

Death Certificate Project



Presenter: Soon Jye Kho

Date: 8/20/18

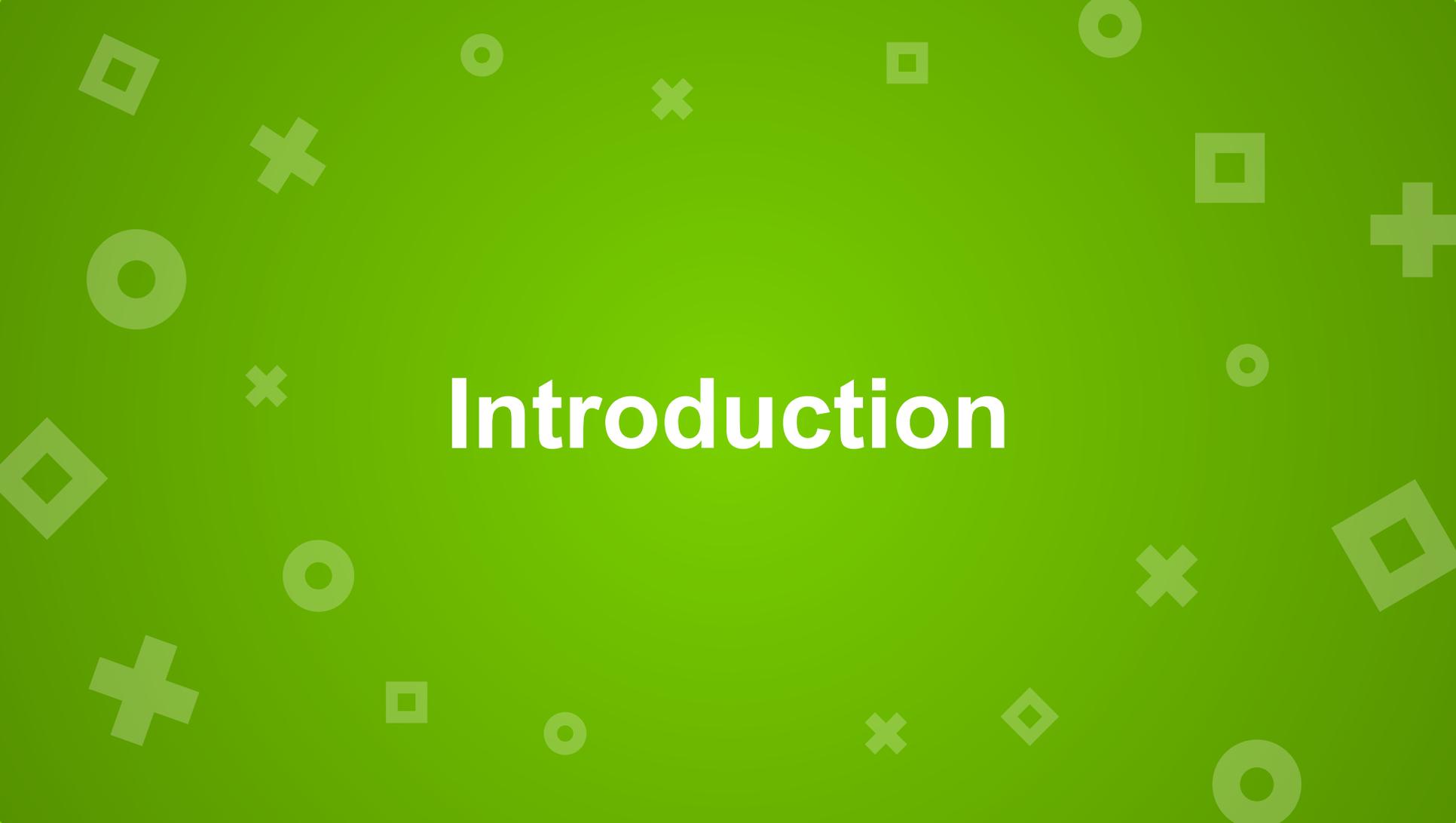
Advisor: Olivier Bodenreider



U.S. National
Library of
Medicine



Centers for Disease
Control and Prevention
National Center for
Health Statistics

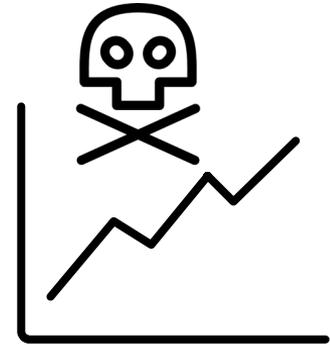
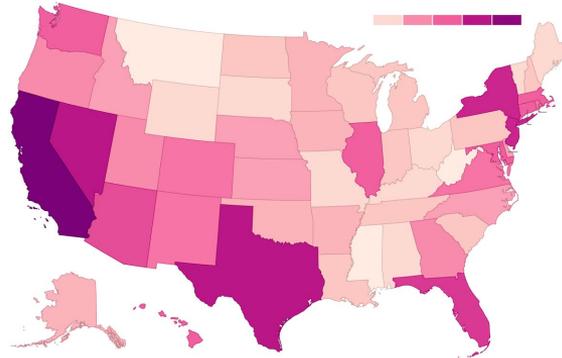
The background is a solid green color with various mathematical symbols scattered across it. These symbols include squares, circles, and plus signs, some of which are slightly rotated or tilted. The symbols are in a lighter shade of green than the background, creating a subtle pattern.

Introduction

Vital Statistics

National Vital Statistics System (NVSS)

- Used by National Center for Health Statistics (NCHS)
- Collect and disseminate national vital statistics



Drug Overdose Trend

Every death certificate is assigned with an ICD-10 code, which corresponds the cause of death of decedent

Table 1
Reported and adjusted drug involvement in 2014 drug poisoning deaths.

Drug mentions	Reported # of Deaths	Prevalence (%)	Adjusted prevalence (%)	% Difference
Drug Involvement (T-Codes)				
Narcotics (40.0–40.9)	30,731	65.3	82.2 [81.3–83.2]	25.9 [24.4–27.4]
Opioid Analgesics (40.2–40.4)	18,893	40.2	52.6 [50.7–54.6]	31.1 [26.3–35.9]
Heroin (40.1)	10,574	22.5	30.0 [28.0–32.0]	33.1 [24.5–42.3]
Cocaine (40.5)	5,115	11.5	15.2 [13.8–16.5]	31.7 [28.3–34.1]
Other Narcotics (40.0, 40.6–40.9)	2,822	6.0	7.5 [6.2–8.8]	34.7 [29.9–40.5]
Sedatives (42.0–42.8)	9,908	19.8	29.2 [27.5–30.9]	47.8 [39.0–56.1]
Psychotropics (43.0–43.9)	9,614	20.4	27.3 [25.5–29.1]	33.5 [24.8–42.3]
Antidepressants (43.0–43.2)	4,768	10.1	14.9 [13.9–15.8]	46.6 [37.1–56.1]
Antipsychotics (43.3–43.5)	1,588	3.4	5.2 [4.7–5.7]	53.0 [38.6–69.2]
Psychostimulants (43.6)	4,298	9.1	11.0 [9.7–12.3]	20.0 [15.9–24.2]
Other Specified (36.0–38.9, 41.0, 41.9, 44.0–48.7, 49.0–50.8)	3,573	7.6	10.3 [9.6–10.9]	35.5 [28.8–44.1]
Unspecified (50.9)	23,347	49.6	38.4 [35.2–41.6]	-22.6 [-29.0–-16.2]
Exclusive Involvement				
Opioid Analgesics	7,769	16.5	19.3 [18.1–20.5]	17.1 [9.8–24.5]
Heroin	5,067	10.8	13.4 [11.9–14.8]	24.2 [10.6–37.7]
Cocaine	1,747	3.7	4.3 [3.7–4.9]	16.1 [0.7–31.5]
Sedatives	814	1.7	2.1 [1.9–2.3]	22.4 [11.6–33.2]
Psychotropics	3,390	7.2	7.9 [7.1–8.8]	10.2 [1.8–22.3]
Other Specified	1,476	3.1	3.5 [3.3–3.8]	12.3 [4.0–20.6]
Unspecified	9,201	19.6	3.5 [3.2–3.7]	-82.2 [-83.5–-81.0]
> 1 Drug Category	16,187	34.4	49.3 [47.5–51.1]	43.2 [38.0–48.4]

Note: Data are from the Multiple Cause of Death files. Drug poisoning deaths include ICD-10 Underlying Cause of Death Codes: X40–44, X60–64, X85, Y10–14, Y35.2, *U01A and *U01.7) Entries in parentheses refer to ICD-10 T codes for drug mentions. > 1 Drug Category refers to drug mentions of two or more of the following drug types: opioid analgesics, heroin, cocaine, other narcotics, sedatives, psychotropics and other specified drugs. Exclusive drug involvement indicates deaths where only the specified class of drugs is mentioned (but unspecified drugs could also be involved). Reported numbers of deaths and prevalences are from death certificates and indicate the percentage of drug poisonings where the specified type of drug is mentioned. Adjusted prevalences are average predicted values from probit models, where at least one specific drug is assumed to be mentioned for all poisoning deaths in the county (SPECIFY=1). Models also control for: sex, race (black, other), Hispanic origin, currently married, education (high school dropout, high school graduate, some college, college graduate), age (<20, 21–30, 31–40, 41–50, 51–60, 61–70, 71–80, > 80), day of the week of death, and census region. % Difference refers to the percentage difference between the adjusted and reported prevalences. These are calculated using more significant digits than are shown in the table, so some differences may appear due to rounding error. 95 percent confidence intervals, shown in brackets, are computed using robust standard errors with clustering at the county level.

