Analyzing Large Drug Prescription Datasets

Principles, Tools and Examples

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Disclosure

OB, VH: No relationships with commercial interest

The views and opinions expressed do not necessarily state or reflect those of the U.S. Government, and they may not be used for advertising or product endorsement purposes.

CR: IQVIA has many clients in the pharmaceutical industry, whose products are the subject of this Tutorial. However, all products are intended to only be mentioned for the purposes of this Tutorial and without any recommendation or judgment of their use.
Learning Objectives

To become familiar with large prescription datasets

To gain knowledge about tools available for analyzing prescription datasets

To gain knowledge about clinical data models, such as OMOP
Overview

Part 1 – Resources and use cases (OB)
- Prescription datasets
- RxNorm and NLM drug APIs; drug classification systems
- Common use cases

Part 2 – Drug data processing in practice (VH)
- Implementing use cases with RxMix and R

Part 3 – Experience with OHDSI (CR)
- Clinical data models
- Handling international drugs
Part 1 – Resources and use cases

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Part 1 overview

Types of drug entities
  • Drugs
  • Drug classes

Prescription datasets
  • Structure
  • Sources

Drug data processing
  • Mapping drugs to standards
  • Aggregating drugs (by ingredient, by class)

Resources for processing drug datasets
  • RxNorm
  • Drug classification systems
  • NLM drug APIs

Common use cases
  • Pharmaco-epidemiology
  • Assess exposure to drugs by ingredient or class
  • Identify potentially inappropriate medications
Types of drug entities

Part 1 – Resources and use cases
Types of drug entities (drugs I)

Ingredient
- Azithromycin

Drug form
- Ingredient + dose form
  - Azithromycin Oral Tablet

Clinical drug (unit of prescription)
- Ingredient + dose form + strength
  - Azithromycin 250 MG Oral Tablet

Pack (packaging level)
- Collection of clinical drugs (unit of dispensation)
  - Z-PAK  {{6 (Azithromycin 250 MG Oral Tablet [Zithromax])}}
- Collection of clinical drugs (bulk)
  - Manufacturer: Apotex Corp.; pack size: 500 in 1 BOTTLE
Types of drug entities (drugs II)

Generic vs. Brand
- \( G \): Azithromycin 250 MG Oral Tablet
- \( B \): Zithromax 250 MG Oral Tablet

Single vs. multi-ingredient drug
- \( S \): Amoxicillin 250 MG Oral Capsule
- \( M \): Amoxicillin 250 MG / Clavulanate 125 MG Oral Tablet

Systemic vs. topical drugs
- \( S \): Azithromycin 250 MG Oral Tablet
- \( T \): Azithromycin 10 MG/ML Ophthalmic Solution

Base vs. salt/ester (as basis of strength substance)
- \( B \): Erythromycin 250 MG Oral Tablet
- \( S \): Erythromycin Ethylsuccinate 400 MG Oral Tablet
Types of drug entities (drug classes)

Atorvastatin

Therapeutic class
  • Anticholesteremic Agent

Chemical structure
  • n/a

Mechanism of action
  • HMG-CoA Reductase Inhibitor

Physiologic effect
  • Decreased Cholesterol Synthesis
Types of drug entities (drug classes)

ANTIINFECTIVES FOR SYSTEMIC USE

ANTIBACTERIALS FOR SYSTEMIC USE

MACROLIDES, LINCOksamides AND STREPTOGRAMINS

Macrolides

azithromycin

SENSORY ORGANS

OPHTHALMOLOGICALS

ANTIINFECTIVES

Antibiotics
Prescription datasets

Part 1 – Resources and use cases
Structure

Transactions captured at dispensation time (pharmacy)
  • Pharmaceutical claims data sent to payers

Common elements
  • Prescription ID 999999
  • Patient identifier 123456
  • Date (prescription) 20161112
  • Product ID (NDC) 00071015623
  • Total quantity dispensed 30
  • Days supply 30
  • Cost data --
  • Drug name LIPITOR TAB 20MG
  • Strength 20
  • Generic name Atorvastatin
  • Prescriber ID 789

NDCs are not unique identifiers for clinical drugs

Drug names are not standardized
### Product Name from Medicaid Claims

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUMADIN</td>
<td>270</td>
</tr>
<tr>
<td>COUMADIN TAB</td>
<td>13</td>
</tr>
<tr>
<td>COUMADIN TABLET</td>
<td>215</td>
</tr>
<tr>
<td>JANTOVEN</td>
<td>130</td>
</tr>
<tr>
<td>JANTOVEN TAB</td>
<td>24</td>
</tr>
<tr>
<td>JANTOVEN TABLET</td>
<td>262</td>
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<tr>
<td>WARFARIN</td>
<td>1,093</td>
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<tr>
<td>WARFARIN TAB</td>
<td>763</td>
</tr>
<tr>
<td>WARFARIN SODIUM</td>
<td>8,717</td>
</tr>
<tr>
<td>WARFARIN SODIUM TA</td>
<td>95</td>
</tr>
<tr>
<td>WARFARIN SODIUM TAB</td>
<td>516</td>
</tr>
<tr>
<td>WARFARIN SODIUM TABL</td>
<td>587</td>
</tr>
<tr>
<td>WARFARIN SODIUM TABLET</td>
<td></td>
</tr>
</tbody>
</table>

Source: Dan Malone
Product Identification: NDCs

National Drug Codes

- Product identification system
- Three components
  - Manufacturer
  - Product
  - Packaging

Introduced in 1972 by FDA

Only format permitted by NCPDP

Mandated by HIPAA regulations for drug transactions

Source: Dan Malone
NDC Elements: 3 segments

XXXXX-XXXX-XX

Manufacturer  Product  Packaging
**NDC Forms**

**Warfarin Sodium 1 MG Oral Tablet**

`XXXX-XXXX-XX (4-4-2)  →  0XXXX XXXXX XX`

0555-0831-02 (Teva Pharmaceuticals USA, Inc.; 100 in 1 BOTTLE)  →  00555083102

`XXXXXX-XXXX-XX (5-3-2)  →  XXXXX 0XXX XX`

21695-672-30 (Rebel Distributors Corp; 30 in 1 BOTTLE)  →  21695067230

`XXXXX-XXXX-X (5-4-1)  →  XXXXX XXXXX 0X`

50090-1213-0 (A-S Medication Solutions; 30 in 1 BOTTLE)  →  50090121300
NDC Characteristics

