RxNav, the RxNorm API and RxMix

Browsing and enabling complex queries to drug information sources

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Acknowledgments

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◆ Former collaborators
  ● Kelly Zeng
  ● Ramez Ghazzaoui
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  ● Jonathan Mortensen

◆ RxNorm
  ● John Kilbourne
Outline

◆ RxNorm
  ● Drug vocabulary integration
  ● Drug vocabulary normalization

◆ Visualizing drug information: RxNav

◆ Processing drug information: RxNorm API

◆ Integrating drug information sources
  ● Sister APIs (RxTerms, NDF-RT, RxImageAccess)

◆ Enabling complex queries: RxMix

◆ Usage and applications
RxNorm

Overview
UMLS-like approach

- 12 source vocabularies
- Synonymous names grouped into an RxNorm concept
- Unique identifiers (RxCUI)
- RRF format

Differences

- RxNorm creates its own names
- Principled use of names relationships
- Limited scope: drug names
- Monthly updates (and weekly additions)
Source vocabularies in RxNorm

<table>
<thead>
<tr>
<th>Source Vocabulary</th>
<th>Terms in Thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomical Therapeutic Chemical Classification</td>
<td>6</td>
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<td>Gold Standard Drug Database</td>
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<td>Medi-Span Master Drug Data Base</td>
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<td>Multum MediSource Lexicon</td>
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<td>FDA National Drug Code Directory</td>
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<td>FDA Structured Product Labels</td>
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<td>First DataBank MedKnowledge</td>
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</tr>
<tr>
<td>VHA National Drug File - NDF-RT</td>
<td>147 (starred)</td>
</tr>
<tr>
<td>US Edition of SNOMED CT (drugs)</td>
<td>88</td>
</tr>
<tr>
<td>VHA National Drug File</td>
<td>52</td>
</tr>
</tbody>
</table>

(terms in thousands, as of Sept. 2013)
Normalization  Lexical level

- GS  Digoxin 0.25mg/1mL Solution for injection
- GS  Digoxin 500mcg/2mL Solution for injection
- MDDB  'Digoxin Inj 0.25 MG/ML
- MMSL  digoxin 250 mcg/mL (0.25 mg/mL) injectable solution
- MMSL  Digoxin, 250 mcg/mL (0.25 mg/mL) injectable solution
- MMX  Digoxin 0.25 MG/ML Injection Solution
- MTHFDA  DIGOXIN 0.25 MG INTRAMUSCULAR INJECTION, SOLUTION
- MTHFDA  DIGOXIN 250 MCG INTRAMUSCULAR INJECTION
- MTHFDA  DIGOXIN 250 MCG INTRAVENOUS INJECTION
- MTHSPL  digoxin 0.25 MILLIGRAM In 1.0 MILLILITER INTRAVENOUS INJECTION
- MTHSPL  Digoxin 250 MICROGRAM In 1 MILLILITER INTRAVENOUS INJECTION, SOLUTION
- NDDF  DIGOXIN 250 mcg/mL INJECTION AMPUL (ML)
- NDDF  DIGOXIN 250 mcg/mL INJECTION DISPOSABLE SYRINGE (ML)
- NDDF  DIGOXIN@250 mcg/mL@INJECTION@AMPUL (ML)
- SNOMEDCT  Digoxin 250 micrograms/mL injection solution 2mL ampule
- SNOMEDCT  Digoxin 500 micrograms/2mL injection
- VANDF  DIGOXIN 0.25MG/ML INJ
- [...]  [...]
Normalization  Structural level

◆ Structural level
  ● Atomic elements
    ■ Ingredient (fluoxetine)
    ■ Strength (10 MG)
    ■ Dose form (oral tablet)
  ● Generic vs. Brand names (fluoxetine vs. Prozac)
  ● Principle set of relationships among the different types
Drug entities in RxNorm

◆ Content

- 11,434 ingredients (P/IN)
- 7,000 brand names
- 20,100 clinical drugs
- 11,080 branded drugs
- 16,661 clinical drug comp.
- 10,458 branded drug comp.
- 8,735 clinical drug forms
- 8,214 branded drug forms
- 337 generic packs
- 413 branded packs
- 104 dose forms