Table 1
Drug involvement in drug poisoning deaths: 1999 and 2012^a

Drug category/Manner of death	1999		2012	
	Percent	Number	Percent	Number
All drug deaths (X40–44, X60–64, X85, Y10–14, Y35.2, *U01(6.–7)) ^b	100.0	16,849	100.0	41,502
Drug mentions (T-codes)				
Narcotics (40.0–40.9)	58.9	9922	60.7	25,187
Opioid analgesics (40.2–40.4)	23.9	4050	38.6	16,007
Methadone (40.3)	4.7	784	9.5	3932
Other opioid analgesics (40.2, 40.4)	19.9	3360	31.4	13,012
Other narcotics (40.0–40.1, 40.5–40.9)	42.4	7137	27.9	11,567
Heroin (40.1)	11.6	1960	14.3	5925
Cocaine (40.5)	22.7	3822	10.6	4404
Miscellaneous (40.0, 40.6–40.9)	17.4	2931	7.2	3006
Sedatives (40.2–40.8)	9.9	1662	18.7	7754
Benzodiazepines (42.4)	6.7	1135	15.7	6524
Other sedatives (42.0–42.3, 42.5–42.8)	3.9	663	4.9	2048
Psychotropics (43.0–43.9)	14.6	2466	18.0	7467
Antidepressants (43.0–43.2)	10.4	1749	10.3	4259
Antipsychotics (43.3–43.5)	1.9	321	3.2	1333
Stimulants (43.6)	3.2	547	6.3	2635
Other specified (36.0–38.9, 41.0, 41.9, 44.0–48.7, 49.0–50.8)	6.9	1171	7.6	3156
Unspecified (50.9)	50.3	8477	49.7	20,612
>1 Major drug class ^c	18.0	3040	26.9	11,176
Manner of death				
Accidental (X40–44)	66.2	11,155	79.9	33,175
Intentional (X60–64)	18.9	3181	13.2	5465
Undetermined intent (Y10–Y14)	14.7	2473	6.7	2782
Homicide (X85, Y35.2, *U01(6.–7))	0.2	40	0.2	80

^aData from the Multiple Cause of Death files
^bEntries in parentheses refer to ICD-10 X and Y codes for the underlying causes of death used to classify drug poisoning and manner of death, and T codes for drug mentions
^cTwo or more of the drug types: opioid analgesics, other narcotics, sedatives, psychotropics, or other specified drugs

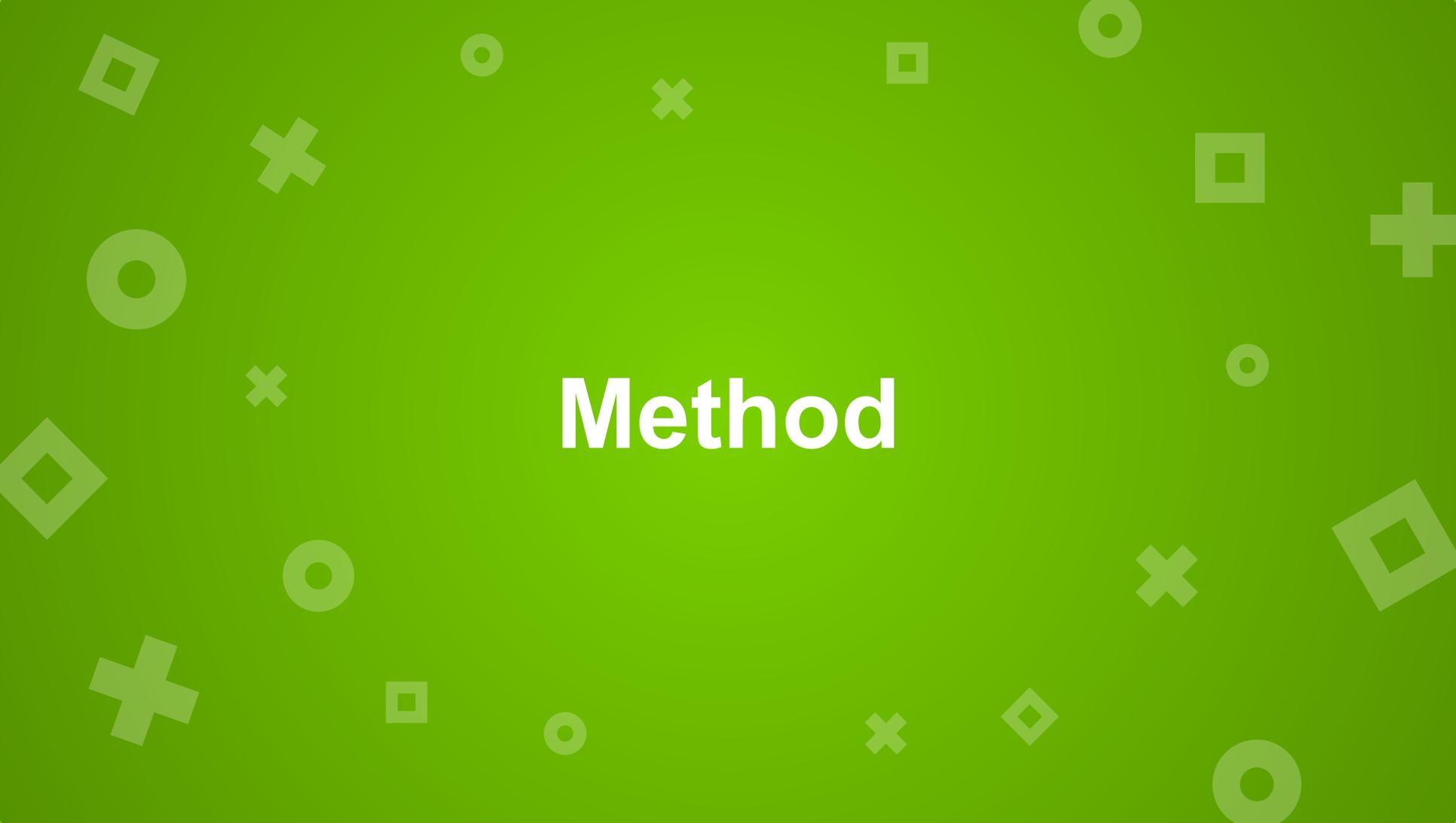
Granularity of ICD-10

What if I want to know about a particular drug instead of the whole drug class?