11 Digit code (leading zero for 4-4-2 format)

Hyphens between segments are missing in claims transmission (Field 407 in NCPDP claim format)

NDC codes set by the manufacturer/labeler

High turnover compared to other drug IDs

Product codes are unique to manufacturer – not to the chemical entity

Package codes are unique to the manufacturer and product – there is no standardization for packaging codes

Source: Dan Malone
Source of prescription datasets

Surescripts transactions

Data from payers
- Medicaid
- Medicare Part D

Commercial health analytics companies
- Truven (120M patients)
- PharMetrics Plus (100M patients)
- Ambulatory EMR (35M patients)
- Open Claims (250M patients)

Reagan-Udall Foundation for the FDA
- IMEDS Research Lab (temporarily suspended)
Drug data processing

Part 1 – Resources and use cases
Mapping and aggregation

Mapping to standard resources (e.g., RxNorm)

- Standard names and codes
- Standard set of relations among drug entities
- Link to drug classification systems
- E.g., NDC → clinical drug

Aggregation

- “roll up” to the appropriate level of granularity for analytics (use case-dependent)
- E.g., branded drug → clinical drug → ingredient → drug class

Temporal aggregation

- Aggregate individual prescriptions into longer spans (“drug eras” in OHDSI)
### Esomeprazole (A02BC05)

<table>
<thead>
<tr>
<th>ATC code</th>
<th>Name</th>
<th>DDD</th>
<th>U</th>
<th>Adm.R</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02BC05</td>
<td>esomeprazole</td>
<td>30</td>
<td>mg</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>esomeprazole</td>
<td>30</td>
<td>mg</td>
<td></td>
<td>P</td>
</tr>
</tbody>
</table>

#### Esomeprazole 40 MG Delayed Release Oral Capsule (606730)

#### Esomeprazole 40 MG Delayed Release Oral Capsule [Nexium] (606731)

**00186504031**

**0186-5040-31**
Resources for processing drug datasets – RxNorm

Part 1 – Resources and use cases
RxNorm

Terminology integration system
  • Structured Product Labels, First DataBank, Micromedex, Multum, MeSH, SNOMED CT, MED-RT, ATC, …

Scope
  • Drug names and codes
  • Drugs available on the U.S. market

Developer: National Library of Medicine

Publicly available*

Monthly updates

Size: > 10k ingredients; 19k clinical drugs

Uses: e-prescription, information exchange, analytics

https://www.nlm.nih.gov/research/umls/rxnorm/
## Normalization  Lexical level

<table>
<thead>
<tr>
<th>Name</th>
<th>Code</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARFARIN (COUMADIN) NA 1MG TAB</td>
<td>4005203</td>
<td>VANDF</td>
</tr>
<tr>
<td>warfarin 1 mg oral tablet</td>
<td>3617</td>
<td>MMSL</td>
</tr>
<tr>
<td>WARFARIN NA 1MG TAB,UD</td>
<td>4014039</td>
<td>VANDF</td>
</tr>
<tr>
<td>WARFARIN NA 1MG TAB,UD [VA Product]</td>
<td>N0000161787</td>
<td>NDFRT</td>
</tr>
<tr>
<td>WARFARIN SODIUM 1 mg ORAL TABLET</td>
<td>14198</td>
<td>NDDF</td>
</tr>
<tr>
<td>WARFARIN SODIUM 1 mg ORAL TABLET</td>
<td>60429-784</td>
<td>MTHSPL</td>
</tr>
<tr>
<td>Warfarin Sodium 1 MG Oral Tablet</td>
<td>104045</td>
<td>MMX</td>
</tr>
<tr>
<td>WARFARIN SODIUM 1 mg ORAL TABLET</td>
<td>63629-4017</td>
<td>MTHSPL</td>
</tr>
<tr>
<td>WARFARIN SODIUM 1 mg ORAL TABLET [Warfarin Sodium]</td>
<td>53808-0985</td>
<td>MTHSPL</td>
</tr>
<tr>
<td>Warfarin Sodium 1 MILLIGRAM In 1 TABLET ORAL TABLET</td>
<td>15330-100</td>
<td>MTHSPL</td>
</tr>
<tr>
<td>WARFARIN SODIUM 1.09 MG ORAL TABLET</td>
<td>281572</td>
<td>MTHFDA</td>
</tr>
<tr>
<td>Warfarin Sodium 1mg Oral tablet</td>
<td>933</td>
<td>GS</td>
</tr>
<tr>
<td>Warfarin sodium 1mg tablet (product)</td>
<td>319733000</td>
<td>SNOMEDCT_US</td>
</tr>
<tr>
<td>Warfarin Sodium Tab 1 MG</td>
<td>6749</td>
<td>MDDB</td>
</tr>
<tr>
<td>Warfarin Sodium, 1 mg oral tablet</td>
<td>3617</td>
<td>MMSL</td>
</tr>
<tr>
<td>WARFARIN SODIUM@1 mg@ORAL@TABLET</td>
<td>14198</td>
<td>NDDF</td>
</tr>
</tbody>
</table>

Warfarin Sodium 1 MG Oral Tablet (855288)
Warfarin Sodium 1 MG (855287)

Clinical drug component

Warfarin Oral Tablet (374319)

Warfarin Sodium 1 MG Oral Tablet (855288)

Clinical drug
Relations among drug entities

- **Ingredient**: Azithromycin
- **C. Drug Comp.**: Azithromycin 250 MG
- **C. Drug Form**: Azithromycin Oral Tablet
- **B. Drug Comp.**: Azithromycin 250 MG
- **B. Drug Form**: Azithromycin Oral Tablet [Zithromax]
- **C. Drug**: Azithromycin 250 MG Oral Tablet
- **G. Pack**: {6 (Azithromycin 250 MG Oral Tablet) } Pack
- **B. Pack**: Z-PAK
- **Brand Name**: Zithromax
- **B. Drug**: Zithromax 250 MG Oral Tablet
RxNav – RxNorm browser

https://mor.nlm.nih.gov/RxNav/
Resources for processing drug datasets – Drug classification systems

Part 1 – Resources and use cases

@AMIAInformatics
@AMIAinformatics
Official Group of AMIA
@AMIAInformatics
#WhyInformatics
ATC/DDD Index

Origin
- World Health Organization (WHO) Collaborating Centre for Drug Statistics Methodology (Norway)

