/>
            <category scheme="informationRecipient" term="PAT"/>
      </entry>
</feed>
```

JSON Knowledge response:


```
{"feed": {
    "xsi": "http://www.w3.org/2001/XMLSchema-instance",
    "base": "http://www.ncbi.nlm.nih.gov/medlineplus/",
    "lang": "en",
    "title": {
        "_value": "MedlinePlus",
        "type": "text"
    },

    "subtitle": {
        "_value": "Diabetes  Mellitus",
        "type": "text"
    },

    "author": {
        "name": {
            "_value": "National Library of Medicine"
        },
        "uri": {
            "_value": "http://medlineplus.gov"
        }
    },
    "updated": {
        "_value": "2010-07-06T14:02:29Z"
    },
    "category": [
        {
            "scheme": "taskContext.c.c",
            "term": "PROBLISTREV"
        },
        {
            "scheme": "mainSearchCriteria.v.c",
            "term": "E11"
        },
        {
            "scheme": "mainSearchCriteria.v.cs",
            "term": "2.16.840.1.113883.6.90"
        },
        {
            "scheme": "mainSearchCriteria.v.dn",
            "term": "Type  2  Diabetes  Mellitus"
        },
        {
            "scheme": "mainSearchCriteria.v.ot",
            "term": "Diabetes  Type  2"
        },
        {
            "scheme": "informationRecipient",
            "term": "PAT"
        }
    ],
    "id": {
        "_value": "urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6"
    },
    "entry": [
```



```
        {
            "lang": "en"
            "summary": {
                "_value": "If you have diabetes, your body cannot
make or properly use insulin.    This leads to high blood
glucose, or sugar, levels in your blood. Healthy eating helps
to reduce your blood sugar.    It is a critical part of
managing your diabetes, because controlling your blood sugar
can prevent the <
href=\"http://www.nlm.nih.gov/medlineplus/diabetescomplications.html\">
complications of diabetes <\/a>.",
                "type": "html"
            },
            "id": "tag:nlm.nih.gov,2011-15-
02:/medlineplus/diabeticdiet.html",
            "category": [
                {
                    "scheme": "mainSearchCriteria.v.c",
                    "term": "E11"
                },
                {
                    "scheme": "mainSearchCriteria.v.cs",
                    "term": "2.16.840.1.113883.6.90"
                },
                {
                    "scheme": "mainSearchCriteria.v.dn",
                    "term": "Type 2 Diabetes Mellitus"
                },
                {
                    "scheme": "mainSearchCriteria.v.c",
                    "term": "D003927"
                },
                {
                    "scheme": "mainSearchCriteria.v.cs",
                    "term": "2.16.840.1.113883.6.177"
                },
                {
                    "scheme": "mainSearchCriteria.v.dn",
                    "term": "Diet"
                },
                {
                    "scheme": "informationRecipient",
                    "term": "PAT"
                }
            ],
    "entry": [
        {
            "lang": "en",
            "title": {
                "_value": "Diabetic diet",
                "type": "text"
            },
            "link": [
                {
                    "hreflang": "en",
                    "title": "Diabetic Diet",
                    "rel": "alternate",
```



```
                    "type": "html",
                    "href": "/diabeticdiet.html"
                },
                {
                    "hreflang": "es",
                    "title": "Dieta para diabeticos",
                    "rel": "alternate",
                    "type": "html",
                    "href": "/spanish/diabeticdiet.html"
                }
            ],
            "id": {
                "_value": "tag:nlm.nih.gov,2011-15-
02:/medlineplus/diabeticdiet.html"
            },
            "updated": {
                "_value": "2011-02-15T00:00:00Z"
            },
            "summary": {
                "_value": "If you have diabetes, your body cannot make
or properly use insulin.  This leads to high blood glucose, or sugar,
levels in your blood.  Healthy eating helps to reduce your blood sugar.
It is a critical part of managing your diabetes, because controlling
your blood sugar can prevent the \u003ca
href\u003d\"http://www.nlm.nih.gov/medlineplus/diabetescomplications.ht
ml\"\u003ecomplications of diabetes\u003c/a\u003e.",
                "type": "html"
            },
            "category": [
                {
                    "scheme": "mainSearchCriteria.v.c",
                    "term": "E11"
                },
                {
                    "scheme": "mainSearchCriteria.v.cs",
                    "term": "2.16.840.1.113883.6.90"
                },
                {
                    "scheme": "mainSearchCriteria.v.dn",
                    "term": "Type  2  Diabetes  Mellitus"
                },
                {
                    "scheme": "mainSearchCriteria.v.c",
                    "term": "D003927"
                },
                {
                    "scheme": "mainSearchCriteria.v.cs",
                    "term": "2.16.840.1.113883.6.177"
                },
                {
                    "scheme": "mainSearchCriteria.v.dn",
                    "term": "Diet"
                },
                {
                    "scheme": "informationRecipient",
                    "term": "PAT"
                }
```