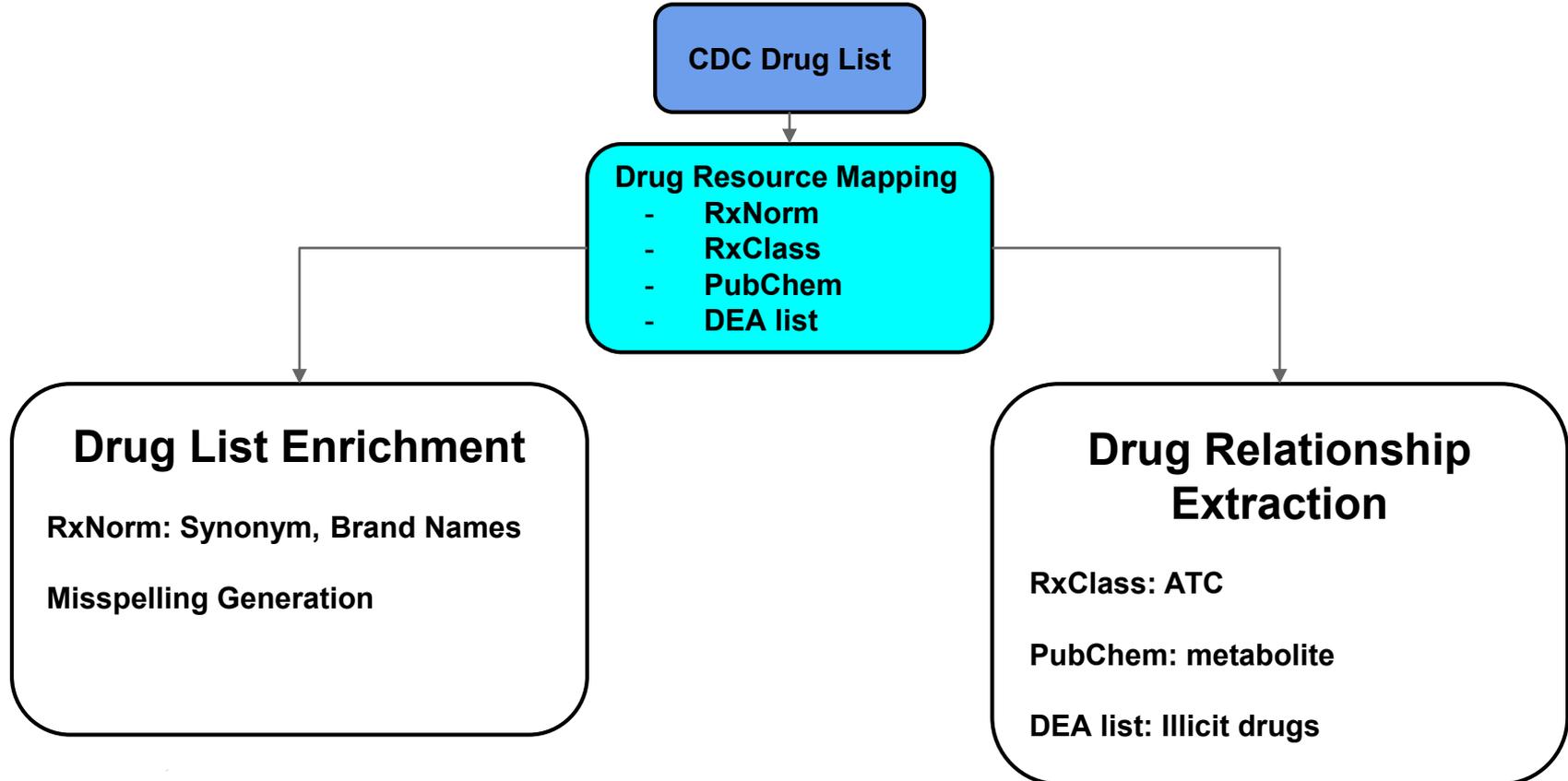
Literal text are recorded in the system

CAUSE OF DEATH (See instructions and examples)				Approximate interval: Onset to death
32. PART I. Enter the <u>chain of events</u> -- diseases, injuries, or complications -- that directly caused the death. DO NOT enter terminal events such as cardiac arrest, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.				
IMMEDIATE CAUSE (Final disease or condition resulting in death) Sequentially list conditions, if any, leading to the cause listed on line a. Enter the UNDERLYING CAUSE (disease or injury that initiated the events resulting in death) LAST.	a.	Literal text	Due to (or as a consequence of):	Causal sequence leading to death
	b.		Due to (or as a consequence of):	
	c.		Due to (or as a consequence of):	
	d.		Due to (or as a consequence of):	
PART II. Enter other <u>significant conditions contributing to death</u> but not resulting in the underlying cause given in Part I.				
Literal text				
35. DID TOBACCO USE CONTRIBUTE TO DEATH? <input type="checkbox"/> Yes <input type="checkbox"/> Probably <input type="checkbox"/> No <input type="checkbox"/> Unknown		36. IF FEMALE: <input type="checkbox"/> Not pregnant within past year <input type="checkbox"/> Pregnant at time of death <input type="checkbox"/> Not pregnant but pregnant within 42 days of death <input type="checkbox"/> Not pregnant but pregnant 43 days to 1 year before death <input type="checkbox"/> Unknown if pregnant within the past year		29. MANNER OF DEATH <input type="checkbox"/> Natural <input type="checkbox"/> Pending <input type="checkbox"/> Accident <input type="checkbox"/> Investigation <input type="checkbox"/> Suicide <input type="checkbox"/> Could not be determined <input type="checkbox"/> Homicide
38. DATE OF INJURY (Mo/Day/Yr/Spell Month)	39. TIME OF INJURY	40. PLACE OF INJURY (e.g., Decedent's home, construction site, restaurant, wooded area)		41. INJURY AT WORK? <input type="checkbox"/> Yes <input type="checkbox"/> No
42. LOCATION OF INJURY: State: _____ City or Town: _____			Apartment No. _____ Zip Code: _____	
43. DESCRIBE HOW INJURY OCCURRED Literal text				44. IF TRANSPORTATION INJURY, SPECIFY <input type="checkbox"/> Other (Specify)

Method



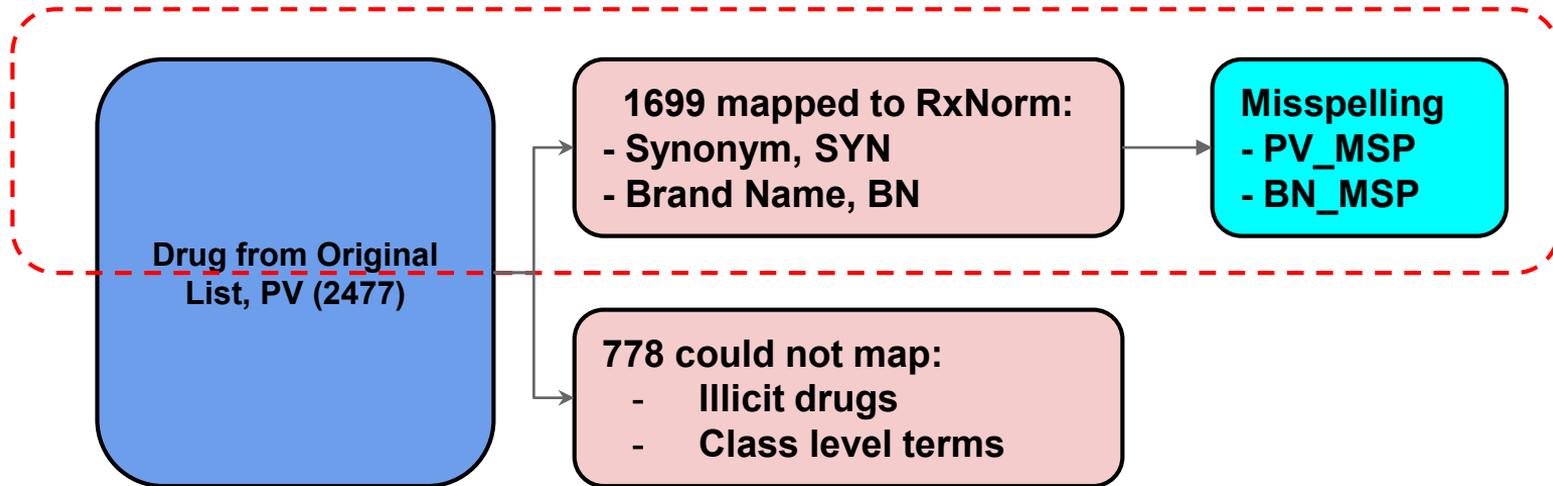
Method Workflow



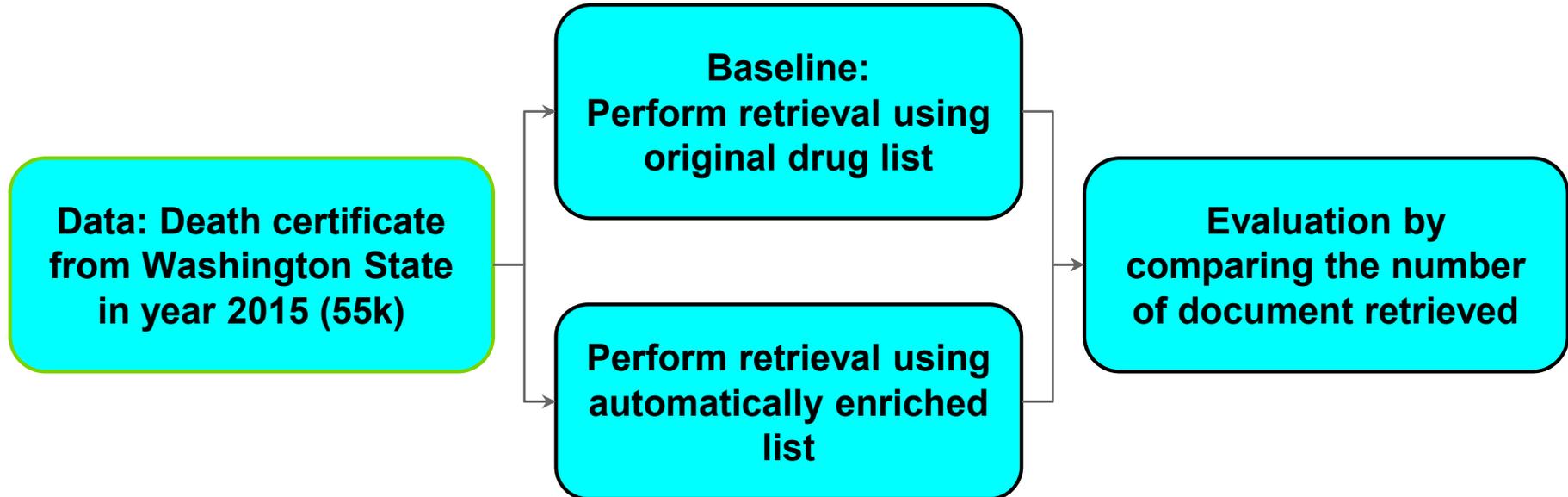
Drug List Enrichment

Get as many terminology variant of drug as possible
To have better recall in retrieving documents