Purpose
- For drug utilization research / pharmaco-epidemiology

~1300 classes (1-4)

Organization
- Drug classification on 4 levels
  - Anatomical
  - Therapeutic
  - Chemical
- Drugs (5th level)

http://www.whocc.no/atc_ddd_index/

<table>
<thead>
<tr>
<th>ATC code</th>
<th>Name</th>
<th>DDD</th>
<th>U</th>
<th>Adm.R</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>J01CA04</td>
<td>amoxicillin</td>
<td>1 g</td>
<td>O</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Established Pharmacologic Classes (EPCs)

Origin
- Veterans Health Administration’s Medication Reference Terminology (MED-RT)
  - For use by the U.S. Food and Drug Administration (FDA)

Purpose
- For drug classification in the Structured Product Labels

~600 classes

No hierarchical organization

Examples
- Macrolide antibacterial (e.g., Azithromycin)
Mechanism of action (MoA)  
Physiologic effect (PE)  
Chemical structure (Chem)

Origin
- Veterans Administration’s Medication Reference Terminology (MED-RT)

Purpose
- For drug classification in the Structured Product Labels
- For drug classification at the VA

Number of classes
- MoA: ~600; PE: ~1900; Chem: ~10,000

Hierarchical organization

Examples
- MoA: HMG-CoA Reductase Inhibitor (e.g., atorvastatin)
- PE: Decreased Blood Pressure (e.g., enalapril)
- Chem: Penicillins (e.g., amoxicillin)
VA Classes

Origin
• Veterans Administration’s National Drug File

Purpose
• For drug classification in the VA formulary

~500 classes

Shallow hierarchical organization (3 levels)

Examples
• L1: ANTIMICROBIALS
• L2: PENICILLINS AND BETA-LACTAM ANTIMICROBIALS
• L3: QUINOLONES (e.g., Ofloxacin 200 MG Oral Tablet)

NB: links to clinical drugs rather than ingredients
RxClass – Drug class browser

[Image of RxClass webpage]

class: Macrolide Antimicrobial / id: N0000175935 / class type: EPC / show context

3 RxNorm generic drugs for has_EPC in DailyMed / similar classes

<table>
<thead>
<tr>
<th>Type</th>
<th>RXCUI</th>
<th>RxNorm Name</th>
<th>Relation</th>
<th>All classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN</td>
<td>19631</td>
<td>Azithromycin</td>
<td>DIRECT</td>
<td>Show</td>
</tr>
<tr>
<td>IN</td>
<td>21212</td>
<td>Clarithromycin</td>
<td>DIRECT</td>
<td>Show</td>
</tr>
<tr>
<td>IN</td>
<td>4053</td>
<td>Erythromycin</td>
<td>DIRECT</td>
<td>Show</td>
</tr>
</tbody>
</table>
Resources for processing drug datasets – NLM drug APIs
Part 1 – Resources and use cases
NLM drug APIs

Expose the content of RxNorm, RxTerms and MED-RT (and other resources)

- Logical structure, not storage format
- Up-to-date information (monthly updates of RxNorm)
- Additional features
  - Normalized and approximate matching; spelling correction
  - Drug-drug interactions checking (from DrugBank)
  - Link to drug classes (from ATC, DailyMed, MeSH, MED-RT)
  - Archive of NDCs since 2007
- Optimized graph traversal (pre-computed)

For use in applications

- Web services
- SOAP, REST (XML, JSON)
- Independent of any programming language
API documentation and examples

RxNorm API

The RxNorm API is a web service for accessing the current RxNorm data set. With one exception, no license is needed to use the RxNorm API. This is because the data returned from the API is from the RxNorm vocabulary, a non-proprietary vocabulary developed by the National Library of Medicine.

The API can be accessed by clients in two different ways:
- RxNorm RESTful web services
- RxNorm SOAP web services

Please check RxNorm API changes for the current updates.

Functions and Resources

In the table, the base URI (https://rxnav.nlm.nih.gov/REST/) for the REST resources has been omitted to improve readability.

<table>
<thead>
<tr>
<th>SOAP Function</th>
<th>REST resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filterByProperty</td>
<td>/rxcu/{rxcu}/filter</td>
<td>Filter by property</td>
</tr>
<tr>
<td>findRxcuById</td>
<td>/rxcu?idtype</td>
<td>Search by identifier to find RxNorm concepts</td>
</tr>
<tr>
<td>findRxcuByString</td>
<td>/rxcu/name</td>
<td>Search by name to find RxNorm concepts</td>
</tr>
<tr>
<td>getAllClasses</td>
<td>/classes</td>
<td></td>
</tr>
<tr>
<td>getAllConceptsByTTY</td>
<td>/allConcepts</td>
<td>Return the RxNorm concepts for the specified term types</td>
</tr>
<tr>
<td>getAllHistoricalNDCs</td>
<td>/rxcu/{rxcu}/allhistoricalncks</td>
<td>Return all National Drug Codes (NDC) for a concept</td>
</tr>
<tr>
<td>getAllNDCs</td>
<td>/rxcu/{rxcu}/allndc</td>
<td>TO BE DEPRECATED. Use getAllHistoricalNDCs or /rxcu/{rxcu}/allhistoricalndc instead.</td>
</tr>
<tr>
<td>getAllProperties</td>
<td>/rxcu/{rxcu}/allProperties</td>
<td>Return all properties for a concept</td>
</tr>
<tr>
<td>getAllRelatedInfo</td>
<td>/rxcu/{rxcu}/allrelated</td>
<td>Return all related concept information</td>
</tr>
</tbody>
</table>
Esomeprazole (283742) → Esomeprazole (A02BC05)


rxnrm:findRxcuiById("NDC", "0186-5040-31", 0) → 606731
<table>
<thead>
<tr>
<th>ATC code</th>
<th>Name</th>
<th>DDD</th>
<th>U</th>
<th>Adm.R</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02BC05</td>
<td>esomeprazole</td>
<td>30 mg</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 mg</td>
<td>P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Esomeprazole (283742) → Esomeprazole (A02BC05)


rxclass:getClassByRxNormDrugId ("283742", "ATC", "ALL") → A02BC, Proton pump inhibitors
<table>
<thead>
<tr>
<th>ATC Code</th>
<th>Name</th>
<th>DDD</th>
<th>U</th>
<th>Adm. R</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>esomeprazole</td>
<td>30</td>
<td>mg</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>A02</td>
<td>esomeprazole</td>
<td>30</td>
<td>mg</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

