Using Advanced Analytics to Improve Patient Safety Event Report Analysis

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Conflict of Interest Disclosure

Jessica L. Howe, MA, reported no relevant financial relationships or relationships she has with ineligible companies of any amount during the past 24 months.

Presenter

Jessica L. Howe

Human Factors Research Scientist & Systems Safety Specialist

Ms. Howe's research focuses on understanding the human dimension and employing various human factors research methodologies to provide effective, efficient, and safe solutions. Her expertise includes understanding the impact of health information technology on usability, safety, and public policy. Jessica has also led numerous patient safety initiatives examining various aspects of the healthcare system and provided systems solutions to impact change. Her research has been published in high-impact journals such as The Journal of the American Medical Association and has helped shape public policy. She is also currently a Science Policy Fellow with the Human Factors and Ergonomics Society.

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Disclosures

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  - Agency for Healthcare Research and Quality
  - National Institutes of Health
  - National Science Foundation
  - Pennsylvania Patient Safety Authority

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Agenda

1. Introduction to Human Factors
2. Safety Report Data & User Needs
3. Visualization and Analytics

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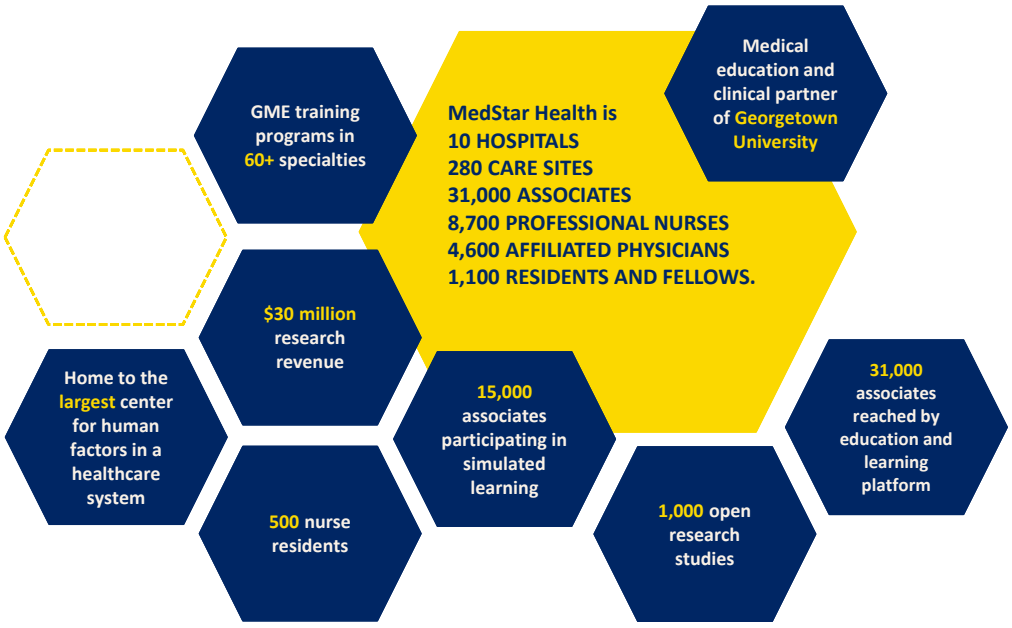
About MedStar Health

Discover.
Innovate.
Learn.



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National Center for Human Factors in Healthcare

We focus on studying human capabilities and *designing technology, systems, and processes to meet these capabilities* for safety, efficiency, & quality

Multidisciplinary approach:
- Human factors
- Medicine
- Engineering
- Computer Science
- Psychology

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National Center for Human Factors in Healthcare

Applied Research
- Grants and contracts from government, foundations, and industry
- Publications, presentations, interventions, policy recommendations

Usability Services
- Medical devices
- Digital health

Safety Integration
- Safety consults
- Serious safety event reviews

Education and Outreach
- Georgetown University: Medicine, Informatics, Quality and Patient Safety
- Workshops, talks, and trainings

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Human Factors

How many of you have pulled a door that was meant to be pushed?

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Human Factors

How many of you have turned a knob and started the wrong burner on the stove?

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The Central Tenet of Human Factors

"We don't redesign humans;

we redesign the system within which humans work."

