



“Informatics and Interoperability: Practical Tools and Strategies for Analyzing Real World Data”

Presented by:

Scott D. Nelson, PharmD, MS, Assistant Professor, Department of Biomedical Informatics
Vanderbilt University Medical Center, Nashville, TN, USA

Olivier Bodenreider, MD, PhD, Senior Scientist & Branch Chief, Cognitive Science Branch
U.S. National Library of Medicine, Bethesda, MD, USA

Daniel C. Malone, PhD, RPh, FAMCP, Professor of Pharmacy, College of Pharmacy &
Mel and Enid Zuckerman College of Public Health
University of Arizona, Tucson, AZ, USA

Richard D. Boyce, PhD, Associate Professor, Department of Biomedical Informatics,
University of Pittsburgh, Pittsburgh, PA, USA

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Objectives

- Describe three levels of information interoperability and explain why they are important to outcomes research.
- Explain the strengths and limitations of different methods for identifying medications within a clinical data set.
- Access and utilize medication information contained in RxNorm.
- List several potential strengths and limitations of using a common data model and standard vocabulary for outcomes and pharmacoepidemiologic research.



Meet and greet!

- Communication
 - Meet your neighbor
 - Name
 - Where you're from
 - Why you're here
 - Something interesting



What is interoperability?

“the ability of two or more systems or components to exchange information and to use the information that has been exchanged.”

- Institute for Electrical and Electronics Engineering (IEEE)



Example

- Send a message to your neighbor
 - Pt. X (1234) has a blood pressure of 120/80
 - Pt. Y (9876) is taking 81 mg of aspirin by mouth once a day
 - Pt. Z (4567) has blood type O negative
 - Must be parse-able
 - Special character for separating fields
 - .,|\@_-*



Pt. X (1234) has a blood pressure of 120/80

Pt name,MRN,Observtion,Value
“X”,1234,“BP”,“120/80”

Pt name	MRN	Observation	Value
X	1234	BP	120/80

Blood_pressure = MRN^Systolic_BP^Diastolic_BP
Blood pressure^1234^120^80

MRN	Systolic BP	Diastolic BP
1234	120	80



Example

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Example

- Send a message to your neighbor
 - How was the message sent?
 - Text message, messenger, paper, etc.
 - What was the message structure?
 - What was first? How was the data separated?
 - Was there a coding scheme used?
 - Abbreviations? Codes? Or free-text?



Levels of interoperability

Foundational

- Ability to communicate
- Send and receive messages

Structural

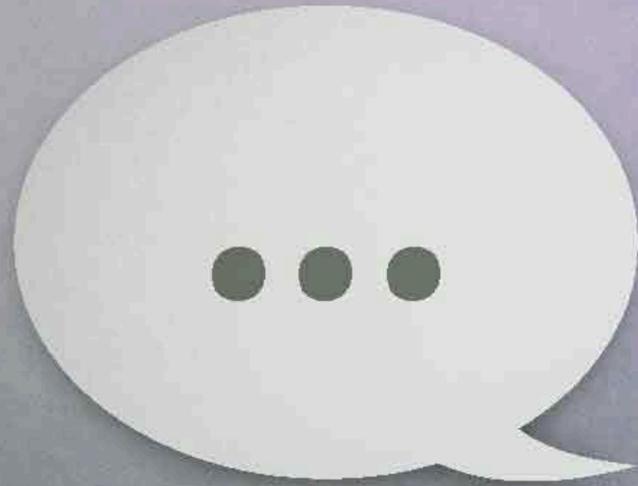
- Functional understanding
- Can understand data fields, but not contents

Semantic

- Shared understanding
- Recognize and interpret data fields and contents



Foundational Interoperability





Foundational Interoperability

Hospital A

Patient taking APAP, and has
serum creatinine of 1.2

Hospital B

50580-112-06|1|PO|Q4h
OBX|1|CE|A028^S. CRT

Hospital C

D000082_1_PO_MESHPA
1.2_scrt_1245_pt



Structural Interoperability

CONSULADO GENERAL DE PANAMA

SOLICITUD DE VISAS AUTORIZADAS

FECHA: _____

NOMBRE COMPLETO: _____

PASAPORTE No. _____

EXPIRACION: _____

NACIONALIDAD: _____

OCUPACION: _____
OCCUPATION:

FECHA DE NACIMIENTO: _____

PAIS DE RESIDENCIA _____

DEPENDIENTES: _____

VISA QUE SOLICITA: _____

TIEMPO DE ESTADIA: _____

MOTIVO DE VIAJE: _____

VISAS DE OTROS PAISES: _____



Structural Interoperability





Structural Interoperability



- HL7 V2.x
- HL7 V3.x
- Clinical Document Architecture (CDA)
- FHIR  FHIR[®]©

Helps structure the information being sent

Sample HL7 v2.x Message

```
MSH|^~\&|LABGL1||DMCRES||199812300100||ORU^R01|LABGL1199510221838581|P|2.3
||NE|NE
PID||6910828^Y^C8||Newman^Alfred^E||19720812|M|W|25 Centscheap Ave^^
Whatmeworry^UT^85201^^P|| (555)777-6666| (444)677-7777||M||773789090
OBR||110801^LABGL|387209373^DMCRES|18768-2^CELL COUNTS+DIFFERENTIAL TESTS
(COMPOSITE)^LN||199812292128||35^ML|||||
IN2973^Schadow^Gunther^^^^MD^UPIN
|||||||^Once|||||CA20837^Spinosa^John^^^^MD^UPIN

OBX||NM|4544-3^HEMATOCRIT (AUTOMATED)^LN||45||39-49
|||F||199812292128||CA20837
OBX||NM|789-8^ERYTHROCYTES COUNT (AUTOMATED)^LN||4.94|10*12/mm3
|4.30-5.90||||F||199812292128||CA20837
```

Segments

- MSH: Message Header
- PID: Patient Identification
- OBR: Observation Request
- OBX: Observation Result

Delimiters

- | Field
- ^ Component
- & Subcomponent
- ~ Repetition
- \ Escape Character



```
<Patient xmlns="http://hl7.org/fhir">
```

```
<id value="glossy"/>
```

```
<meta>
```

```
<lastUpdated value="2014-11-13T11:41:00+11:00"/>
```

```
</meta>
```

```
<text>
```

```
<status value="generated"/>
```

```
<div xmlns="http://www.w3.org/1999/xhtml">
```

```
<p>Henry Levin the 7th</p>
```

```
<p>MRN: 123456. Male, 24-Sept 1932</p>
```

```
</div>
```

```
</text>
```

```
<extension url="http://example.org/StructureDefinition/trials">
```

```
<valueCode value="renal"/>
```

```
</extension>
```

```
<identifier>
```

```
<use value="usual"/>
```

```
<type>
```

```
<coding>
```

```
<system value="http://hl7.org/fhir/v2/0203"/>
```

```
<code value="MR"/>
```

```
</coding>
```

```
</type>
```

```
<system value="http://www.goodhealth.org/identifiers/mrn"/>
```

```
<value value="123456"/>
```

```
</identifier>
```

```
<active value="true"/>
```

```
<name>
```

```
<family value="Levin"/>
```

```
<given value="Henry"/>
```

```
<suffix value="The 7th"/>
```

```
</name>
```

```
<gender value="male"/>
```

```
<birthDate value="1932-09-24"/>
```

```
<careProvider>
```

```
<reference value="Organization/2"/>
```

```
<display value="Good Health Clinic"/>
```

```
</careProvider>
```

```
</Patient>
```

Resource
Identity &
Metadata

Human
Readable
Summary

Extension
with URL to
definition

Standard
Data:
• MRN
• Name
• Gender
• Birth Date
• Provider





Structural Interoperability

Hospital A

OBX||1|CE|2730-72^Creatinine

Hospital B

OBX||1|CE|A028^S. CRT

Hospital C

OBX||1|CE|35^Serum Creatinine

HL7 2.x



Example modifications

- Make the following modifications to you message:
 - Blood pressure in the right arm
 - Blood pressure laying down
 - History of aspirin $\frac{1}{4}$ of a 325 mg tablet
 - Blood type of fetus
 - Blood type of donor
 - Negation and uncertainty



Pre- vs post-coordination

- warfarin 5 mg tablet

Pre-coordinated

Medication

SCD:

Medication

SCDF:

Strength:

Post-coordinated

Medication

Ingredient:

Dose form:

Strength:



Pre- vs post-coordination

Pre-coordinated

Left arm x-ray

Right arm x-ray

$$2 * 1 * 1 = 2$$

Post-coordinated

Left arm x-ray

Right

$$2 + 1 + 1 = 4$$



Pre- vs post-coordination

Pre-coordinated

- Left arm x-ray
- Right arm x-ray
- Left leg x-ray
- Right leg x-ray

$$2 * 2 * 1 = 4$$

Post-coordinated

- Left arm x-ray
- Right leg

$$2 + 2 + 1 = 5$$



Pre- vs post-coordination

Pre-coordinated

- Left arm x-ray
- Right arm x-ray
- Left leg x-ray
- Right leg x-ray
- Left arm MRI
- Right arm MRI
- Left leg MRI
- Right leg MRI

$$2 * 2 * 2 = 8$$

Post-coordinated

- Left arm x-ray
- Right leg MRI

$$2 + 2 + 2 = 6$$



Pre- vs post-coordination

Pre-coordinated

- Left arm x-ray
- Left arm MRI
- Left arm CT
- Left arm US
- Left hand x-ray
- Left hand MRI
- Left hand CT
- Left hand US
- Left leg x-ray
- Left leg MRI
- Left leg CT
- Left foot x-ray
- Left foot MRI
- Left foot CT
- Left foot US
- Left breast x-ray
- Left breast MRI
- Left breast CT
- Left breast US
- Left kidney x-ray
- Left kidney MRI
- Left kidney CT
- Left kidney US
- Left knee x-ray
- Left knee MRI
- Left knee CT
- Left knee US

KABOOM

$$3 * 7 * 4 = 84$$

Post-coordinated

- Left arm x-ray
- Right hand MRI
- Bilat leg CT
- foot US
- breast
- kidney
- knee

$$3 + 7 + 4 = 14$$



Structural Interoperability

The/dog/eats/red/meat

Article/subject noun/verb/adjective/direct object noun

The/cat/sings/blue/trees



Structural Interoperability

When is a cold just a cold?

- Cold – sickness (patient has a cold)
- Cold – temperature (object is cold – give pt. cold packs)
- Cold – feeling (pt. complains of feeling cold in here)
- Cold – symbolism (gave me the cold shoulder)
- COLD - Computer Output to Laser Disk (term for CD or DVD)



Semantic Interoperability

Form 1040	Department of the Treasury—Internal Revenue Service (99) U.S. Individual Income Tax Return	2014	OMB No. 1545-0074	IRS Use Only—Do not write or staple in this space.
For the year Jan. 1–Dec. 31, 2014, or other tax year beginning _____, 2014, ending _____, 20_____			See separate instructions.	
Your first name and initial _____		Last name _____		Your social security number _____
If a joint return, spouse's first name and initial _____		Last name _____		Spouse's social security number _____
Home address (number and street). If you have a P.O. box, see instructions. _____			Apt. no. _____	▲ Make sure the SSN(s) above and on line 6c are correct.
City, town or post office, state, and ZIP code. If you have a foreign address, also complete spaces below (see instructions).				
Foreign country name _____		Foreign province/state/country _____	Foreign postal code _____	
				Presidential Election Campaign Check here if you, or your spouse if filing jointly, want \$3 to go to this fund. Checking a box below will not change your tax or refund. <input type="checkbox"/> You <input type="checkbox"/> Spouse
Filing Status	Check only one box.			
	1 <input type="checkbox"/> Single 2 <input type="checkbox"/> Married filing jointly (even if only one had income) 3 <input type="checkbox"/> Married filing separately. Enter spouse's SSN above and full name here. ▶ _____ 4 <input type="checkbox"/> Head of household (with qualifying person). (See instructions.) If the qualifying person is a child but not your dependent, enter this child's name here. ▶ _____ 5 <input type="checkbox"/> Qualifying widow(er) with dependent child			
Exemptions	6a <input type="checkbox"/> Yourself. If someone can claim you as a dependent, do not check box 6a b <input type="checkbox"/> Spouse			
	Boxes checked on 6a and 6b _____ No. of children on 6c who: • lived with you _____ • did not live with you due to divorce or separation (see instructions) _____ Dependents on 6c not entered above _____ Add numbers on lines above ▶ _____			
	c Dependents:			
	(1) First name	Last name	(2) Dependent's social security number	(3) Dependent's relationship to you
				(4) <input checked="" type="checkbox"/> if child under age 17 qualifying for child tax credit (see instructions)
				<input type="checkbox"/>
	d. Total number of exemptions claimed _____			

If more than four dependents, see instructions and check here



Structural vs Semantic

Structural

Source	Lab	Value	Units
Hospital A	2730-72	1.6	mg/dl
Hospital B	A028	0.014	g/L
Hospital C	35	0.9	mg/dl

Semantic

Source	Lab	Value	Units
Hospital A	2160-0	1.6	mg/dl
Hospital B	2160-0	1.4	mg/dl
Hospital C	2160-0	0.9	mg/dl



Semantic Interoperability

Requires standard format and standard terminology





Standard Vocabularies

Domain	Vocabulary
Labs	LOINC, SNOMED CT
Medications	RxNORM, NDC, ATC, NDF-RT, FDB, Medi-span, Multium, FDA, MeSH, SNOMED CT
Demographics	CDC race, HL7 administrative
Findings/conditions	SNOMED CT, MEDRA, ICD-10, ICD-9
Procedures/diagnoses	HCPCS, ICD-10, ICD-9, CPT
Observations	LOINC, SNOMED CT

HOW STANDARDS PROLIFERATE:

(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION:
THERE ARE
14 COMPETING
STANDARDS.

14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES.

YEAH!

SOON:

SITUATION:
THERE ARE
15 COMPETING
STANDARDS.

The beauty about standards is that there are many to choose from...



Best available Standards

- Labs and vitals
 - LOINC
- Medications
 - RxNorm
- Observations
 - SNOMED CT
- <https://www.healthit.gov/policy-researchers-implementers/section-i-best-available-vocabularycode-setterminology-standards-and>
- <http://hl7.org/fhir/terminologies-systems.html>



Labs – LOINC

- Logical Observation Identifiers Names and Codes (LOINC)
- Preferred for labs and vital signs
- Developed by Regenstrief
- More info at
 - loinc.org
 - search.loinc.org



Labs – LOINC

- Component
 - Creatinine, INR, sodium, ejection fraction, etc.
- Property
 - Mass, pressure, length, temp, etc.
- Timing
 - Point in time, max, min, time range, etc.
- System
 - Urine, blood, serum, tricuspid valve, etc.
- Scale
 - Quantitative, ordinal, nominal, etc.
- Method (optional)
 - Siting, estimated, count, etc.



LOINC	LongName	Component	Property	Timing	System	Scale	Method
20624-3	Creatinine [Mass/volume] in 24 hour Urine	Creatinine	MCnc	24H	Urine	Qn	
2159-2	Creatinine [Mass/volume] in Amniotic fluid	Creatinine	MCnc	Pt	Amnio fld	Qn	
38483-4	Creatinine [Mass/volume] in Blood	Creatinine	MCnc	Pt	Bld	Qn	
12190-5	Creatinine [Mass/volume] in Body fluid	Creatinine	MCnc	Pt	Body fld	Qn	
2160-0	Creatinine [Mass/volume] in Serum or Plasma	Creatinine	MCnc	Pt	Ser/Plas	Qn	
2161-8	Creatinine [Mass/volume] in Urine	Creatinine	MCnc	Pt	Urine	Qn	
35674-1	Creatinine [Mass/volume] in Urine collected for unspecified duration	Creatinine	MCnc	XXX	Urine	Qn	



Medications – RxNorm

- Unique identifiers for drugs and ingredients
- Crosswalk between other terminologies
- Produced by National Library of Medicine (NLM)
- More info at
 - **RxNorm**
 - www.nlm.nih.gov/research/umls/rxnorm
 - RxNav
 - Visual navigation of RxNorm
 - mor.nlm.nih.gov/RxNav
 - RxMix
 - API for RxNorm and RxImageAccess
 - mor.nlm.nih.gov/RxMix



Observations – SNOMED CT

- Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT)
- Contains
 - Concepts, descriptions, and relationships
- Maintained by the International Health Terminology Standards Development Organization (IHTSDO)
- More info at
 - www.nlm.nih.gov/research/umls/Snomed/snomed_main.html
 - browser.ihtsdotools.org



Diagnosis codes – ICD-10

- International Statistical Classification of Diseases and Related Health Problems, 10th revision
Maintained by the World Health Organization (WHO)
- More info at

<http://www.icd10data.com/ICD10PCS/Codes>





ICD-9: 250 Diabetes mellitus

- 250.0 Diabetes mellitus without mention of complication
- 250.1 Diabetes with ketoacidosis
- 250.2 Diabetes with coma
- 250.3 Diabetes with renal manifestations
- 250.4 Diabetes with ophthalmic manifestations
- 250.5 Diabetes with neurological manifestations
- 250.6 Diabetes with peripheral circulatory disorders
- 250.7 Diabetes with other specified manifestations
- 250.9 Diabetes with unspecified complications



ICD-10: E10-E14 Diabetes Mellitus

- E10 Insulin-dependent diabetes mellitus
 - .0 With coma
 - .1 With ketoacidosis
 - .2+ With renal complications
 - .3+ With ophthalmic complications
 - .4+ With neurological complications
 - .5 With peripheral circulatory complications
 - .6 With other specified complications
 - .7 With multiple complications
 - .8 With unspecified complications
 - .9 Without complications
- E11 Non-insulin-dependent diabetes mellitus
- E12 Malnutrition-related diabetes mellitus
- E13 Other specified diabetes mellitus
- E14 Unspecified