**rxclass:getClassGraph(“A02BC”)**

- **A02B**, DRUGS FOR PEPTIC ULCER AND GASTRO-OESOPHAGEAL REFLUX DISEASE (GORD);
- **A02**, DRUGS FOR ACID RELATED DISORDERS;
- **A**, ALIMENTARY TRACT AND METABOLISM
Graphical interface to the drug APIs

- RxNorm, MED-RT, RxTerms, RxImage, Interactions, RxClass, MedEx, DailyMed

Handles interoperability between functions

Helps users compose complex queries

- Find all the NDC codes for a given allergy class (e.g., barbiturates)

Supports batch execution
Common use cases

Part 1 – Resources and use cases
Common use cases

Pharmaco-epidemiology

- Assess exposure to drugs (by ingredient or class)
- Assess prescribed daily dose

Identify potentially inappropriate medications

- Elderly (Beers)
- Pregnant women (Briggs)
Use case #1
Pharmaco-epidemiology

[Bodenreider, AMIA, 2014]
Prescribed vs. defined daily dose

Dataset
- Surescripts feed
- All prescriptions to ER patients
- For 3 months in 2011 in a Bethesda hospital

Reference for defined daily dose: ATC

Methods
- RxNorm clinical drug $\rightarrow$ RxNorm ingredient $\leftrightarrow$ ATC ingredient $\rightarrow$ ATC defined daily dose $\leftrightarrow$ prescribed daily dose
- Restricted to systemic drugs (based on dose form)

Findings
- Confirmed feasibility
- 25% of the prescriptions exactly match the ATC DDD
- 50% of the prescriptions within 66-150% of the ATC DDD
- 75% of the prescriptions within 50-200% of the ATC DDD
Methods Example

RxNorm
- Amoxicillin 500 MG Oral Capsule (308191)
- Amoxicillin (723)
- Oral Capsule

ATC/DDD Index
- amoxicillin (J01CA04)
- 1 g

Surescripts
- Amoxicillin 500 MG Oral Capsule (308191)
- 40 capsules
- 10 days
- 40 x 500 mg / 10 = 2 g
Results  Prescription classification

Frequency of drugs by level-1 ATC group in the Surescripts prescription dataset

N=86,578

ALIMENTARY TRACT AND METABOLISM (A)
BLOOD AND BLOOD FORMING ORGANS (B)
CARDIOVASCULAR SYSTEM (C)
DERMATOLOGICALS (D)
GENITO URINARY SYSTEM AND SEX HORMONES (G)
SYSTEMIC HORMONAL PREP., EXCL. SEX HORMONES AND INSULINS (H)
ANTIINFECTIVES FOR SYSTEMIC USE (J)
ANTINEoplastIC AND IMMUNOMODULATING AGENTS (L)
MUSCULO-SKELETAL SYSTEM (M)
NERVOUS SYSTEM (N)
ANTIPARASITIC PRODUCTS, INSECTICIDES AND REPELLENTS (P)
RESPIRATORY SYSTEM (R)
SENSORY ORGANS (S)
VARIABLES (V)

Atorvastatin  Simvastatin  Lisinopril  Amlodipine  Furosemide  Metoprolol  Hydrochlorothiazide
Zolpidem  Sertraline  Escitalopram  Alprazolam  Clonazepam  Gabapentin  Quetiapine  Oxycodone  Fluoxetine  Duloxetine
Deviation of the prescribed daily dose (PDD) in Surescripts from the defined daily dose (DDD) in ATC for 68,462 oral solid dose form prescriptions

- 86.1% of the prescriptions are within 33%-300% of the ATC DDD
- 10.4% < 33% of the ATC DDD
- 3.5% > 300% of the ATC DDD
- 76.1% of the prescriptions are within 50%-200% of the ATC DDD
- 28.6% of the prescriptions exactly match the ATC DDD
- 49.5% of the prescriptions are within 66%-150% of the ATC DDD
Use case #2

Identifying potentially inappropriate medications for elderly patients

[Mundkur, AMIA, 2016]
PIMs for elderly patients

Dataset
- Medicare Part D
- 1M beneficiaries ≥ 65
- All prescriptions for one year (2009)

Reference list of PIMs: Beers list

Methods
- NDC → RxNorm clinical drug → ingredient ↔ Beers
- Restricted to systemic drugs (based on dose form)

Findings
- 47% of all beneficiaries were prescribed at least 1 PIM
- Top PIMs: zolpidem (6.3%), nitrofurantoin (4.5%)
Methods

Example

**RxNorm**

- **5511047901**
  - Zolpidem tartrate 10 MG Oral Tablet (854873)
- **zolpidem**
- **Oral Tablet**

**Beers**

- **zolpidem**
- **Oral Pill**
- **DFG filter**

**Medicare**

- **5511047901**
- **Demographic data**
  - 470,523 prescriptions
Use case #3

Identifying potential risk in drug prescriptions during pregnancy

[Dhombres, AMIA, 2016]
Potential risk during pregnancy

Dataset
- Large prescription dataset from private insurer (150M patients)
- 3.7M pregnant women; 19M prescriptions (2003-2014)
- OMOP common data model

Reference list for risk during pregnancy: Briggs textbook

Methods
- RxNorm clinical drug \(\rightarrow\) ingredient \(\leftrightarrow\) Briggs drug \(\rightarrow\) fetal risk
- Restricted to systemic drugs (based on dose form)

Findings
- 41.2% compatible with pregnancy or probably compatible
- 55.6% potential risk
- 3.29% high risk or contraindicated
Specific challenge

Obsolete identifiers

• NDC = drug + manufacturer + packaging information
  • ~250,000 active NDCs
  • ~300,000 obsolete NDCs in the past 10 years
  • ~220,000 “alien” NDCs (not curated by RxNorm)

• Obsolete NDCs
  • Removed from RxNorm (e-prescribing use case)
  • Needed for analytics (longitudinal datasets)

• RxNorm API provides access to obsolete NDCs
  • Mapping obsolete NDCs to active drugs
    • `rxnorm:getNDCStatus( ndc, startDate, endDate, option )`
  • List of all NDCs – active or obsolete – for a given drug
    • `rxnorm:getAllHistoricalNDCs( rxcui, history )`
Other challenges

