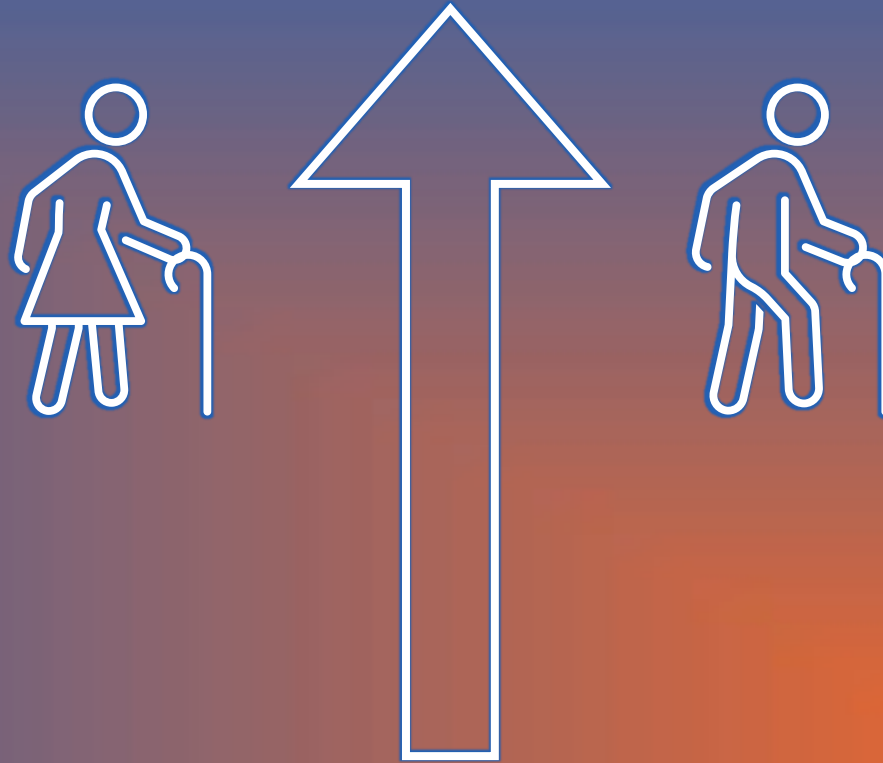# Growing Complexity of Clinical Care

No better way to look at care complexity than an elderly population

AGING POPULATION

2035

More people
over 65 than under 18

The US Healthcare System

Evolving Complexity

- There is perpetual address of "chronic illness", reactive care
  - Multimorbidity
  - Noncommunicable disease
- The most complex patients have the most complex care delivery models
  - Less than 50% of elderly patients are up to date with screenings
  - Elderly patients take up to 19 medication doses daily
  - Multiple care providers
    - Yearly – 7 doctors across 4 practices
    - Surgical patients see 27 different care providers
  - 1 in 5 are readmitted in 30 days
  - Patients that are admitted follow up less than half the times after hospital discharge

Medication Errors

EHRs should be the solution, but all too often, they contribute to the problem

The Toll of Medication Errors

Tariq et. al.

- 7,000-9,000 deaths annually
- 100's of thousands experience a medication error that is not reported
- $40 billion cost associated with errors
- Psychological pain and suffering and patient satisfaction

Medication Dispensing Errors And Prevention - StatPearls - NCBI Bookshelf (nih.gov)

Medications in Transitions of Care

Bethishou, et. al.

Medication transitions
- 67% of patients faced unintended medication error
- 40% were due to miscommunications in handoffs
  - 80% of these were due to transitional communications
    - Differences in style
    - Distractions
    - Lack of standardization

https://patientsafetyj.com/index.php/patientsaf/article/view/med-safety-toc/169

Accuracy of Medication Data in EHRs in a Geriatric Population

Wagner, et. al.

Medication presentation in a geriatric center:

- 91% represented correctly the compound
- 1.38 medications were missing or uncoded per patient
  - Patient reporting errors – 36.1%
  - Failures of capturing changes to medications by outside clinicians - 25.9%
  - Transcription errors – 8.2%
  - 90% were correct in terms of compound identity
  - 0.37 current medications were missing altogether
  - Additional errors of omission due to "free text" – uninterpretable to medical decision support systems

The accuracy of medication data in an outpatient electronic medical record. - PMC (nih.gov)

EHR Related Errors

Carayon, et. al.