```
            ]
        },
        {
            "lang": "es",
            "title": {
                "_value": "Diabetic foot",
                "type": "text"
            },
            "link": [
                {
                    "hreflang": "en",
                    "title": "Diabetic Foot",
                    "rel": "alternate",
                    "type": "html",
                    "href": "/diabeticfoot.html"
                },
                {
                    "hreflang": "es",
                    "title": "Pie diabetico",
                    "rel": "alternate",
                    "type": "html",
                    "href": "/spanish/diabeticfoot.html"
                }
            ],
            "id": {
                "_value": "tag:nlm.nih.gov,2011-02-
11:/medlineplus/diabeticfoot.html"
            },
            "updated": {
                "_value": "2011-02-11T00:00:00Z"
            },
            "summary": {
                "_value": "If you have \u003ca
href\u003d\"http://www.nlm.nih.gov/medlineplus/diabetes.html\"\u003edia
betes\u003c/a\u003e, your blood sugar levels are too high.  Over time,
this can damage your nerves or blood vessels.  Nerve damage from
diabetes can cause you to lose feeling in your feet.",
                "type": "html"
            },
            "category": [
                {
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                    "term": "E11.621"
                },
                {
                    "scheme": "mainSearchCriteria.v.cs",
                    "term": "2.16.840.1.113883.6.90"
                },
                {
                    "scheme": "mainSearchCriteria.v.c",
                    "term": "Type  2  diabetes  mellitus  with  foot
ulcer"
                },
                {
                    "scheme": "informationRecipient",
                    "term": "PAT"
                }
```



```
            ]
        }
    ]
}}
```

5.2 Example 2

Knowledge Request: A provider reviewing a problem list of a female, 67 years-old patient, with "bacterial pneumonia." The provider wishes to retrieve clinical knowledge content on the "treatment of bacterial pneumonia."

Knowledge request URL:

```
taskContext.c.c=PROBLISTREV&performer=PROV&informationRecipient=PROV&ma
inSearchCriteria.v.c=53084003&mainSearchCriteria.v.cs=2.16.840.1.113883
.6.96&mainSearchCriteria.v.dn=Bacterial+Pneumonia&subtopic.v.c=Q000628&
subtopic.v.cs=2.16.840.1.113883.6.177&subtopic.v.dn= Treatment&
knowledgeResponseType=text/XML
```

Knowledge Response (KnowledgeResponsePayload_example2.xml): A knowledge resource (PubMed) retrieves a knowledge response with three potentially relevant entries that represent article abstracts indexed in PubMed.

The overall language of the response is English (see *feed.xml:lang* attribute) since PubMed only supports English abstracts. Each entry contains the article abstract (*entry.summary* element), a *link* to the abstract in PubMed, and possibly an *alternative link* to the full-text article. Since PubMed indexes English abstracts of full-text articles that are written in other languages, each alternative *entry.link* element has an *hreflang* attribute that specifies the language of the full-text article (e.g., entry #3 contains a link to a full-text article in Chinese).

The overall feed is tagged with a category element that conveys "treatment (MeSH code Q000628) of bacterial pneumonia (SNOMED-CT code 53084003) in people 65 years old or above (Aged, MeSH code D000368)". Each entry is also tagged with a category that indicates a more specific subject of the article in addition to bacterial pneumonia (e.g., Methicillin-Resistant Staphylococcus aureus).

XML Knowledge response:

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
      xml:base="http://www.ncbi.nlm.nih.gov/medlineplus/"
      xml:lang="en">
      <title type="text">PubMed - Clinical Queries</title>
      <subtitle type="text">Bacterial Pneumonia</subtitle>
      <author>
            <name>National Library of Medicine</name>
            <uri>http://http://www.ncbi.nlm.nih.gov/pubmed/</uri>
      </author>
      <updated>2010-07-13T14:02:29Z</updated>
      <!-- The feed covers the subject "bacterial pneumonia", subtopic
"treatment", in people in the "aged" age group (65 years old and
above)-->
      <category scheme="mainSearchCriteria.v.c" term="53084003"/>
      <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.96"/>
```



```
      <category scheme="mainSearchCriteria.v.c" term="Bacterial
Pneumonia"/>
      <category scheme="ageGroup.v.c" term="D000368"/>
      <category scheme="ageGroup.v.cs" term="2.16.840.1.113883.6.177"/>
      <category scheme="ageGroup.v.dn" term="Aged"/>
      <category scheme="subTopic.v.c" term="Q000628"/>
      <category scheme="subTopic.v.cs" term="2.16.840.1.113883.6.177"/>
      <category scheme="subTopic.v.dn" term="therapy"/>
      <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af6</id>
      <!-- The entry covers the subject "treatment of bacterial
pneumonia", more specifically "Methicillin-Resistant Staphylococcus
aureus" -->
      <entry xml:lang="en">
            <title>Effect of vancomycin plus rifampicin in the
treatment of nosocomial methicillin-resistant Staphylococcus aureus
pneumonia</title>
            <link href="20050336" rel="alternate" type="html"
hreflang="en" title="Effect of vancomycin plus rifampicin in the
treatment of nosocomial methicillin-resistant Staphylococcus aureus
pneumonia"/>
            <id>tag:nlm.nih.gov,2010-05-01:20050336</id>
            <updated>2010-05-01T00:00:00Z</updated>
            <summary type="text">OBJECTIVE: To investigate whether
adding rifampicin to vancomycin could cure more patients with
nosocomial methicillin-resistant Staphylococcus aureus pneumonia
compared with vancomycin-only. DESIGN: Prospective randomized open-
label study. Setting: Medical intensive care unit in Seoul, Korea.
Patients: Ninety-three of 183 patients with Gram-positive nosocomial
pneumonia. Interventions: The enrolled patients with subsequently
documented methicillin-resistant Staphylococcus aureus pneumonia
(modified intention-to-treat population) were treated with vancomycin
(1 g intravenous every 12 hrs) plus rifampicin (300 mg twice daily by
mouth) (n = 41) or with vancomycin-only (n = 42). The intended
treatment (at least 5 days) was completed in 30 patients in the
vancomycin plus rifampicin group and 34 patients in the vancomycin-only
group (per protocol population). MEASUREMENTS AND MAIN RESULTS: The
primary outcome was the clinical cure rate on day 14 of treatment. The
secondary outcomes were intensive care unit mortality on days 28 and
60, and microbiological eradication on day 14. The clinical cure rate
in the modified intention-to-treat population was 53.7% (22 of 41) in
the vancomycin plus rifampicin group, and 31.0% (13 of 42) in the
vancomycin-only group (p = .047), and the respective rates in the per
protocol population were 63.3% (19 of 30) and 38.2% (13 of 34) (p =
.079). The respective mortality rates were nine (22.0%) of 41 and 16
(38.1%) of 42 on day 28 (p = .151), and 11 (26.8%) of 41 and 21 (50.0%)
of 42 on day 60 (p = .042). The microbiological eradication rate did
not differ between groups (p = .472). CONCLUSIONS: Vancomycin plus
rifampicin seems to be more effective than vancomycin alone in the
treatment of nosocomial methicillin-resistant Staphylococcus aureus
pneumonia.</summary>
            <category scheme="mainSearchCriteria.v.c"
term="266096002"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.96"/>
            <category scheme="mainSearchCriteria.v.dn"
term="Methicillin resistant Staphylococcus aureus infection"/>
            <category scheme="relevanceScore" term="0.5"/>
```

```
            <category scheme="strengthOfRecommedation" term="2A"/>
      </entry>
      <!-- This entry has a link to the source (article abstract in