Reuse of identifiers
  • NDCs (time-indexed)

Insufficient coverage in RxNorm
  • International drugs
  • Over-the-counter drugs

Granularity of knowledge
  • Ingredient-class vs. clinical drug-class

Heterogeneity of drug classification
  • Different use cases
Impact assessment

1B prescriptions from Medicare analyzed

- Over a 10-year period (2005-2014)

Vast majority of NDCs can be resolved with the RxNorm API functions

- Minor issues
  - Start/End date do not match prescription date
  - Ambiguous mapping (multiple RxCUIs; often clinically insignificant – generic vs. brand)
- <5% unmapped NDCs (mostly supplies; OTCs)
Part 2 – Drug data processing in practice

Olivier Bodenreider, MD, PhD, NLM
Vojtech Huser, MD, PhD, NLM
Christian Reich, MD, PhD, IQVIA
Part 2 overview

Detailed look at the API

Try it yourself (Follow-along examples with RxMix)

- and get help (if you hit a problem)
- 5-10 min

R code examples
Links

https://github.com/lhncbc/r-snippets-bmi/tree/master/rxnorm

https://github.com/mpancia/RxNormR (not used in this session)
Detailed look at the API

Part 2 – Drug data processing in practice
API and RxMix web-tool

https://rxnav.nlm.nih.gov/

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

Functions and Resources

In the table, the base URI (https://rxnav.nlm.nih.gov/REST/) for the REST resources has been omitted to improve readability.

<table>
<thead>
<tr>
<th>SOAP Function</th>
<th>REST resource</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>byProperty</td>
<td>/rxcui/{rxcui}/filter</td>
<td>Filter by property</td>
</tr>
<tr>
<td>findRxculByld</td>
<td>/rxcul?ldtype</td>
<td>Search by identifier to find RxNorm concepts</td>
</tr>
<tr>
<td>findRxculByString</td>
<td>/rxcul?name</td>
<td>Search by name to find RxNorm concepts</td>
</tr>
<tr>
<td>getAllClasses</td>
<td>/classes</td>
<td>TO BE DEPRECATED. Use the RxClass API functions to return the drug class concepts for the specified drug vocabulary</td>
</tr>
<tr>
<td>getAllConceptsByTTY</td>
<td>/allconcepts</td>
<td>Return the RxNorm concepts for the specified term types</td>
</tr>
<tr>
<td>getAllNDCs</td>
<td>/rxcul/{rxcul}/allNDCs</td>
<td>Return all National Drug Codes (NDC) for a concept</td>
</tr>
</tbody>
</table>
**Esomeprazole (A02BC05)**

**Esomeprazole (283742)**

**Esomeprazole 40 MG Delayed Release Oral Capsule (606730)**

**Esomeprazole 40 MG Delayed Release Oral Capsule [Nexium] (606731)**

00186504

031

0186-5040-31
Functions

rxnorm:findRxucuiById

- Parameters
  - id_string: NDC
  - AllSourcesFlag: 0
- Input: 00186504031 or 0186-5040-31
- Output: 606731

rxnorm:getRelatedByType

- Parameters:
  - term_type: IN
- Input: 606731
- Output: Esomeprazole 283742
Try it yourself (Follow-along examples with RxMix)

Part 2 – Drug data processing in practice
RxMix

Creating Applications from NLM Drug APIs

Introduction
RxMix is an interface for building applications that use RxNorm, RxTerms, NDF-RT, RxClass, Interact, and other APIs. It can run either interactively or in batch mode.

Sample RxMix configurations
- Find drug interaction brands for Morphine
- Find allergy drugs for Proton Pump Inhibitors

APIs
- RxNorm
- NDF-RT
- RxTerms
- RxImageAccess
- Interaction
- RxClass
- DailyMed
- MedEx
Library of pre-built workflows

Find brand and ingredients of an ATC drug class
This workflow finds the RxNorm ingredients and brands associated with an ATC drug class. Sample input: N03CF.

Find pill image information for a brand or an ingredient
This workflow retrieves pill image information for an ingredient or brand name. If no ingredient is specified, then all pill image information for the ingredient and brands containing the ingredient are returned. A brand name input will return the pill information only for the brand. Sample input: Cymbalta.

Find brand names containing an ingredient
This simple workflow gets a string and finds the RxNorm concept identifier, then finds the related brands. It can be used to enter ingredients and find the brand names which contain that ingredient. Sample input: warfarin.

Find the National Drug Codes (NDCs) for clinical drugs of an ingredient
This workflow finds the RxNorm Identifier (RxCID) for an ingredient name and retrieves all the clinical drugs for that name. The final step retrieves the NDCs for all the clinical drugs. Sample input: simvastatin.

Find the clinical drugs of an ingredient class
This workflow finds the drug class for an ingredient name (e.g. hydroxyzine) and gets all the ingredients of the class. Then it gets the clinical drugs associated with ingredients. Sample input: hydroxyzine.
Lyrica 150 MG Oral Capsule
NCD: 00071101668

LYRICA- pregabalin capsule
LYRICA- pregabalin solution
Resolving NDC 00071101668 in RxNav
Getting all other NDCs for Lyrica 150 MG Oral Capsule

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Getting all RxNorm entities related to Lyrica 150 MG Oral Capsule

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<td>598443</td>
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SBDC

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SBDF

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</table>
Selecting parameters

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

- **Select Function**: getClassByRxNormDrugId
- **Optional Parameters**:
  - `relaSource`:
    - ALL
    - ATC
    - DAILYMED
    - FDASPL
    - MESH
    - MEDRT
    - VA

- **Add to Workflow**
- **LOAD**:
  - From workflow library
  - From my workflows

**INPUT**

**WORKFLOW**

- RxNorm.getNDCProperties
Getting drug-drug interactions for Lyrica 150 MG Oral Capsule

Interactions for pregabalin

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<td>221109</td>
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</tbody>
</table>
Nonsensical query returning no results
```json
{
  "function": {
    "input": "raloxifene",
    "level": 0,
    "name": "findRxCuiByString",
    "outputs": {
      "output": {
        "RXCUI": 72143
      }
    }
  },
  "function": {
    "input": 72143,
    "level": 1,
    "name": "getRelatedByType",
    "outputs": {
      "output_type": "BN",
      "output": {
        "RXCUI": 217010,
        "name": "Evista",
        "term_type": "BN"
      }
    }
  }
}
```
Saving your workflow
R code examples