◆ 120,115 drug entities overall

(active concepts, as of Sept. 2013)
Visualizing drug information

RxNav
RxNav

- **Visualization and navigation**
  - **RxNorm browser**
    - Search on names and codes (including proprietary)
      - Auto-completion and spelling correction
    - Display all non-proprietary information
      - Graph
      - Tabular format
    - Integrate information beyond RxNorm
      - RxTerms, NDF-RT, Pill images, MeSH and ATC classes
      - Link out to DailyMed, MedlinePlus, NLM Drug Info. Portal
  - **Standalone online application**
    - Latest RxNorm database at NLM
    - Leverages the RxNorm API
  - **First release: September 2004**
RxNav demo

http://rxnav.nlm.nih.gov/
RxNav

Launch RxNav

Content:
- Overview
- Starting RxNav
- Using RxNav
- RxNav Views
- RxNav new features [updated 8/05/2013]

Overview

RxNav is a browser for several drug information sources, including RxNorm, RxTerms and NDF-RT. RxNav finds drugs in RxNorm from the names and codes in its constituent vocabularies. RxNav displays links from clinical drugs, both branded and generic, to their active ingredients, drug components and related brand names. RxNav also provides lists of NDC codes and links to package inserts in DailyMed. The RxTerms record for a given drug can be accessed through RxNav, as well as clinical information from NDF-RT, including pharmacologic classes, mechanisms of action, physiologic effects and drug-drug interactions.

Starting RxNav

To start RxNav, click on "Launch RxNav" if the link is present; Otherwise, click on "Download and install the lastest JRE and RxNav". You will arrive at the Sun download homepage, browse to find the JRE download link, and install it. Then return to this RxNav home page, where the link now should read "Launch RxNav" and RxNav installation will be automatically launched. During installation, you can elect to have the shortcut on your desktop.

For Firefox users, open with Java Web Start Launcher.

RxNav code is digitally signed. You need to accept its security certificate to launch the browser.

RxNav uses Java Web Start Technology and requires JRE 1.6 or higher.

Using RxNav

Searching RxNav
### RxNorm Properties

**RxCUI**: 313990

<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAMES</td>
<td>RxNorm Name</td>
<td>Fluoxetine 10 MG Oral Tablet</td>
</tr>
<tr>
<td></td>
<td>RxNorm Synonym</td>
<td>fluoxetine 10 MG (as fluoxetine hydrochloride 11.2 MG) Oral Tablet</td>
</tr>
<tr>
<td>CODES</td>
<td>RxCUI</td>
<td>313990</td>
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<td>UMLSCUI</td>
<td>C0981444</td>
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<td>ANDA</td>
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<td>SCD</td>
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<tr>
<td></td>
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</table>

For more information about RxNorm, please visit [RxNorm](https://www.nlm.nih.gov/research/umls/rxnorm/).
National Drug Codes
RxCUI = 313990

# of NDCs: 41

<table>
<thead>
<tr>
<th>NDC</th>
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<tr>
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<td>00093718856</td>
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<tr>
<td>00172451070</td>
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<td>35386064930</td>
</tr>
<tr>
<td>42291027890</td>
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<tr>
<td>45865037851</td>
</tr>
<tr>
<td>45865037860</td>
</tr>
<tr>
<td>45865037890</td>
</tr>
<tr>
<td>49884073401</td>
</tr>
<tr>
<td>49884073410</td>
</tr>
</tbody>
</table>
DailyMed provides high quality information about marketed drugs. Drug labeling on this Web site is the most recent submitted to the Food and Drug Administration (FDA) and currently in use; it may include, for example, strengthened warnings undergoing FDA review or minor editorial changes. These labels have been reformatted to make them easier to read.

At the present time this Web site does not contain a complete listing of labels for approved prescription drugs. Currently this Web site contains 64420 drugs.