Procedures – CPT

- Current Procedural Terminology (CPT)
- Part of Healthcare Common Procedural Coding System
 - HCPCS codes by CMS
- Contains
 - Billable procedures
- Maintained by the American Medical Association (AMA)
- More info at
 - <http://www.ama-assn.org/ama/pub/physician-resources/solutions-managing-your-practice/coding-billing-insurance/cpt.shtml>
 - http://www.cms.gov/Medicare/Coding/MedHCPCSGenInfo/HCPSC_Coding_Questions.html



CPT code examples

- 92526** Treatment of swallowing dysfunction and/or oral function for feeding
- 92507** Treatment of speech, language, voice, communication, and/or auditory processing disorder, individual
- 92521** Evaluation of speech fluency (eg, stuttering, cluttering)
- 92522** Evaluation of speech sound production (eg, articulation, phonological process, apraxia);
- 92524** Behavioral and qualitative analysis of voice and resonance



Questions





Issues in Drug Product Identification

Dan Malone, RPh, PhD

Professor

University of Arizona



Pharmaceutical Claims

- National Council for Prescription Drug Programs (NCPDP) Standard
- Telecommunication between pharmacies and payers

Mandatory
Transaction Header Segment <i>Segment Separator</i>
Insurance Segment
Situational
<i>Segment Separator</i> Patient Segment
Mandatory - first Claim/Encounter
<i>Group Separator</i> <i>Segment Separator</i> Claim Segment <i>Segment Separator</i> Pricing Segment
Situational
<i>Segment Separator</i> Pharmacy Provider Segment <i>Segment Separator</i> Prescriber Segment <i>Segment Separator</i> Coordination of Benefits/Other Payments Segment <i>Segment Separator</i> Workers' Compensation Segment <i>Segment Separator</i> DUR/PPS Segment <i>Segment Separator</i> Coupon Segment <i>Segment Separator</i> Compound Segment <i>Segment Separator</i> Clinical Segment <i>Segment Separator</i>



Pharmaceutical Claims

- Real-time pharmaceutical claims permit assessment of drug exposure
- Common elements in prescription claims:
 - Date of service (Mandatory)
 - Provider (pharmacy)
 - Cardholder ID (Mandatory)
 - Person code (Situational)
 - Product identifier
 - Product quantity
 - Prescriber identifier



Pharmaceutical claim **REQUIRED** data elements

- Product service ID (NDC)
- Prescription number
- Quantity dispensed
- Days supply
- Date prescription written
- Ingredient cost
- Gross amount due



Pharmaceutical claim OPTIONAL data elements

- Patient first name
- Number of refills authorized
- Unit of measure
- Prior authorization number
- Patient paid amount
- Prescriber ID; Prescriber Last Name



Drug Knowledge Databases

- Proprietary companies build and maintain drug knowledge databases
- Primary purpose: Drug pricing
- Secondary purposes (not exhaustive):
 - Pharmacy reimbursement
 - Clinician decision support
 - Drug-drug interactions
 - Auxiliary labels
 - Consumer drug information



Drug Product Identification

- How do I identify the products of interest for my study?
 - Drug name
 - Multiple spellings
 - National Drug Codes
 - Useful for limited number of products
 - Very specific
 - Therapeutic Classes
 - Useful for many “similar” products
 - Not specific



Methods to Identify Exposure

- Drug Name
- Manufacturer NDC codes
 - Single source – limited manufacturers
 - Multiple source (generic) – many manufacturers
- Therapeutic classification



Product Name from Medicaid Claims

Product Name	Frequency
COUMADIN	270
COUMADIN TAB	13
COUMADIN TABLET	215
JANTOVEN	130
JANTOVEN TAB	24
JANTOVEN TABLET	262
WARFARIN	1,093
WARFARIN TAB	763
WARFARIN SODIUM	8,717
WARFARIN SODIUM TA	95
WARFARIN SODIUM TAB	516
WARFARIN SODIUM TABL	587
WARFARIN SODIUM TABLET	8,555



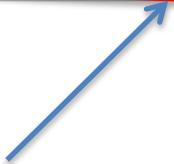
Product Names for Warfarin in Medi-Span Drug Database

Product	Frequency	Percentage
Coumadin	117	28.2
Jantoven	42	10.1
Warfarin Sodium	253	61.0
Warfarin Sodium Amorphous	2	0.5
Warfarin Sodium Clathrateform	1	0.2
Total NDCs	415	100.0



Select “Warfarin” Observations from Medi-Span File

prodNam	totPkgQty	pkgDesc	mfgName	labelerTyp	fmtIdNbr	genericNam
WARFARIN SODIUM	1,000.00	BOTTLE	TEVA PHARMACEUTICALS USA	G	00555-0831-05	Warfarin Sodium
JANTOVEN	100.00	BOTTLE	UPSHER-SMITH	O	00832-1211-00	Warfarin Sodium
WARFARIN SODIUM	30.00	BOTTLE	DISPENSEXPRESS	G	68115-0359-30	Warfarin Sodium
WARFARIN SODIUM	15.00	BOTTLE	PHYSICIANS TOTAL CARE	O	54868-4349-02	Warfarin Sodium
COUMADIN	100.00	BOTTLE	B-M SQUIBB U.S. (PRIMARY CARE)	B	00056-0169-70	Warfarin Sodium
WARFARIN SODIUM	100.00	BOTTLE	TARO	G	51672-4027-01	Warfarin Sodium



Brand name product



NDC



Unique Warfarin Manufacturers Listed in Medi-Span

Manufacturers/Labelers	Manufacturers/Labelers
A-S MEDICATION SOLUTIONS	NUCARE PHARMACEUTICALS
AMERICAN HEALTH PACKAGING	PALMETTO STATE PHARMACEUTICALS
AQ PHARMACEUTICALS	PCCA
B-M SQUIBB U.S. (PRIMARY CARE)	PDRX PHARMACEUTICAL
CORE PHARMACEUTICAL	PHYSICIAN PARTNER
DHS INC. WORKMAN COMP	PHYSICIANS TOTAL CARE
DISPENSEXPRESS	PREPAK SYSTEMS
DISPENSING SOLUTIONS INC.	QUALITY CARE
DRX	SANDOZ
GENPHARM LP	SOUTHWOOD PHARMACEUTICALS
H.J. HARKINS COMPANY, INC.	SPECTRUM
MALLINCKRODT PHARM	TARO
MCKESSON PACKAGING SERVICES	TEVA PHARMACEUTICALS USA
MEDISCA	UPSHER-SMITH
MEDVANTX	VA CMOP DALLAS
	ZYDUS PHARMACEUTICALS (USA)



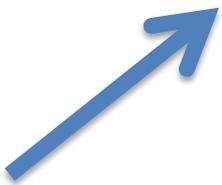
Product Identification: NDCs

- 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



NDC Elements

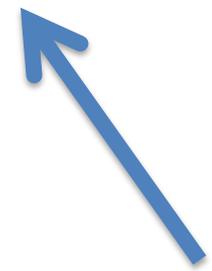
XXXXXX - XXXX - XX



Manufacturer



Product



Packaging



NDC Forms

9999-9999-99 (4-4-2)

99999-999-99 (5-3-2)

99999-9999-9 (5-4-1)



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
- Approximately 200 NDC's added/deleted per month (Source: First DataBank: AMIA 2002 annual meeting)
- 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



Issues with NDCs

- NDC is specific to the manufacturer
- Corporate mergers will affect the NDC value (sometimes)
- Bulk purchasers and relabelers must use a new NDC code
- NDC codes can be re-used after 5 years
- Manufacturers may not follow coding “rules”
 - See Simonaitis and McDonald (AJHP 2009)

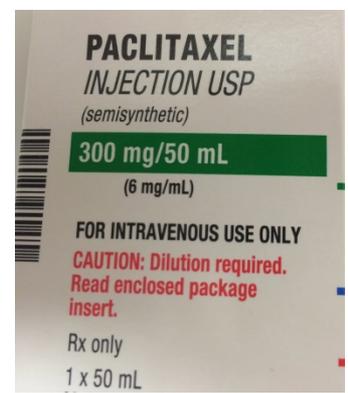


Issues with NDCs

- Reused NDC codes
 - 00074-4335-01(Liposyn)



- 00074-4335-01 (Paclitaxel)





Other Considerations in using NDC

- “Old” NDCs deleted
 - Some vendors provide comprehensive database of all NDCs ever used
- Non-prescription items
 - Most payer databases won’t contain OTC medications



Therapeutic Classes: An Alternative Methods for Product Identification

- Therapeutic classes are present in all proprietary databases
- Class and sub-class designation varies by vendor
- Medications might fall into multiple therapeutic categories



Some Proprietary Drug Knowledge Databases (DKB)

- First DataBank (National Drug Data File Plus)
- Wolter Kluwer (Medi-Span Master Drug Data Base)
- Cerner-Multum (Multum Lexicon)
- Thomson Corporation (Micromedex Red Book)
- Others...



Medi-Span's GPI Code

- 14 digit code to represent drug product
- Hierarchical
- Able to drill down to very specific drugs

Digits	Meaning	Example
58	Drug group	Antidepressants
58-20	Drug class	Tricyclic agents
58-20-00	Drug sub-class	
58-20-00-60	Drug name	Nortriptyline
58-20-00-60-10	Drug name extension	Hydrochloride
58-20-00-60-10-01	Dosage form	Capsule
58-20-00-60-10-01-05	Strength	10mg



First DataBank Generic Sequence Number

- Other names
 - Clinical formulation ID
 - Formerly GCN Sequence number
- 6 Digits
- No Hierarchy
- Multiple classification systems
 - Enhanced Therapeutic Classification System used for group at organ system, therapeutic class and subclass, and active ingredient (with/without salt)
 - Hierarchical Ingredient code (HIC)



First DataBank Examples

- GCN
 - 16033 - Morphine sulfate (10mg/ml Rapi-Ject)
 - 16034 - Morphine sulfate (5mg/ml Rapi-Ject)
 - 25793 - Warfarin Sodium (5mg Tablet)
- Hierarchical Ingredient Code

Characters	Information	Example
1	Organ system	Nervous system
1-2	Pharmacological class	Analgesics
1-3	Therapeutic class	Narcotic Analgesics
1-4	Ingredient (base)	Morphine
1-6	Ingredient (specific)	Morphine Sulfate



AHFS Codes

- American Hospital Formulary Service therapeutic classification system
- Hierarchical classification system
 - 2 digit sequence up to 8 digits
 - Leading zero



Non-Proprietary Classification Systems

- ATC
- Department of Veterans Affairs



Anatomical Therapeutic Chemical Classification (ATC)

- Created and maintained by World Health Organization
- Based on organ system and pharmacological action
 - Single chemical can have more than one code
 - ASA
 - A01AD05 (local oral treatment)
 - B01AC06 (platelet inhibitor)
 - N02BA01 (analgesic / pyretic)



Anatomical Therapeutic Chemical Classification (ATC)

- Five different levels
 - Level One – 14 Anatomical groups

Code	Description
A	Alimentary tract and metabolism
B	Blood and blood forming organs
C	Cardiovascular
D	Dermatologicals
H	Hormonal prep (excluding sex hormones and insulin)
J	Antiinfectives for systemic use
L	Antineoplastic and immunomodulating agents

Code	Description
M	Musculoskeletal system
N	Nervous system
P	Anti-parasitic products
R	Respiratory system
S	Sensory organs
V	Various



Anatomical Therapeutic Chemical Classification (ATC)

- Five different levels
 - Level One – 14 Anatomical groups
 - Level Two - Therapeutic main group
 - 2 digits
 - Ex. A10 - drug used in diabetes



Anatomical Therapeutic Chemical Classification (ATC)

- Five different levels
 - Level One – 14 Anatomical groups
 - Level Two - Therapeutic main group
 - Level Three – Pharmacological/therapeutic subgroups
 - 1 digit
 - Ex. A10B – Blood glucose lowering (excluding insulin)



Anatomical Therapeutic Chemical Classification (ATC)

- Five different levels
 - Level One – 14 Anatomical groups
 - Level Two - Therapeutic main group
 - Level Three – Pharmacological/therapeutic subgroups
 - Level Four – Chemical subgroup
 - 1 digit
 - Ex. A10BA - Biguanides



Anatomical Therapeutic Chemical Classification (ATC)

- Five different levels
 - Level One – 14 Anatomical groups
 - Level Two - Therapeutic main group
 - Level Three – Pharmacological/therapeutic subgroups
 - Level Four – Chemical subgroup
 - Level Five – Chemical substance
 - 2 digits
 - Ex. A10BA02 - Metformin



Anatomical Therapeutic Chemical Classification (ATC)

- Characteristics of ATC
 - Immediate and slow release have same code
 - Different codes for different formulations and route of administration
 - ATC is not strictly a therapeutic classification system
 - New products not belonging to existing 4 level group will be assigned a code of X
 - Combination products typically have 5th level code as 20 or 30



VANDF Classifications

- Department of Veterans Affairs (VA) Drug Classification
 - 5 digit code
 - 2 alpha characters
 - Major classifications
 - AM – antimicrobials
 - HS – Hormones
 - 3 numeric characters
 - AM111 – Penicillins, amino acid derivatives
 - AM113 – Penicillins, extended spectrum penicillins



VA Class Sources

- Available from Pharmacy Benefits Management Services
 - <http://www.pbm.va.gov/nationalformulary.asp>
- Not all NDCs are assigned a VA class code
 - Some products not used in the Department of Veterans Affairs



Summary

- Defining drug exposure can be difficult
- Numerous approaches to selecting drugs of interest
- No approach is 100% accurate
- Don't limit NDCs to originator's codes



RxNorm in action

Olivier Bodenreider, MD, PhD



Lister Hill National Center
for Biomedical Communications
Bethesda, Maryland - USA





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RXNORM BASICS



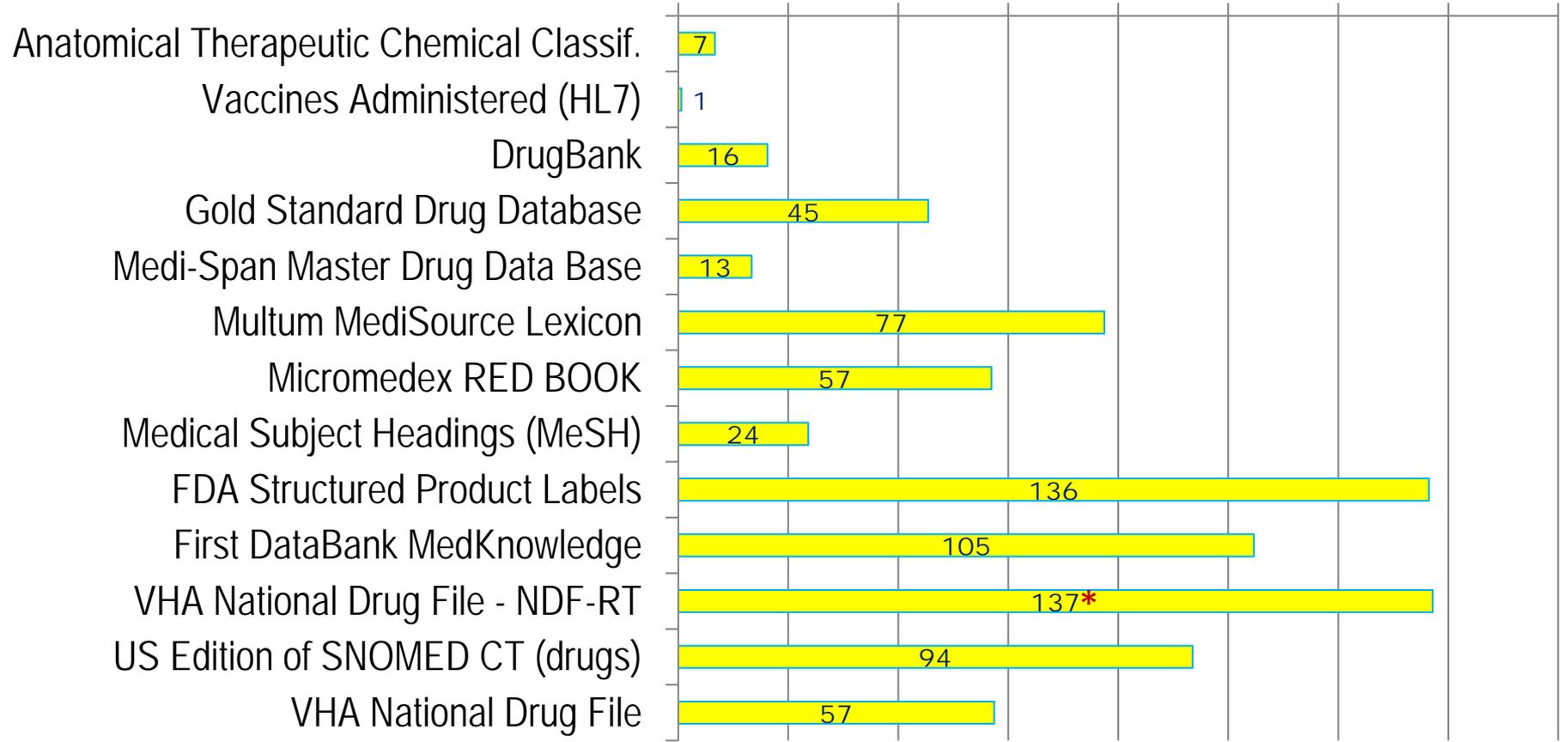
Interoperability among drug vocabularies

- Exchange of information requires standardized names
 - Ordering drugs
 - Checking interactions
 - Inventory management
- No standard naming conventions for drugs
- Integrating drug vocabularies
- Unique identifiers for drugs
- Specify relations among drug entities