Part 2 – Drug data processing in practice
# callingAPI.R

# wrapping a call to API into R function

```r
findRxCuibyString < - function (input) {
  url2 <- URLencode (url)
  j <- jsonlite::fromJSON(url2)
  # result in variable j, we can traverse JSON as traversing
  out <- data.frame(rxnormId = as.integer(j$idGroup$rxnormId))
  # output is just a list of strings, we will extend it with more
  if (nrow(out) > 0) {
    out$input = input; out$match = 1:nrow(out)
  }
  out
}
```

example = 'lyrica'
example = 'findRxCuibyString(example)
rxnormId  input match
1 593441 lyrica 1

example = 'atenolol'
example = 'nexium'
example = 'Esomeprazole'
example = 'esomeprazole'
Example = 'lyrica'
findRxCuibyString(example)

# JSON parsing
input = '283742' # esomeprazole
whatFunction = 'allrelated'

j2 <- fromJSON(URLencode(url))
str(j2, max.level = 1)
str(j2$allRelatedGroup$conceptGroup)

```r
# traverse the tree
str(j2$allRelatedGroup)

# using JSON parsing shortcut
j3<-jsonlite::fromJSON(URLEncode(url)
str(j3$allRelatedGroup$conceptGroup)
str(j3$allRelatedGroup$conceptProperties)

# making it one large table
oneBigTable<-plyr::bind.fill(j3$allRelatedGroup$conceptGroup)
oneBigTable

# A tibble: 68 x 7
  rxuci name    synonym tty language suppress umlscui
  <chr> <chr>    <chr> <chr> <chr>    <chr>    <chr>
1 593441 Lyrica ""    BN    ENG    N    C15702~
2 316945  Extende~ ""    DF    ENG    N    C09915~
3 316965 Oral Ca~ ""    DF    ENG    N    C09915~
4 316968 Oral So~ ""    DF    ENG    N    C09915~
5 187832  pregaba~ ""    IN    ENG    N    C06579~
6 607018  pregaba~ Lyrica 1~ SBD  ENG    N    C16367~
7 607020  pregaba~ Lyrica 1~ SBD  ENG    N    C16383~
8 607022  pregaba~ Lyrica 2~ SBD  ENG    N    C16373~
9 607024  pregaba~ Lyrica 2~ SBD  ENG    N    C16367~
```
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<td>24 HR Lyrica 82.5 MG Ext...</td>
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<td>N</td>
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<td>ENG</td>
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<td>SBD</td>
<td>ENG</td>
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<td>C1630443</td>
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Showing 12 to 25 of 86 entries
Part 3 – Experience with OHDSI

Olivier Bodenreider, MD, PhD, NLM
Vojtech Huser, MD, PhD, NLM
Christian Reich, MD, PhD, IQVIA
Part 3 overview

Clinical data models

Handling international drugs
Clinical data models

Part 3 – Experience with OHDSI
FDA Regulatory Action over Time

Number of FDA-caused Withdrawals

- 1960ies
- 1970ies
- 1980ies
- 1990ies
- 2000ies
FDAAA calls for establishing Risk Identification and Analysis System

SEC. 905. ACTIVE POSTMARKET RISK IDENTIFICATION AND ANALYSIS.

(a) IN GENERAL.—Subtitle (k) of section 505 of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 355) is amended by adding at the end the following:

“3) ACTIVE POSTMARKET RISK IDENTIFICATION.—

“A) DEFINITION.—In this paragraph, the term ‘data’ refers to information with respect to a drug approved under this section or under section 351 of the Public Health Service Act, including claims data, patient survey data, standardized analytic files that allow for the pooling and analysis of data from disparate data environments, and any other data deemed appropriate by the Secretary.

“B) DEVELOPMENT OF POSTMARKET RISK IDENTIFICATION AND ANALYSIS METHODS.—The Secretary shall, not later than 2 years after the date of the enactment of the Food and Drug Administration Amendments Act of 2007, in collaboration with public, academic, and private entities—

“(i) develop methods to obtain access to disparate data sources, including the data sources specified in subparagraph (C);

“(ii) develop validated methods for the establishment of a postmarket risk identification and analysis system to link and analyze safety data from multiple sources, with the goals—

“(1) at least 25

“(II) at least 10

“(III) convene a core group of individuals who are recognized for data privacy and security to the Secretary on the methods for the ethical communication of, pursuant to subparagraph (C), include the development of effective means of drug safety questions.

“C) ESTABLISHMENT OF RISK IDENTIFICATION AND ANALYSIS SYSTEM:

Risk Identification and Analysis System: a systematic and reproducible process to efficiently generate evidence to support the characterization of the potential effects of medical products from across a network of disparate observational healthcare data sources
OMOP Experiment 1 (2009-2010)

- 10 data sources
- Claims and EHRs
- 200M+ lives

OMOP Methods Library

- Inception cohort
- Case control
- Logistic regression

Common Data Model

- Open-source
- Standards-based

Drug

<table>
<thead>
<tr>
<th>Drug</th>
<th>ACE Inhibitors</th>
<th>Angiotension B</th>
<th>Antibiotics: erythromycin, sulfonamides, tetracyclines</th>
<th>Antiepileptics: carbamazepine, phenytoin</th>
<th>Bisphosphonates: alendronate</th>
<th>Tricyclic antidepressants</th>
<th>Typical antipsychotics</th>
<th>Warfarin</th>
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<td>Acute Liver Injury</td>
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<td>Hospitalization</td>
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<td>Mortality after MI</td>
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</table>
OMOP Experiment 2 (2011-2012)

**Methods**
- Case-Control
- New User Cohort
- Disproportionality methods
- ICTPD
- LGPS
- Self-Controlled Cohort
- SCCS

**Drug-outcome pairs**

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<tr>
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<th>Positives</th>
<th>Negatives</th>
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<tr>
<td><strong>Total</strong></td>
<td>165</td>
<td>234</td>
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<td>Myocardial Infarction</td>
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<td>66</td>
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<td>Upper GI Bleed</td>
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<td>Acute Liver Injury</td>
<td>81</td>
<td>37</td>
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<tr>
<td>Acute Renal Failure</td>
<td>24</td>
<td>64</td>
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</tbody>
</table>