Search results for

Fluoxetine 10 MG Oral Tablet

Total Results Found: [Count:20]

FLUOXETINE (fluoxetine hydrochloride) tablet
[Dr. Reddy’s Laboratories Limited]

FLUOXETINE (fluoxetine hydrochloride) tablet
[Dr. Reddy’s Laboratories Limited]

FLUOXETINE (fluoxetine hydrochloride) tablet, film coated
[Teva Pharmaceuticals USA Inc]

FLUOXETINE (fluoxetine hydrochloride) tablet, film coated
[Teva Pharmaceuticals USA Inc]

FLUOXETINE HYDROCHLORIDE (fluoxetine hydrochloride) tablet, film coated
[AvKARE, Inc.]
Fluoxetine
(floo ox’ e teen)

Why is this medication prescribed?
How should this medicine be used?
Other uses for this medicine
What special precautions should I follow?
What should I do if I forget a dose?
What side effects can this medication cause?

A small number of children, teenagers, and young adults (up to 24 years of age) who took antidepressants (‘mood elevators’) such as fluoxetine during clinical studies became suicidal (thinking about harming or killing oneself or planning or trying to do so). Children, teenagers, and young adults who take antidepressants to treat depression or other mental illnesses may be more likely to become suicidal than children, teenagers, and young adults who do not take antidepressants to treat these conditions. However, experts are not sure about how great this risk is and how much it should be considered in deciding whether a child or teenager should take an antidepressant.

You should know that your mental health may change in unexpected ways when you take fluoxetine or other antidepressants even if you are an adult over 24 years of age. You may become suicidal, especially at the beginning of your treatment and any time that your dose is increased or decreased. You, your family, or your caregiver should call your doctor right away if you experience any of the following symptoms: new or worsening depression; thinking about harming or killing yourself, or planning or trying to do so; extreme worry; agitation; panic attacks; difficulty falling asleep or staying asleep; aggressive behavior; irritability; acting without thinking; severe restlessness; and frenzied abnormal excitement. Be sure that your family or caregiver knows which symptoms may be serious so they can call the doctor if you are unable to seek treatment on your own.

Your healthcare provider will want to see you often while you are taking fluoxetine, especially at the beginning of your treatment. Be sure to keep all appointments for office visits with your doctor.

The doctor or pharmacist will give you the manufacturer’s patient information sheet (Medication Guide) when you begin treatment with fluoxetine. Read the information carefully and ask your doctor or pharmacist if you have any questions. You also can obtain the Medication Guide from the FDA website: http://www.fda.gov/Drugs/DrugSafety/InformationbyDrugClass/UCM396273

IMPORTANT WARNING:

What should I know about storage and disposal of this medication?
In case of emergency/overdose
What other information should I know?
Brand names
Brand names of combination products
No exact matches were found for this search
Record(s) were found for: FLUOXETINE

**Search Results**

**Drug Name:** Fluoxetine [USAN:INN:BAN]  [show more names]  [show structure]

**Search Term:** FLUOXETINE 10 MG ORAL TABLET

**Description:** The first highly specific serotonin uptake inhibitor. It is used as an antidepressant and often has a more acceptable side-effects profile than traditional antidepressants.

**Categories:**  Antidepressive Agents  [show more categories]

---

**Summary**

- Summary of drug information (MedlinePlusDrug)
- Summary of consumer health information (MedlinePlusTopics)
- Summary of the effect on breastfeeding (LactMed)
- Summary of Drug-Induced Liver Injury (LiverTox)
- Manufacturers drug label (DailyMed)
- Clinical trials (ClinicalTrials.gov)
- Drug Identification and Image Display (Pillbox beta)

**Detailed Summary**

- Summary of reviewed biological and physical data (HSDB)
- References from scientific journals (Medline/PubMed)
- References from toxicological journals (TOXLINE)
- Biological activities and chemical structures (PubChem)
- Toxicological and chemical resources (ChemIDplus)

**Additional Resources**

- Information from the US Food & Drug Administration (Drugs@FDA)
- Search engine for other government resources (USA.gov)
Fluoxetine 10 MG Oral Tablet
RxCUI = 313900
Images and Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Image 1</th>
<th>Image 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td>![Image 1](G FL10.png)</td>
<td>![Image 2](9 3 7188.png)</td>
</tr>
<tr>
<td>Acq Date</td>
<td>02-09-2011</td>
<td>01-10-2013</td>
</tr>
<tr>
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<td>Teva Pharmaceuticals USA Inc</td>
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<tr>
<td>SpiSetId</td>
<td>Link to DailyMed</td>
<td>Link to DailyMed</td>
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<tr>
<td>NDC</td>
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<tr>
<td>Shape</td>
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<td>N/A</td>
</tr>
</tbody>
</table>