Source vocabularies in RxNorm

0 20 40 60 80 100 120 140 160



(terms in thousands, as of March 2017)



Normalization Lexical level

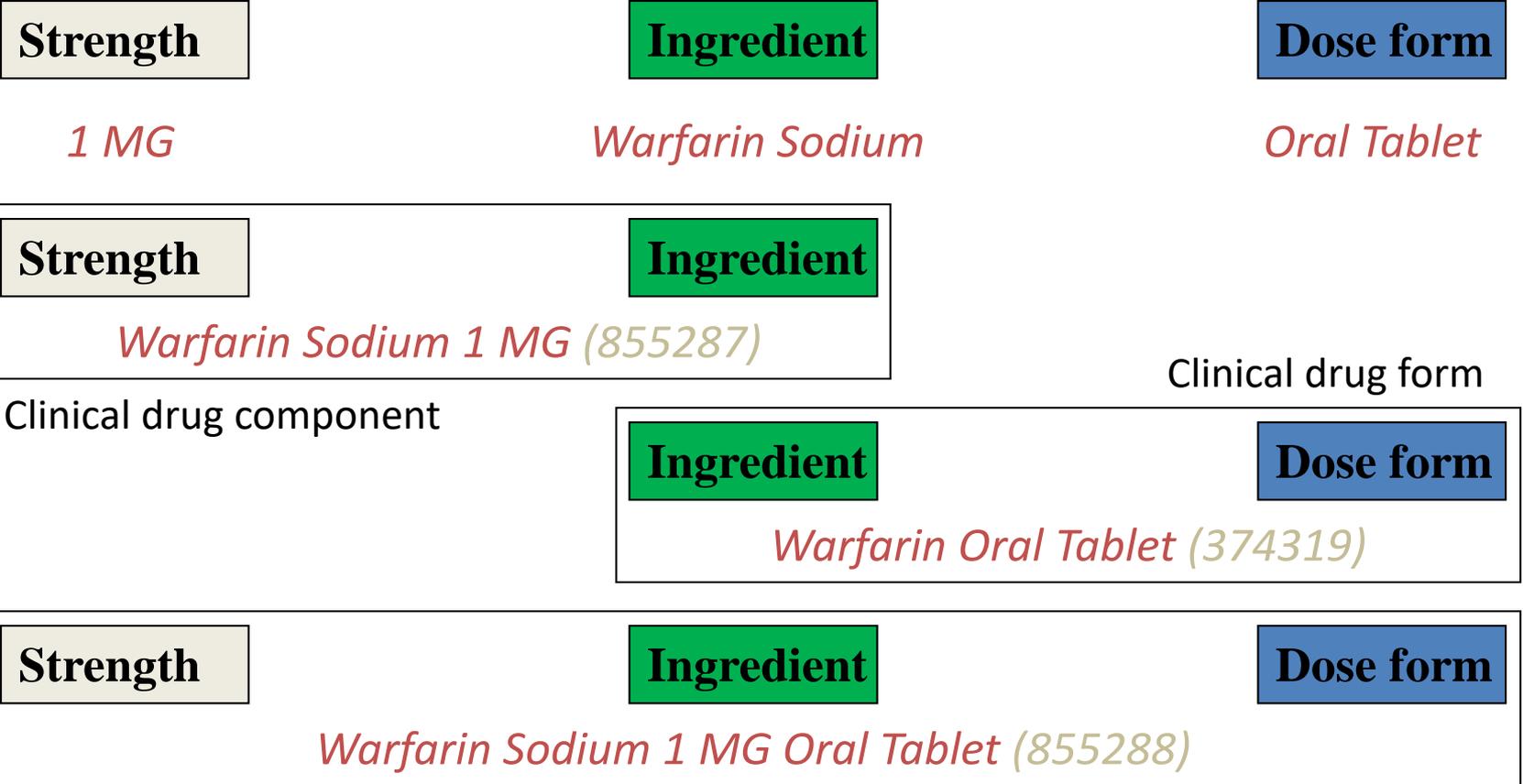
Name	Code	Source
WARFARIN (COUMADIN) NA 1MG TAB	4005203	VANDF
warfarin 1 mg oral tablet	3617	MMSL
WARFARIN NA 1MG TAB,UD	4014039	VANDF
WARFARIN NA 1MG TAB,UD [VA Product]	N0000161787	NDFRT
WARFARIN SODIUM 1 mg ORAL TABLET	14198	NDDF
WARFARIN SODIUM 1 mg ORAL TABLET	60429-784	MTHSPL
Warfarin Sodium 1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



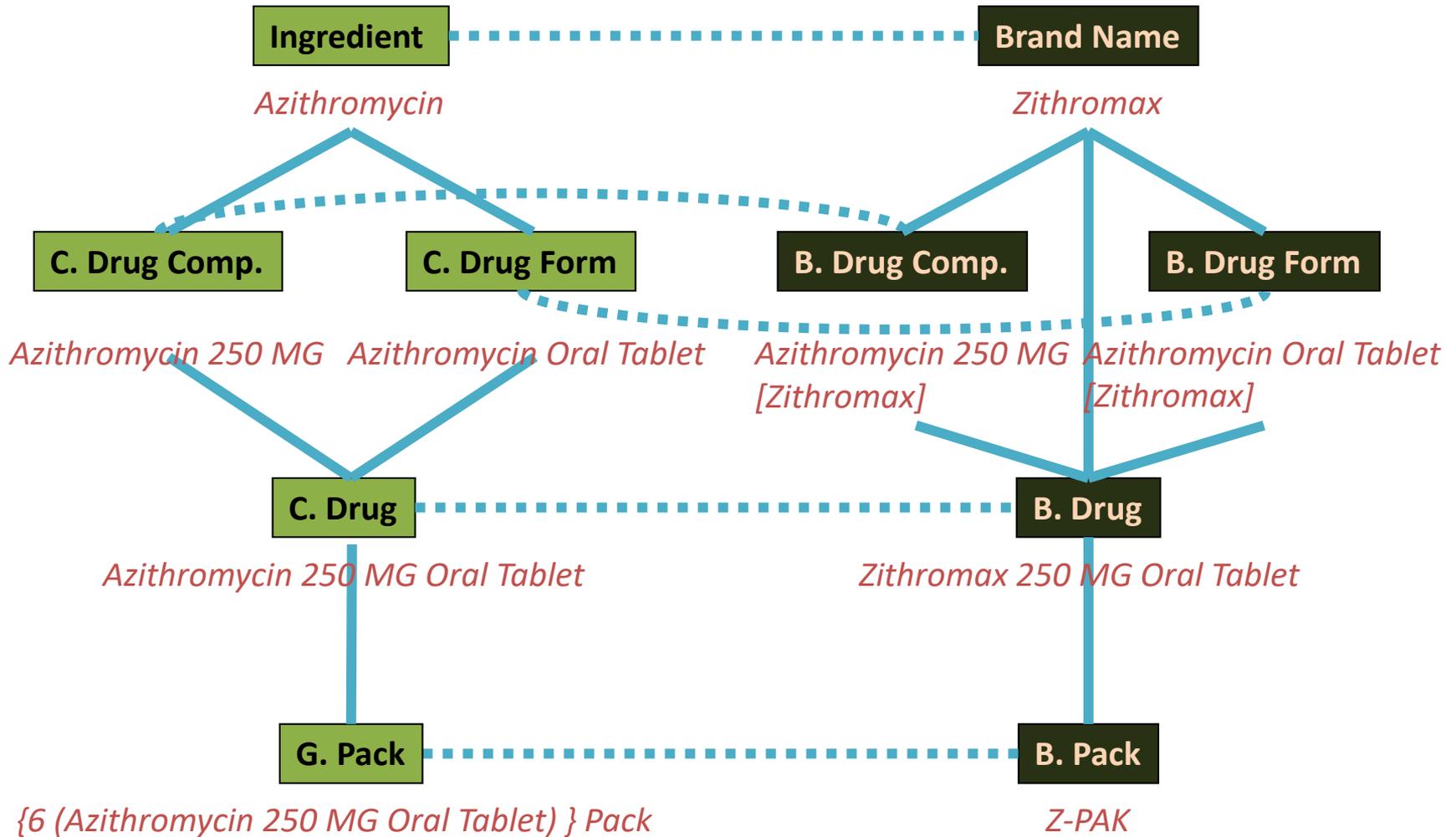
Warfarin Sodium 1 MG Oral Tablet (855288)



Normalized form



Relations among drug entities





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RXNORM IN ACTION



Example Mapping NDCs to ATC drug classes

- NDCs are attached to a clinical drug (SCD) or a branded (drug)
- Branded drugs are mapped to clinical drugs
- Clinical drugs are linked to their ingredient
- Many drug classification systems link classes to ingredient-level drugs (e.g., ATC, NDF-RT, EPC, MeSH pharmacologic action)

A **ALIMENTARY TRACT AND METABOLISM**

A02 **DRUGS FOR ACID RELATED DISORDERS**

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A02BC **Proton pump inhibitors**

ATC code	Name	DDD	U	Adm.R	Note
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		30	mg	P	

Esomeprazole (283742)

Esomeprazole (A02BC05)

Esomeprazole 40 MG Delayed Release Oral Capsule (606730)

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

00186504031

0186-5040-31



NDC 0186-5040-31

Nexium[®]
(esomeprazole magnesium)

30 Delayed-Release Capsules

40 mg*

Rx only

Dispense the accompanying Medication Guide to each patient.

AstraZeneca

*Each delayed-release capsule contains 40 mg esomeprazole. Keep container tightly closed. Store at 25°C (77°F); excursions permitted to 15–30°C (59–86°F). [See USP Controlled Room Temperature]. USUAL ADULT DOSAGE: See package insert. NEXIUM and the color purple as applied to the capsule are registered trademarks of the AstraZeneca group. © AstraZeneca 2012 Mfd. for: AstraZeneca LP, Wilmington, DE 19850 By: Merck Sharp & Dohme Corp., a subsidiary of Merck & Co., Inc., Whitehouse Station, NJ 08889, USA Product of France

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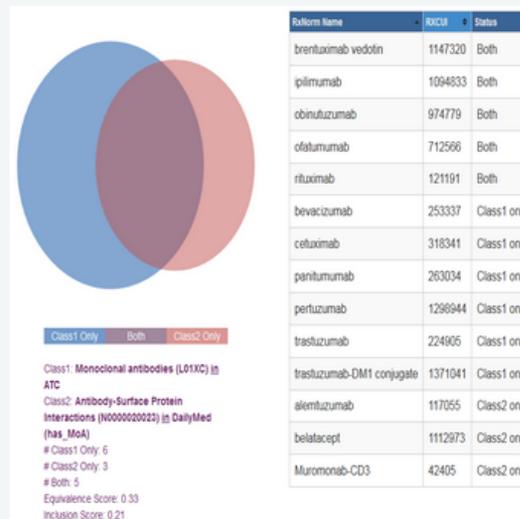
Lot

A new RxNav web application has replaced the java version.

Please help us to improve your site experience by providing us feedback at this [link](#)

RxClass

The RxClass Browser is a web application for exploring and navigating through the class hierarchies to find the RxNorm drug members associated with each class.



RxNav

APIs

RxMix

RxClass

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

News

Statistics

RxNav brand names

Recent brand names added

Arymo	Corphedra
Daxbia	DavOuil HBP

High Priority Drug-Drug Interactions Added

A set of high priority drug-drug interactions have been added to the Interactions API and displayable in RxNav. The source is named

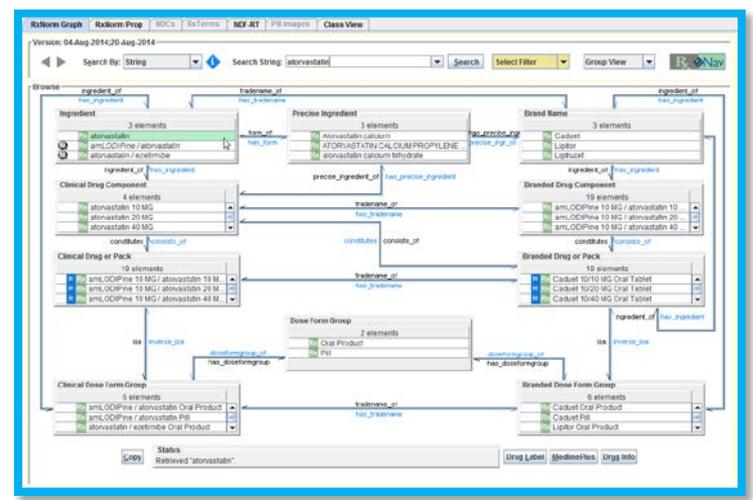
RxNav web version is here!

The RxNav web application is now available, replacing the RxNav java version. Check out the new design and responsiveness. [More](#)

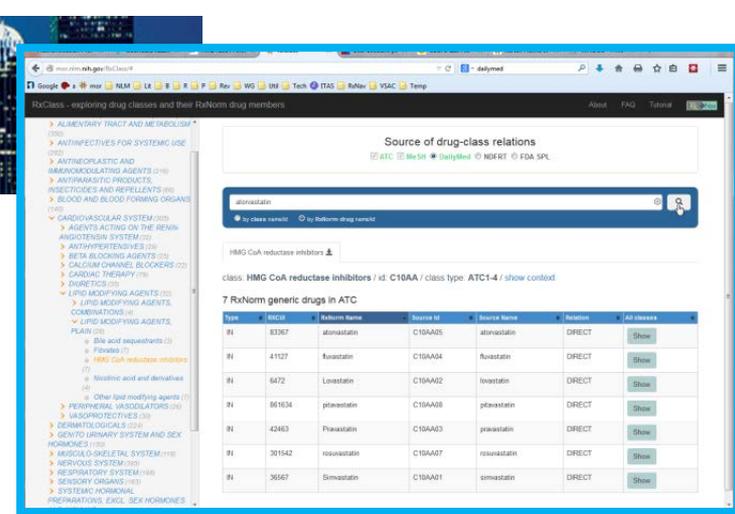


RxNav

- **Drug-centric browser**
 - RxNorm
 - Prescribable subset
 - RxTerms
 - NDF-RT
 - Pill images
 - Drug-drug interactions



- Supports navigation to the rich RxNorm and NDF-RT graphs
- Links to other drug resources
 - DailyMed, MedlinePlus, NLM Drug Information Portal
- Drug-centric “class view”
- Leverages the drug APIs



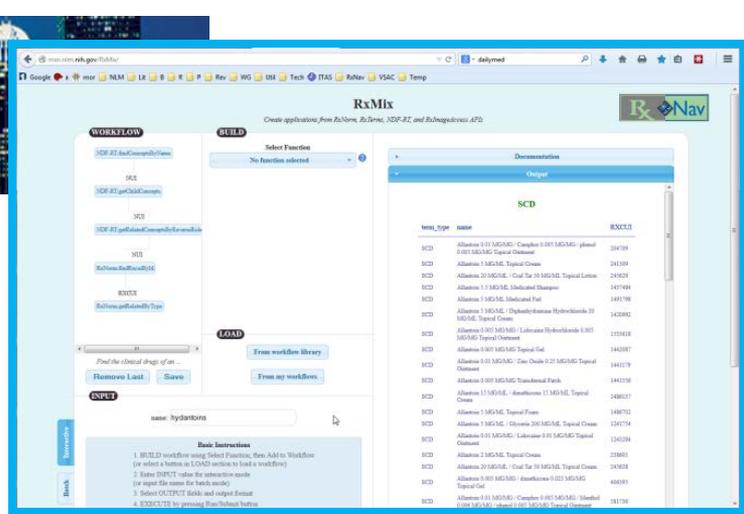
RxClass

- **Class-centric browser for RxNorm drugs**
 - ATC
 - DailyMed (Mechanism of action, Physiologic effect, Chemical structure, FDA classes)
 - MeSH (Pharmacologic actions)
 - NDF-RT (VA classes, Diseases for indications/contra-indications)
- Supports search by drug or by class
- Features
 - Display and navigation
 - All the drugs for a class
 - All the classes for a drug
 - Compute similarity among drug classes (based on shared drug members)



Application programming interfaces (APIs)

- Expose the content of RxNorm, RxTerms and NDF-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, NDF-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



RxMix

- Graphical interface to the drug APIs
 - RxNorm, NDF-RT, RxTerms, RxImageAccess, 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



RxNorm use cases

- E-prescribing
 - *NCPDP SCRIPT standard for e-prescribing requires RxNorm*
- Information exchange
 - *DoD and VA rely on RxNorm to mediate drug information across their electronic medical record systems*
- Formulary development
 - *CMS uses RxNorm in their Formulary Reference File, as part of the guideline for Medicare drug benefits*
- Reference value sets
 - *The drug value sets used in clinical quality measures for Meaningful Use are defined in reference to RxNorm*
- Analytics
 - *OHDSI, the Observational Health Data Sciences and Informatics research group, uses RxNorm to analyze prescription data*



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FOLLOW-ALONG EXAMPLES



Follow-along examples

- Using ***RxNav***:

- Find the ATC class for NDC **0186-5040-31** (Nexium 40 mg delayed-released capsule)

- NDC → RxNorm branded drug → RxNorm ingredient → ATC ingredient → ATC class

- Using ***RxClass***:

- Find all RxNorm ingredients from the same class as ***esomeprazole***

- Search classes by ingredient (or just click on a class in RxNav)

A **ALIMENTARY TRACT AND METABOLISM**

A02 **DRUGS FOR ACID RELATED DISORDERS**

A02B **DRUGS FOR PEPTIC ULCER AND GASTRO-OESOPHAGEAL REFLUX DISEASE (GORD)**

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Esomeprazole (283742)

Esomeprazole (A02BC05)

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

00186504031

0186-5040-31



NDC 0186-5040-31

Nexium[®]
(esomeprazole magnesium)

30 Delayed-Release Capsules

40 mg*

Rx only

Dispense the accompanying Medication Guide to each patient.