- Study on Intensive Care Units
  - 1622 total preventable adverse drug events
    - 624 (34%) related to EHR
  - EHR related errors derived from overdose, omissions, wrong medications, duplication, wrong dates and wrong documentation
  - EHR related errors had significant more risk of serious harm and equivalent risk of life-threatening harm

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8311113/

EHR Related Errors

Graber et. al.

- 248 malpractice claims involving EHRs
  - 31% of EHR related claims involved medication errors
    - 63% related to user errors
    - 80+% led to severe harm

The Anatomy & Physiology of a Med Sig

What is a Sig?

How does it look?

What vocabulary does it use?

The Anatomy of a Prescription

Our focus will be on Med Sigs as these present the greatest variability and source of error

State of New Jersey
PRESCRIPTION BLANK

PAULO BANDEIRA PINHO, M.D.

(908) 34
(844) 56

LICENSE # 25MA07338700   DEA
IF PRESCRIPTION IS WRITTEN AT ALTERNATE PRACTICE SITE, CHECK HERE ☐
AND PRINT ALTERNATE ADDRESS AND TELEPHONE NUMBER ON REVERSE SIDE

PATIENT   Jane Doe   D.O.B. 2/28/68
ADDRESS   123 Mainstreet Spangle Ohio   DATE 3/14/23
          12378

Rx

Amlodipine 5mg

Disp #30

T PO QD

SUBSTITUTION PERMISSIBLE ___   DO NOT SUBSTITUTE X
DO NOT REFILL ___
REFILL 2 TIMES   SIGNATURE OF PRESCRIBER
Use a separate form for each controlled substance prescription
THEFT, UNAUTHORIZED POSSESSION AND/OR USE OF THIS FORM INCLUDING ALTERATIONS OR FORGERY, ARE CRIMES PUNISHABLE BY LAW

- Prescriber Information
- DEA Number
- Patient Information / Date of Prescription
- Superscript (Recipe)
- Inscription (Medication Prescribed)
- Subscription (Instructions for Pharmacy)
- **Signatura (Directions for Patient)**
- Provider Signature

Signatura
(abbreviated Signa or Sig)
These include:
1. The method of administration or application
2. The dose if the preparation is for internal use
3. The time of administration
4. The diluents (ie. Water) or means of application (ie. Brush)
5. The part of the body where the preparation is to be used
6. Any special instructions or conditions of use

Med Sig Abbreviations

Part of the problem!!

Prescription Abbreviations Decoded

Ever wonder what all of those cryptic initials mean on the prescription your doctor hands you to be filled by the pharmacist? Many of the abbreviations you see are derived from Latin, which can make it even more difficult to try and make sense of them. Here is a handy guide to some of the most frequently used abbreviations for prescriptions:

a.c. = before meals	h. or hr. = hour	stat. = immediately
a.d. = right ear	h.s. = at bedtime	Subc or subq =
a.m. = morning	HBP = high blood pressure	subcutaneously
a.s. = left ear	HT = hypertension	sum. tal. = take one each
a.u. = each ear	IM = intramuscular	sup. = suppository
aq. = water	IV = intravenous	
b.i.d. = twice daily	liq = liquid	susp. = suspension
b.i.n. = twice a night	m. et n. = morning and night	syr. = syrup
bis = twice	mg = milligram	tab. = tablet
BP = blood pressure	ml = milliliter	tbsp = tablespoon
c. = with	N.R. = do not repeat	tid = three times a day
cap. = capsule	NPO = nothing by mouth	tiw = three times a week
CBC = complete blood count	o.d. = right eye	top = topically
cc = cubic centimeter	o.l.or o.s. = left eye	tsp. = teaspoon
D = dose	oz. = ounce	U or u = unit
deib. alt. = every other day	p.c. = after meals	u.d. or ut dict = as directed
dieb. tert. = every third day	p.m. = afternoon, evening	URI = upper respiratory
dil. = dilute	p.o. = by mouth	infection
disc or D.C. = discontinue	p.r.n. = as needed	UTI = urinary tract infection
disp. = dispense	q = every	w/ = with
div. = divide	qd = every day	w/o = without
dos. = dose	qh = every hour	x = times
dr = dram	qid = four times a day	y.o. = year old
e.m.p. = as directed	qod = every other day	
et = and	R = rectal	
ex aq. = in water	s. = without	
fl or fld = fluid	Sig. = write on label	
g = gram	SOB = shortness of breath	
gr. or gr = grain	sol. = solution	
gtt. = drop	ss. = one-half	

