NLP Applications for Enhancing Clinical Decision Making

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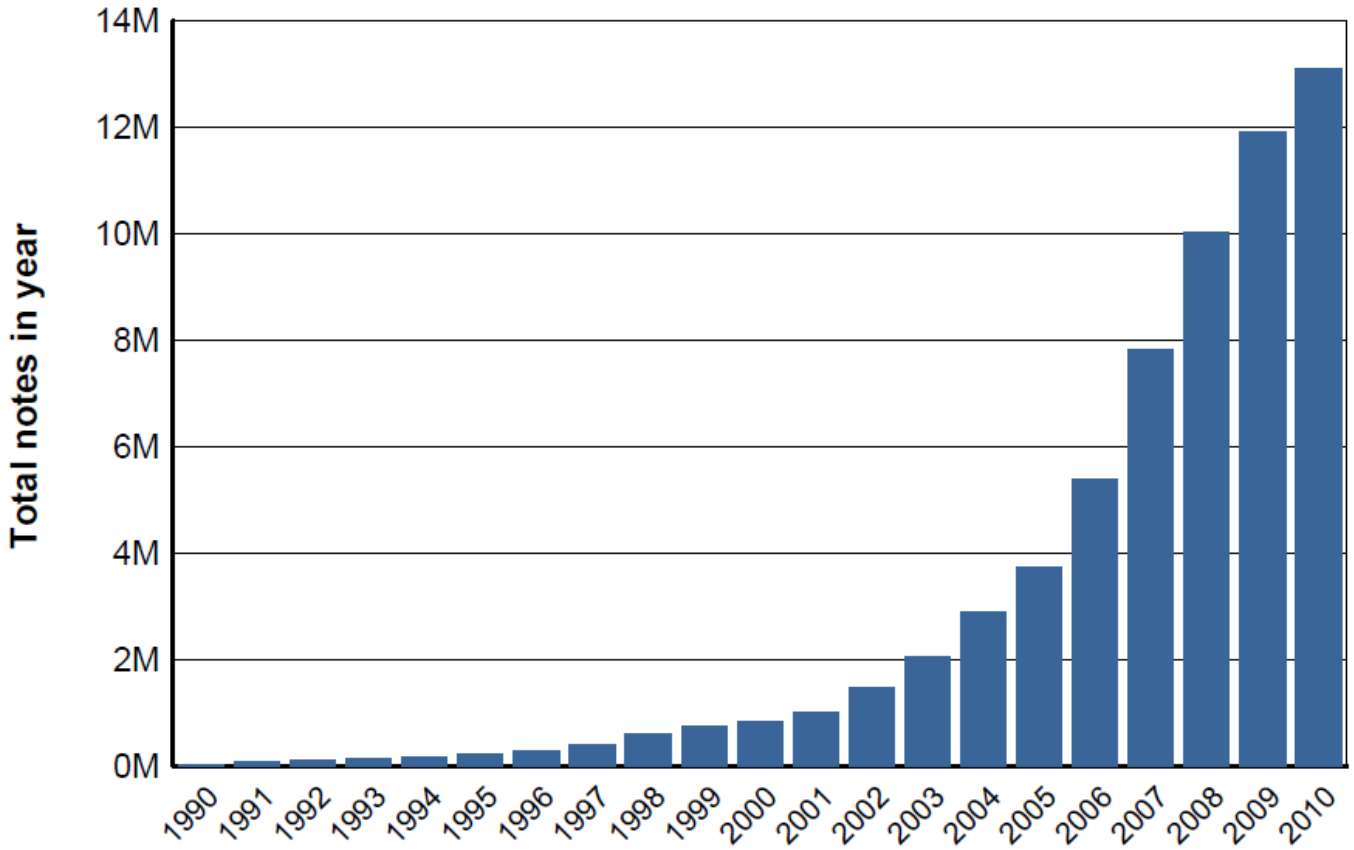
Why Do We Need NLP in CDS?