For more information about Pill images, please visit Pill Image Website and DISCLAIMER.
ATC Classes - fluoxetine

NERVOUS SYSTEM

PSYCHOANALEPTICS

ANTIDEPRESSANTS

Selective serotonin reuptake inhibitors

fluoxetine

Legend

DRUG isa ATC CLASS isa ATC CLASS
Processing drug information

RxNorm Application Programming Interface (API)
RxNorm API

- Made available in March 2008
- Based on Web Services
  - SOAP, REST (XML, JSON)
  - Independent of any programming language
- Used by RxNav and other applications
- Enable access to all information displayed in RxNav
- Documentation
  - http://rxnav.nlm.nih.gov/RxNormAPIs.html#
Main API functions

- **Map drug codes and names to RxNorm**
  - Including proprietary names and codes
  - Spelling correction
  - Various types of matching tailored to drugs
    - Exact, normalized, approximate

- **Get RxNorm information**
  - Properties (synonyms, NDCs, attributes, sources)
    - Proprietary names and codes require UMLS credentials
  - Relations (pairwise relations between entity types)

- **Others**
  - Concept status
    - Point to the current version of obsolete codes
  - List of all drug terms
<table>
<thead>
<tr>
<th>SOAP Function</th>
<th>REST resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>approxMatch</td>
<td>/approx?term=value</td>
<td>Search by name to find the closest RxNorm concepts</td>
</tr>
<tr>
<td>findRemapped</td>
<td>/remap/{rxuc}</td>
<td>Return the re-mapped concept identifiers from an obsolete concept</td>
</tr>
<tr>
<td>findRxucByString</td>
<td>/rxuc?name=value&amp;srclid=value&amp;allsrc=value&amp;search=value</td>
<td>Search by name to find RxNorm concepts</td>
</tr>
<tr>
<td>getAllConceptsByTTY</td>
<td>/allconcepts?ttty=values</td>
<td>Return the RxNorm concepts for the specified term types</td>
</tr>
<tr>
<td>getAllProperties</td>
<td>/rxuc{rxuc}/allProperties?prop=values</td>
<td>Return all properties for a concept</td>
</tr>
<tr>
<td>getAllRelatedInfo</td>
<td>/rxuc{rxuc}/allrelated</td>
<td>Return all related concept information</td>
</tr>
<tr>
<td>getApproximateMatch</td>
<td>/approximateTerm?term=value&amp;maxEnties=value&amp;option=value</td>
<td>Approximate match search to find closest strings</td>
</tr>
<tr>
<td>getDisplayTerms</td>
<td>/displaynames</td>
<td>Return the auto suggestion names</td>
</tr>
<tr>
<td>getDrugs</td>
<td>/drugs?name=value</td>
<td>Return the related drugs</td>
</tr>
<tr>
<td>getIdTypes</td>
<td>/dtype</td>
<td>Return the available identifier types</td>
</tr>
<tr>
<td>getMultiIngredBrand</td>
<td>/brands?ingredientids=value</td>
<td>Return the brands containing the specified ingredients</td>
</tr>
<tr>
<td>getNDCs</td>
<td>/rxuc{rxuc}/ndcs</td>
<td>Return all National Drug Codes (NDC) for a concept</td>
</tr>
<tr>
<td>getPropCategories</td>
<td>/propCategories</td>
<td>Return the property categories</td>
</tr>
<tr>
<td>getPropNames</td>
<td>/propnames</td>
<td>Return the property names</td>
</tr>
<tr>
<td>getProprietaryInformation</td>
<td>/rxuc{rxuc}/proprietary?srclid=values&amp;ticket=value&amp;rxui=value</td>
<td>Return the proprietary information for a concept</td>
</tr>
<tr>
<td>getQuantity</td>
<td>/rxuc{rxuc}/quantity</td>
<td>Return the quantity attribute for a concept</td>
</tr>
<tr>
<td>getRelatedByRelationship</td>
<td>/rxuc{rxuc}/related?rel=values</td>
<td>Return the related concepts of specified relationship types</td>
</tr>
<tr>
<td>getRelatedByType</td>
<td>/rxuc{rxuc}/related?ttty=values</td>
<td>Return the related concepts of specified term types</td>
</tr>
<tr>
<td>getRelaTypes</td>
<td>/relatypes</td>
<td>Return the available relationship types</td>
</tr>
<tr>
<td>getRxConceptProperties</td>
<td>/rxuc{rxuc}/properties</td>
<td>Return the concepts properties</td>
</tr>
<tr>
<td>getRxuiStatus</td>
<td>/rxuc{rxuc}/status</td>
<td>Return the status of the concept</td>
</tr>
<tr>
<td>getRxNormVersion</td>
<td>/version</td>
<td>Return the RxNorm data set version</td>
</tr>
<tr>
<td>getSourceTypes</td>
<td>/sourceTypes</td>
<td>Return the available vocabulary abbreviated source types</td>
</tr>
<tr>
<td>getSpellingSuggestions</td>
<td>/spellingsuggestions?name=value</td>
<td>Return spelling suggestions for a name</td>
</tr>
<tr>
<td>getSplSetid</td>
<td>/rxuc{rxuc}/spisetid</td>
<td>Return the structured product label set identifiers for a concept</td>
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<tr>
<td>getStrength</td>
<td>/rxuc{rxuc}/strength</td>
<td>Return the strength attribute for a concept</td>
</tr>
<tr>
<td>getTermTypes</td>
<td>/termtypes</td>
<td>Return the available term types</td>
</tr>
<tr>
<td>getUNII</td>
<td>/rxuc{rxuc}/uni</td>
<td>Return the UNII Code for a concept</td>
</tr>
</tbody>
</table>
RESTful API Example