Valley Direct

Avoid Dangerous Abbreviations

- Letter "U" for *unit*
- "QD" or "qd" for *daily*
- "QOD" or "q.o.d." for *every other day*
- IU (International Unit) may be mistaken for IV (intravenous)

Prescription Abbreviations Decoded - common sig codes used in medical prescriptions | Pharmacy technician study, Medical prescription, Medical terminology study (pinterest.ca)

PPT - Systems Analysis, Causes of Medication Errors, and Error-Prone Abbreviations PowerPoint Presentation - ID:1408170 (slideserve.com)

Why pursue NLP?

NLP can unlock data that enriches the record and leads to better outcomes!

WILLIAM WESTON

Clinical Note

CC: Patient presents to the primary care office for follow up of a hospitalization where he was admitted for hyperglycemia, dehydration and hyperosmolar coma due to poorly controlled diabetes with accelerated increase in blood sugar

HPI:

Medications:

 Lantus pen 100 UNIT/ML Subcutaneous inject 5 [IU] by subcutaneous injection once daily – this dosing was discontinued

Parsing performed by HIE solution and abstracted by skilled nursing facility and perpetuated in his outpatient provider record

PLAN:

WILLIAM WESTON

Clinical Note

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 Lantus pen 100 UNIT/ML Subcutaneous inject 5 [IU] by subcutaneous injection once daily – this dosing was discontinued

PLAN:

Continue Lantus pen Subcutaneous 30 UNITS DAILY INCREASE BY 5 UNIT DAILY UNTIL FASTING FSBS < 150 Nov, 2022 Started in Hospital due to Underdosing

Dose Correction

WILLIAM WESTON

Clinical Note

CC: Patient presents to the primary care office for follow up of a hospitalization where he was admitted for hyperglycemia, dehydration and hyperosmolar coma due to poorly controlled diabetes with accelerated increase in blood sugar

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Structured Medical Record

Unstructured Medical Record

Continue Lantus pen Subcutaneous 30 UNITS DAILY INCREASE BY 5 UNIT DAILY UNTIL FASTING FSBS < 150 Nov, 2022 Started in Hospital due to Underdosing

Dose Correction

The Combined Power of Fusion and JSL SparkNLP for Improved Med Sig Parsing

Holistic Data Quality Improvement Process –
Upcycling™ - "Longitudinalized" Semantic Normalization of Clinical Data and More

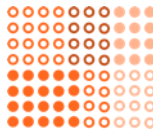**Availity** clinical solutions

Data Upcycling™

NORMALIZE data to industry standard terminologies
Create a common language for data exchange and achieve semantic interoperability
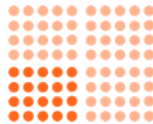
ENRICH data with standard metadata and classifications
Ensure efficient analytic queries and optimize data for most effective downstream use

REORGANIZE data to appropriate clinical document sections
Create a complete, updated view of patient history for appropriate outreach and care delivery

DEDUPLICATE data across disparate inbound sources
Eliminate duplicates to accurately report volumetric data and trend over time

SUMMARIZE data into complete, digital patient records
Build a summarized record to effectively trend health and clinical improvement over time

Med Sig Parsing Availity Fusion

lisinopril 5mg Oral Tablet; Active medication; Take 5 mg BID with meals

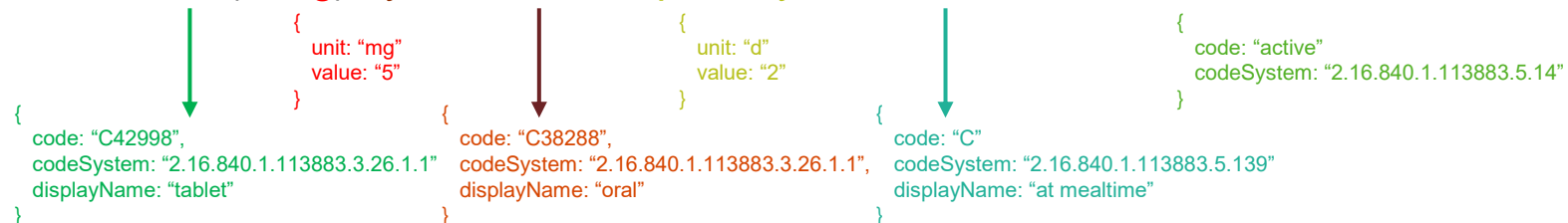*Unstructured → Structured*

(active) take 5 mg lisinopril twice per day with meals

```
{
    code: "29046",
    codeSystem: "2.16.840.1.113883.6.88",
    codeSystemName: "RxNorm",
    displayName: "lisnopril"
}
```