- Much information that could support CDS is textual and therefore cannot be leveraged by a CDS system without NLP

NLP ---------- > CDS

My journey in and perspectives of the two areas

Natural Language Processing

NLP in CDS

Input

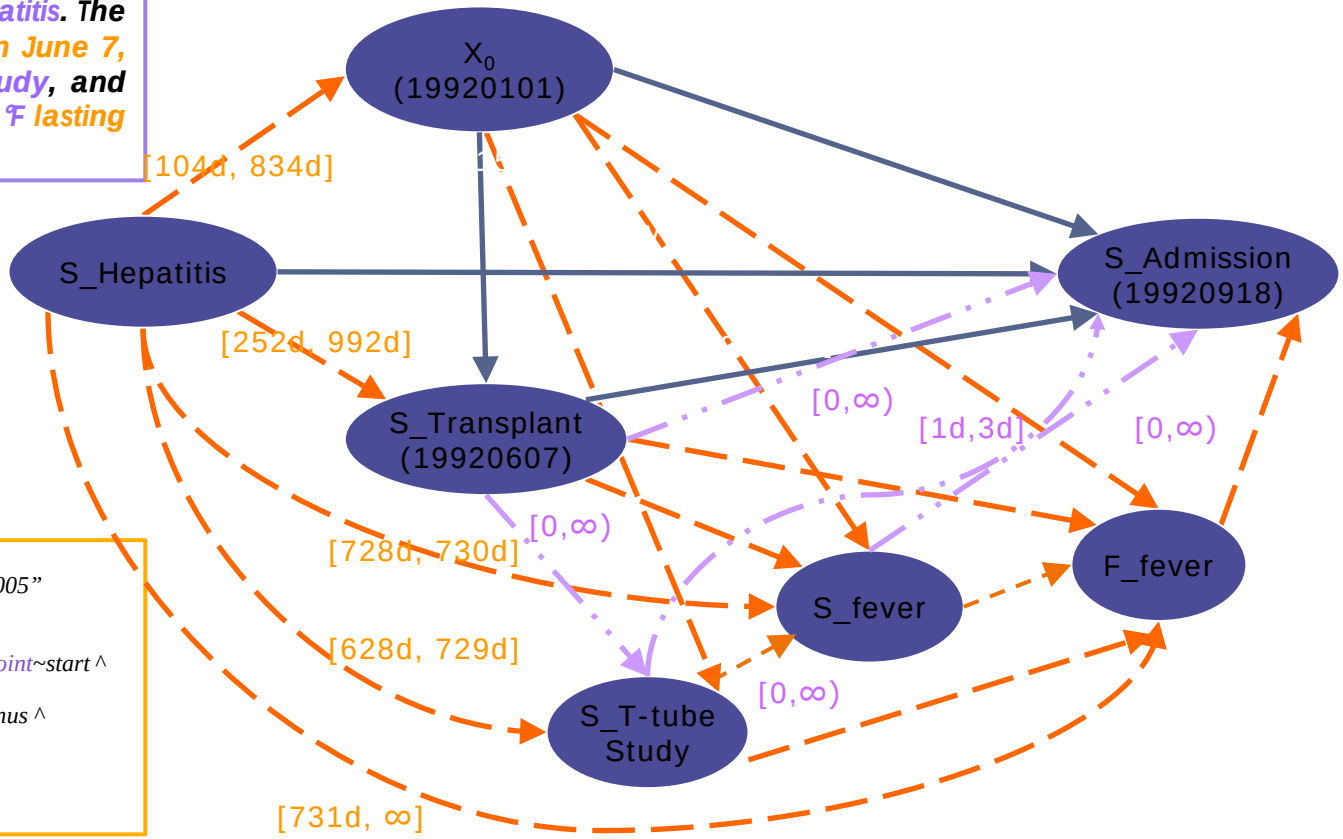
Two years prior to admission **the patient was diagnosed with** *hepatitis*. **The patient had a** *liver transplant on June 7, 1992*. **He underwent a** *t-tube study*, **and** *now* **presents with a** *fever of 101℉ lasting more than two days.*

NLP

Output

```
<problem name = "hepatitis" code = "128241005"
        coding system = "SNOMED">
    <date v = "event_point~unspecified ^
              anchor~admission ^ anchor_point~start ^
              relation~equal ^ quantity~2 ^
              time_unit~year ^ direction~minus ^
              interval_op~jump">
    </date>
</problem>
.....
```

TimeText --- Temporal Reasoning



Zhou L, Friedman C, Parsons S, Hripcsak G. System architecture for temporal information extraction, representation and reasoning in clinical narrative reports. AMIA Annu Symp Proc :869-73.

Clinical Decision Support

- CDS Interventions: reminders, alerts, infobutton, order sets, etc.
- Inpatient/outpatient EHRs: CPOE/e-prescribing, eMAR, etc.
- Structured knowledge representation and knowledge sharing
- Service-oriented architecture

Where will NLP have an impact in CDS?