AstraZeneca

*Each delayed-release capsule contains 40 mg esomeprazole. Keep container tightly closed. Store at 25°C (77°F); excursions permitted to 15–30°C (59–86°F). [See USP Controlled Room Temperature]. USUAL ADULT DOSAGE: See package insert. NEXIUM and the color purple as applied to the capsule are registered trademarks of the AstraZeneca group. © AstraZeneca 2012 Mfd. for: AstraZeneca LP, Wilmington, DE 19850 By: Merck Sharp & Dohme Corp., a subsidiary of Merck & Co., Inc., Whitehouse Station, NJ 08889, USA Product of France

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0186-5040-31



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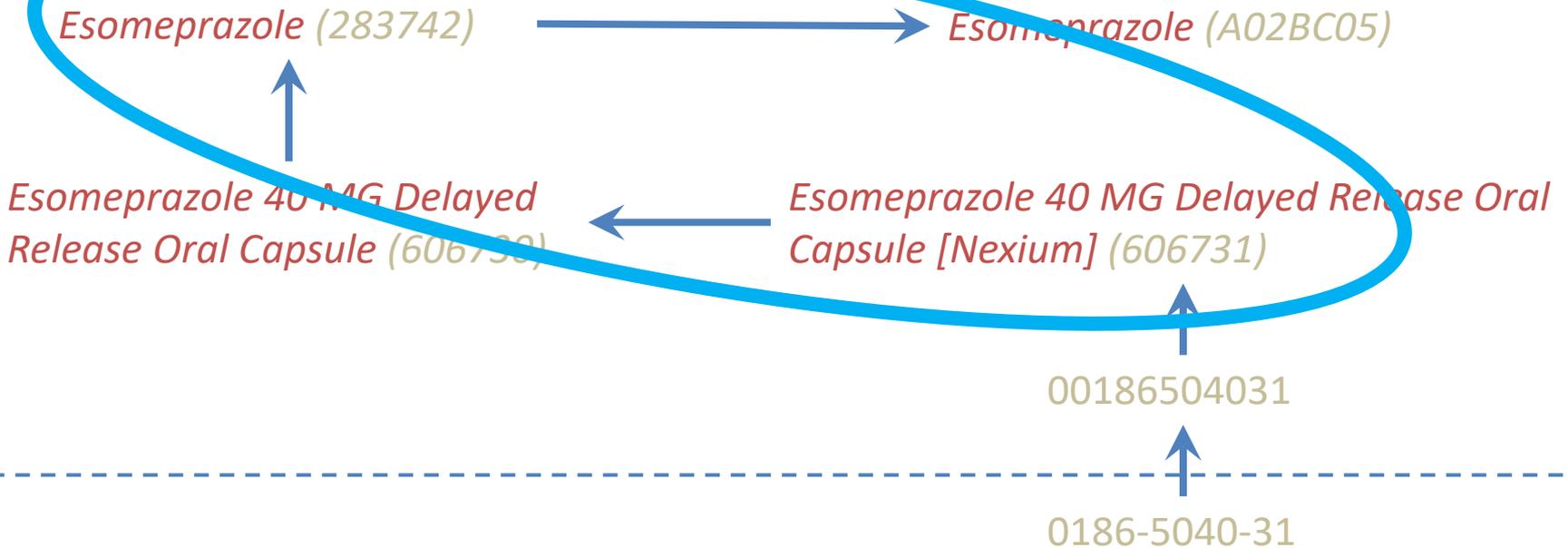
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NDC 0186-5040-31

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(esomeprazole magnesium)

30 Delayed-Release Capsules

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String  

Esomeprazole [RxCUI = 283742]

- RxNorm Graph
- RxNorm Properties**
- NDC
- RxTerms
- NDF-RT
- Pill Images
- Class View
- Interaction View

- Views
- Classic
 - Simple
 - Table

- Filters
- H
 - V
 - Rx
 - S

Group Form

Links

- Legend
- MIN
 - Pack
 - Multi

[Download](#)

IN/MIN	Ingredient (2)
H Rx S	Esomeprazole
H Rx M	Esomeprazole / Naproxen

PIN	Precise Ingredient (4)
Rx S	Esomeprazole magnesium
Rx S	esomeprazole magnesium dihydrate
Rx S	esomeprazole sodium
H Rx S	Esomeprazole Strontium

BN	Brand Name (2)
H Rx S	NexIUM
H Rx M	Vimovo

SCDC	Clinical Drug Component (7)
H Rx S	Esomeprazole 10 MG
H Rx S	Esomeprazole 2.5 MG
H Rx SM	Esomeprazole 20 MG
H Rx S	Esomeprazole 40 MG
H Rx S	Esomeprazole 5 MG
H Rx S	Esomeprazole Strontium 24.65 MG



SBDC	Branded Drug Component (7)
H Rx S	Esomeprazole 10 MG [NexIUM]
H Rx S	Esomeprazole 2.5 MG [NexIUM]
H Rx M	Esomeprazole 20 MG / Naproxen 375 MG [Vimovo]
H Rx M	Esomeprazole 20 MG / Naproxen 500 MG [Vimovo]
H Rx S	Esomeprazole 20 MG [NexIUM]
H Rx S	Esomeprazole 40 MG [NexIUM]

SCD/GPCK	Clinical Drug or Pack (18)
H Rx S	Esomeprazole 10 MG Granules for Oral Suspension
H Rx S	Esomeprazole 2.5 MG Granules for Oral Suspension
H Rx M	Esomeprazole 20 MG / Naproxen 375 MG Delayed Release Oral Tablet
H Rx M	Esomeprazole 20 MG / Naproxen 500 MG Delayed Release Oral Tablet
H Rx S	Esomeprazole 20 MG Delayed Release Oral Capsule
H Rx S	Esomeprazole 20 MG Delayed Release Oral Tablet

SBD/BPCK	Branded Drug or Pack (12)
H Rx S	NexIUM 10 MG Granules for Delayed Release Oral Suspension
H Rx S	NexIUM 2.5 MG Granules for Delayed Release Oral Suspension
H Rx S	NexIUM 20 MG Delayed Release Oral Capsule
H Rx S	NexIUM 20 MG Delayed Release Oral Tablet

SCDG	Clinical Dose Form Group (6)
H Rx M	Esomeprazole / Naproxen Oral Product
H Rx M	Esomeprazole / Naproxen Pill
H Rx S	Esomeprazole Granule Product
H Rx S	Esomeprazole Injectable Product
H Rx S	Esomeprazole Oral Product
H Rx S	Esomeprazole Pill

DFG	Dose Form Group (4)
HvRx S	Granule Product
HvRx S	Injectable Product
HvRx S	Oral Product
HvRx S	Pill

SBDG	Branded Dose Form Group (6)
H Rx S	NexIUM Granule Product
H Rx S	NexIUM Injectable Product
H Rx S	NexIUM Oral Product
H Rx S	NexIUM Pill
H Rx M	Vimovo Oral Product
H Rx M	Vimovo Pill

<https://mor.nlm.nih.gov/RxNav/>

A **ALIMENTARY TRACT AND METABOLISM**

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Esomeprazole (283742)

Esomeprazole (A02BC05)

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00186504031

0186-5040-31



NDC 0186-5040-31

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(esomeprazole magnesium)

30 Delayed-Release Capsules

40 mg*

Rx only

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Lot



Esomeprazole [RxCUI = 283742]

- RxNorm Graph**
- RxNorm Properties**
- NDC
- RxTerms
- NDF-RT
- Pill Images
- Class View**
- Interaction View

Views

- Attributes
- **Codes**
- Names
- Sources

[Download](#)

Property	Value
ATC	A02BC05
MMSL_CODE	GNd04749
NUI	N0000148700
NUI	N0000189434
RxCUI	283742
SPL_SET_ID	069d7015-a2e4-4dbb-8255-2172e22a6300
SPL_SET_ID	0907236c-786f-4e36-b360-6c499986fe9a
SPL_SET_ID	0a4e27bd-151c-462f-ac47-4d0a1105aa9d
SPL_SET_ID	0eea6d43-db1e-471c-ba0a-1f8321c6293b
SPL_SET_ID	15023261-51c8-2388-3439-48dace49ec02
SPL_SET_ID	1f0ba9c8-e5f2-4d65-a0e3-19a6541a03b5
SPL_SET_ID	31ec2d55-9a3e-4150-8a98-a2895a4174b7
SPL_SET_ID	3a65d9b7-7a8d-4fc6-a290-50c3543dc485
SPL_SET_ID	3c916d32-f9e9-1d15-e054-00144ff88e88
SPL_SET_ID	3cdfcf9-b5fa-4622-9e83-ce29ecccc93
SPL_SET_ID	42b67915-43ca-4119-8f66-ed449b445f7c
SPL_SET_ID	4332634f-fde0-4b98-8735-d3ab865189c3
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SPL_SET_ID	477cfda2-44cf-4d0e-bdc4-e30bf16bfea9
SPL_SET_ID	4a9fe897-db08-4e14-b243-d2124a07d1d1
SPL_SET_ID	4b6c6f3c-fbd3-4eeb-a6fe-17eeb4a51cfa
SPL_SET_ID	44500d4-4a22-4445-0000-000000000000

<https://mor.nlm.nih.gov/RxNav/>

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00186504031

0186-5040-31



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Dispense the accompanying Medication Guide to each patient.

AstraZeneca

*Each delayed-release capsule contains 40 mg esomeprazole. Keep container tightly closed. Store at 25°C (77°F); excursions permitted to 15–30°C (59–86°F). [See USP Controlled Room Temperature]. USUAL ADULT DOSAGE: See package insert. NEXIUM and the color purple as applied to the capsule are registered trademarks of the AstraZeneca group. © AstraZeneca 2012 Mfd. for: AstraZeneca LP, Wilmington, DE 19850 By: Merck Sharp & Dohme Corp., a subsidiary of Merck & Co., Inc., Whitehouse Station, NJ 08889, USA Product of France

30 | No. 5040

0000000000

Lot

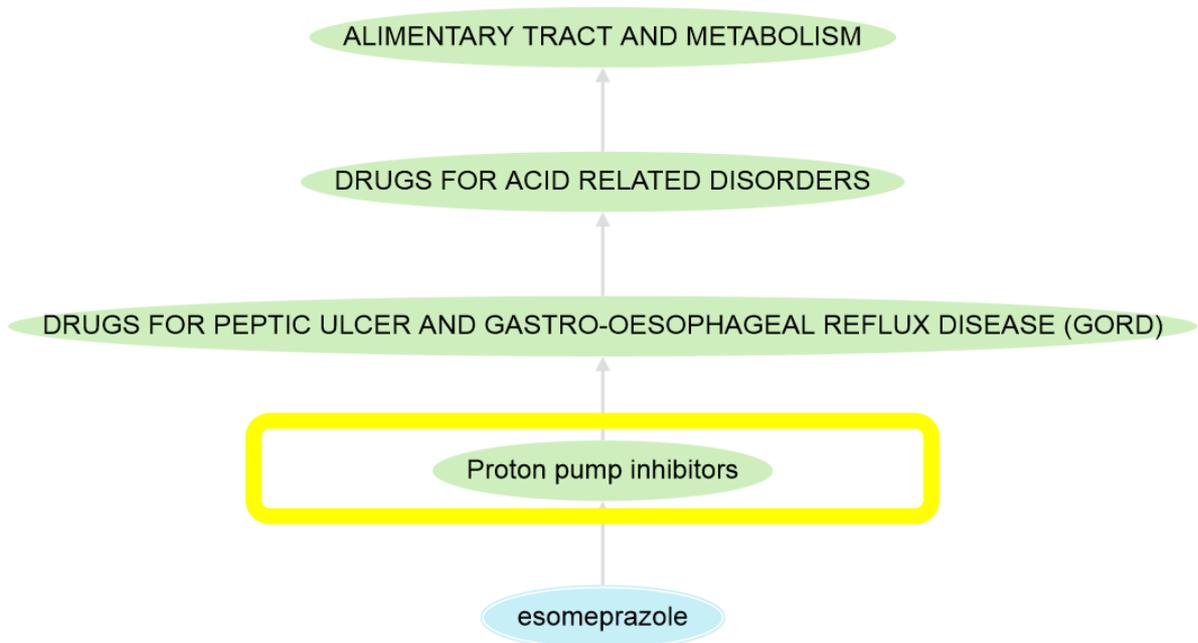


String Esomeprazole

Show Drug's Relation to Drug Class
Esomeprazole [RxCUI = 283742]

- RxNorm Graph
- RxNorm Properties**
- NDC
- RxTerms
- NDF-RT
- Pill Images
- Class View
- Interaction View

- Views
- **ATC**
 - MESH
 - Drug
 - Disease
 - DF
 - CHEM
 - MoA
 - PK
 - PE
- Hide Legend



<https://mor.nlm.nih.gov/RxNav/>



News

ATC/DDD Index

Updates included in the ATC/DDD Index

ATC/DDD methodology

ATC

DDD

ATC/DDD alterations, cumulative lists

ATC/DDD Index and Guidelines

Use of ATC/DDD

Courses

Meetings/open session

Deadlines

Links

Postal address:
WHO Collaborating
Centre for Drug Statistics
Methodology
Norwegian Institute of
Public Health
P.O.Box 4404 Nydalen
0403 Oslo
Norway

Visiting/delivery
address:
Marcus Thranes gate 6
0473 Oslo
Norway

Tel: +47 21 07 81 60
E-mail: whocc@fhi.no

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[New search](#) [Show text from Guidelines](#)

- A **ALIMENTARY TRACT AND METABOLISM**
- A02 **DRUGS FOR ACID RELATED DISORDERS**
- A02B **DRUGS FOR PEPTIC ULCER AND GASTRO-OESOPHAGEAL REFLUX DISEASE (GORD)**
- A02BC **Proton pump inhibitors**

ATC code	Name	DDD	U	Adm.R	Note
A02BC01	omeprazole	20	mg	O	
		20	mg	P	
A02BC02	pantoprazole	40	mg	O	
		40	mg	P	
A02BC03	lansoprazole	30	mg	O	
A02BC04	rabeprazole	20	mg	O	
A02BC05	esomeprazole	30	mg	P	
		30	mg	O	
A02BC06	dexlansoprazole	30	mg	O	
A02BC07	dexrabeprazole*				
A02BC53	lansoprazole, combinations				
A02BC54	rabeprazole, combinations				

*dexrabeprazole
not on the U.S.
market*

[List of abbreviations](#)

Last updated: 2016-12-19

Class Browser

- ▼ Anatomical Therapeutic Chemical (ATC1-4)
 - ▼ ALIMENTARY TRACT AND METABOLISM (370)
 - ▶ ANABOLIC AGENTS FOR SYSTEMIC USE (9)
 - ▶ ANTIDIARRHEALS, INTESTINAL ANTIINFLAMMATORY/ANTIINFECTIVE AGENTS (42)
 - ▶ ANTIEMETICS AND ANTINAUSEANTS (13)
 - ▶ ANTI OBESITY PREPARATIONS, EXCL. DIET PRODUCTS (12)
 - APPETITE STIMULANTS (0)
 - BILE AND LIVER THERAPY (13)
 - DIGESTIVES, INCL. ENZYMES (7)
 - ▼ DRUGS FOR ACID RELATED DISORDERS (35)
 - ▶ ANTACIDS (14)
 - ▼ DRUGS FOR PEPTIC ULCER AND GASTRO-OESOPHAGEAL REFLUX DISEASE (GORD) (21)
 - Combinations for eradication of *Helicobacter pylori* (1)
 - H2-receptor antagonists (5)
 - Other drugs for peptic ulcer and gastro-oesophageal reflux disease (GORD) (8)
 - Prostaglandins (1)
 - Proton pump inhibitors (6)
 - OTHER DRUGS FOR ACID RELATED DISORDERS (0)
 - ▶ DRUGS FOR CONSTIPATION (35)
 - ▶ DRUGS FOR FUNCTIONAL GASTROINTESTINAL DISORDERS (44)
 - ▶ DRUGS USED IN DIABETES (61)
 - ▶ MINERAL SUPPLEMENTS (30)
 - ▶ OTHER ALIMENTARY TRACT AND METABOLISM PRODUCTS (32)

RxClass

Exploring drug classes and their RxNorm drug members

Search...

by class name/id
 by RxNorm drug name/id
 ingredient drug only

Proton pump inhibitors

class: Proton pump inhibitors / id: A02BC / class type: ATC1-4 / [show context](#)

Print

6 RxNorm generic drugs in ATC / similar classes

Type	RXCUI	RxNorm Name	Relation	All classes
IN	816346	dexlansoprazole	DIRECT	<input type="button" value="Show"/>
IN	283742	Esomeprazole	DIRECT	<input type="button" value="Show"/>
IN	17128	lansoprazole	DIRECT	<input type="button" value="Show"/>
IN	7646	Omeprazole	DIRECT	<input type="button" value="Show"/>
IN	40790	pantoprazole	DIRECT	<input type="button" value="Show"/>
IN	114979	rabeprazole	DIRECT	<input type="button" value="Show"/>



Example of the value of interoperable data for clinical research:

Richard D. Boyce¹

¹Department of Biomedical Informatics, University of Pittsburgh

May 20th, 2017



Databases for research



Evidence
generation



- Electronic Health Records
- Insurance claims
- Registries

- Diseases
- Health care provided
- Effects of treatments
- Differences between patients
- Personalized medicine



Research networks

- Data may be at different sites
- Sites often cannot share data at the patient level
- Data can be in very different formats