Structured → Encoded

take 1 tablet (5 mg) by mouth twice per day at mealtime and resolved active status

```
{
    unit: "mg"
    value: "5"
}
```

```
{
    unit: "d"
    value: "2"
}
```

```
{
    code: "active"
    codeSystem: "2.16.840.1.113883.5.14"
}
```

```
{
    code: "C42998",
    codeSystem: "2.16.840.1.113883.3.26.1.1",
    displayName: "tablet"
}
```

```
{
    code: "C38288",
    codeSystem: "2.16.840.1.113883.3.26.1.1",
    displayName: "oral"
}
```

```
{
    code: "C"
    codeSystem: "2.16.840.1.113883.5.139"
    displayName: "at mealtime"
}
```
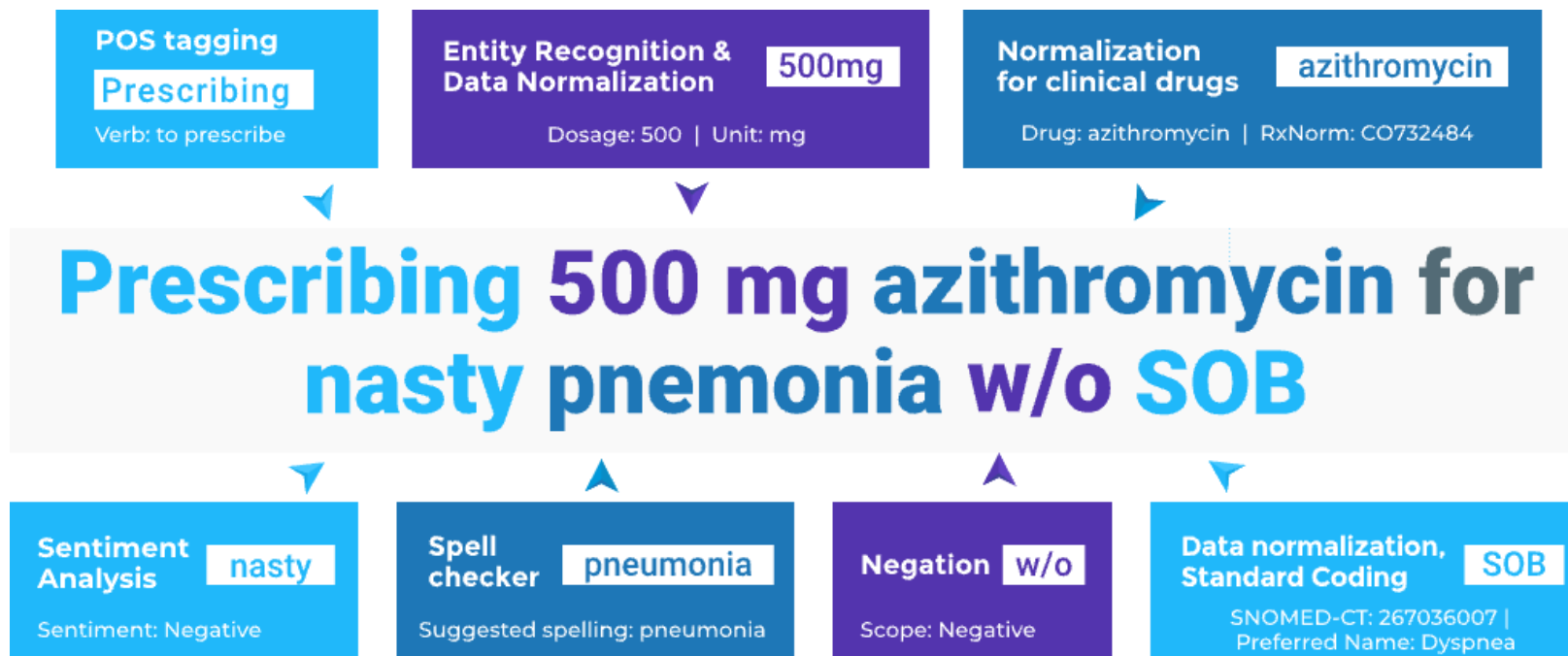
Combined Med Sig Parsing Pipeline