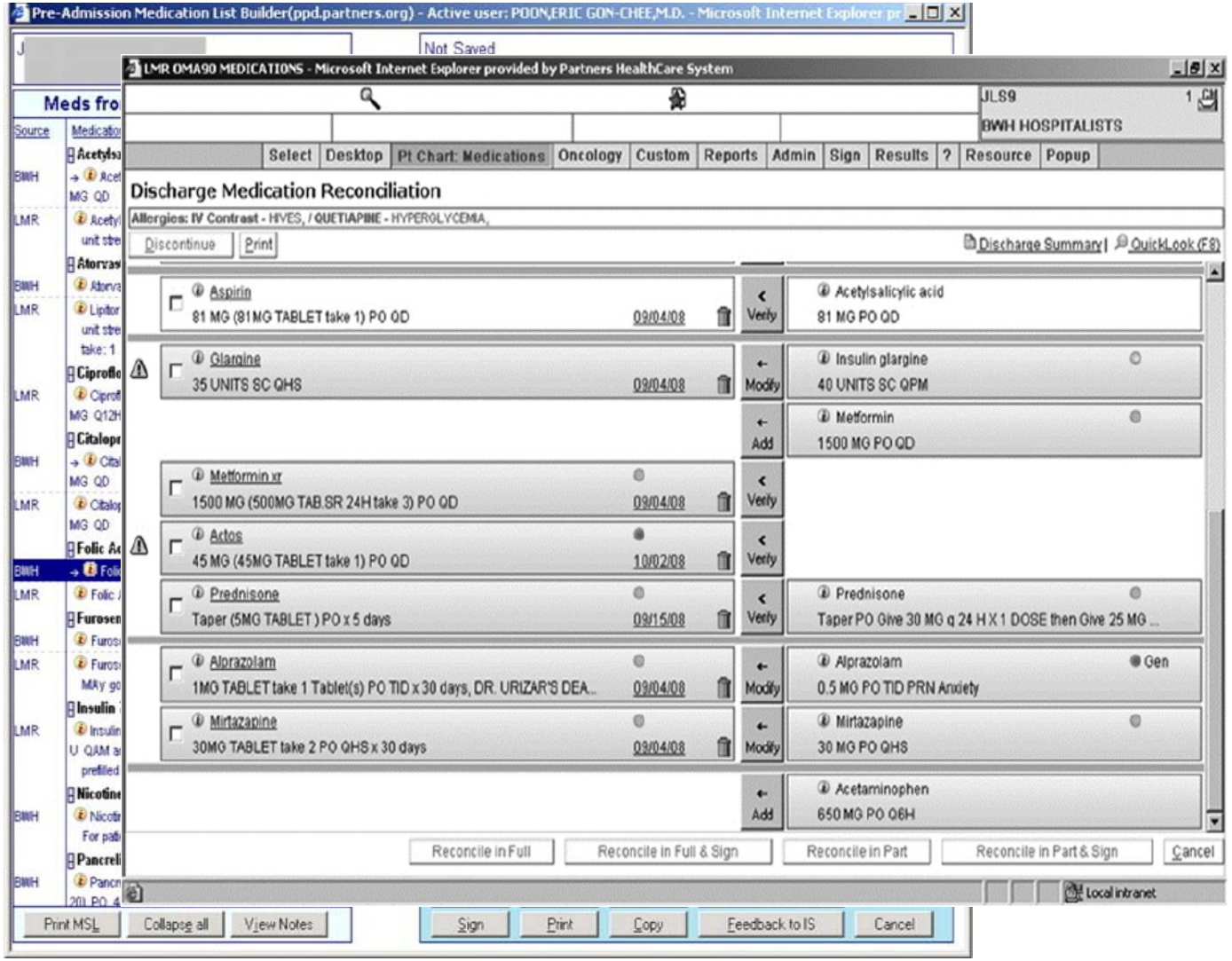
- Improving patient safety
  - Improving medication management
- Enhancing EHR functions
  - Facilitating computerized provider order entry
- Reducing health care cost
  - Identifying high-risk, high-cost patients prospectively

Patient Safety & Medication List

- Medication errors can cause injuries, are common, and are very costly
  - Adverse drug events and medication errors are estimated to cost the US health care system $177 billion annually
- Medication lists within patients' EHRs are often ***outdated***, ***incomplete*** or ***inaccurate***, which is a major cause of medication errors
  - Active medications are often not added in a timely manner to the structured medication list
    - Wagner and Hogan found discrepancies between the number of medications that patients reported taking (5.7) and those listed in their EHRs (4.7)
  - Outdated medications are frequently not deleted
    - 67.4% of medications were still active one calendar day after their inactive status was documented in the clinic notes