Patient level, identifiable information



Practice



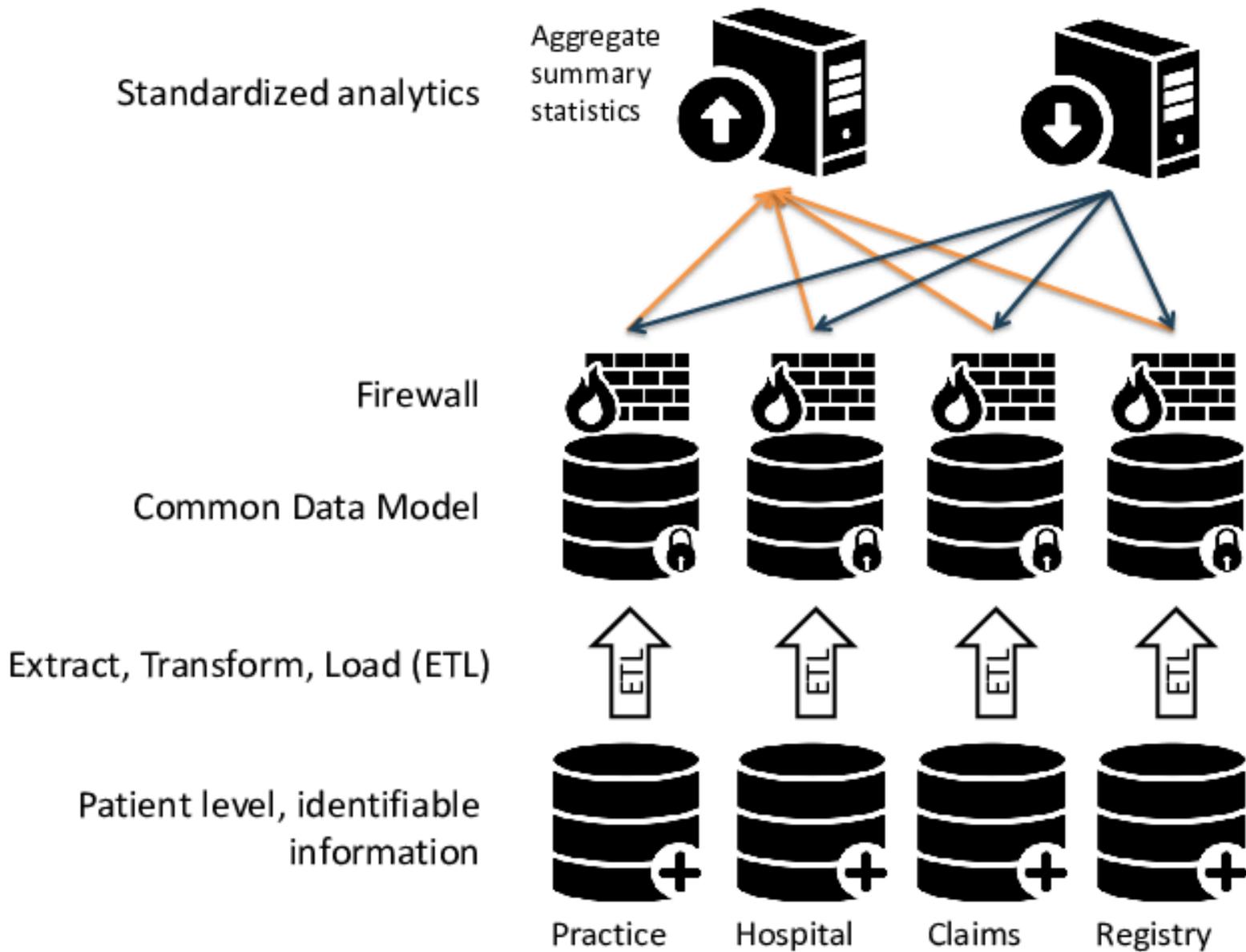
Hospital

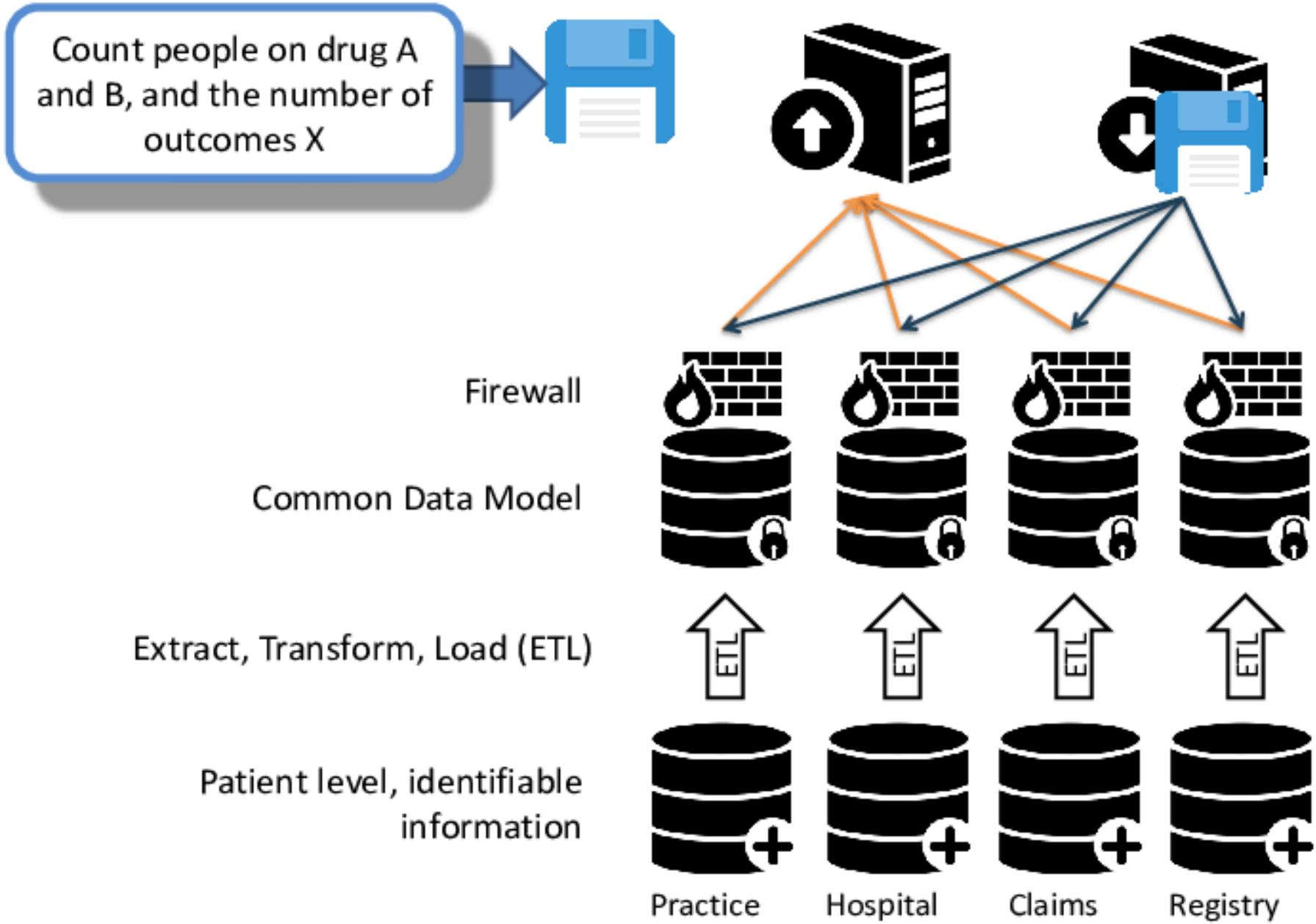


Claims

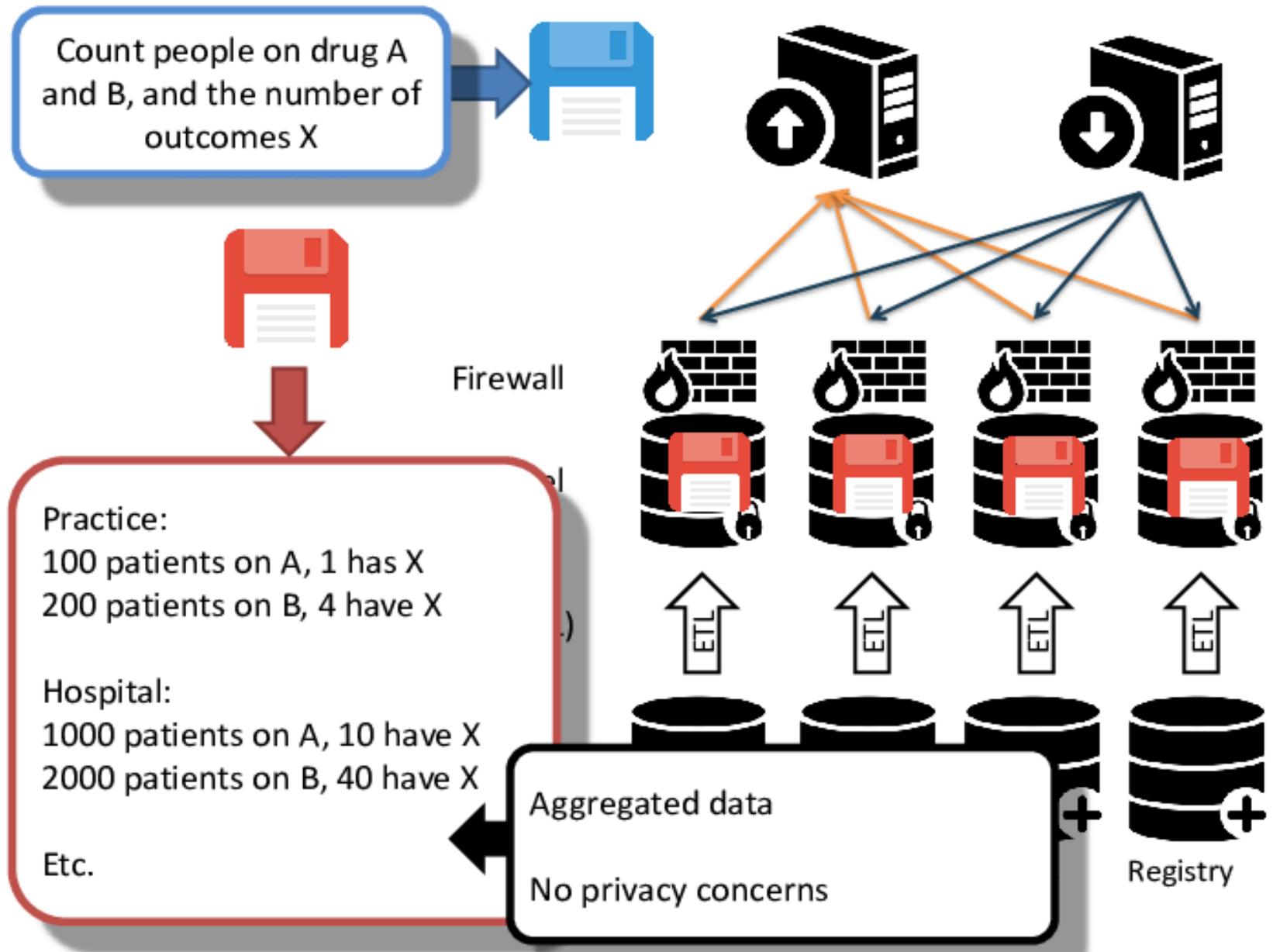


Registry





Schuemie , M., How to extract transform and load observational data? Janssen Research & Development. Beijing, China. May 2015. <http://goo.gl/ArRX5u>. Last accessed 5/5/2016.





“Common Data Models” and Interoperability

- What is a “Common Data Model” (CDM)

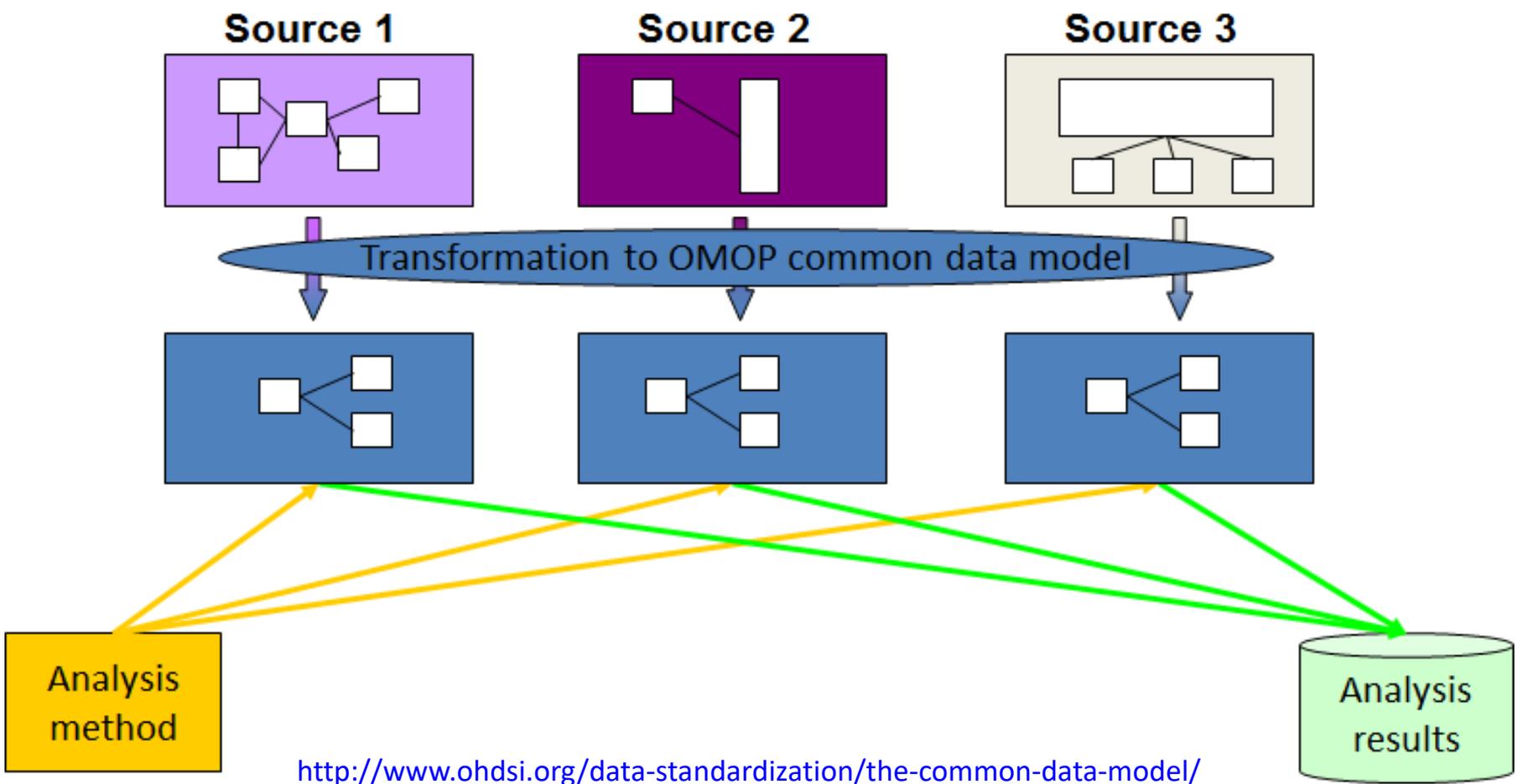
“A **common data model** allows for the systematic analysis of disparate observational databases.

The concept behind this approach is to **transform** data contained within disparate databases **into a common format** (data model), and then perform systematic analyses using a library of standard analytic routines that have been written based on the common format.” -

<http://www.ohdsi.org/data-standardization/the-common-data-model/>



Going from multiple databases to one



<http://www.ohdsi.org/data-standardization/the-common-data-model/>



Common Data Model

- A common **structure**

Person

- person_id
- year_of_birth
- month_of_birth
- day_of_birth
- gender_concept_id

- A common **vocabulary**

How do we store gender?