John Snow LABS

Med Sig

Strip HTLM

Sentence Detector

Direction Detector – "Take"

Route Parser

Strip Dates

Parts of Speech

Modifier Detector – "PRN"

Form Parser

Aggregate Double Numbers

Named Entity Recognition

Known Terms Detector "PO QD"

Named Entity Recognition Converter

Dosage Parser

Sig Chunk Filter

Range Detector "one-two"

Strength Parser

Sig Writer

Number Detector – "1/2"

Frequency Parser

Rebuilt Med Sig

Unit Detector – "mg"

Duration Parser

Definitions

- Routine
    - **Simple** - take 1 tablet by mouth once daily
    - **Conditional** - take 2 tablets by mouth once daily <u>as needed for pain</u>
    - **Variable Frequency** - take 1 tablet by mouth <u>every four to six hours</u>
    - **Variable Dose** - take <u>1-2 tablets</u> by mouth every six hours
- Non-Routine
    - **Complex** - Azithromycin (Zithromax) 250 Mg TABLET - TAKE 500 MG (2 TABS) THE FIRST DAY THEN 250 MG (1 TAB) DAYS 2-5
    - **Variable Dose/Conditional** - <u>One or two tablets</u> every 6 hours <u>as need for break through pain</u>
    - **Detailed Instructions** - Apply 1 packet (50 mg) to skin daily <u>in the morning to shoulder, upper arms or abdomen</u>
    - **Detailed Instructions/Conditional** - Take 3 mLs by nebulization every 4 (four) hours <u>as needed</u> for <u>wheezing. Should be inhaled</u>
    - **Variable Dose/Detailed Instructions/Conditional** - Take <u>1-2</u> po 30 mins <u>prior to sexual activity</u> <u>(max 5 per day)</u>
- Excluded
    - **Non Med** - Take blood sugars 2 times daily
    - **Poor Inbound Rx** - Follow schedule on package instructions

Definitions

Accuracy
Captures Med Sig Correctly – Validates Clinical Intent of the Prescriber
Captures Med Sig Partially – At No Risk to Patient Safety
Captures Med Sig Erroneously – Risk to Patient Safety

Handling of Routine Med Sig

Type of Sig	Original Sig	Fusion Rebuilt	Fusion & JSL SparkNLP
Simple sig once daily with oral medication	Aspirin 81 MG Orally Once a day 1 tablet 24h 17 Sep, 2014 Active	take 1 tablet by mouth once daily	take 1 tablet (81 mg) by mouth per day
Simple sig multiple times daily with oral medication	1 TAB PO QID dx m54.2, m54.12, G56.03	take 1 tablet by mouth four times daily	take 1 tablet by mouth 4 times per day
Simple sig once daily with inhalable medication	Inhale 1 puff 1 (one) time each day.	take 1 puff(s) by inhalation once daily	take 1 puff by inhalation per day
Multiple unit doses	Take 2 Tabs by mouth one time a day as needed.	take 2 tablets by mouth once daily as needed	take 2 tablets by mouth per day (as needed)
Once daily at a specific time of day	Take 1 capsule orally in A.M.	take 1 capsule by mouth in the morning	take 1 capsule by mouth in the morning
Variable unit doses with condition	Take 1-2 tablets by mouth every 6 (six) hours as needed for Pain.	take 1-2 tablets by mouth every six hours as needed for pain	take 1-2 tablets by mouth every 6 hours (as needed), for pain.
Multiple unit doses with condition	TAKE TWO TABLETS BY MOUTH EVERY 6 HOURS AS NEEDED FOR PAIN	take 2 tablets by mouth every six hours as needed for pain	take two tablets by mouth every 6 hours (as needed), for pain
Injectable medication alternating weeks	1 ml. given IM every 2 weeks	inject 1 mL by intramuscular injection every other week	take 1 mL by intramuscular injection every 2 weeks
Mg strength injectable weekly	Inject 0.85 mL (2 mg total) under the skin 1 (one) time per week.	inject 0.85 mL by subcutaneous injection every week	take 0.85 mL (2 mg total by injection per week