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Data, Data, Everywhere …

- Health care facilities collect thousands of patient safety event reports
- Patient safety organizations collect tens of thousands
- Federal databases contain millions
- Recent study shows **+30 million** reports in publicly available database

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And Not A Safety Thought to Think!

- Challenges:
  - Different/changing taxonomies
  - Insights are in free-text, but too many reports to read
  - Can't "see" patterns in the data
- Current state:
  - Spreadsheets for tracking
  - Memory based processes

ORIGINAL ARTICLES

Usability and Accessibility of Publicly Available Patient Safety Databases

Sheehan, Julia G. BS*; Howe, Jessica L. MA*; Fong, Allan MS*; Krevat, Seth A. MD*,†; Ratwani, Raj M. PhD*,‡

Author Information

Journal of Patient Safety: September 2022 - Volume 18 - Issue 6 - p 565-569
doi: 10.1097/PTS.0000000000001018

ORIGINAL STUDIES

Making Patient Safety Event Data Actionable: Understanding Patient Safety Analyst Needs

Puthumana, Joseph Stephen BA*; Fong, Allan MS*; Blumenthal, Joseph BA*; Ratwani, Raj M. PhD*,†

Author Information

Journal of Patient Safety: September 2021 - Volume 17 - Issue 6 - p e509-e514
doi: 10.1097/PTS.0000000000000400

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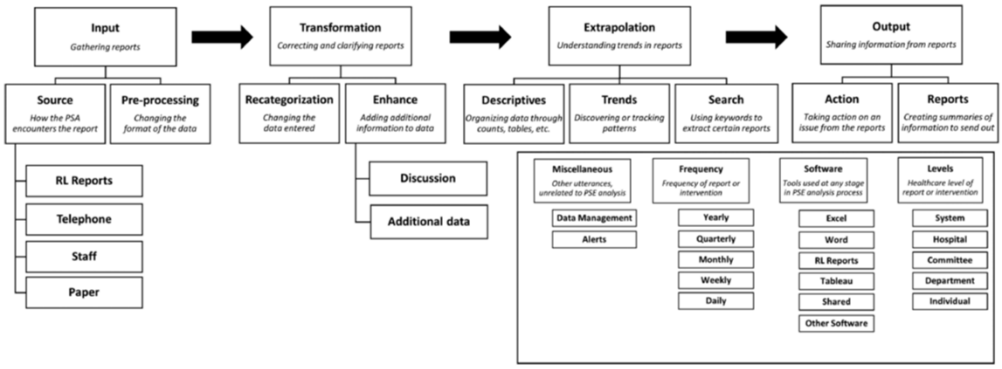
Patient Safety Officer Needs

- 21 patient safety analysts
  - 11 hospitals from 3 health care systems
- Semi-structured interviews



Puthumana, J. S., Fong, A., Blumenthal, J., & Ratwani, R. M. (2017). Making Patient Safety Event Data Actionable: Understanding Patient Safety Analyst Needs. Journal of patient safety.

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Current Analysis Shortcomings

- User needs analysis:
  - Graphs are static…cannot easily manipulate data to see trends
  - Have to read reports and code them, but coding keeps changing
  - Each question requires more coding
- Desire for improved tools to support safety analysis

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Analytics to Meet User Needs

- Our principles:
  - Let the user see and interact with the data
    - Dashboards and details on demand
  - Use natural language processing to identify patterns and trends in free text
    - Focus on free text – analysis says taxonomies keep changing
  - Human is the decision-maker

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Hospital dashboard: Examine severity level, department breakdown and status of reports

Severity level of all events. Can click to see specific events by department, etc.

Status update of which reports are open, in-progress and new.

Department level breakdown of events with severity level indicated.

Specific event details on demand.

Quickly analyze patterns in the data.

See who is reporting.

Breakdown of reports by event category.

Specific record details presented here.

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System wide interactive dashboard for trend analysis

Change the time window of analysis.