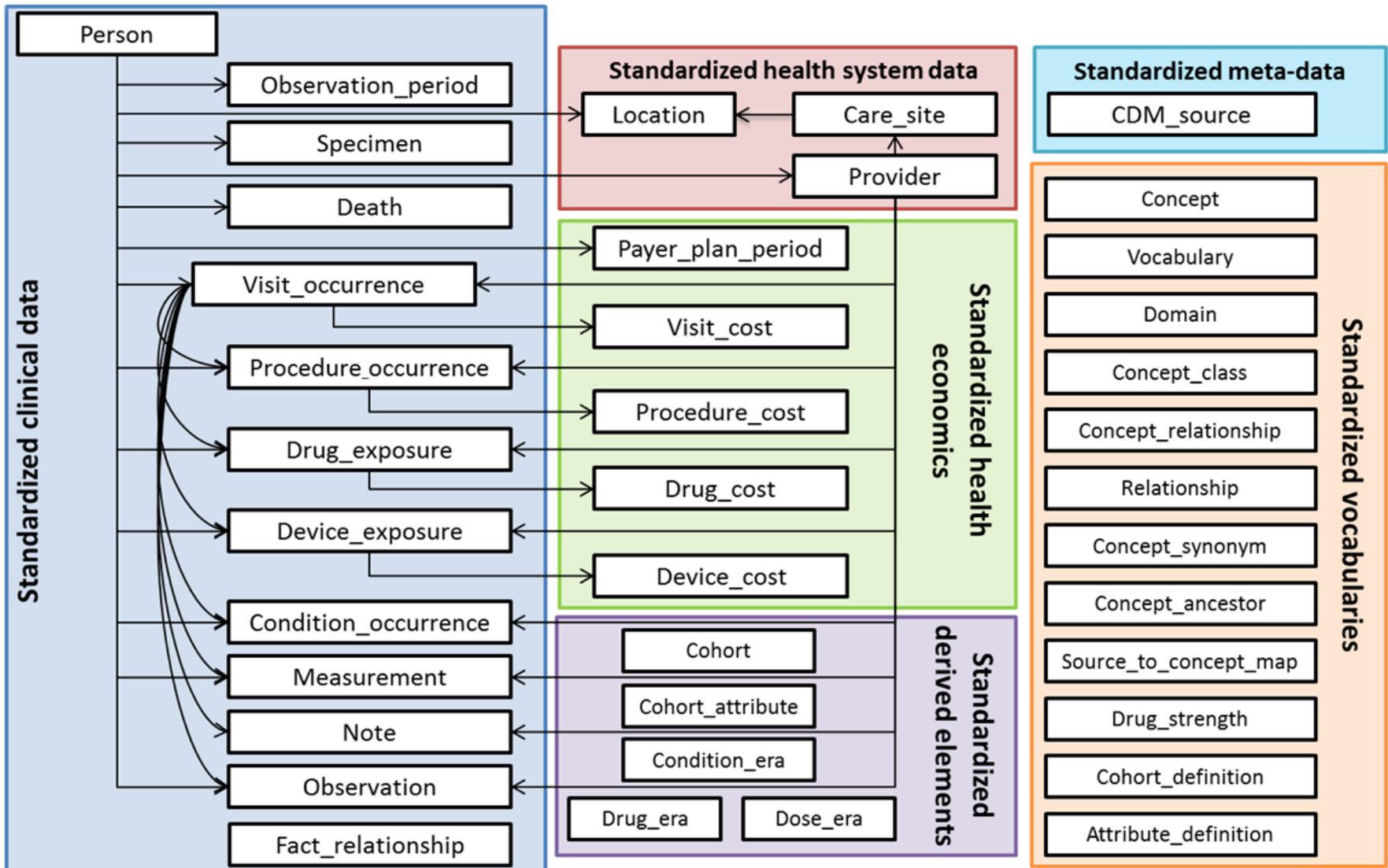
- M, F, U
- 0, 1, 2
- 8507 (male), 8532 (female), 8851 (unknown gender), 8570 (ambiguous gender)



OMOP Common Data Model

- Designed for **various types of data** (EHR, insurance claims) in **various countries**
- Developed by the OMOP / OHDSI community
- Currently on 5th version
- ‘Easy to get data in, easy to get data out’

OMOP CDM Version 5





CDM principles

- Person centric
- Data is split into domains (e.g. conditions, drugs, procedures)
- Preserve source values and map to standard values
- Store the source of the data
- Separate verbatim data from inferred data



OMOP Vocabulary

All codes are mapped to **standard coding systems**

- Drugs: RxNorm
- Conditions: SNOMED
- Measurements: LOINC
- Procedures: ICD9Proc, HCPCS, CPT-4



MEDDRA

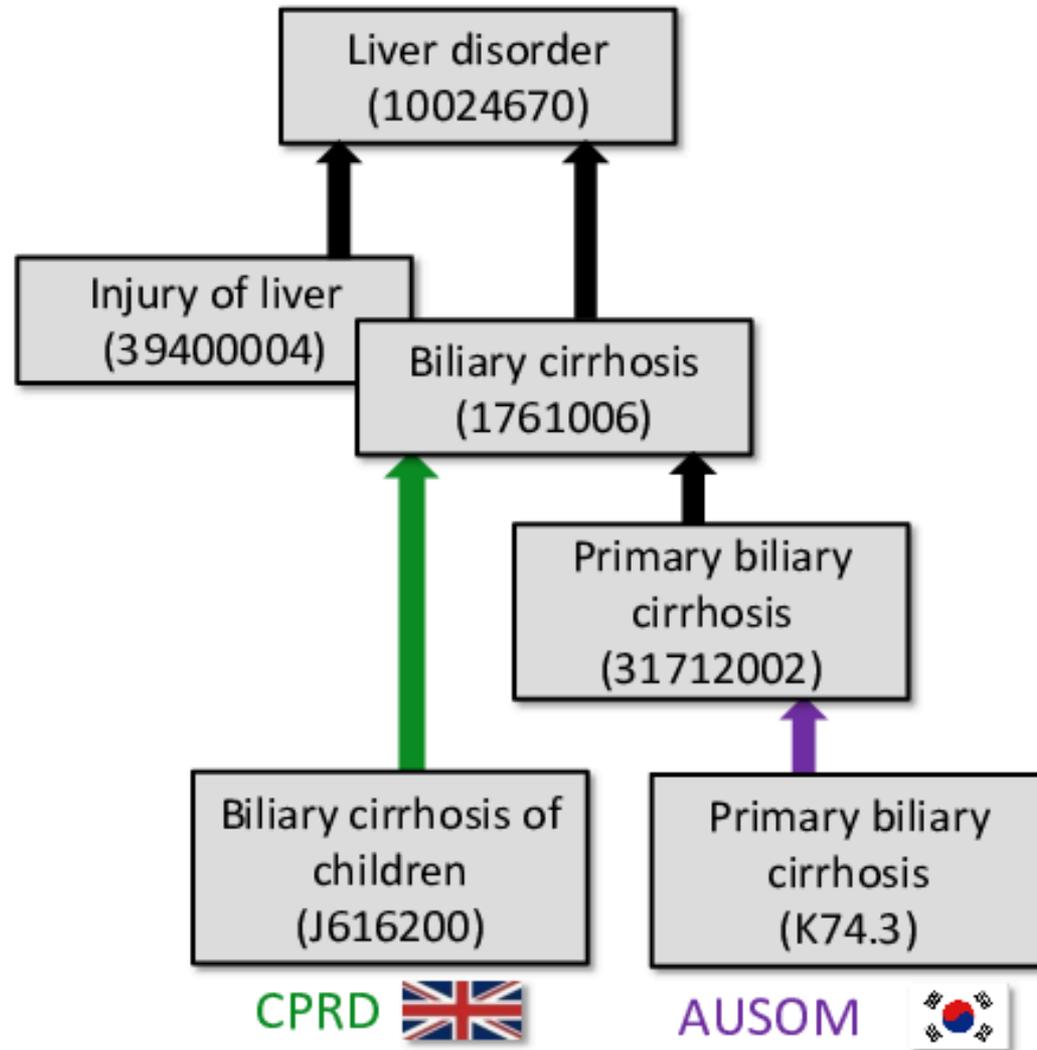


SNOMED



Source codes

Vocabulary





An example with Drug data

Source Data – drug dispensing

ptId | gpi | ndc | start | end | drug name | form | strength | sig | prn

Drug Exposure

Column Name	Data Type	Nullable
DRUG_EXPOSURE_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_EXPOSURE_START_DATE	DATE	No
DRUG_EXPOSURE_END_DATE	DATE	Yes
DRUG_TYPE_CONCEPT_ID	NUMBER(38, 0)	No
STOP_REASON	VARCHAR2(20 BYTE)	Yes
REFILLS	NUMBER(38, 0)	Yes
QUANTITY	FLOAT	Yes
DAYS_SUPPLY	NUMBER(38, 0)	Yes
SIG	CLOB	Yes
ROUTE_CONCEPT_ID	NUMBER(38, 0)	Yes
EFFECTIVE_DRUG_DOSE	FLOAT	Yes
DOSE_UNIT_CONCEPT_ID	NUMBER(38, 0)	Yes
LOT_NUMBER	VARCHAR2(50 BYTE)	Yes
PROVIDER_ID	NUMBER(38, 0)	Yes
VISIT_OCCURRENCE_ID	NUMBER(38, 0)	Yes
DRUG_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DRUG_SOURCE_CONCEPT_ID	NUMBER(38, 0)	Yes
ROUTE_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DOSE_UNIT_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes

Drug Era

Column Name	Data Type	Nullable
DRUG_ERA_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_ERA_START_DATE	DATE	No
DRUG_ERA_END_DATE	DATE	No
DRUG_EXPOSURE_COUNT	NUMBER(38, 0)	Yes
GAP_DAYS	NUMBER(38, 0)	Yes



An example with Drug data cont...

ptId ...



Drug Exposure

COLUMN_NAME	DATA_TYPE	NULLABLE
DRUG_EXPOSURE_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_EXPOSURE_START_DATE	DATE	No
DRUG_EXPOSURE_END_DATE	DATE	Yes
DRUG_TYPE_CONCEPT_ID	NUMBER(38, 0)	No
STOP_REASON	VARCHAR2(20 BYTE)	Yes
REFILLS	NUMBER(38, 0)	Yes
QUANTITY	FLOAT	Yes
DAYS_SUPPLY	NUMBER(38, 0)	Yes
SIG	CLOB	Yes
ROUTE_CONCEPT_ID	NUMBER(38, 0)	Yes
EFFECTIVE_DRUG_DOSE	FLOAT	Yes
DOSE_UNIT_CONCEPT_ID	NUMBER(38, 0)	Yes
LOT_NUMBER	VARCHAR2(50 BYTE)	Yes
PROVIDER_ID	NUMBER(38, 0)	Yes
VISIT_OCCURRENCE_ID	NUMBER(38, 0)	Yes
DRUG_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DRUG_SOURCE_CONCEPT_ID	NUMBER(38, 0)	Yes
ROUTE_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DOSE_UNIT_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes

Drug Era

COLUMN_NAME	DATA_TYPE	NULLABLE
DRUG_ERA_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_ERA_START_DATE	DATE	No
DRUG_ERA_END_DATE	DATE	No
DRUG_EXPOSURE_COUNT	NUMBER(38, 0)	Yes
GAP_DAYS	NUMBER(38, 0)	Yes



An example with Drug data cont...

... gpi | ndc ...



RxNorm clinical drug

RxNorm ingredient

Drug Exposure

Drug Era

DRUG_EXPOSURE_ID	NUMBER(38,0)	No
PERSON_ID	NUMBER(38,0)	No
DRUG_CONCEPT_ID	NUMBER(38,0)	No
DRUG_EXPOSURE_START_DATE	DATE	No
DRUG_EXPOSURE_END_DATE	DATE	Yes
DRUG_TYPE_CONCEPT_ID	NUMBER(38,0)	No
STOP_REASON	VARCHAR2(20 BYTE)	Yes
REFILLS	NUMBER(38,0)	Yes
QUANTITY	FLOAT	Yes
DAYS_SUPPLY	NUMBER(38,0)	Yes
SIG	CLOB	Yes
ROUTE_CONCEPT_ID	NUMBER(38,0)	Yes
EFFECTIVE_DRUG_DOSE	FLOAT	Yes
DOSE_UNIT_CONCEPT_ID	NUMBER(38,0)	Yes
LOT_NUMBER	VARCHAR2(50 BYTE)	Yes
PROVIDER_ID	NUMBER(38,0)	Yes
VISIT_OCCURRENCE_ID	NUMBER(38,0)	Yes
DRUG_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DRUG_SOURCE_CONCEPT_ID	NUMBER(38,0)	Yes
ROUTE_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DOSE_UNIT_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes

⚡ COLUMN_NAME	⚡ DATA_TYPE	⚡ NULLABLE
DRUG_ERA_ID	NUMBER(38,0)	No
PERSON_ID	NUMBER(38,0)	No
DRUG_CONCEPT_ID	NUMBER(38,0)	No
DRUG_ERA_START_DATE	DATE	No
DRUG_ERA_END_DATE	DATE	No
DRUG_EXPOSURE_COUNT	NUMBER(38,0)	Yes
GAP_DAYS	NUMBER(38,0)	Yes





... gpi | ndc ...



RxNorm clinical drug

RxNorm ingredient

How to create code mappings:

1. Prepare the data

- codes
- descriptions
- Frequencies

2. Use existing mappings if available

- Free mappings
 - RxNorm maps to NDC, NDF-RT, SPL, ATC
 - Others exist in the UMLS (<https://www.nlm.nih.gov/research/umls/>)
- Proprietary mappings (e.g., RxNorm to Medi-Span ©)

3. If necessary, create a new mapping

- Run  **USAGI** <https://github.com/OHDSI/Usagi>

Usagi in action

File Edit View Help

Status	Source code	Source term	Frequency	Match score	Concept ID	Concept name	Domain	Concept class	Vocabulary	Concept code
Unchecked	180677	ABACAVIR 600 ...	0	0.97	45775747	abacavir 600 ...	Drug	Clinical Drug	RxNorm	1546888
Unchecked	14369	ABCIXIMAB 10 ...	0	0.85	43536091	abciximab 10...	Drug	Clinical Drug	Multilex	1019961
Unchecked	70305	ABILIFY 2 MG T...	0	0.97	757759	aripiprazole 2 ...	Drug	Branded Drug	RxNorm	615172
Approved	36437	ABILIFY 5 MG T...	0	0.97	19102836	aripiprazole 5 ...	Drug	Branded Drug	RxNorm	404602
Unchecked	8939	ACEBUTOLOL 2...	0	0.93	1320038	Acebutolol 20...	Drug	Clinical Drug C...	RxNorm	328656
Approved	113	ACETAZOLAMID...	0	0.97	19018781	Acetazolamide...	Drug	Clinical Drug	RxNorm	197304
Unchecked	8962	ACETAZOLAMID...	0	0.83	19072239	Acetazolamide...	Drug	Clinical Drug	RxNorm	307701
Unchecked	128434	ACTEMRA IV	0	0.75	40171291	tocilizumab 20 ...	Drug	Branded Drug	RxNorm	895764
Unchecked	171177	ACYCLOVIR 200...	0	0.93	19072293	Acyclovir 40 M...	Drug	Clinical Drug	RxNorm	307730
Unchecked	8969	ACYCLOVIR 200...	0	0.97	19018786	Acyclovir 200 ...	Drug	Clinical Drug	RxNorm	197310
Unchecked	8971	ACYCLOVIR 400...	0	0.97	1703691	Acyclovir 400 ...	Drug	Clinical Drug	RxNorm	197311
Approved	8972	ACYCLOVIR 800...	0	0.97	1703743	Acyclovir 800 ...	Drug	Clinical Drug	RxNorm	197313
Unchecked	128500	ACYCLOVIR (BU...	0	0.62	1703697	Acyclovir	Drug	Ingredient	RxNorm	201

Source code

Source code	Source term	Frequency
180677	ABACAVIR 600 MG-DOLUTEGRAVIR 50 MG-LAMIVUDINE 300 MG ...	0

Target concepts

Synonym	Concept ID	Concept name	Domain	Concept class	Vocabulary	Concept code	Valid start date	Valid end date	Invalid reason
abacavir 600 MG...	45775747	abacavir 600 MG...	Drug	Clinical Drug	RxNorm	1546888	20141201	20991231	

Remove concept

Search

Query

Use source term as query
 Query:

Filters

Filter by automatically select concepts
 Filter by concept class: **Admin Concept**
 Filter by domain: **Condition**

Filter invalid concepts
 Filter by vocabulary: **APC**

Results

Score	Synonym	Concept ID	Concept name	Domain	Concept class	Vocabulary	Concept code	Valid start date	Valid end date	Invalid reason
0.97	abacavir 600 ...	45775747	abacavir 600 ...	Drug	Clinical Drug	RxNorm	1546888	20141201	20991231	
0.85	abacavir / dolu...	45775746	abacavir / dolu...	Drug	Clinical Drug F...	RxNorm	1546886	20141201	20991231	
0.84	abacavir 600 ...	45775751	abacavir 600 ...	Drug	Branded Drug	RxNorm	1546894	20141201	20991231	
0.83	abacavir 600 ...	45775749	abacavir 600 ...	Drug	Branded Drug ...	RxNorm	1546890	20141201	20991231	
0.80	abacavir 600 ...	19122306	abacavir 600 ...	Drug	Clinical Drug	RxNorm	602393	20060226	20991231	
0.70	abacavir / dolu...	45775750	abacavir / dolu...	Drug	Branded Drug ...	RxNorm	1546891	20141201	20991231	

Replace concept Add concept

Approve



... start | end ...



The date of a single exposure

Dates of continuous exposure

Drug Exposure

DRUG_EXPOSURE_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_EXPOSURE_START_DATE	DATE	No
DRUG_EXPOSURE_END_DATE	DATE	Yes
DRUG_TYPE_CONCEPT_ID	NUMBER(38, 0)	No
STOP_REASON	VARCHAR2(20 BYTE)	Yes
REFILLS	NUMBER(38, 0)	Yes
QUANTITY	FLOAT	Yes
DAYS_SUPPLY	NUMBER(38, 0)	Yes
SIG	CLOB	Yes
ROUTE_CONCEPT_ID	NUMBER(38, 0)	Yes
EFFECTIVE_DRUG_DOSE	FLOAT	Yes
DOSE_UNIT_CONCEPT_ID	NUMBER(38, 0)	Yes
LOT_NUMBER	VARCHAR2(50 BYTE)	Yes
PROVIDER_ID	NUMBER(38, 0)	Yes
VISIT_OCCURRENCE_ID	NUMBER(38, 0)	Yes
DRUG_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DRUG_SOURCE_CONCEPT_ID	NUMBER(38, 0)	Yes
ROUTE_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DOSE_UNIT_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes



Drug Era

⚡ COLUMN_NAME	⚡ DATA_TYPE	⚡ NULLABLE
DRUG_ERA_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_ERA_START_DATE	DATE	No
DRUG_ERA_END_DATE	DATE	No
DRUG_EXPOSURE_COUNT	NUMBER(38, 0)	Yes
GAP_DAYS	NUMBER(38, 0)	Yes





... drug name | form | strength | sig | prn ...