PubMed in English) as well as two alternate links to the full-text
article at PubMed Central and BioMed Central) -->
      <!-- The entry covers the subject "treatment of bacterial
pneumonia", more specifically "Levofloxacin" in the treatment of
pneumonia-->
      <entry xml:lang="en">
            <title>Efficacy and safety of tigecycline versus
levofloxacin for community-acquired pneumonia.</title>
            <link href="19740418" rel="alternate" type="html"
hreflang="en" title="Efficacy and safety of tigecycline versus
levofloxacin for community-acquired pneumonia"/>
            <link
href="http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&a
mp;pubmedid=19740418" rel="alternate" type="html" hreflang="en"
title="Full-text in PubMed Central"/>
            <link href="http://www.biomedcentral.com/1471-2466/9/44"
rel="alternate" type="html" hreflang="en" title="Full-text in BioMed
Central"/>
            <id>tag:nlm.nih.gov,2009-09-01:19740418</id>
            <updated>2009-09-01T00:00:00Z</updated>
            <summary type="text">BACKGROUND: Tigecycline, an expanded
broad-spectrum glycylcycline, exhibits in vitro activity against many
common pathogens associated with community-acquired pneumonia (CAP), as
well as penetration into lung tissues that suggests effectiveness in
hospitalized CAP patients. The aim of the present study was to compare
the efficacy and safety of intravenous (IV) tigecycline with IV
levofloxacin in hospitalized adults with CAP. METHODS: In this
prospective, double-blind, non-inferiority phase 3 trial, eligible
patients with a clinical diagnosis of CAP supported by radiographic
evidence were stratified by Fine Pneumonia Severity Index and
randomized to tigecycline or levofloxacin for 7-14 days of therapy. Co-
primary efficacy endpoints were clinical response in the clinically
evaluable (CE) and clinical modified intent-to-treat (c-mITT)
populations at test-of-cure (Day 10-21 post-therapy). RESULTS: Of the
428 patients who received at least one dose of study drug, 79% had CAP
of mild-moderate severity according to their Fine score. Clinical cure
rates for the CE population were 88.9% for tigecycline and 85.3% for
levofloxacin. Corresponding c-mITT population rates were 83.7% and
81.5%, respectively. Eradication rates for Streptococcus pneumoniae
were 92% for tigecycline and 89% for levofloxacin. Nausea, vomiting,
and diarrhoea were the most frequently reported adverse events. Rates
of premature discontinuation of study drug or study withdrawal because
of any adverse event were similar for both study drugs. CONCLUSION:
These findings suggest that IV tigecycline is non-inferior to IV
levofloxacin and is generally well-tolerated in the treatment of
hospitalized adults with CAP. TRIAL REGISTRATION:
NCT00081575.</summary>
            <category scheme="mainSearchCriteria.v.c"
term="387552007"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.96"/>
            <category scheme="mainSearchCriteria.v.dn"
term="Levofloxacin"/>
            <category scheme="relevanceScore" term="0.5"/>
```



```
            <category scheme="strengthOfRecommedation" term="2B"/>
      </entry>
      <!-- This entry has a link to the source (article abstract in
PubMed in English) as well as an alternate link to the full-text
article at the publisher's Web site in Chinese) -->
      <!-- The entry covers the subject "treatment of bacterial
pneumonia", more specifically "Community-Acquired Infections"-->
      <entry xml:lang="en">
            <title>The value of serum procalcitonin in treatment of
community acquired pneumonia in outpatient.</title>
            <link href="19576090" rel="alternate" type="html"
hreflang="en" title="The value of serum procalcitonin in treatment of
community acquired pneumonia in outpatient"/>
            <link href="http://open.oriprobe.com/order.htm?id=15286572"
rel="alternate" type="html" hreflang="zh" title="Full-text in Zhonghua
Nei Ke Za Zhi [Chinese journal of internal medicine]"/>
            <id>tag:nlm.nih.gov,2009-03-01:19576090</id>
            <updated>2009-03-01T00:00:00Z</updated>
            <summary type="text">OBJECTIVE: To evaluate the value of
serum procalcitonin (PCT) on antibiotic use in treatment of community
acquired pneumonia (CAP) in outpatient. METHODS: From November 2006 to
February 2008, a total of 127 patients with CAP in outpatient were
randomly assigned into two groups: PCT group (n = 63) and control group
(n = 64). PCT levels of all patients were measured after study
admission. On the base of similarly normal treatment, the control group
received antibiotics according to the attending physicians and the PCT
group were treated with antibiotics according to serum PCT levels:
antibiotic treatment was applied with PCT level > or = 0.25 microg/L
and was discouraged with PCT level &lt; 0.25 microg/L. Clinical
efficacy, rate of antibiotics use, duration courses and costs of
antibiotics were observed. RESULTS: Clinical efficacy of the PCT group
was similar with the control group (92.1% vs 87.5%, P > 0.05); rate and
costs of antibiotics use was lower, antibiotic duration of the PCT
group was shorter than that of the control group (P &lt; 0.05, P &lt;
0.001, P &lt; 0.001). CONCLUSION: PCT could be used in treatment of CAP
for antibiotic use in outpatient, which may reduce antibiotic use,
shorten antibiotic duration and lower costs of antibiotic.
            </summary>
            <category scheme="mainSearchCriteria.v.c"
term="385093006"/>
            <category scheme="mainSearchCriteria.v.cs"
term="2.16.840.1.113883.6.177"/>
            <category scheme="mainSearchCriteria.v.dn" term="Community
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            <category scheme="relevanceScore" term="0.5"/>
      </entry>
</feed>
```