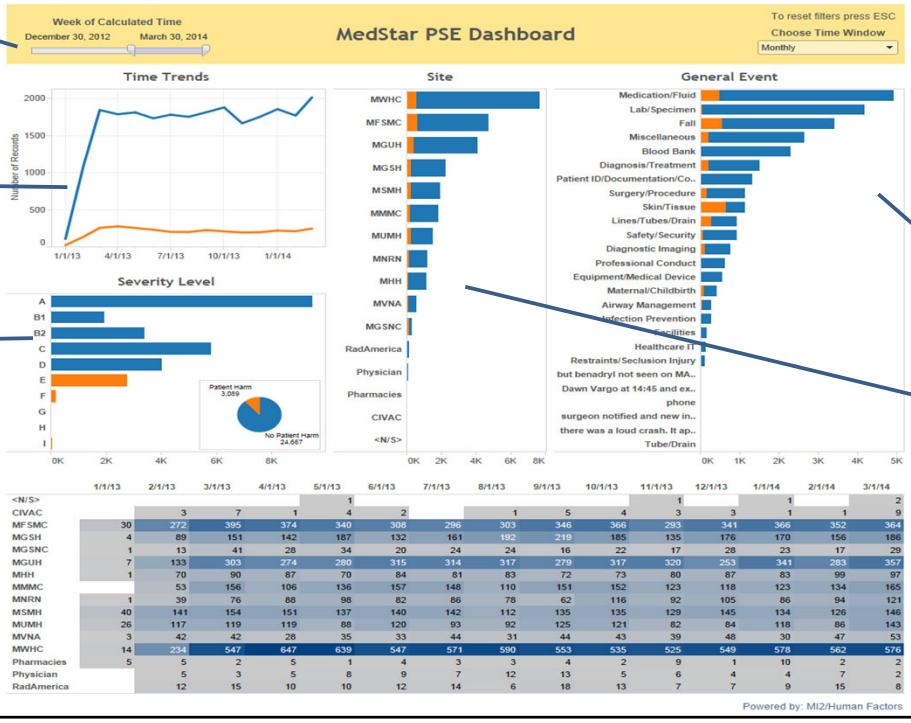
Snapshot of trends over time.

Severity level for all cases being reported.

Trends by site and time.

Breakdown of cases by event type.

Severity level by reporting site.



	1/1/13	2/1/13	3/1/13	4/1/13	5/1/13	6/1/13	7/1/13	8/1/13	9/1/13	10/1/13	11/1/13	12/1/13	1/1/14	2/1/14	3/1/14
<N/S>					1						1		1		2
CIVAC		3	7	1	4	2		1	5	4	3	3	1	1	9
MFSMC	30	272	395	374	340	308	296	303	346	366	293	341	366	352	364
MGSH	4	89	151	142	187	132	161	192	219	185	135	176	170	156	186
MGSNC	1	13	41	28	34	20	24	24	16	22	17	28	23	17	29
MGUH	7	133	303	274	280	315	314	317	279	317	320	253	341	283	357
MHH	1	70	90	87	70	84	81	83	72	73	80	87	83	99	97
MMMC		53	156	106	136	157	148	110	151	152	123	118	123	134	165
MNRN	1	39	76	88	98	82	86	78	62	116	92	105	86	94	121
MSMH	40	141	154	151	137	140	142	112	135	135	129	145	134	126	146
MUMH	26	117	119	119	88	120	93	92	125	121	82	84	118	86	143
MVNA	3	42	42	28	35	33	44	31	44	43	39	48	30	47	53
MWHC	14	234	547	647	639	547	571	590	553	535	525	549	578	562	578
Pharmacies	5	5	2	5	1	4	3	3	4	2	9	1	10	2	2
Physician		5	3	5	8	9	7	12	13	5	6	4	4	7	2
RadAmerica		12	15	10	10	12	14	6	18	13	7	7	9	15	8

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Machine Learning & Natural Language Processing 101

- Uses statistical patterns in sentences to group reports based on similarities
- Modeling
  - Unsupervised: no “categories” or “labels given to the computer
    - Given a database of reports, what clusters emerge?
    - Easy to develop; results are of mixed value
  - Supervised: categories provided to the computer
    - Given the data given to the computer, what category does this new report belong to?
    - Harder to develop; results show promise

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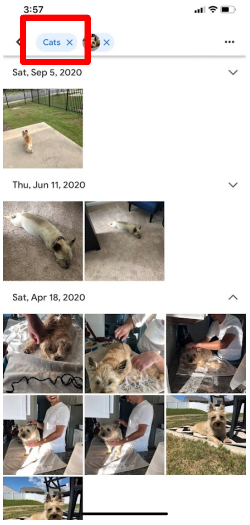
Machine Learning & Natural Language Processing 101

Dog?