Medication Reconciliation

NLP in CDS



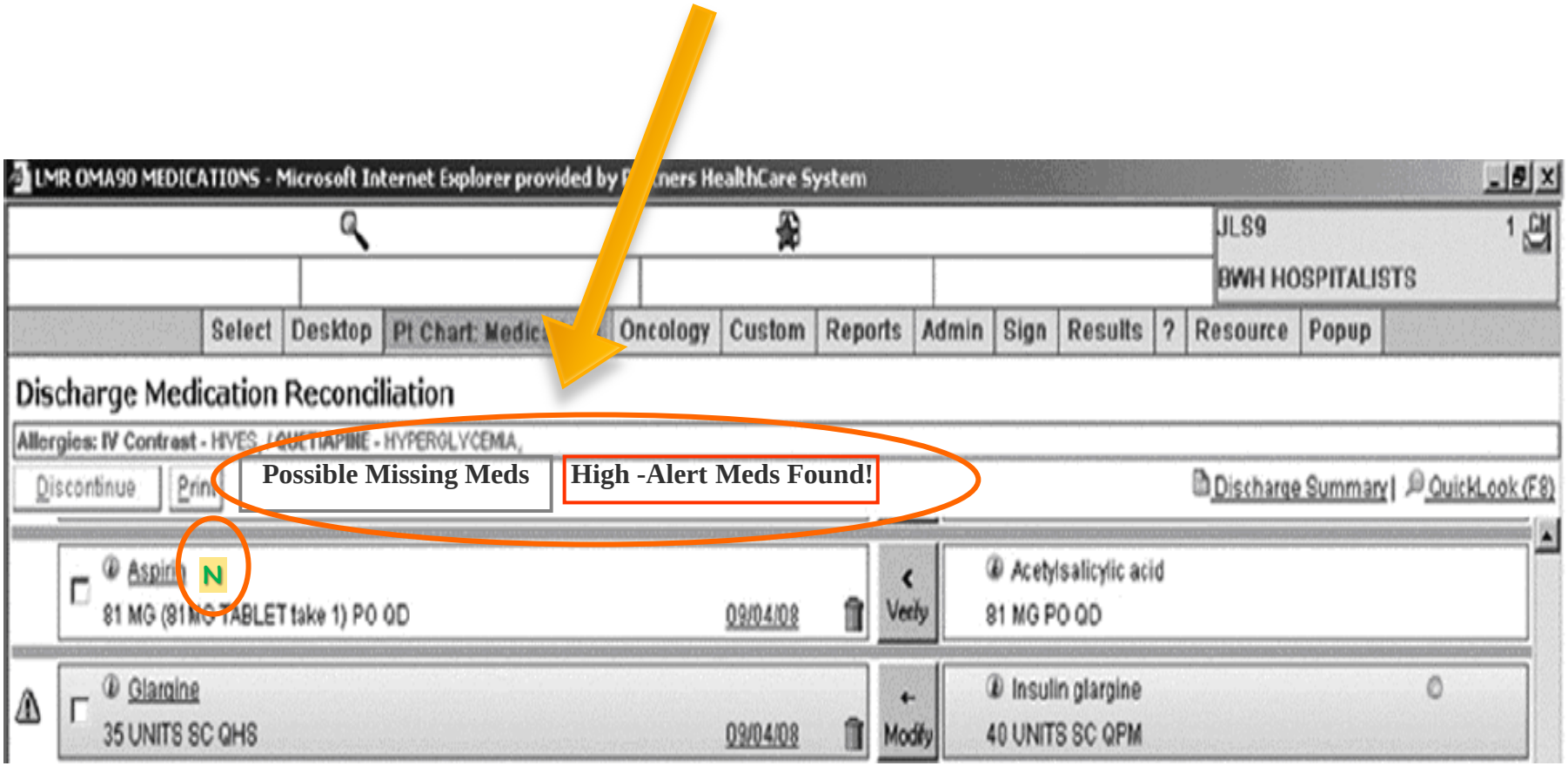
Bobb et al. Development of a tool for medication reconciliation after hospital discharge. *JAMIA. 2011;18(3):308-13.*

Poon et al. Design and implementation of an application and associated service to support interdisciplinary medication reconciliation at admission and discharge. *JAMIA. 2006;13(6):581-92.*