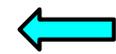
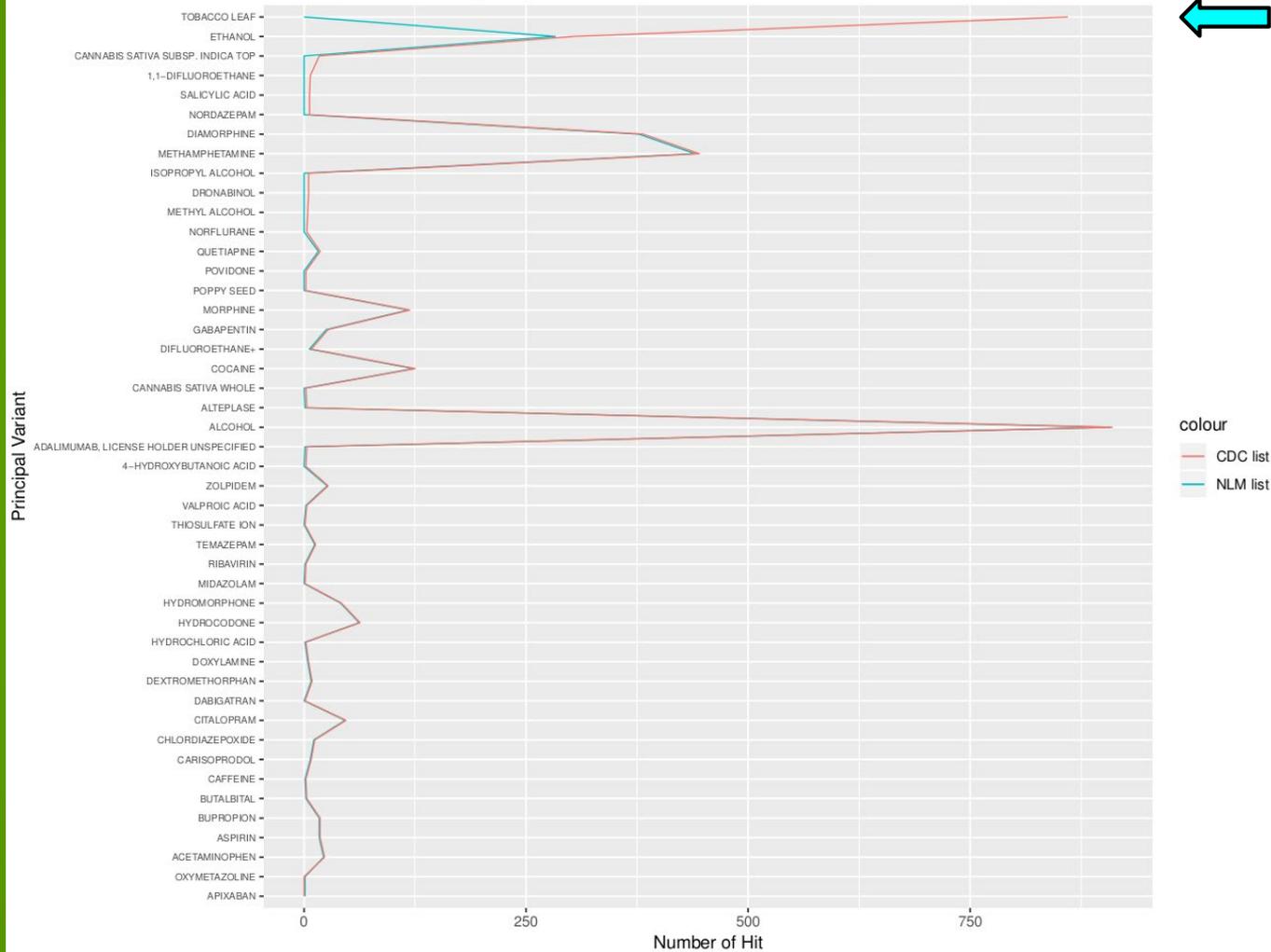
Number of terms enriched



Evaluation of enriched prescription drug list



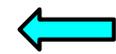
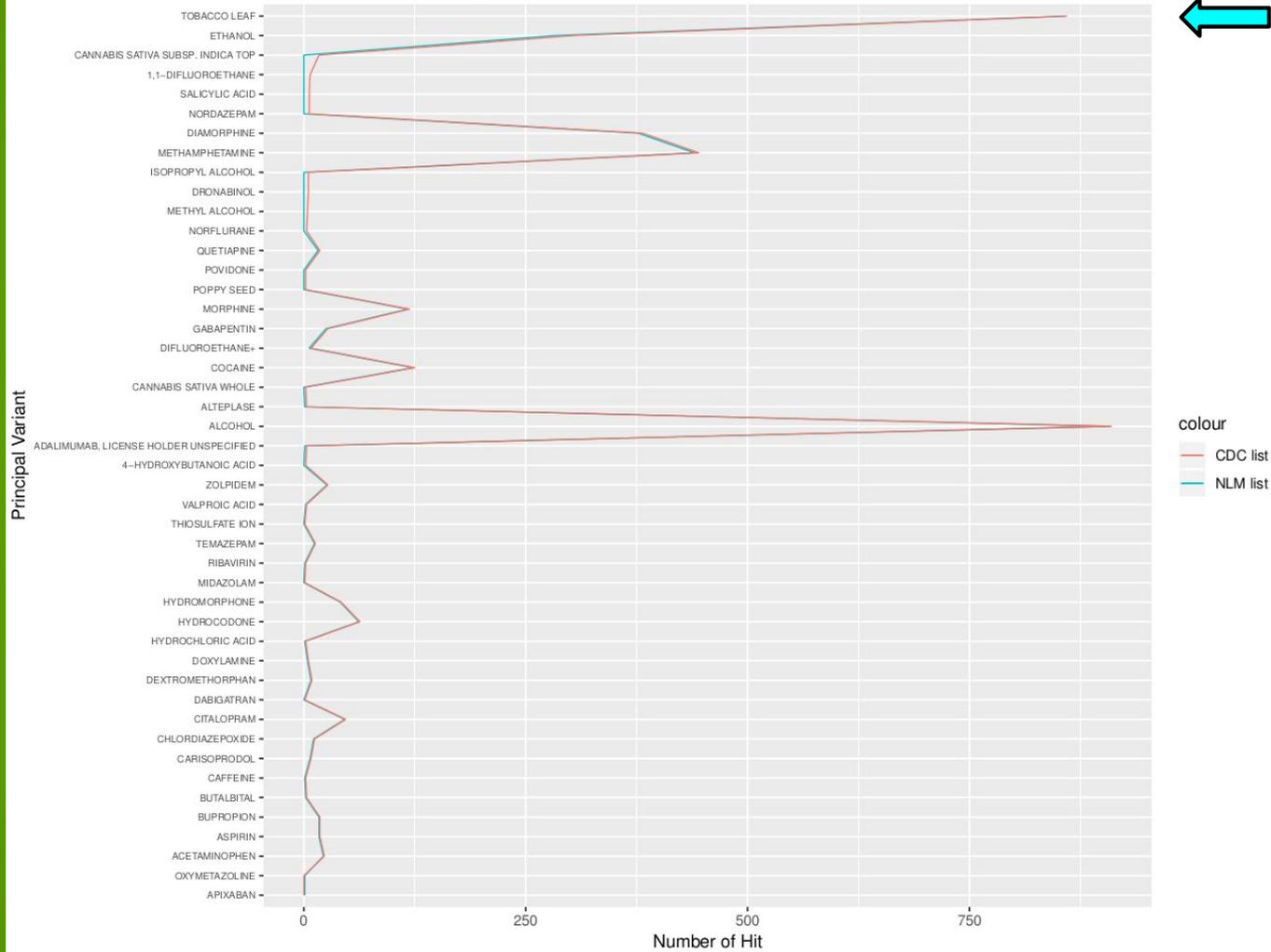
Number of hit for each principal variant