XML output

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<rxnormdata>
  <idGroup>
    <name>bactrim</name>
    <rxcui>151399</rxcui>
  </idGroup>
</rxnormdata>
```

JSON output

```json
{
  "idGroup" : {
    "rxcui" : "151399",
    "name" : "bactrim"
  }
}
```
Differences from the database

- Does not require local installation / updates
- Focus on the logical representation of drug information
  - Not its storage
- Functions not available in SQL queries
  - Normalization and approximate matching
  - Remapping of obsolete concepts
- Optimized graph traversal / instantiation
  - All pairwise relations between entity types pre-computed
Building Applications to Use the RxNorm (SOAP) API

This page describes how to build applications to use the RxNorm SOAP API. The same steps can be used for the Prescribable, RxTerms and NDF-RT APIs by substituting the appropriate service names contained in the WSDL files for those APIs.

We provide documentation for coding Java and .Net applications. Documentation for building applications in other programming languages (e.g. Perl) may be added at a later time.

- Building a Java Application to use the RxNorm API
- Building a .Net Application to use the RxNorm API

Building a Java Application to use the RxNorm API

The RxNorm API provides developers with functions for retrieving RxNorm data from the most current RxNorm data set. Building applications to use the RxNorm API require initial setup of the development environment and developing code. Each of these is described in detail in this chapter.

Java Development Environment Setup

Setup of a Java developer’s environment involves the following steps. All steps must be completed before application code can be compiled and built to execute requests with the RxNorm API.

1. Obtain a Simple Object Access Protocol (SOAP) 1.2 compatible engine for web service message routing.
2. Download the WSDL for the RxNorm API web service.
3. Generate the client side stubs using Axis’s WSDL2Java utility for the WSDL (for applications written in Java).

1. Obtaining a SOAP 1.2 Engine

Developers will require a Simple Object Access Protocol (SOAP) 1.2 compatible engine to route the web service messages to/from the RxNorm API. The client programs shown in this guide have been tested with Apache Axis Version 1.4 Follow the link to their website and download and install the version onto your development machine. The location of this download will be referred to as &lt;AXIS_DIR&gt; in this guide.

2. Downloading the RxNorm WSDL

The RxNorm WSDL may be downloaded from the RxNav web site. Right-click on the RxNorm Service WSDL and save the WSDL file to your development machine. The path to this file will be hereafter referred to as &lt;RXNORM_WSDL_LOCATION&gt;.

3. Generating Client Stubs for Java
Integrating drug information sources

“Sister APIs”
NDF-RT

- Developed by the Veterans Health Administration
- Integrated in RxNorm since June 2010
- Provides the clinical information “missing” from RxNorm
  - Therapeutic intent, contra-indications
  - Mechanism of action, physiologic effect
  - Pharmacologic classes
  - Drug-drug interactions