- Drug name, form, strength handled by the vocabulary
- SIG entered directly
- 'PRN' – by concatenating with the SIG string

Drug Exposure

DRUG_EXPOSURE_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_EXPOSURE_START_DATE	DATE	No
DRUG_EXPOSURE_END_DATE	DATE	Yes
DRUG_TYPE_CONCEPT_ID	NUMBER(38, 0)	No
STOP_REASON	VARCHAR2(20 BYTE)	Yes
REFILLS	NUMBER(38, 0)	Yes
QUANTITY	FLOAT	Yes
DAYS_SUPPLY	NUMBER(38, 0)	Yes
SIG	CLOB	Yes
ROUTE_CONCEPT_ID	NUMBER(38, 0)	Yes
EFFECTIVE_DRUG_DOSE	FLOAT	Yes
DOSE_UNIT_CONCEPT_ID	NUMBER(38, 0)	Yes
LOT_NUMBER	VARCHAR2(50 BYTE)	Yes
PROVIDER_ID	NUMBER(38, 0)	Yes
VISIT_OCCURRENCE_ID	NUMBER(38, 0)	Yes
DRUG_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DRUG_SOURCE_CONCEPT_ID	NUMBER(38, 0)	Yes
ROUTE_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes
DOSE_UNIT_SOURCE_VALUE	VARCHAR2(50 BYTE)	Yes

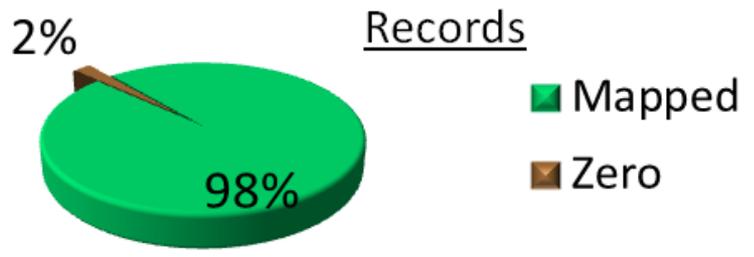
Drug Era

◇ COLUMN_NAME	◇ DATA_TYPE	◇ NULLABLE
DRUG_ERA_ID	NUMBER(38, 0)	No
PERSON_ID	NUMBER(38, 0)	No
DRUG_CONCEPT_ID	NUMBER(38, 0)	No
DRUG_ERA_START_DATE	DATE	No
DRUG_ERA_END_DATE	DATE	No
DRUG_EXPOSURE_COUNT	NUMBER(38, 0)	Yes
GAP_DAYS	NUMBER(38, 0)	Yes

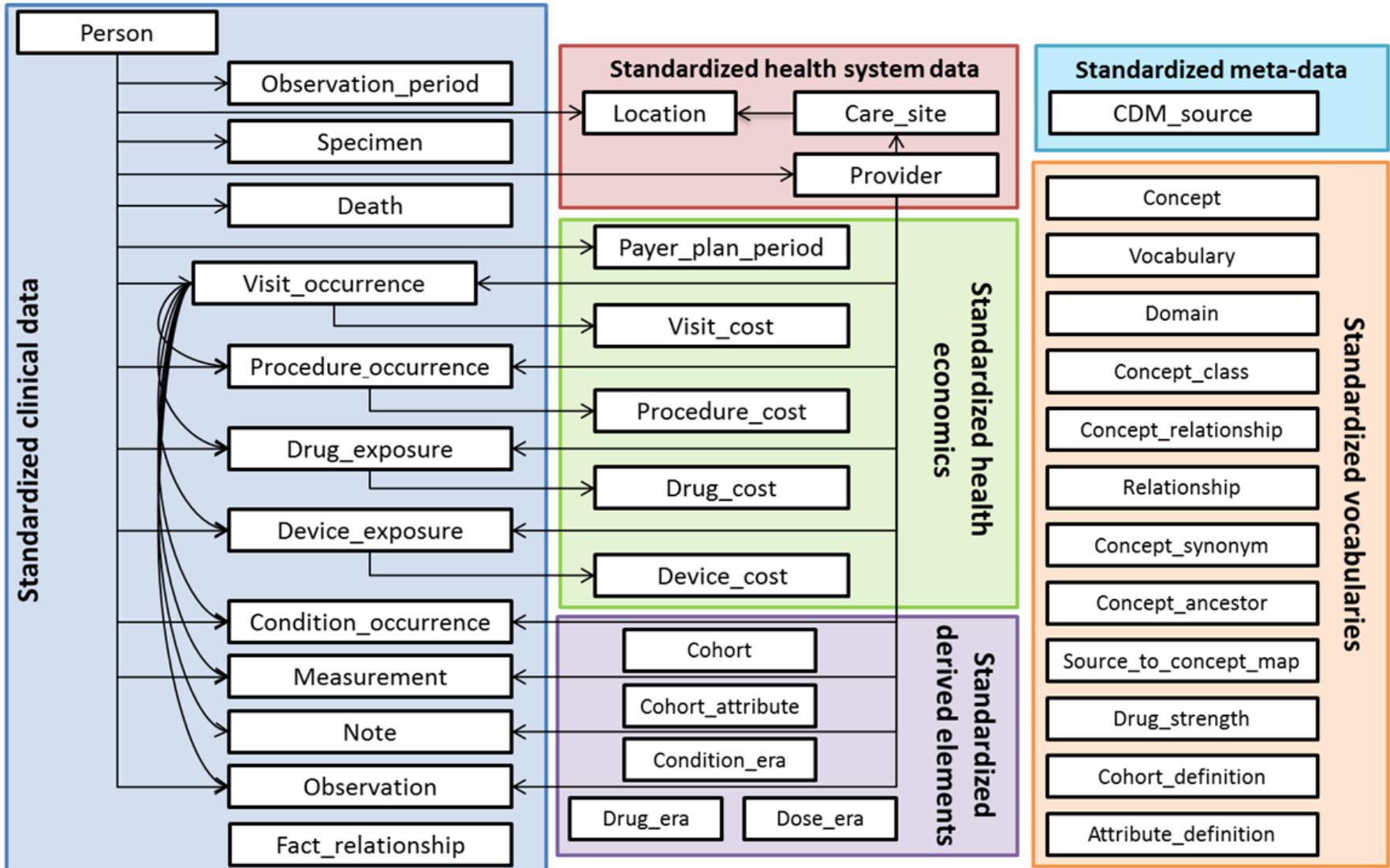


- Real world cases:
 - Nursing home dataset (5K patients)
 - 430,910 dispensing records
 - 40,950 (9.5%) records dropped for not providing a GPI that could be mapped to RxNorm
 - » the great majority were for gastrointestinal aids
 - Truven CCAE (2003 - 2011, <https://goo.gl/pR7IUI>)

Unique concepts	112,164
Mapped	76,633
Not Mapped	35,531



A similar process for other domains

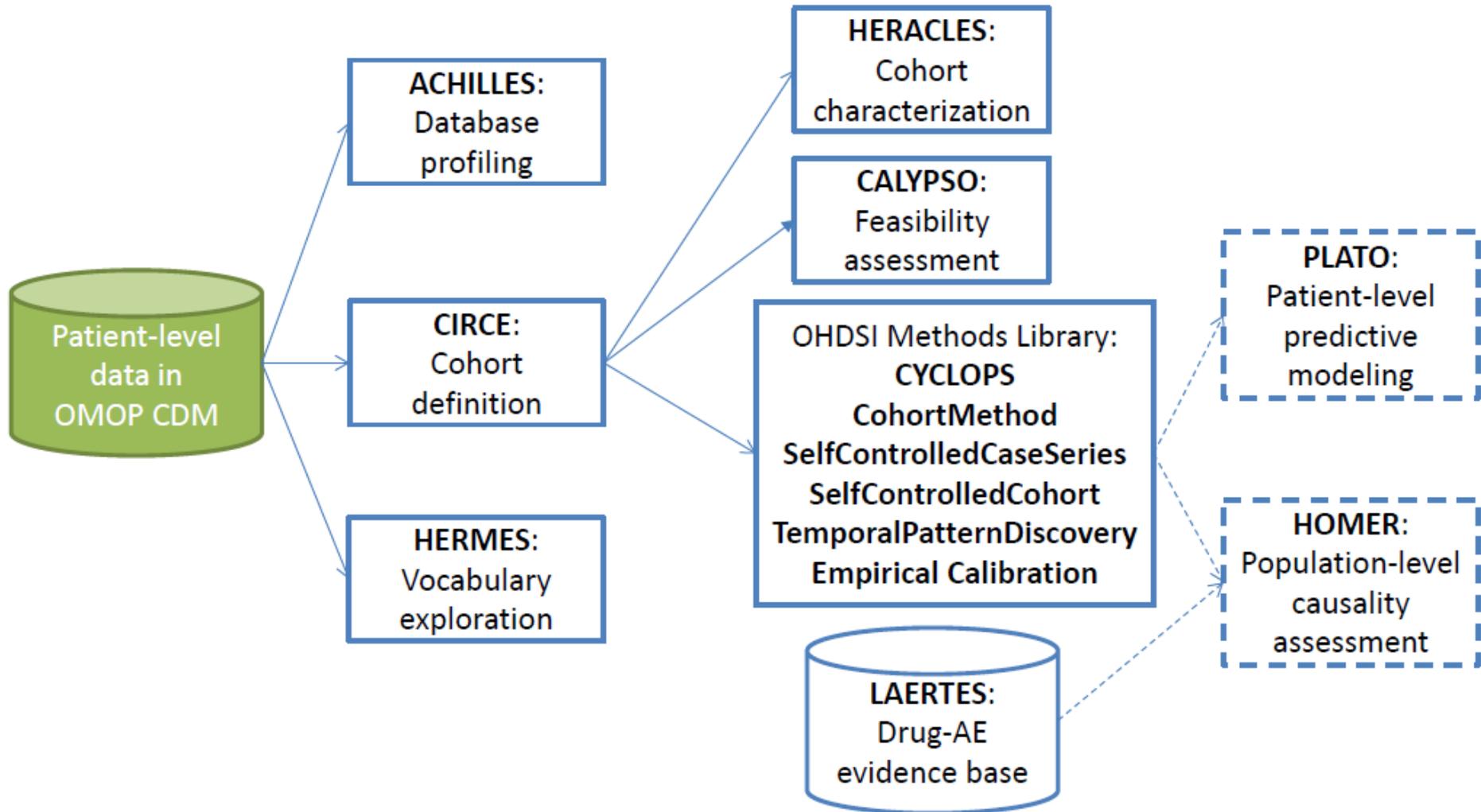




Pros and Cons of extraction, translation, and load (ETL) into the OHDSI CDM

- Pros
 - Our project now becomes a part of the OHDSI research network
 - International consortium of very skilled researchers to provide input
 - Sets us up nicely to do any number of other observational studies
 - Speeds up the generation of new evidence
- Cons
 - More work initially
 - potentially much less in the long run
 - Requires additional validation
 - E.g., records might be dropped because of no mapping to the CDM or vocabulary

OHDSI Tools Potentially Enabled by using the CDM a for a clinical dataset





Let's look at two example OHDSI tools

- Achilles
 - Automated Characterization of Health Information at Large-scale Longitudinal Evidence Systems
 - ETL quality assurance
- Atlas
 - a unified web interface that attempts to integrate features from various OHDSI applications into a single cohesive experience.

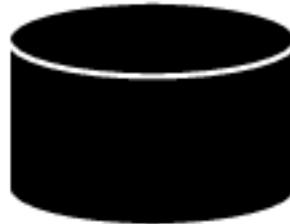


ACHILLES

Automated Characterization of Health Information at Large-scale Longitudinal Evidence Systems



Data in CDM



Aggregate statistics:

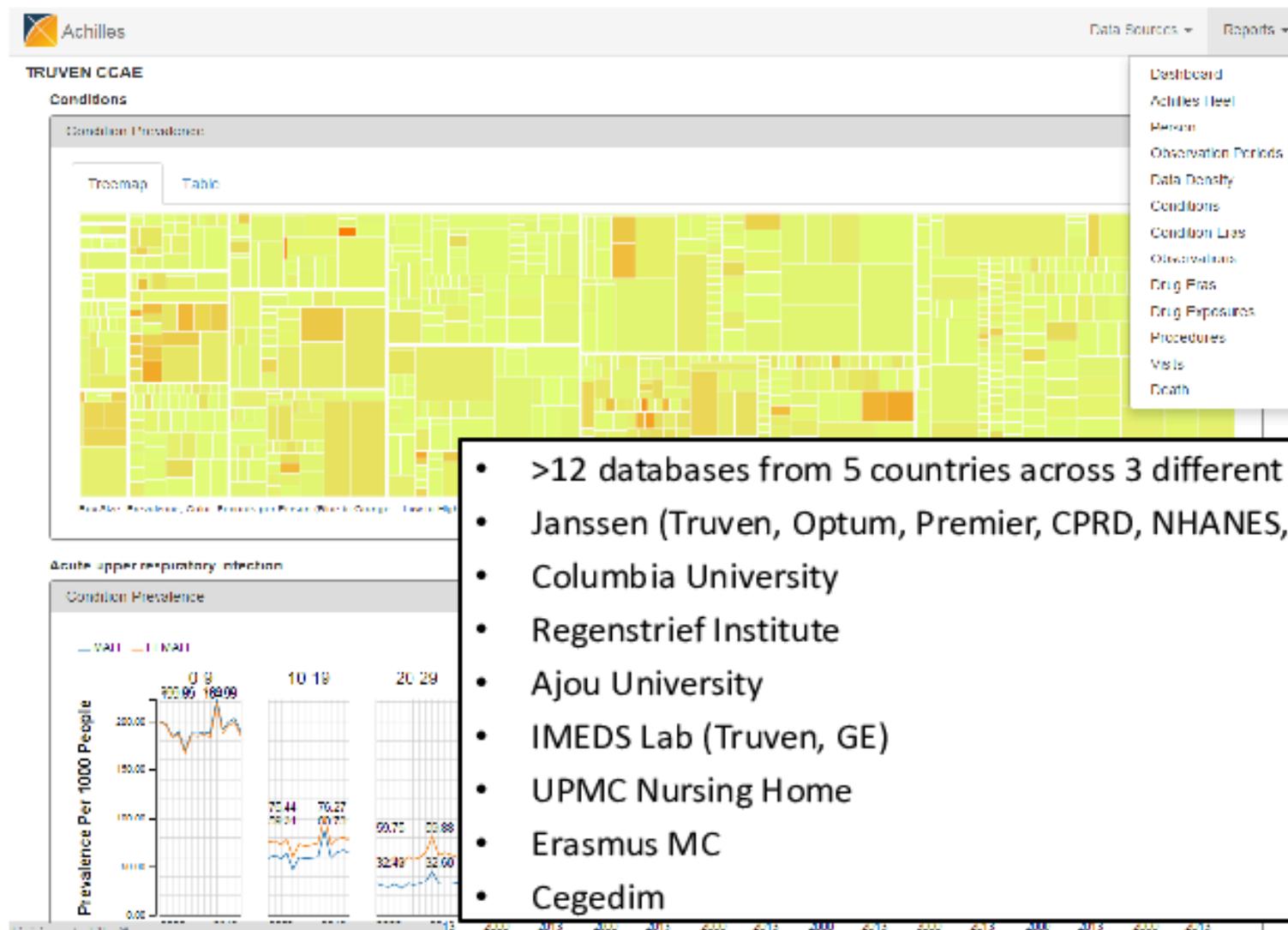
- Persons
- Conditions
- Drugs
- Lab results
- ...