Tobacco Leaf
- **Tobacco**

	Total number of documents retrieved
CDC	5010
NLM	4025
Diff	985

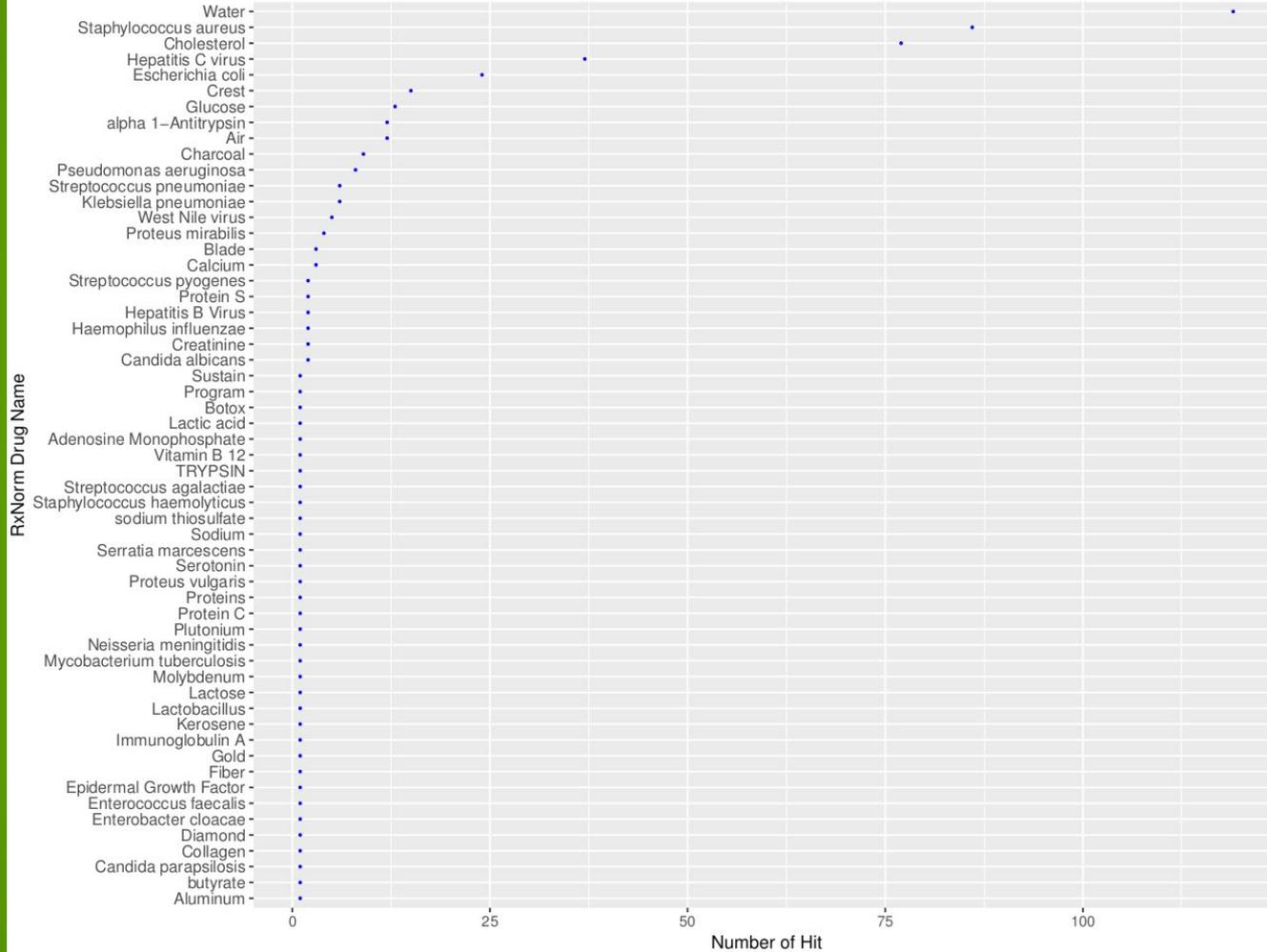
Number of hit for each principal variant



**Adding synonym
'tobacco'**

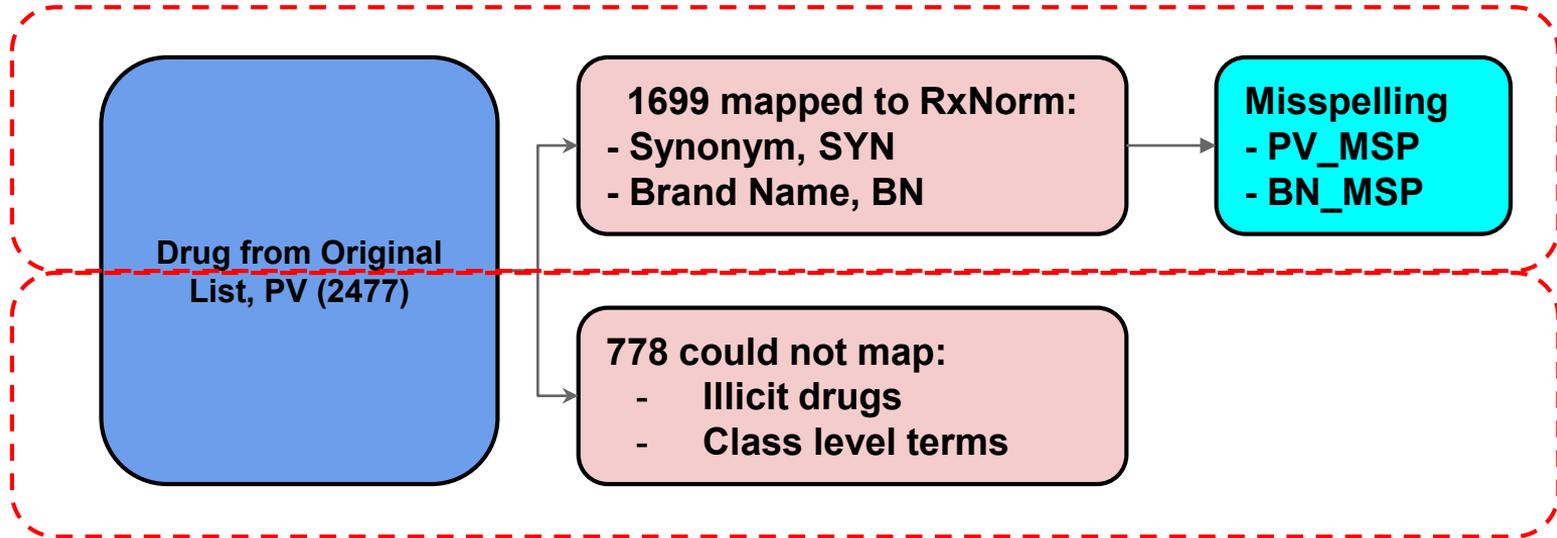
	Total number of documents retrieved
CDC	5010
NLM	4883
Diff	127