**Observational data**
- 4 claims databases
- 1 ambulatory EMR
European OMOP Experiment

Observational data
- Aarhus
- Pedianet
- ARS
- IPCI
- HS
- PHARMO

Methods
- Case-Control
- New User Cohort
- Disproportionality methods
- ICTPD
- LGPS
- Self-Controlled Cohort
- SCCS

Drug-outcome pairs

<table>
<thead>
<tr>
<th>Condition</th>
<th>Positives</th>
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<tbody>
<tr>
<td>Total</td>
<td>165</td>
<td>234</td>
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<tr>
<td>Myocardial Infarction</td>
<td>36</td>
<td>66</td>
</tr>
<tr>
<td>Upper GI Bleed</td>
<td>24</td>
<td>67</td>
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<tr>
<td>Acute Liver Injury</td>
<td>81</td>
<td>37</td>
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<tr>
<td>Acute Renal Failure</td>
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<tr>
<td>Name</td>
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<td>Population</td>
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<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<td>Aarhus</td>
<td>Danish national health registry, covering the Aarhus region. Includes inhabitant registry, drug dispensations, hospital claims, lab values, and death registry.</td>
<td>Denmark</td>
</tr>
<tr>
<td>ARS</td>
<td>Italian record linkage system covering the Tuscany region, including inhabitant registry, drug dispensations, hospital claims, and death registry.</td>
<td>Italy</td>
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<tr>
<td>Health-Search</td>
<td>Italian general practice database (no children)</td>
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<tr>
<td>IPCI</td>
<td>Dutch general practice database</td>
<td>Netherlands</td>
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<tr>
<td>Pedianet</td>
<td>Italian general practice pediatric database</td>
<td>Italy</td>
</tr>
<tr>
<td>PHARMO</td>
<td>Dutch record linkage system. Includes inhabitant registry, drug dispensations, hospital claims, and lab values.</td>
<td>Netherlands</td>
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</tbody>
</table>
OBSERVATIONAL MEDICAL OUTCOMES PARTNERSHIP
• Heterogeneity in estimates due to choice of database
• Heterogeneity in estimates due to analysis choices
• Except little heterogeneity due to outcome definitions
• Good performance (AUC > 0.7) in distinguishing positive from negative controls for optimal methods when stratifying by outcome and restricting to powered test cases
• Self controlled methods perform best for all outcomes
Observational Health Data Sciences and Informatics (OHDSI)
Plans and Ambitions
OMOP: ended in 2013 with Symposium

IMEDS: Program at Reagan-Udall Foundation of the FDA
- Methodological research to inform Industry and Agency
- Research Lab

OHDSI: Open Research Collaborative started by OMOP PIs and coordinated through Columbia University
- Multiple stakeholders: academia, government, industry
- Multiple geographies: US, Europe, Asia-Pacific
- Multiple disciplines: Statistics, epidemiology, informatics, clinical sciences
- Maintains OMOP CDM and Vocabularies
OHDSI’s vision

OHDSI collaborators access a network of 1 billion patients to generate evidence about all aspects of healthcare. Patients and clinicians and other decision-makers around the world use OHDSI tools and evidence every day.

Join us on the journey

http://ohdsi.org
OHDSI: a global community

OHDSI Collaborators:
- >220 researchers in academia, industry and government
- >21 countries

OHDSI Data Network:
- >114 databases from 19 countries
- 1.9 billion patients records (duplicates)
- ~222 million non-US patients
A caricature of the patient journey
Questions asked across the patient journey

- Which treatment did patients choose after diagnosis?
- Which patients chose which treatments?
- How many patients experienced the outcome after treatment?
- What is the probability I will develop the disease?
- What is the probability I will experience the outcome?
- Does treatment cause the outcome more than an alternative?
- Does treatment cause the outcome?
Classifying questions across the patient journey

Clinical characterization: What happened to them?
• What treatment did they choose after diagnosis?
• Which patients chose which treatments?
• How many patients experienced the outcome after treatment?

Patient-level prediction: What will happen to me?
• What is the probability that I will develop the disease?
• What is the probability that I will experience the outcome?

Population-level effect estimation: What are the causal effects?
• Does treatment cause outcome?
• Does one treatment cause the outcome more than an alternative?
OMOP Common Data Model

- Person
  - Observation_period
  - Specimen
  - Death
  - Visit_occurrence
  - Procedure_occurrence
  - Drug_exposure
  - Device_exposure
  - Condition_occurrence
  - Measurement
  - Note
  - Observation
  - Fact_relationship

- Standardized health system data
  - Location
  - Care_site
  - Provider
  - Payer_plan_period
  - Visit_cost
  - Procedure_cost
  - Drug_cost
  - Device_cost

- Standardized economics
  - Concept
  - Vocabulary
  - Concept_relationship
  - Relationship
  - Concept_synonym
  - Concept_ancestor
  - Source_to_concept_map
  - Drug_strength
  - Cohort_definition

- Standardized derived elements
  - Cohort
  - Drug_era
  - Dose_era
  - Condition_era

- Standardized meta-data
  - CDM_source

- Standardized clinical data
  - OMOP Common Data Model
  - Standardized health system data
  - Standardized economics
  - Standardized derived elements
  - Standardized meta-data
Drug Hierarchy

Classifications
- VA Class
- CVX
- NDFRT
- NDFRT Ind
- ATC
- FDB Ind
- ETC
- SPL
- SNOMED

Drugs
- Ingredients
- Drug Forms and Components
- Drug products

Source codes
- CIEL
- NDC
- GPI
- VA-Product
- Gemscript
- EU Product
- DPD
- HCPCS
- MeSH
- Multum
- Oxmis
- Read
- Genseqno
- dm+d
- AMIS
- BDPM
- CPT4

Drug Codes

Procedure Drugs

Standard Drug Vocabulary:
Simple Use Case

Give me all patients who take

Plavix 75 mg Tablets
Branded Drug

clopidogrel 75 MG Oral Tablet [Plavix]
Branded Drug

clopidogrel 75 MG Oral Tablet [Plavix]

Plavix
OMOP Vocabulary

Clinical Drug

clopidogrel 75 MG Oral Tablet

clopidogrel 75 MG Oral Tablet [Plavix]
Drug Form

clopidogrel Tablet

clopidogrel Tablet [Plavix]

clopidogrel 75 MG Oral Tablet

clopidogrel 75 MG Oral Tablet [Plavix]
Drug Form

clopidogrel Tablet

clopidogrel 75 MG Oral Tablet

clopidogrel 75 MG Oral Tablet [Plavix]

clopidogrel Tablet [Plavix]