JSON Knowledge response:

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```
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  "subtitle": {
    "_value": "Bacterial Pneumonia",
    "type": "text"
  },

  "author": {
    "name": {
      "_value": "National Library of Medicine"
    },
    "uri": {
      "_value": " http://http://www.ncbi.nlm.nih.gov/pubmed/"
    }
  },
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    {
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    {
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      "term": "Bacterial Pneumonia"
    },
    {
      "scheme": "ageGroup.v.c",
      "term": "D000368"
    },
    {
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      "term": "2.16.840.1.113883.6.177"
    },
    {
      "scheme": "ageGroup.v.dn",
      "term": "Aged"
    },
    {
      "scheme": "subTopic.v.c",
      "term": "Q000628"
    },
    {
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      "term": "2.16.840.1.113883.6.177"
    },
    {
      "scheme": "subTopic.v.dn",
      "term": "therapy"
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  ],
  "id": {
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  },

  "entry": [
    {
      "summary": {
        "_value": "OBJECTIVE: To investigate whether adding rifampicin
to vancomycin could cure more patients with nosocomial methicillin-
resistant Staphylococcus aureus pneumonia compared with vancomycin-
only. DESIGN: Prospective randomized open-label study. Setting: Medical
intensive care unit in Seoul, Korea. Patients: Ninety-three of 183
patients with Gram-positive nosocomial pneumonia. Interventions: The
enrolled patients with subsequently documented methicillin-resistant
Staphylococcus aureus pneumonia (modified intention-to-treat
population) were treated with vancomycin (1 g intravenous every 12 hrs)
plus rifampicin (300 mg twice daily by mouth) (n \u003d 41) or with
vancomycin-only (n \u003d 42). The intended treatment (at least 5 days)
was completed in 30 patients in the vancomycin plus rifampicin group
and 34 patients in the vancomycin-only group (per protocol population).
MEASUREMENTS AND MAIN RESULTS: The primary outcome was the clinical
cure rate on day 14 of treatment. The secondary outcomes were intensive
care unit mortality on days 28 and 60, and microbiological eradication
on day 14. The clinical cure rate in the modified intention-to-treat
population was 53.7% (22 of 41) in the vancomycin plus rifampicin
group, and 31.0% (13 of 42) in the vancomycin-only group (p \u003d .047),
and the respective rates in the per protocol population were 63.3% (19
of 30) and 38.2% (13 of 34) (p \u003d .079). The respective mortality
rates were nine (22.0%) of 41 and 16 (38.1%) of 42 on day 28 (p \u003d
.151), and 11 (26.8%) of 41 and 21 (50.0%) of 42 on day 60 (p \u003d
.042). The microbiological eradication rate did not differ between
groups (p \u003d .472). CONCLUSIONS: Vancomycin plus rifampicin seems to
be more effective than vancomycin alone in the treatment of nosocomial
methicillin-resistant Staphylococcus aureus pneumonia.",
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        },
        {
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infection"
        },
        {
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```



```
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treatment of nosocomial methicillin-resistant Staphylococcus aureus
pneumonia",
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      "summary": {
        "_value": "BACKGROUND: Tigecycline, an expanded broad-spectrum
glycylcycline, exhibits in vitro activity against many common pathogens
associated with community-acquired pneumonia (CAP), as well as
penetration into lung tissues that suggests effectiveness in
hospitalized CAP patients. The aim of the present study was to compare
the efficacy and safety of intravenous (IV) tigecycline with IV
levofloxacin in hospitalized adults with CAP. METHODS: In this
prospective, double-blind, non-inferiority phase 3 trial, eligible
patients with a clinical diagnosis of CAP supported by radiographic
evidence were stratified by Fine Pneumonia Severity Index and
randomized to tigecycline or levofloxacin for 7-14 days of therapy. Co-
primary efficacy endpoints were clinical response in the clinically
evaluable (CE) and clinical modified intent-to-treat (c-mITT)
populations at test-of-cure (Day 10-21 post-therapy). RESULTS: Of the
428 patients who received at least one dose of study drug, 79% had CAP
of mild-moderate severity according to their Fine score. Clinical cure
rates for the CE population were 88.9% for tigecycline and 85.3% for