Explore statistics
in a web browser



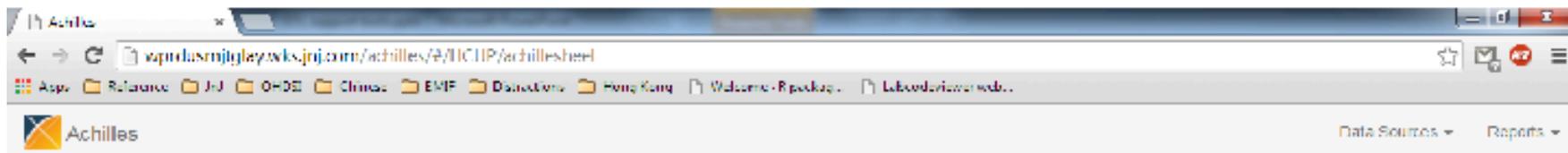
ACHILLES



- >12 databases from 5 countries across 3 different platforms:
- Janssen (Truven, Optum, Premier, CPRD, NHANES, HCUP)
- Columbia University
- Regenstrief Institute
- Ajou University
- IMEDS Lab (Truven, GE)
- UPMC Nursing Home
- Erasmus MC
- Cegedim



Achilles Heel



HCUP

Achilles Heel Report

Data Quality Messages

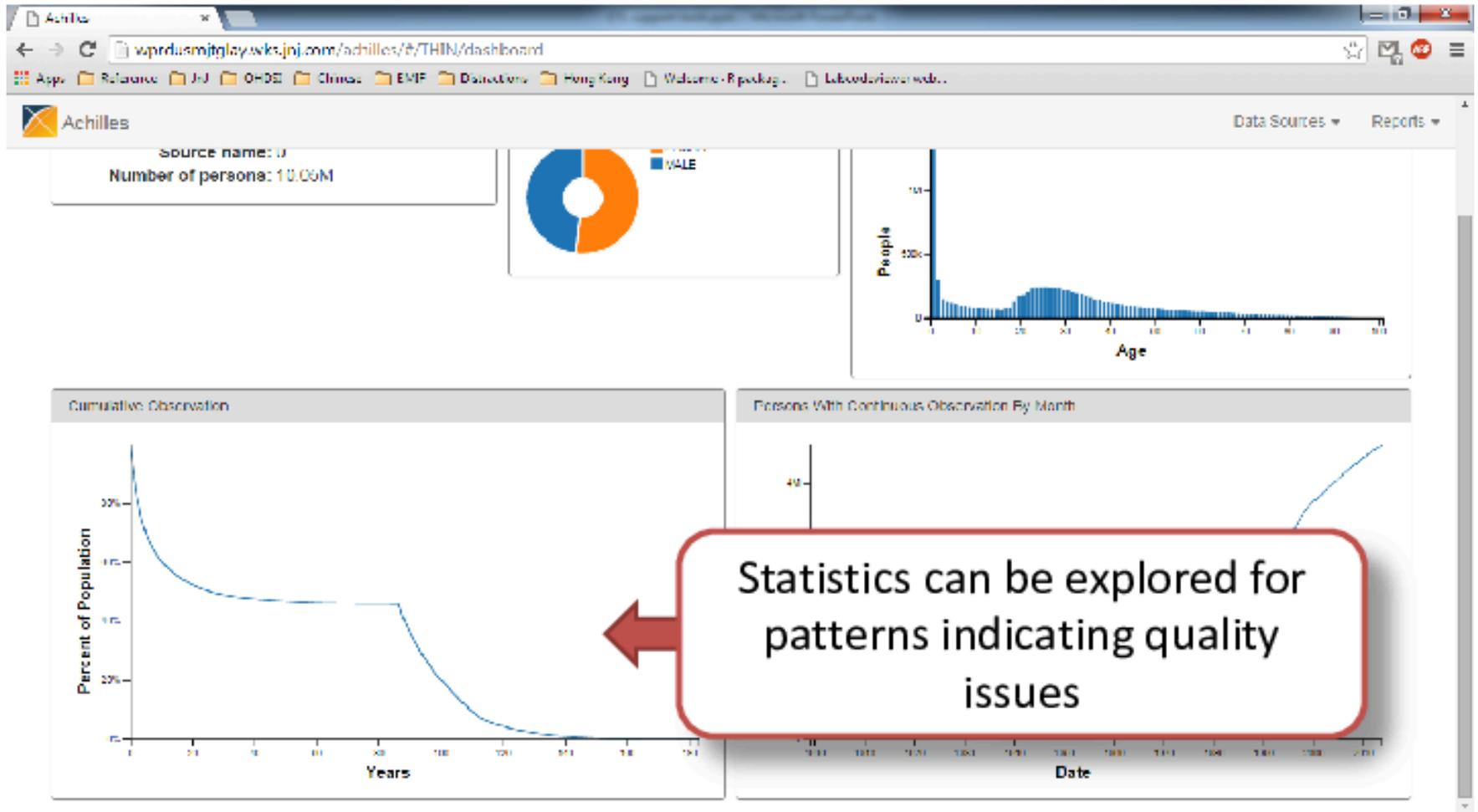
Search:

Message Type	Message
ERROR	3-Number of persons by year of birth, should not have year of birth < 1900. (n=65847)
ERROR	101-Number of persons by age, with age at first observation period, should not have age > 100. (n=38865)
ERROR	400-Number of persons with at least one condition occurrence, by condition_concept_id: 121 concepts in data are not in correct vocabulary (SNOMED)
ERROR	1000-Number of persons with at least one condition era, by condition_concept_id: 121 concepts in data are not in correct vocabulary (SNOMED)
WARNING	5-Number of persons by ethnicity, data with unmapped concepts
WARNING	400-Number of persons with at least one condition occurrence, by condition_concept_id: data with unmapped concepts
	1000-Number of persons with at least one condition occurrence, by condition_concept_id: 1785 concepts have a 100% change in monthly count of events
	1000-Number of persons with at least one condition occurrence, by procedure_concept_id: data with unmapped concepts
	1000-Number of persons with at least one condition occurrence, by procedure_concept_id: 777 concepts have a 100% change in monthly count of events
	1000-Number of persons with at least one condition occurrence, by condition_concept_id: 1023 concepts have a 100% change in monthly count of events
	1000-Number of persons with at least one condition occurrence, by condition_concept_id: data with unmapped concepts

Lists data quality issues



Achilles





- Demonstration of Achilles on a nursing home dataset
- Try it yourself on a simulated population!
 - <http://www.ohdsi.org/web/achilles/>

Atlas brings together several OHDSI tools

The screenshot displays the ATLAS web application interface. The browser address bar shows the URL `localhost/Atlas/#/home`. The left sidebar contains the ATLAS logo and a navigation menu with the following items: Home, Data Sources, Vocabulary, Concept Sets, Cohorts, Jobs, Configuration, and Feedback. The main content area is titled "Home" and features a "Welcome to ATLAS" message. Below the welcome message, there is a link to the ATLAS user guide. A "Getting Started" section contains two green buttons: "Define a New Cohort" and "Search the Vocabulary". The "Release Notes" section is also visible, detailing the current version (1.0) and listing various updates and bug fixes.

ATLAS

Home

Welcome to ATLAS

ATLAS is an open source application developed as a part of OHDSI intended to provide a unified interface to patient level data and analytics.

The ATLAS user guide can be found [here](#).

Getting Started

[Define a New Cohort](#) Begin performing research by defining the group of people you intend to study

[Search the Vocabulary](#) Search the different ontologies used to describe patient level data around the world

Release Notes

Version 1.0 Current Release Notes

- Integrated Data Source Characterization (project achilles)
- Integrated Cohort Definitions (project circe)
- Integrated Cohort Reporting (project heracles)
- Bug Fixes listed in Additional Details below

Additional Details:

This latest release contains **30** feature enhancements and issue resolutions.

- Error when opening cohort definition that hasn't been generated
- Concept Set JSON import problems
- Cohort report drilldown errors
- Atlas WebAPI Configuration
- Hide Patient Profile
- Concept set expression: include 'source codes' if non-standard concepts selected in conceptset expression
- Concept Set - Enforce Unique Names
- Cohort export to JSON
- Concept Set Saving Issues
- Remove Cohort Reporting left hand menu item
- Importing source codes, they do not get added to cart

Atlas- vocabulary exploration

ATLAS

localhost/Atlas/#/search/simvastatin

ATLAS

Vocabulary

Search Results for simvastatin

Search Advanced Results Import

Show 15 entries

Showing 1 to 15 of 3,075 entries

Filter:

Previous 1 2 3 4 5 ... 205 Next

Id	Code	Name	Class	RC	DRC	Domain	Vocabulary
45408439	96785839662900	*Simvastatin (Bulk) Powder***	GPI	timeout	timeout	Drug	GPI
19129329	761907	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet	Quant Clinical Drug	timeout	timeout	Drug	RxNorm
1518133	763228	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	Quant Branded Drug	timeout	timeout	Drug	RxNorm
45190421	54868590401	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
45071318	54868590400	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
44838579	00074331690	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
45281999	00074345590	24 HR Niacin 1000 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
40224128	999935	24 HR Niacin 1000 MG / Simvastatin 40 MG Extended Release Oral Tablet	Quant Clinical Drug	timeout	timeout	Drug	RxNorm
40224129	999939	24 HR Niacin 1000 MG / Simvastatin 40 MG Extended Release Oral Tablet [Simcor]	Quant Branded Drug	timeout	timeout	Drug	RxNorm
45128053	00074345790	24 HR Niacin 1000 MG / Simvastatin 40 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
45156278	54868616900	24 HR Niacin 1000 MG / Simvastatin 40 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
19129330	761909	24 HR Niacin 500 MG / Simvastatin 20 MG Extended Release Oral Tablet	Quant Clinical Drug	timeout	timeout	Drug	RxNorm
45162170	00074331207	24 HR Niacin 500 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
44952017	54868588600	24 HR Niacin 500 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC
44866903	54868588601	24 HR Niacin 500 MG / Simvastatin 20 MG Extended Release Oral Tablet [Simcor]	11-digit NDC	timeout	timeout	Drug	NDC

Vocabulary
 NDC (2086)
 SNOMED (320)
 SPL (224)
 RxNorm (113)
 Multilex (86)
 VA Product (73)
 NDFRT (50)
 Gemscrip (43)

Class
 11-digit NDC (1635)
 9-digit NDC (451)
 Pharma/Biol Product (314)
 Prescription Drug (123)
 Clinical Drug (111)
 SPL (101)
 VA Product (73)
 Drug Interaction (45)

Domain
 Drug (3057)
 Observation (7)
 Measurement (6)
 Condition (5)

Standard Concept
 Non-Standard (2841)
 Classification (125)
 Standard (109)

Invalid Reason
 Valid (2941)
 Invalid (134)

Has Records
 false (3075)

Has Descendant Records
 false (3075)

Atlas – Concept set generation

ATLAS

Concept Sets

Concept Set Repository

Local

Show 10 entries

Filter Repository Concept Sets:

Id	Title
2523	Aldosterone Antagonists
1433	Amiodarones
240	Anticoagulants
2546	Aspirins
1572	Azoles
2562	Azoles w/o Fluconazoles
1894	Beta-Blockers
1861	Calciums
2587	Calciums (IV)
1129	CCA-Cognitive-Scale

Showing 1 to 10 of 63 entries

Previous 1 2 3 4 5 6 7 Next

ATLAS

Concept Set

Aldosterone Antagonists

Close Save

Concept Set Expression

Included Concepts 7

Included Source Codes

Export

Show 25 entries

Showing 1 to 7 of 7 entries

Search:

Previous 1 Next

	Concept Id	Concept Code	Concept Name	Domain	Standard Concept Caption	Exclude	Descendants	Mapped
🛒	970283	198223	Spironolactone 50 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	19079658	313096	Spironolactone 25 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	970282	198222	Spironolactone 100 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	974226	198224	Hydrochlorothiazide 25 MG / Spironolactone 25 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	1309801	351257	eplerenone 50 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	1309800	351256	eplerenone 25 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
🛒	1309832	351258	eplerenone 100 MG Oral Tablet	Drug	Standard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Classification Non-Standard Standard

Atlas – Study cohort generation

ATLAS

localhost/Atlas/#/cohortdefinitions

ATLAS

Cohorts

Cohort Definition Repository

Local

▼ Last Modified
2+ Weeks Ago (20)

▼ Author
system (20)

Show 15 entries

Showing 1 to 15 of 20 entries

Filter:

Previous 1 2 Next

Id	Name	Created	Updated	Author
138	Fall Risk	2/2/2016	2/25/2016	system
180	Tramadol - antidepressant	2/17/2016	2/17/2016	system
167	Fall Risk - High 4 levels - obs	2/11/2016	2/11/2016	system
166	Fall Risk - Med 4 levels (Q3)	2/10/2016	2/11/2016	system
165	Fall Risk - Low 4 level	2/9/2016	2/11/2016	system
168	Fall Risk - Med - 4 levels - obs (Q3)	2/11/2016	2/11/2016	system
164	Fall Risk - High 4 levels	2/9/2016	2/9/2016	system
130	metformin test 1	2/1/2016	2/1/2016	system
120	Test antibiotic 1	2/1/2016	2/1/2016	system
60	NH Data Test 7	1/19/2016	1/19/2016	system
1	NH Data test 1	1/9/2016	1/19/2016	system
28	NH data set test 6	1/11/2016	1/11/2016	system
8	NH Data Test 5	1/10/2016	1/10/2016	system
4	NH Data Test 4	1/9/2016	1/9/2016	system
2	NH Data test 2	1/9/2016	1/9/2016	system

Atlas – Study cohort generation cont...

The screenshot displays the ATLAS web interface for defining a study cohort. The browser address bar shows the URL `localhost/Atlas/#/cohortdefinition/180`. The left sidebar contains navigation options: Tramadol - antidepressant, Home, Data Sources, Vocabulary, Concept Sets, Cohorts, Jobs, Configuration, and Feedback. The main content area is titled 'Cohort' and shows the configuration for 'Tramadol - antidepressant'. The 'Definition' tab is active, showing a description: 'Co-exposure to tramadol and an antidepressant'. The primary event filter is set to 'a drug exposure of antidepressants' with observation windows of 0 days prior and 0 days after index. The secondary filter is 'a drug exposure of tramadol' occurring between All days Before and All days After index. The interface includes buttons for 'Save', 'Show SQL', 'Close', 'Copy', and 'Delete Cohort', as well as 'Add Filter...', 'Delete Filter', and 'Remove Additional Filters'.

ATLAS

Tramadol - antidepressant

Home

Data Sources

Vocabulary

Concept Sets

Cohorts

Jobs

Configuration

Feedback

Cohort

Tramadol - antidepressant

Save Show SQL Close Copy Delete Cohort

Definition Concept Sets Generation Reporting Print Friendly JSON

Description:

Co-exposure to tramadol and an antidepressant

People having any of the following: [Add Primary Event Filters...](#)

a drug exposure of antidepressants [Add Filter...](#) [Delete Filter](#)

with observation at least 0 days prior and 0 days after index

Limit primary events to: all events per person.

For people matching the Primary Events, include:

People having all of the following criteria: [Add New Criteria...](#)

with at least 1 using all occurrences of: [Add Filter...](#)

a drug exposure of tramadol

occurring between All days Before and All days After index [Delete Filter](#)

[Remove Additional Filters](#)

Limit cohort expression results to: all events per person.

Atlas – Study cohort characterization

ATLAS Cohort

Tramadol - antidepressant

Save Show SQL Close Copy Delete Cohort

Definition Concept Sets **Generation** Reporting Print Friendly JSON

Source Name	Generation Status	Distinct People	Generated	Generation Duration
dbmi ohdsi oracle	COMPLETE	253	2/17/2016 3:44:17 PM	3.025s

Generate

ATLAS

- Tramadol - antidepressant
- antidepressants 1
- Home
- Data Sources
- Vocabulary
- Concept Sets
- Cohorts
- Jobs
- Configuration
- Feedback

ATLAS Cohort

Tramadol - antidepressant

Save Show SQL Close Copy Delete Cohort

Definition Concept Sets Generation **Reporting** Print Friendly JSON

Report dbmi ohdsi oracle

Cohort Specific	⚠️	<input type="checkbox"/>
Condition	✅	<input checked="" type="checkbox"/> view
Condition Eras	✅	<input checked="" type="checkbox"/> view
Conditions By Index	⚠️	<input type="checkbox"/>
Death	⚠️	<input type="checkbox"/>
Drug Eras	✅	<input checked="" type="checkbox"/> view
Drug Exposure	⚠️	<input type="checkbox"/>
Drugs by Index	⚠️	<input type="checkbox"/>
Observation Periods	⚠️	<input type="checkbox"/>
Person	✅	<input checked="" type="checkbox"/> view
Procedure	⚠️	<input type="checkbox"/>
Procedures by Index	⚠️	<input type="checkbox"/>

Generate Export

Condition Report (DBMI_OHDSI)

Condition Prevalence

Treemap Table

Box Size: Prevalence, Color: Records per Person (Light to Dark = Low to High), Use Ctrl-Click to Zoom, Alt-Click to Reset Zoom

ATLAS

- Tramadol - antidepressant
- Home
- Data Sources
- Vocabulary
- Concept Sets
- Cohorts
- Jobs
- Configuration
- Feedback

Atlas – Study cohort characterization cont...

The screenshot displays the ATLAS web application interface. The browser address bar shows `localhost/Atlas/#/cohortdefinition/180`. The main header includes the ATLAS logo and a navigation menu with items like Home, Data Sources, Vocabulary, Concept Sets, Cohorts, Jobs, Configuration, and Feedback. The central area is titled 'Cohort' and shows the cohort name 'Tramadol - antidepressant' with buttons for Save, Show SQL, Close, Copy, and Delete Cohort. Below this is a 'Report' section for 'dbmi ohdsi oracle' with a list of metrics and their status (e.g., Cohort Specific, Condition, Condition Eras, etc.). A 'Condition Report (DBMI)' is open, showing a treemap visualization for 'Anemia'. The treemap is a hierarchical chart where the size of each box represents prevalence and the color represents records per person. A tooltip for 'Anemia' provides the following data: Prevalence: 49.41%, Number of People: 125, and Records per Person: 5.84. A legend at the bottom explains the treemap: 'Box Size: Prevalence, Color: Records per Person (Light to Dark = Low to High), Use Ctrl-Click to Zoom, Alt-Click to Reset Zoom'.

ATLAS

Tramadol - antidepressant
antidepressants

Home
Data Sources
Vocabulary
Concept Sets
Cohorts
Jobs
Configuration
Feedback

Cohort

Tramadol - antidepressant

Save Show SQL Close Copy Delete Cohort

Definition Concept Sets Generation Reporting Print Friendly JSON

Report dbmi ohdsi oracle

Cohort Specific

Condition view

Condition Eras view

Conditions By Index

Death

Drug Eras view

Drug Exposure

Drugs by Index

Observation Periods

Person view

Procedure

Procedures by Index

Condition Report (DBMI)

Condition Prevalence

Treemap Table

Anemia
Prevalence: 49.41%
Number of People: 125
Records per Person: 5.84

Blood and lymphatic system disorders
Red blood cell disorders
Red blood cell abnormal findings NEC
Red blood cell abnormality

Box Size: Prevalence, Color: Records per Person (Light to Dark = Low to High), Use Ctrl-Click to Zoom, Alt-Click to Reset Zoom



- Demonstration of Atlas on a nursing home dataset
- Try it yourself on a simulated population!
 - <http://www.ohdsi.org/web/atlas/#/home>



Conclusion

- Structural and semantic interoperability are important for clinical research
- Placing your clinical data into a common data model and standard vocabulary are essential first steps
 - Perhaps more work initially
 - However, several benefits
 - Network research
 - Common tools and methods
 - Quality assurance
 - Study design
- The OHDSI CDM and tools can be very helpful



Learn more about interoperability for clinical research

- Observational Health Data Sciences and Informatics (OHDSI) collaborative: <http://www.ohdsi.org/>

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Weber GM, Murphy SN, McMurry AJ, Macfadden D, Nigrin DJ, Churchill S, Kohane IS. The Shared Health Research Information Network (SHRINE): a prototype federated query tool for clinical data repositories. J Am Med Inform Assoc. 2009 Sep-Oct;16(5):624-30. PMC2744712.



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ISPOR SHORT COURSES



Discussion