Clopidogrel is a Platelet Aggregation Inhibitor (PAI) that is used to decrease platelet aggregation and coagulation activity. It is available in several formulations, including Clopidogrel Bisulfate 75mg Tab. Clopidogrel is commonly used to prevent myocardial infarction and has a physiologic effect on hemorrhage.

Legend:
- **has PE**: has physiologic effect
- **CI with**: contra-indicated with
NDF-RT API

- Made available in 2011
- SOAP and REST flavors
- Relies on the OWL version of NDF-RT
- Support for limited inference
  - All indications of a drug
    - Stated or inferred
  - All drugs that treat some disease
    - Drugs that treat the disease or any of its descendants
- Used to display NDF-RT information in RxNav
FLUOXETINE HCL 10MG TAB
Drug Interactions

FLUOXETINE

- CITALOPRAM [Critical]
- CLOZAPINE [Critical]
- DOFETILIDE [Critical]
- HYPERICUM PERFORATUM (ST. JOHN’S WORT) [Critical]
- ISOGARBOXAZID [Critical]
- LINEZOLID [Critical]
- PARGYLINE [Critical]
- PHENELZINE [Critical]
- PIMOZIDE [Critical]
- PROCARBAZINE [Critical]
- RITONAVIR [Critical]
- SELEGILINE [Critical]
- SIBUTRAMINE HYDROCHLORIDE [Critical]
- TAMOXIFEN [Critical]
- THIORIDAZINE [Critical]
- TRANYLCYPROMINE [Critical]

ALMOTRIPTAN [Significant]
ALPRAZOLAM [Significant]
RxTerms

◆ Drug interface terminology derived from RxNorm for prescription writing or medication history recording
  ● Commonly used synonyms and abbreviations (e.g. HCTZ for hydrochlorothiazide)
  ● "tall man" lettering recommended by FDA to avoid medication errors (e.g. ChlorproMAZINE and ChlorproPAMIDE)
◆ Developed at NLM
◆ Many RxTerms features have been integrated in RxNav
Enabling complex queries to drug information sources

RxMix
Motivation

◆ Drug information sources can be used programmatically through Application Programming Interfaces (APIs)
  ● RxNorm, NDF-RT, RxTerms, RxImageAccess
◆ Difficult to compose complex queries within and across multiple APIs
  ● Interoperability of functions
    → Model for interoperability
  ● Programming is required
    → Graphical interface
Example use case

◆ Find all the brand name products available for a given clinical drug string
  ● Input: citalopram 20 mg oral tablet
  ● Output: Celexa

◆ Workflow

\[\text{findRxcuiById} \quad \text{getRelatedByType}\]

- **name (clinical drug)**: citalopram 20 mg oral tablet
- **RxNorm ID (clinical drug)**: 200371, citalopram 20 mg oral tablet
- **Name + ID (brand name)**: 215928, Celexa
Interoperability among API functions

◆ Interoperability rule
  ● If the input of function $B$ matches the output of function $A$, then function $A$ is potentially interoperable with function $B$

◆ Implementation
  ● Supported by an ontology describing the input or output of functions
    ■ Also used to drive the RxMix application

◆ Example
  ● A: $\text{rxnorm:findRxcuiById has_output RxCUI}$
  ● B: $\text{rxnorm:getRelatedByType has_input RxCUI}$
  ● input of $B$ matches the output of $A$
    $\Rightarrow \text{rxnorm:getRelatedByType interoperable_with rxnorm:findRxcuiById}$
“Real-life” use case

- Find all the NDC codes for a given allergy class (e.g., barbiturates)
  - Input: [NDF-RT] Barbiturates (N0000008016)
  - Output: [RxNorm] list of NDC codes

- Complex workflow