Fusion Success with JSL SparkNLP Error

Type of Sig	Original Sig	Fusion Rebuilt	Fusion & JSL SparkNLP	Error Reason
"AM before breakfast"	Take 1 tablet orally first thing in AM before breakfast	take 1 tablet by mouth before breakfast	take 1 tablet by mouth morning 1	The frequency was captured as 1
"30 minutes before breakfast"	Take one Tab by mouth daily 30 minutes before breakfast	take 1 tablet by mouth once daily 30 minutes before breakfast	take one tablet by mouth minute 30	The frequency was captured as 30
Missing route of administration	Inject 1 mL (4,000 units total) under the skin once a week Indications: Anemia due to CKD	inject 1 mL by subcutaneous injection every week	take 4,000 [IU] per week	Route was captured as by injection but not displayed
Erroneous strength	1.5 mg subcutaneously weekly	inject 1.5 mg by subcutaneous injection every week	take 5 mg by subcutaneous injection per week	5 mg was captured as the strength
Special Instruction	one tab po TID prn pain	take 1 tablet by mouth three times daily as needed for pain	take one tablet by mouth 3 times per day (as needed)	Pain was not captured

Partial Sig Capture of Detailed Instructions

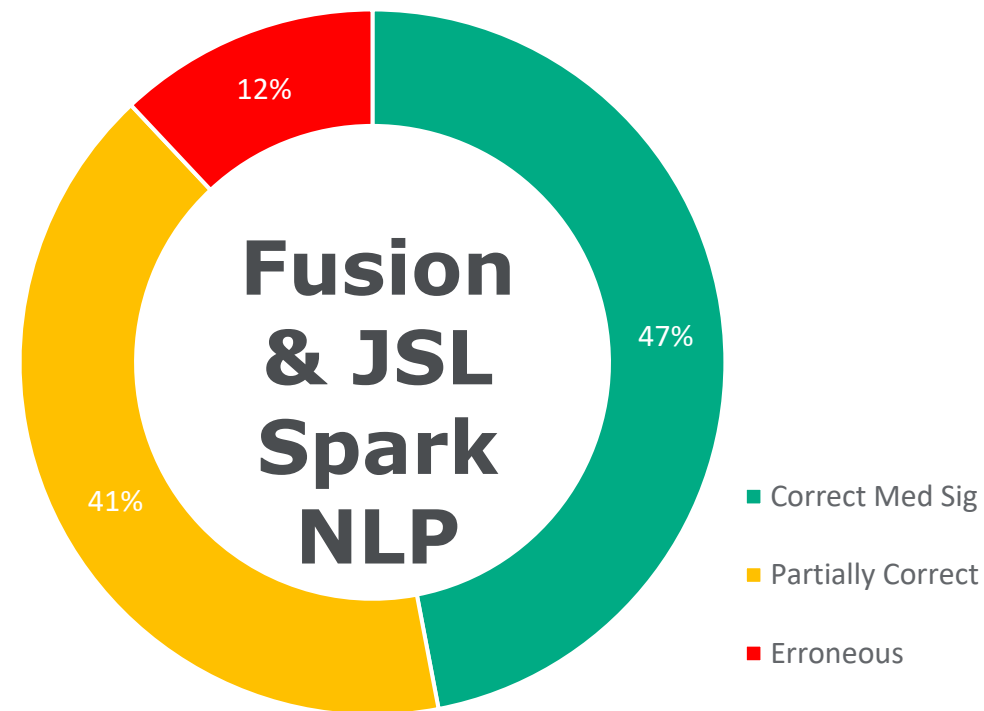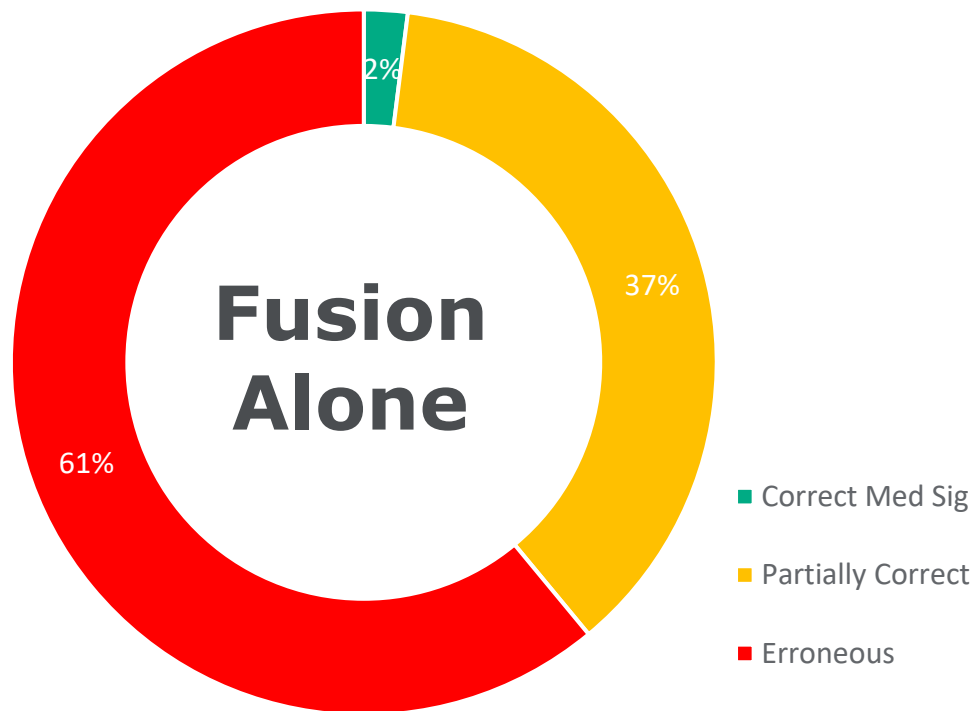| Type of Sig	Original Sig	Fusion Rebuilt	Fusion & JSL SparkNLP	Error Reason
Special Instruction	1 patch transdermally 2 times per day to most painful area	apply 1 dose transdermal route twice daily	take 1 patch transdermal 2 times per day	Special instruction not captured
Special Instruction	Administer 1 spray into each nostril 2 (two) times a day. Shake gently. Before first use, prime pump. After use, clean tip and replace cap.	take 1 spray(s) nasal route twice daily	administer 1 spray topically 1, and replace cap.	Special instruction not captured
Special Instruction	Inhale 2 puffs every 4 (four) hours as needed for wheezing. 2 PUFFS EVERY 4 HOURS ONLY WHEN NEEDED	take 2 puff(s) by inhalation every four hours as needed for wheezing, then take 2 puff(s) by inhalation every four hours as needed for wheezing	take 2 puffs by inhalation every 4 hours (as needed), for wheezing. 2 puffs every 4 hours (as needed)	Duplicate special instruction captured a second time
Special Instruction	1 drop into affected eye every 6 hours	take 1 drop(s) into the eye(s) every six hours	apply 1 drop into the eye(s) every 6 hours	"affected eye" not captured