Tablet
OMOP Vocabulary Relationships

clopidogrel 75 MG

Drug Component

clopidogrel 75 MG
Oral Tablet [Plavix]

clopidogrel 75 MG
Oral Tablet

clopidogrel 75 MG

75 MG
OMOP Vocabulary

Ingredient

clopidogrel

clopidogrel 75 MG

clopidogrel Tablet

clopidogrel Tablet [Plavix]

clopidogrel 75 MG [Plavix]

clopidogrel 75 MG Oral Tablet

clopidogrel 75 MG Oral Tablet [Plavix]

RxNorm
OMOP Vocabulary

Platelet Aggregation Alteration

Platelet Aggregation Inhibitors & Combinations

ANTITHROMBOTIC AGENTS

Platelet aggregation inhibitors excl. heparin

Cerebral Thromboembolism Prevention

clopidogrel 75mg/1 ORAL TABLET, FILM COATED

Clopidogrel 75 MG

clopidogrel Tablet

clopidogrel Tablet [Plavix]

clopidogrel 75 MG [Plavix]

clopidogrel 75 MG Oral Tablet

clopidogrel 75 MG Oral Tablet [Plavix]

Clopidogrel Bisulfate Tab 75 MG (Base Equiv)

clopidogrel bisulfate 75mg/1 ORAL TABLET, FILM COATED [plavix]

CLOPIDOGREL EL 75 MG Oral Enteric Coated Tablet [PLAV]

Clopidogrel 75mg tablets

GPI

ND

BDPM France

SPL
Relationships
OMOP Vocabulary Common Data Model

1. All concepts in concept table
2. Direct relationships between concepts listed in concept_relationship
3. Multi-step hierarchical relationships pre-processed in concept_ancestor
4. Local codes mapped to concepts through source_to_concept_map
CONCEPT – Single standardized Table

All vocabularies stacked up in one table

Vocabulary ID
All Content in CDM is Coded as Concepts

Concepts are referred to by concept_id

All details are in the `CONCEPT` table:

```sql
SELECT *
FROM concept
WHERE concept_id = 1322185;
```
### 3. Check Descendants (other drug products containing Warfarin and Dabigatran)

```sql
SELECT max_levels_of_separation, descendant.*
FROM concept_ancestor a, concept_descendant d
WHERE a.ancestor_concept_id = 1310149 /* Warfarin or 1322185 Clopidogrel*/
AND descendant_concept_id = descendant.concept_id
ORDER BY max_levels_of_separation;
```
Members of our Drug Classes

Check Ingredient Descendants of Drug Class Anticoagulants

```
SELECT max_levels_of_separation, descendant.*
FROM concept_ancestor a, concept descendant
WHERE a.ancestor_concept_id = 21600961 /* ATC Antithromboic Agent */
AND a.descendant_concept_id = descendant.concept_id
AND descendant.concept_class = 'Ingredient'
ORDER BY max_levels_of_separation;
```
Fulfilling the Use Case

Example queries for the Drug Era table

```sql
/*
Find all periods of exposure for patients exposed to warfarin
*/

CREATE TEMPORARY TABLE warfarin_all_exposures AS
SELECT
    person_id,
    drug_concept_id,
    drug_start_date,
    drug_end_date
FROM drug_era
WHERE
drug_concept_id IN (1310149 /* warfarin */)
```
Fulfilling Another Use Case

```
/* Find all periods of exposure for patients exposed to warfarin */

CREATE TEMPORARY TABLE warfarin_all_exposures AS
SELECT
  person_id,
  drug_concept_id,
  drug_era_start_date,
  drug_era_end_date
FROM
  drug_era;

WHERE
  drug_concept_id IN (1310149 /* warfarin */)

/*
Fulfills another use case of finding ETC anticoagulants
*/

WHERE
  drug_concept_id IN (1310149 /* warfarin */)

SELECT descendant.concept_id
FROM concept_ancestor a, concept descendant
WHERE a.ancestor_concept_id = 21500803 /* ETC Anticoagulants */
    AND a.descendant_concept_id = descendant.concept_id
```
Many Other Use Cases

OMOP Vocabulary Queries

Drug Queries

The following drug domain queries are available:

- D01: Find drug concept by concept ID
- D02: Find drug or class by keyword
- D03: Find ingredients of a drug
- D04: Find drugs by ingredient
- D05: Find generic drugs by ingredient
- D06: Find branded drugs by ingredient
- D07: Find single ingredient drugs by ingredient
- D08: Find drug classes for a drug or ingredient
- D09: Find drugs by drug class
- D10: Find ingredient by drug class
- D11: Find source codes by drug class
- D12: Find indications for a drug
- D13: Find indications as condition concepts for a drug
- D14: Find drugs for an indication
- D15: Find drugs for an indication provided as condition concepts
- D16: Find drugs for an indication by indication type
- D17: Find ingredients for an indication

http://vocabqueries.omop.org/
Handling international drugs ("RxNorm extension")

Part 3 – Experience with OHDSI
Germany: AMIS

Ergebnisse

Suchschnitt

Sortierte Suchschnitte sind mit einem * markiert
alle Suchschnitte anzeigen

2 * Arzneimittelnname: clopidogrel? 238
1 AJ25
Stand: 11.11.2016 07:32:00

Arzneimittel

Suchschnitt: Arzneimittelnname: clopidogrel?

Ergebnis 1-10 von 338

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<td>Acino Pharma GmbH (BS 2)</td>
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France

BASE DE DONNÉES PUBLIQUE DES MÉDICAMENTS

Version 1.0

MÉDICAMENT GÉNÉRIQUE : IL A PLUSIEURS CORDES À SON ARC

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Fichier des informations importantes (en direct)
Plavix Prepackaged Product
Resources

Part 3 – Experience with OHDSI
RxNorm Extension Composition

BDMD
Ingredient Drug Products
2081 243
574 13238

NDC
Ingredient Drug Products
2745
19139

dm+d
Ingredient Drug Products
2240 171
6443 25203

RxNorm RxNorm Extension
Drug Forms Internationally

142
1. Download
http://athena.ohdsi.org

2. Rebuild (not for the faint of heart)
https://github.com/OHDSI/Vocabulary-v5.0

3. Documentation (incomplete still)
Questions

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