```
http://mor.nlm.nih.gov/RxMix/
```
RxMix
Create applications from RxNorm, RxTerms, NDF-RT, and RxImageAccess APIs

http://mor.nlm.nih.gov/RxMix/

Introduction

RxMix is an interface for building applications that allows users to combine functions of the RxNorm, RxTerms, NDF-RT, and RxImageAccess APIs. It allows users to run either interactively or in batch mode.

Sample RxMix configurations

- Find drug interaction brands for Morphine (RXCUI = 7052)
- Find allergy drugs for Proton Pump Inhibitors (NUI = N0000000147)

APIs

- RxNorm
- NDF-RT
- RxTerms
- RxImageAccess

References

<table>
<thead>
<tr>
<th>TAG</th>
<th>DEFINITION</th>
</tr>
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<tbody>
<tr>
<td>accuDate</td>
<td>The physical sample acquisition date</td>
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Looking for RxMix tutorial? Click here.
name → NDF-RT ID (chem. ingr.) → NDF-RT ID (drug/ingr.) → RxNorm ID (ingredient) → RxNorm ID (SCD/SBD) → NDC code
Complete workflow
Add input and run
Over 1000 NDCs retrieved

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<thead>
<tr>
<th>NDC</th>
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<tbody>
<tr>
<td>00179008880</td>
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</table>
Examples of use cases

- Finding clinical drugs which may cause allergic reactions
- Finding interactions to RxNorm clinical drugs
- Finding NDF-RT ingredients from RxNorm clinical drugs
- Finding VA classes for RxNorm clinical dose forms
- Finding brand names from clinical drug strings

Library of common use cases integrated in RxMix
Applications & Usage
NLM applications

- RxNav
- MyMedicationList iOS app
- MyRxPad
NLM applications

- MedlinePlusConnect
  - Map NDCs to RxCUIs
  - Remap obsolete RxCUIs
  - Navigate through RxNorm
- Value Set Authority Center
  - Validate RxNorm codes
  - Check entity type
  - Remap obsolete codes
Applications outside NLM  Research

◆ In research projects
  ● RxSafe (OHSU)
    ▪ “improve medication safety for patients”
    ▪ http://www.ohsu.edu/RxSafe/
  ● My-Medi-Health (Vanderbilt)
    ▪ “Child-Centered Medication Management”
  ● Health Ontology Mapper (CTSA-i2b2/SHRINE)
    ▪ “automated formulary data instance mapping”
    ▪ https://community.i2b2.org/wiki/display/HOM/HOM+Home
Applications outside NLM  

- EHR/PHR
  - iBlueButton

- Medication lists / histories
  - Drug Diary
  - RefillWizard
  - PillRack
Usage statistics RxNav sessions

Number of interactive queries and sessions per month

- Queries
- Sessions
- 12 m sliding avg

![Graph showing the number of interactive queries and sessions per month from January 2008 to July 2013. The graph indicates a steady increase in usage, with peaks and troughs reflecting usage patterns.]
Usage statistics  API queries

Number of API queries per month

- all queries
- 12 m sliding avg

July-09 to July-13
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000
12,000,000
14,000,000
Jul-09 Jan-10 Jul-10 Jan-11 Jul-11 Jan-12 Jul-12 Jan-13 Jul-13
Usage statistics  API queries

Number of API queries per year (x1M)

- All queries
- RxNorm
- Rx Terms
- NDF-RT

Years: 2006 to 2017
Values: 0 to 70
Who are our users?

- NLM
  - MedlinePlusConnect (~10%)
- Health application developers
- Academic projects
- Pharmacists (insurance, benefit managers)
- ???
  - 42,000 unique IP addresses (Jan.-Aug. 2013)
  - Top 20 IP addresses account for ~ 80% of the traffic
  - Who is “ec2-50-xx-211-251.us-west-1.compute.amazonaws.com”? (200,000 queries in Aug. 2013)
Spreading the word

- 8 posters (AMIA, Medinfo, MIE)
- 6 demos / webinars
- 5 conference papers (AMIA, Medinfo)
- 2 journal articles
Medical Ontology Research

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