levofloxacin. Corresponding c-mITT population rates were 83.7% and
81.5%, respectively. Eradication rates for Streptococcus pneumoniae
were 92% for tigecycline and 89% for levofloxacin. Nausea, vomiting,
and diarrhoea were the most frequently reported adverse events. Rates
of premature discontinuation of study drug or study withdrawal because
of any adverse event were similar for both study drugs. CONCLUSION:
These findings suggest that IV tigecycline is non-inferior to IV
levofloxacin and is generally well-tolerated in the treatment of
hospitalized adults with CAP. TRIAL REGISTRATION: NCT00081575.",
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          "term": "2.16.840.1.113883.6.96"
        },
        {
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          "term": "Levofloxacin"
        },
        {
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          "term": 0.5
        },
        {
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      ],
      "title": {
        "_value": "Efficacy and safety of tigecycline versus
levofloxacin for community-acquired pneumonia.",
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levofloxacin for community-acquired pneumonia",
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          "type": "html",
          "href":
"http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmed
id=19740418"
        },
        {
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          "title": "Full-text in BioMed Central",
          "rel": "alternate",
          "type": "html",
          "href": "http://www.biomedcentral.com/1471-2466/9/44"
        }
      ],
```



```
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    },
    {
      "summary": {
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procalcitonin (PCT) on antibiotic use in treatment of community
acquired pneumonia (CAP) in outpatient. METHODS: From November 2006 to
February 2008, a total of 127 patients with CAP in outpatient were
randomly assigned into two groups: PCT group (n \u003d 63) and control
group (n \u003d 64). PCT levels of all patients were measured after study
admission. On the base of similarly normal treatment, the control group
received antibiotics according to the attending physicians and the PCT
group were treated with antibiotics according to serum PCT levels:
antibiotic treatment was applied with PCT level \u003e or \u003d 0.25
microg/L and was discouraged with PCT level \u003c 0.25 microg/L.
Clinical efficacy, rate of antibiotics use, duration courses and costs
of antibiotics were observed. RESULTS: Clinical efficacy of the PCT
group was similar with the control group (92.1% vs 87.5%, P \u003e 0.05);
rate and costs of antibiotics use was lower, antibiotic duration of the
PCT group was shorter than that of the control group (P \u003c 0.05, P
\u003c 0.001, P \u003c 0.001). CONCLUSION: PCT could be used in treatment
of CAP for antibiotic use in outpatient, which may reduce antibiotic
use, shorten antibiotic duration and lower costs of antibiotic.",
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        },
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          "scheme": "relevanceScore",
          "term": 0.5
        }
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community acquired pneumonia in outpatient.",
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      },
      "updated": {
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community acquired pneumonia in outpatient",
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        },
        {
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          "title": "Full-text in Zhonghua Nei Ke Za Zhi [Chinese
journal of internal medicine]",
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        }
      ],
      "lang": "en"
    }
  ],
}}
```


6 References

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2. Cimino JJ, Li J, Bakken S, Patel VL. Theoretical, empirical and practical approaches to resolving the unmet information needs of clinical information system users. Proc AMIA Symp. 2002:170-4.
3. HL7 Context-Aware Knowledge Retrieval ("Infobutton"), Knowledge Request Standard. Health Level Seven International. May, 2010. Available at http://www.hl7.org/v3ballot2010may/html/domains/uvds/uvds_Context-awareKnowledgeRetrieval%28Infobutton%29.htm. Retrieved on July 12th, 2010.
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6. RSS 2.0 Specification. Berkman Center for Internet & Society at Harvard Law School. Available at http://cyber.law.harvard.edu/rss/rss.html. Retrieved on July 12th, 2010.
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