Number of Retrieved Documents for RxNorm Drug



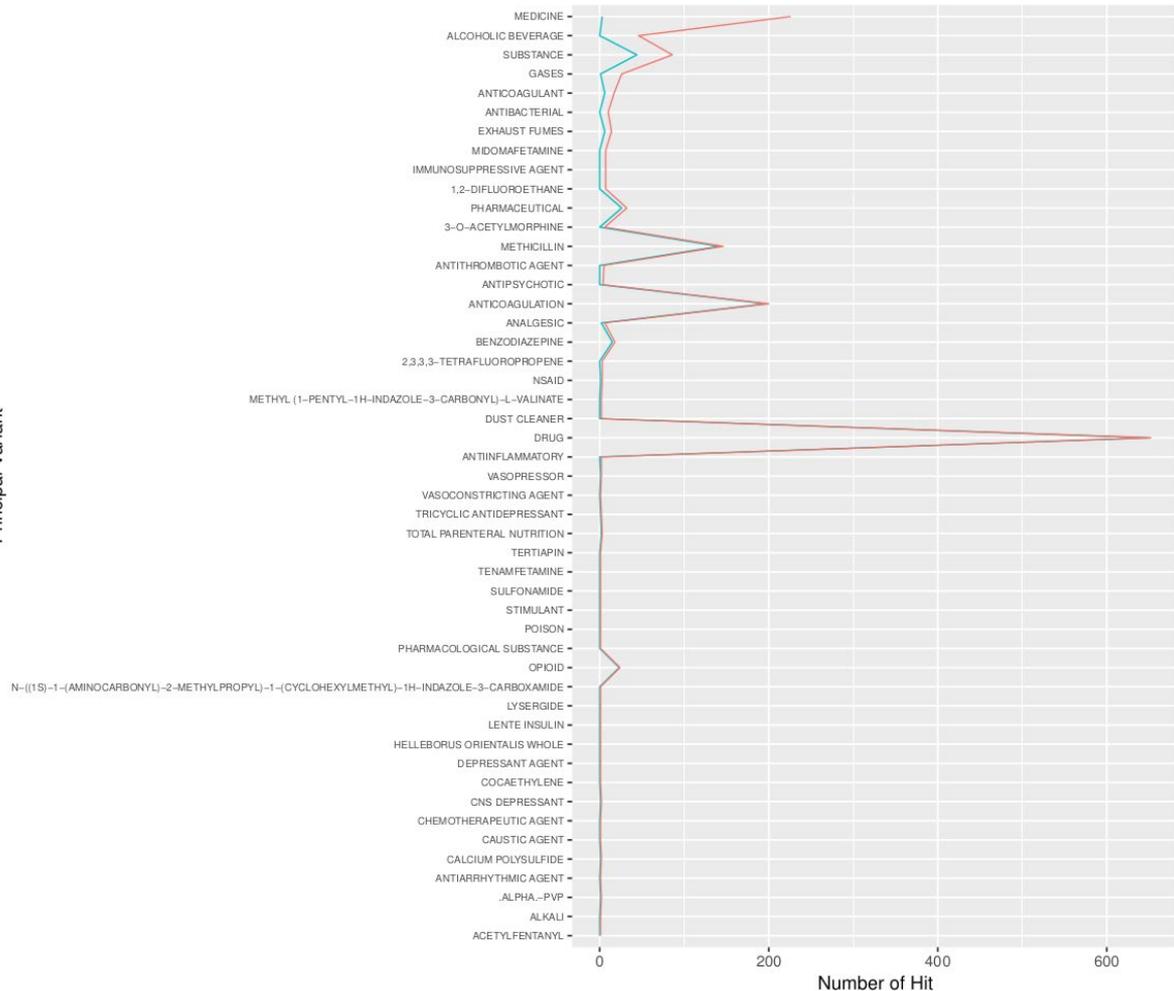
- Use all drug from RxNorm
 - Retrieves 485 more documents
 - But contains a lot of false positive

Number of terms enriched



Number of hit for each principal variant

Principal Variant



colour

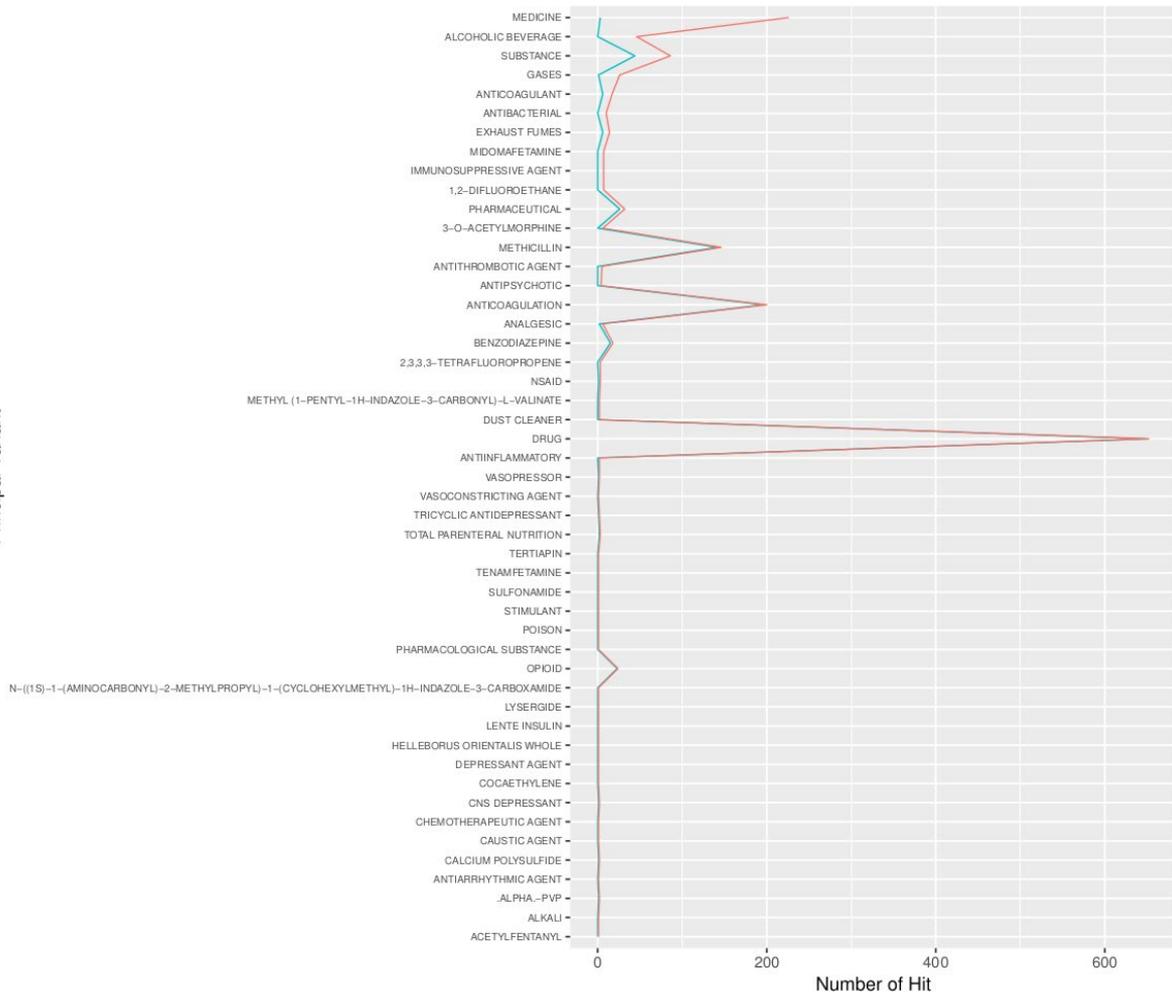
— CDC list

— NLM list

	Total number of documents retrieved
CDC	2332
NLM	1871
Diff	461

Number of hit for each principal variant

Principal Variant



colour
 — CDC list
 — NLM list

Term variant	Total number of documents retrieved
Medication	222
Beverage alcohol	46
Polysubstance	42
Product of Combustion	24
Antiplatelet	5
Anti platelet	3
Antibiotic	10

Drug Relationship Extraction

Have a better retrieval through relationship linkage
Better aggregation in class level

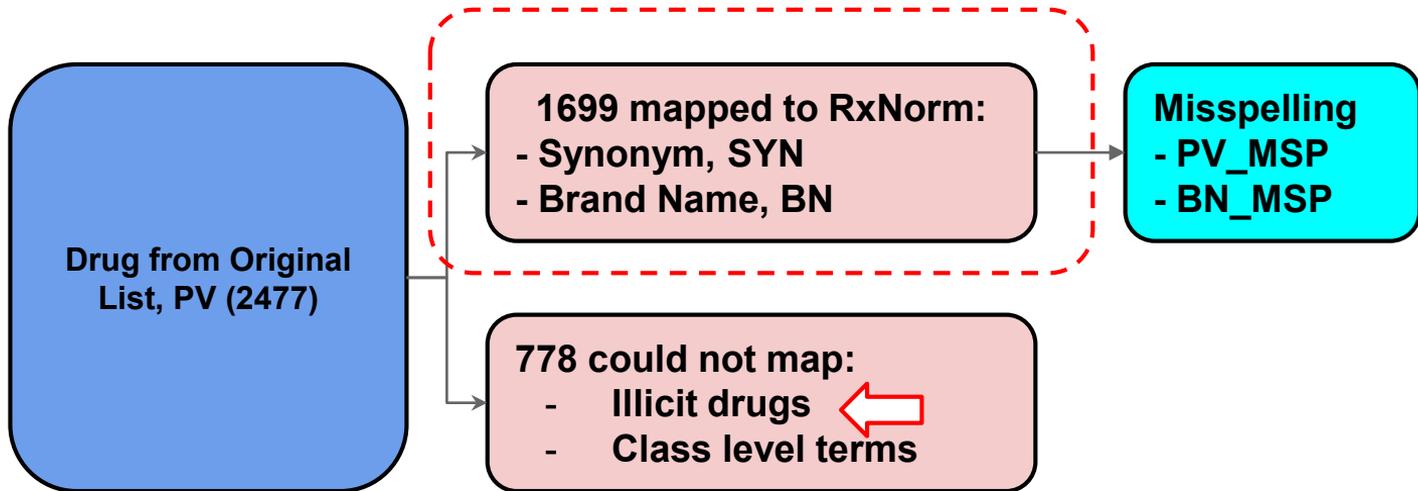
Drug Class Membership (ATC code)