Medications in Clinical notes

- 30% of active medications mentioned in notes were missing from patients' medication list
  - e.g., "trazodone and paxil prescribed by psychiatrist".
- Clinicians often need detailed or additional information beyond the medication list in order to make judgments, changes and other decisions
  - e.g., history and progress of the disease, consultation notes from medical specialists

Medications from NLP Output



Zhou et al. Improving Medication Reconciliation Using Natural Language Processing. The 2011 AHRQ Annual Conference, September 2011, Bethesda, MD

Integrate/couple NLP with CDS

- Data interoperability / terminology standard
  - Medication list may be coded using an institutional or commercial terminology; most existing NLP systems encode clinical text using standard terminologies
  - Code information using multiple medical terminologies
  - Conduct dynamic or static mapping as needed
- System / data integration
  - Integrate NLP system with other EHR applications
  - Conduct data integration, aggregation and summarization
- Conduct reasoning (inference)

** Zhou, et al. Using Medical Text Extraction, Reasoning and Mapping System (MTERMS) to Process Medication Information in Outpatient Clinical Notes. AMIA 2011 Annu Symp Proc: 1639-48.*

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Free-text Order Entry

- 7.1% of medication order entries are free-text
- 9.3% (2,412 out of 26,001) hypoglycemic medication orders were entered using free-text for 2,091 patients
- 75.2% of these free-text entries have an exact name match in the medication dictionary
  - the remaining 24.8% of the free-text entries could be coded if specific formulation information was also provided
- 17.4% of free-text hypoglycemic medication order entries included misspellings
  - e.g., "*Glimepiride", "Glipizide", "Glyburide", "Humalog", "Humulin*"

Zhou et al. How Many Medications are Entered through Free-text in EHR? – a Study on Hypoglycemic Agents. AMIA Annu Symp. 2012.

Free-text Order Entry - CDS

- CDS is not triggered when a medication order is entered as free-text
  - 92 drug-drug interaction (DDI) alerts were not triggered due to free-text entries, affecting 84 different patients
  - 196 patients who had a free-text hypoglycemic order entry also had the same exact drug entered as a structured and coded order during the study period
    - 10% had identical drug entries active in their medication list at the same time
- Only 25.9% of these patients had diabetes recorded in their problem list
- These CDS aspects are critical to patient safety
  - If unintentionally bypassed due to free-text medication order entries may result in potential harm to the patient

NLP ---> CPOE/CDS

- Advanced search function
  - It should not be limited to only detecting exactly spelled medication name
  - It should provide a relevant and smart list (not just a long list to sort through)
- Spelling error detection / correction
  - e.g., suggest a correction, autocorrect
- Efficient user-interface to address workflow issues
  - Auto-fill features
  - “Favorite” list or pick-list (where free-text entries should be monitored)
  - Avoid navigating through multiple screens
- Speech recognition

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NLP → Risk-identification & Stratification

- There is a great need to minimize the cost of care delivered while still meeting quality incentives
  - 5% of patients generally account for up to 50% of costs
  - e.g., prevent readmissions by identifying high-risk, high-cost patients prospectively
- How will NLP help?
  - Most current risk assessment methods use claims and structured data
  - Clinical narrative reports contain rich information, but are untapped
  - Combine structured data with data extracted from free-text using NLP to identify target patients
  - Employ machine learning methods (classification techniques and other probabilistic models) to stratify patients
  - Provide CDS and make recommendations

Summary and Discussion

- Many opportunities to apply NLP to enhance CDS
  - Little things can make a big difference
    - Usability matters a lot
    - Make it easy for clinicians to do the right thing
- Many challenges to tackle
  - Speed is everything (subsecond “screen flips”)
    - If it takes too long to work, it will be useless
    - Optimize system performance, particularly speed
  - Anticipate needs and deliver in real time
    - Bring information from free-text to clinicians at the time they need it
  - Fit into the user’s workflow
    - e.g., develop an efficient user interface to present NLP output

** Bates & Middleton, et al Ten Commandments for Effective Clinical Decision Support: Making the Practice of Evidence-based Medicine a Reality. JAMIA. 2003.*

Summary and Discussion

- Many challenges to tackle (cont.)
  - Standards and system interoperability
  - Service oriented architecture
  - Others: organizational issues; diverse clinical domains; users with diverse roles, background and needs

- Other requirements
  - Simple interventions work best
    - Simplify and condense NLP output and make it useful
  - Continuous monitor impact, receive feedback and make improvement

** Bates & Middleton, et al Ten Commandments for Effective Clinical Decision Support: Making the Practice of Evidence-based Medicine a Reality. JAMIA. 2003.*

Thanks!

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