Special Instruction	Take 1 tablet by mouth at onset of migraine. May repeat after 2 hours if needed.	take 1 tablet by mouth every two hours	take 1 tablet by mouth 2 times per hour	Special instruction not captured
Special Instruction	Inhale 1 puff two times a day Rinse mouth after each use	take 1 puff(s) by mouth twice daily	take 1 puff by mouth 2 times per day	Special instruction not captured

The Added Value of NLP for Non-Routine Sigs

Type of Sig	Original Sig	Fusion Rebuilt	Fusion & JSL SparkNLP
Complex, conditional sig	Levemir FlexTouch pen 100 UNIT/ML Subcutaneous MAX 100 UNITS DAILY 30 UNITS DAILY INCREASE BY 1 UNIT DAILY UNTIL FASTING FSBS <110 14 Nov, 2016 Active	inject 1 [IU] by subcutaneous injection once daily	max 100 [IU] by subcutaneous injection per day and take 30 [IU] per day, increase by 1 [IU] per day, until fasting fsbs <110,
Staged Instructions	Azithromycin (Zithromax*) 250 Mg TABLET Discontinued 250 MG PO .zpack As Directed 6 April 6th, 2016 11:05am January 27th, 2020 TAKE 500 MG (2 TABS) THE FIRST DAY THEN 250 MG (1 TAB) DAYS 2-5	take 2-5 tablets by mouth once daily	take 2 tablets (500 mg) by mouth day 1, then 1 tablet days 2-5
Special Instruction with an end date	Inject 1 (one) Pen subcutaneously every 14 days for 30 days	inject 1 UNKNOWN UNIT by subcutaneous injection UNKNOWN TIMING	take 1 pen by subcutaneous injection every 14 days, for 30 days
End date and non-traditional mode of administration	Insert 1 applicator into the rectum 2 (two) times a day for 10 days For hemorrhoids	take 1 UNKNOWN UNIT rectal route twice daily	insert 1 applicator rectal 2 times per day, for 10 days, for hemorrhoids
Odd dosing frequency	Administer 1.1 ml's IM every 10 days	inject 1.1 mL by intramuscular injection UNKNOWN TIMING	administer 1.1 mL by intramuscular injection every 10 days
Special Instruction with an end date	One po bid x 2 weeks	take 1 UNKNOWN UNIT by mouth twice daily	take one by mouth 2 times per day, x 2 weeks
Conditional and complex with an end date	Place 1 patch (1.5 mg total) on the skin every 3rd (third) day if needed (Increased Secretions. Place behind patient's ear.).	apply 1 UNKNOWN UNIT transdermal route once	take 1 patch (1.5 mg total) every 3rd days (as needed)