ICD-10	Poisoning by
T43.0	Tricyclic and Tetracyclic Antidepressant
T43.1	Monoamine-oxidase-inhibitor antidepressants
T43.21	Selective serotonin and norepinephrine reuptake inhibitors
T43.22	Selective serotonin reuptake inhibitors
T43.3	Phenothiazine antipsychotics and neuroleptics
T43.4	butyrophenone and thiothixene neuroleptics

Succinimide	N03AD
Ethosuximide	N03AD01
Phensuximide	N03AD02
Mesuximide	N03AD03

Carboxamide (N03AF)	N03AF
Carbamazepine	N03AF01
Oxcarbazepine	N03AF02
Rufinamide	N03AF03
Eslicarbazepine	N03AF04

Number of terms enriched



Abused Drugs Classification

DEA Drug of Abuse

Contents

Welcome	7	VI. Depressants	56
I. Controlled Substances Act	8	Barbiturates	58
Drug Scheduling	15	Benzodiazepines	59
Schedule I	15	GHB	60
Schedule II	22	Rohypnol	62
Schedule III	24	VII. Hallucinogens	64
Schedule IV	27	Ecstasy/MDMA	66
Schedule V	29	Ketamine	68
Federal Trafficking Penalties	30	LSD	70
Federal Trafficking Penalties—Marijuana	31	Peyote & Mescaline	71
II. U.S. Chemical Control	32	Psilocybin	72
Listed Chemicals Chart	34	VIII. Marijuana/Cannabis	74
III. Introduction to Drug Classes	36	Marijuana Concentrates	76
IV. Narcotics	38	IX. Steroids	78
Fentanyl	40	X. Inhalants	80
Heroin	42	XI. Drugs of Concern	82
Hydromorphone	43	DXM	82
Methadone	44	Kratom	84
Morphine	45	Salvia Divinorum	85
Opium	46	XII. Designer Drugs	86
Oxycodone	47	Bath Salts or Designer Cathinones	86
V. Stimulants	48	K2/Spice	88
Amphetamines	50	Synthetic Opioids	90
Cocaine	51	XIII. Resources	92
Khat	53		
Methamphetamine	54		

Eight Classes

Narcotics
Stimulants
Depressants
Hallucinogens
Cannabis
Steroids
Inhalants
Designer Drugs

DEA drug list

Report Description	Drug Synonyms	NFLIS Drug Subcategory
p-Fluorobutanyl fentanyl		Narcotic Analgesics
l-8-Hydroxythiofentanyl		Narcotic Analgesics
W-18		Narcotic Analgesics
W-15		Narcotic Analgesics
Despropionyl fentanyl		Narcotic Analgesics
Butynyl fentanyl		Narcotic Analgesics
MT-45		Narcotic Analgesics
Acetyl fentanyl		Narcotic Analgesics
AH 7921		Narcotic Analgesics
6-Monoacetylcodeine (6-MAC)		Narcotic Analgesics
Hydrocotarnine		Narcotic Analgesics
Dihydromorphone		Narcotic Analgesics
Mitragynine		Narcotic Analgesics
Oripavine		Narcotic Analgesics
Pethidine		Narcotic Analgesics
Dextropropoxyphene		Narcotic Analgesics
Hydrocodonone		Narcotic Analgesics
Tramadol		Narcotic Analgesics
Opiates		Narcotic Analgesics
Thiofentanyl		Narcotic Analgesics
Thienylfentanyl		Narcotic Analgesics
Beta-Hydroxy-3-Methylfentanyl		Narcotic Analgesics
Beta-Hydroxyfentanyl		Narcotic Analgesics
Benzylfentanyl		Narcotic Analgesics
3-Methylfentanyl		Narcotic Analgesics
P-Fluorofentanyl		Narcotic Analgesics
Fentanyl		Narcotic Analgesics
Lofentanil		Narcotic Analgesics
Sufentanil		Narcotic Analgesics
Remifentanil		Narcotic Analgesics
Butorphanol		Narcotic Analgesics
Pentazocine		Narcotic Analgesics
Minor Alkaloids Of Opium		Narcotic Analgesics
Noroxymorphone		Narcotic Analgesics

Illicit Drugs Class-based Retrieval

CLASS	EXAMPLE OF DRUGS	Number of Hit
NARCOTICS	OPIOID, OPIATE AGONIST, MORPHINE, METHADONE, CODEINE, ...	1200
STIMULANTS	STIMULANT, .ALPHA.-PVP, METHAMNETAMINE, BREPHEDRONE, ...	595
DEPRESSANTS	DEPRESSANTS, BARBITURATE, PENTOBARBITAL, BENZODIAZEPINE, DIAZEPAM, ...	281
HALLUCINOGENS	HALLUCINOGEN, DESCHLOROKETAMINE, NBOME, PSILOCIN, ...	1
CANNABIS	CANNABIS, CANNABINOID AGONIST, JWH CANNABINOID, MDMB-CHMICA, ...	13
INHALANTS	INHALANT, DEODORIZER, ORGANIC SOLVENT, REFRIGERANT, PAINT REMOVER, GLUE, ...	14
STEROIDS	STEROID, ANABOLIC STEROID, THENODONE ENANTHATE	67
DESIGNER DRUGS	1-(1-BENZOFURAN-6-YL)-N-METHYLPROPAN-2-AMINE, BATH SALTS	0

ICD-10 code: T40 Poisoning by, adverse effect of and underdosing of narcotics and psychodysleptics [hallucinogens]

CODE	Narcotics Related	SUBSTANCE	DRUGS INCLUDED
T40.0	✓	Opium	
T40.1	✓	Heroin	
T40.2	✓	Opioids	Oxycodone, hydrocodone, morphine, hydromorphone, oxymorphone...
T40.3	✓	Methadone	
T40.4	✓	Synthetic narcotics	Fentanyl, tramadol
T40.5		Cocaine	
T40.6	✓	Unspecified narcotics	
T40.7		Cannabis	
T40.8		Lysergide (LSD)	
T40.9		Unspecified psychodysleptics [hallucinogen]	

Narcotics Subtype

Narcotics	ICD-10	PV	No. of PV	Num_hit
OPIUM	T40.0	Opium	1	0
OPIATES		Opiate	1	235
HEROIN	T40.1	Diamorphine	1	377
OXYCODONE	T40.2 Opioid	Oxycodone	1	157
HYDROCODONE		Hydrocodone	1	62
MORPHINE		Morphine	1	117
HYDROMORPHONE		Hydromorphone	1	41
OXYMORPHONE		Oxymorphone	1	14
CODEINE		Codeine	1	21
Others		Levomethorphan, Apomorphine, Nicomorphine, Morphinone, Dextrorphan, Racemorphan, Levorphanol	7	0
METHADONE	T40.3	Methadone(138)	1	138
Others		Phenadoxone, Dimepheptanol	2	0
FENTANYL	T40.4	Fentanyl (36), Remifentanil (1), Carfentanil, Alfentanil, 3-methylfentanyl, Sufentanil, ...	23	37
TRAMADOL		Tramadol	1	36

Depressants Subtype

Depressants	ICD-10	PV	No. of PV	Num_hit
DEPRESSANTS	T42.7	CNS DEPRESSANT (1), SEDATIVE	2	1
BARBITURATES	T42.3	PENTOBARBITAL (7), PHENOBARBITAL (4), SECOBARBITAL (1), CYCLOBARBITAL, APROBARBITAL, AMOBARBITAL, HEXOBARBITAL, BARBITAL, PRIMIDONE, ALLOBARBITAL, MEPHOBARBITAL, METHOHEXITAL, TALBUTAL, THIOPENTAL, BARBITURATE, METHYLBARBITURIC ACID	16	12
BENZODIAZEPINES	T42.4	ALPRAZOLAM (60), DIAZEPAM (39), ZOLPIDEM (26), LORAZEPAM (21), BENZODIAZEPINE (15), TEMAZEPAM (12), CHLORDIAZEPOXIDE (11), CLONAZEPAM (11), OXAZEPAM (5), TRIAZOLAM (1), MIDAZOLAM, ZOPICLONE, FLURAZEPAM, PRAZEPAM, ESTAZOLAM, ZALEPLON, LORMETAZEPAM, FLUBROMAZOLAM, NORDAZEPAM, QUAZEPAM, HALAZEPAM, BROMAZEPAM, ESZOPICLONE, NITRAZEPAM, ETIZOLAM, CLONAZOLAM, CLOBAZAM	27	201

Refinement for the classification?