Non-Routine Sig Results – 51 Med Sigs

Fusion Alone

- 2%
- 37%
- 61%

Legend:
- ■ Correct Med Sig
- ■ Partially Correct
- ■ Erroneous

Fusion & JSL Spark NLP

- 47%
- 41%
- 12%

Legend:
- ■ Correct Med Sig
- ■ Partially Correct
- ■ Erroneous

Handling of Non-Routine Med Sigs – Complex, Detailed and Combinations

Type of Sig	Total Count	Fusion Rebuilt						Fusion & JSL SparkNLP					
Complex	3	0	0%	0	0%	3	100%	2	67%	0	0%	1	33%
Variable Dose/Conditional	3	0	0%	0	0%	3	100%	1	33%	2	67%	0	0%
Detailed Instructions	40	0	0%	19	48%	21	53%	17	43%	19	48%	4	10%
Detailed Instructions/Conditional	4	1	25%	0	0%	3	75%	4	100%	0	0%	0	0%
Detailed Instructions/Conditional /Detailed Instructions	1	0	0%	0	0%	1	100%	0	0%	0	0%	1	100%
Totals	51	1	2%	19	37%	31	61%	24	47%	21	41%	6	12%

Conclusions

- Medication errors are pervasive given:
  - Increased medical complexity of an aging population
  - Personalized medication treatments and regimens
  - Transitions of care
  - Documentation variability posed by EHRs, providers and patient factors
- Medication errors provide a fair amount of negative impact on morbidity, mortality and cost of care
- For those errors that are related to transcription and documentation variability the combination of data upcycling™ and NLP solutions can drive impact
- The addition of NLP had substantial impact on all Med Sigs, but especially as complexity of Sigs increase
- The most complex sigs, were conditional and had variable dosing frequency continue to pose problems
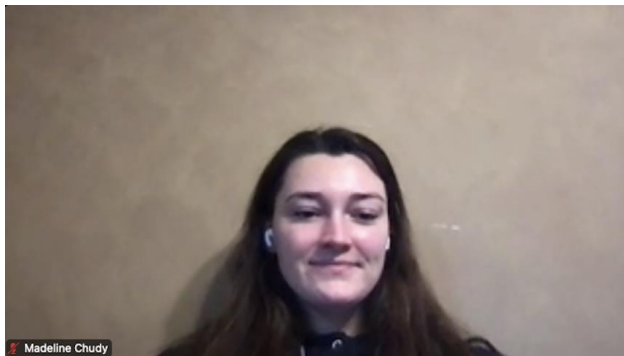- It takes a healthcare ecosystem to improve patient outcomes, patient satisfaction and improve costs

Working with WPI

WPI — Worcester Polytechnic Institute · 1865

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Chun-Kit (Ben) Ngan

ASSISTANT TEACHING PROFESSOR

PhD Information Technology

DIAMETER HEALTH — NOW A PART OF Availity

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Sam Schifman — Chief Architect for Clinical Solutions

Sam Schifman

CHIEF ARCHITECT, AVAILITY CLINICAL SOLUTIONS

Kewal Mishra

MASTERS STUDENT

Madeline Chudy

MASTERS STUDENT

Dr. Paulo Pinho

VP & MEDICAL DIRECTOR FOR INNOVATION

Thank You

Where healthcare **connects**.