Narcotics (T40.6)

- Heroin (T40.1)
- Oxycodone (T40.2)
- Hydrocodone (T40.2)
- Morphine (T40.2)
- Methadone (T40.3)
- Fentanyl (T40.4)
- Tramadol (T40.4)
- Codeine

Stimulants (T43.69)

- Amphetamine (T43.61)
- Cocaine (T40.5)
- Cathinone
- Methamphetamine

Depressants (T42.7)

- Barbiturates (T42.3)
- Benzodiazepines (T42.4)

Should Opioid and Opiate be separated?

Should these be grouped together into synthetic opioid?

Should we have a deeper hierarchy?

Is this class necessary?
Is it better to remove it or merge with others?

What else subclass is there?

Hallucinogens (T40.9)

- Ketamine
- Psilocybin
- Peyote & Mescaline
- LSD (T40.8)

Cannabis (T40.7)

- Cannabinoid
- Marijuana

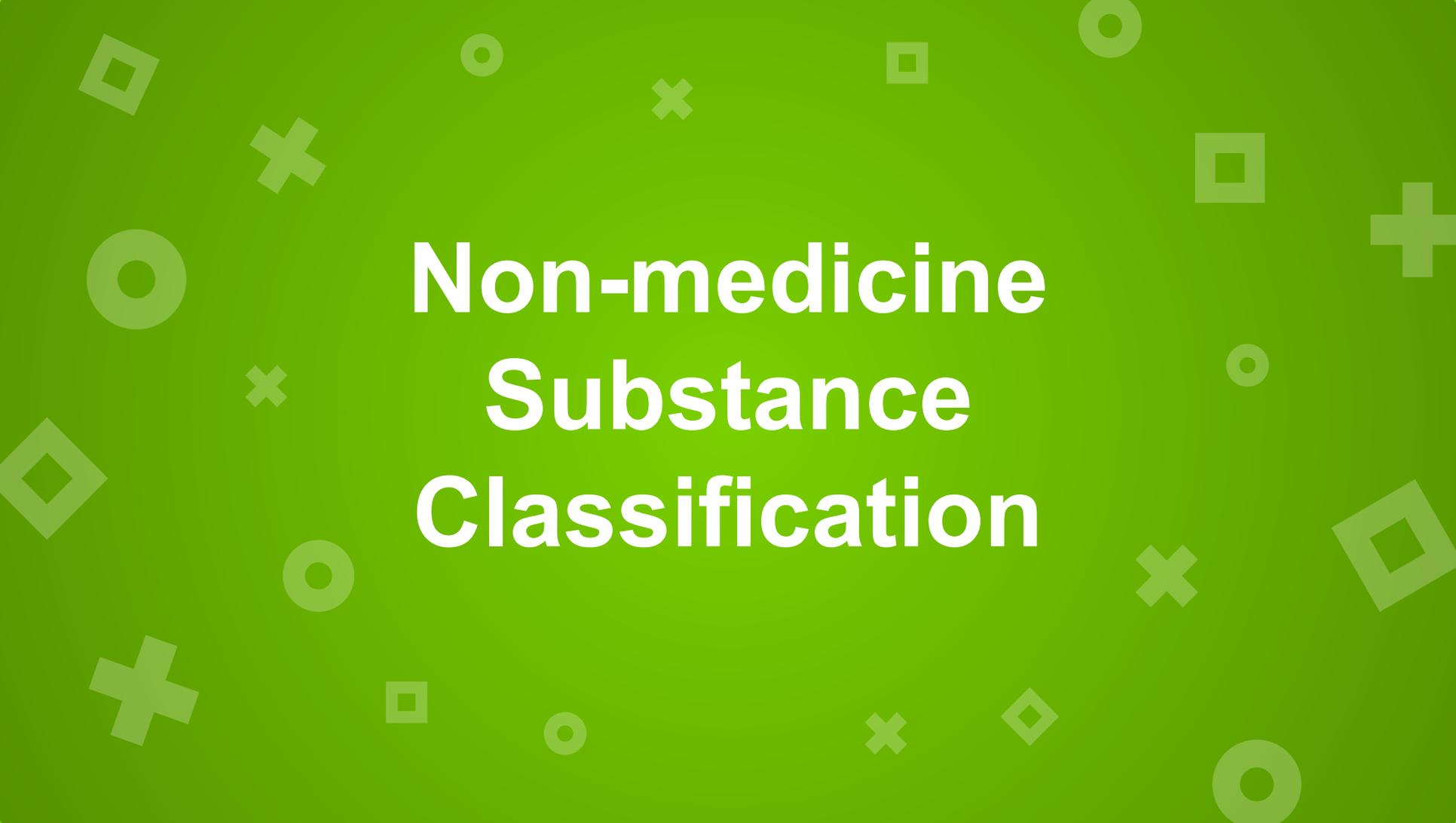
Steroids (T38.7)

Inhalants

- Variety of Household products
- Petroleum

Designer Drugs

- Bath salts



Non-medicine Substance Classification

Non-medicine Source

Toxin	Intoxicant, Carcinogen, Irritant, Pollutant, Mouse poison, ...	
Organic	Chlorofluorocarbon, Hydrobromide, Organophosphate, Organofluorine, Alkyl Nitrite, Short Chain ...	T53*
Inorganic	Metal alloy, Heavy metal, Inert gas, Metalloid, Mineral fibers, Inorganic salt, Asbestos, ...	T56*
Medicine	Transplant medication, Sleeping drug, Appetite suppressant, Nondepolarizing Blocking Agent, ...	
Chemical	Alkali, Reagent, Acidic chemical, Chemical, Photo finishing chemical	T54*
Cigar	Cigar, Cigar Smoke, Smoke, Second hand smoke, Cigarette, Snuff, Cigarette, Cigarette smoke, ...	
Cleaning Product	Acidic wheel cleaner, Metal cleaner, Rust remover, Brake fluid, Detergent, Fuel injector cleaner, ...	T55
Diagnostic Agent	Radioactive seed, radiocontrast agent, Iodinated Contrast Agent, Radiocontrast agent, ...	
Plant	Amanita, Mushroom, Plant extract, Ephedra	T62*
Hormone	Hormone, Catecholamine, Statin, Estrogen, Insulin, Endorphin	

* indicates partially consistent

Non-medicine Source

Alcohol	Hard alcohol, Moonshine, Rum, Tequila, Whiskey, Beer, Schnapps, Vodka, ...	T51
Supplement	Nutritional supplement, Dietary supplement, Weight loss supplement, Bodybuilding supp...	
Agriculture	Rodenticide, Pesticide, Defoliant, Algaecide, Herbicide, Insecticide, Fungicide, Silo gas, ...	T60
Alkaloids	Alkaloid, Herbal alkaloid, Belladonna alkaloid, Morphine type alkaloid, Aconitine type alkaloid	
Fuel	Gasoline, Petroleum, Torch fuel, Aromatic petroleum	T52
Gas	Gasoline fumes, Exhaust fumes, Petroleum oxidation fume	
Nutrition	Nutrition, Enteral nutrition, Total parenteral nutrition, supplemental enteral nutrition	
Substance	Substance, Methicone, Povidone	
Caffeine	Caffeine, Caffeinated beverage	T43.61

Discussion - Drug List Enrichment

Type of variants:

Synonym, Brand Name, Misspelling

Example:

Fluoxetine - name

Prozac - brand name

Prozak - misspelling of brand name

Warfarin:

132 documents retrieved

- **70 by 'warfarin'**
- **62 by 'coumadin'**

Using RxNorm:

- **2% recall vs tedious manual effort of experts**
- **Identify new drug but need to aware of false positive**

For terms other than prescription drug:

- **Locate any resource**
- **Create rules for variant generation**

Discussion - Drug Relationship Extraction

Extract drug class membership (ATC) and metabolism relationship (PubChem)

Example:

Norfentanyl - is metabolite of - Fentanyl

Sertraline (N06AB06) - belong to class - SSRI (N06AB)

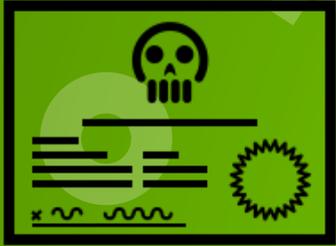
Future Work

Classification refinement

- **Feedback from experts**
- **Better fit for practical use case**

Utilize 10 years death certificate data

Thank You



U.S. National
Library of
Medicine



Centers for Disease
Control and Prevention
National Center for
Health Statistics