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Natural Language Processing

"... patient had MRI ordered. Pt needed premedication. Pt called for at 1100. At 1130 nurse said she needed to call MD to get meds. At 1145 nurse called to say pt was given meds and would be sent up. At 1225 nurse called to ask why we hadn't gotten the pt. When asked if she called transport, she said no. I told her that transport needs to be called or they won't come. At 1245 transport called us back to let us know the pt was on the way. Pt was on the MRI table in the scanner. Before we could start, she started yelling and tried to get out of the scanner. It was difficult to get her back on the stretcher to continue the scan. We made several attempts to reach her nurse and decided to send her back downstairs without the MRI. Called the charge nurse to have her let her nurse know since we couldn't reach her. We were later told that the family was very angry saying that the delay caused the medicine to wear off..."

Imaging

Communication

Med

Family

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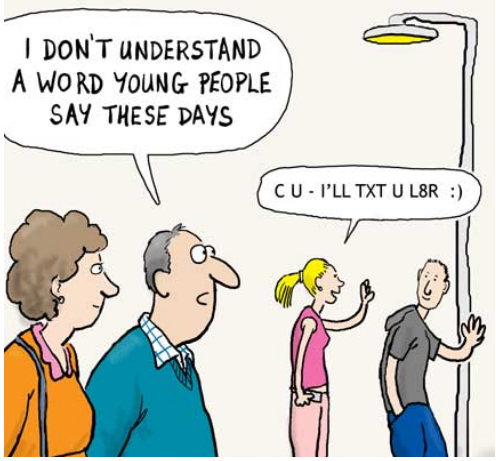
Not So Fast!

- ER: extended release? emergency room?
- OR: operating room? or?
- Pt: Patient? physical therapy?
- Hr: Hour? heart rate?

- Context is critical



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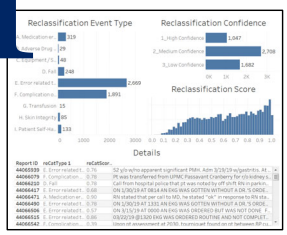
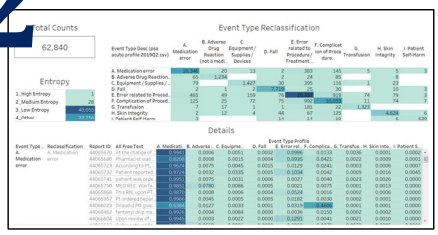
Safety Report Machine Learning Algorithms

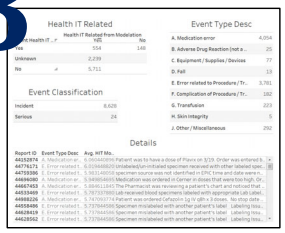
1 Miscellaneous



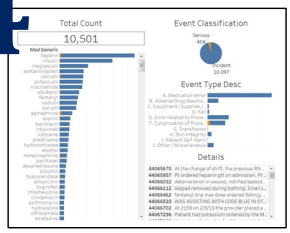
2 Profile



3 Health IT



4 Medication



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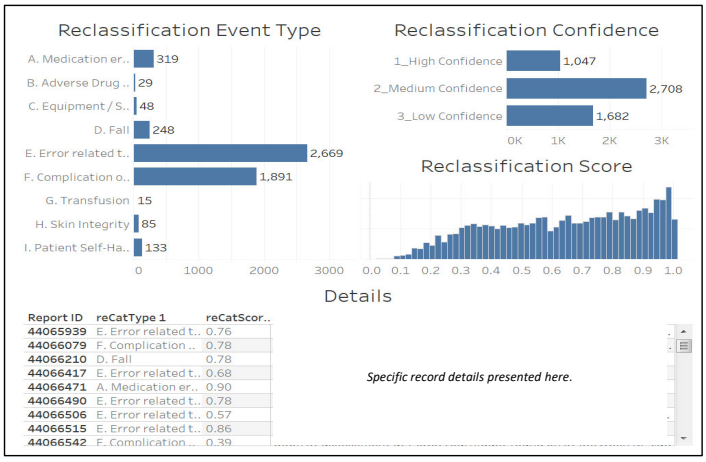
Miscellaneous



Recategorize reports entered with a category into an appropriately matching category.

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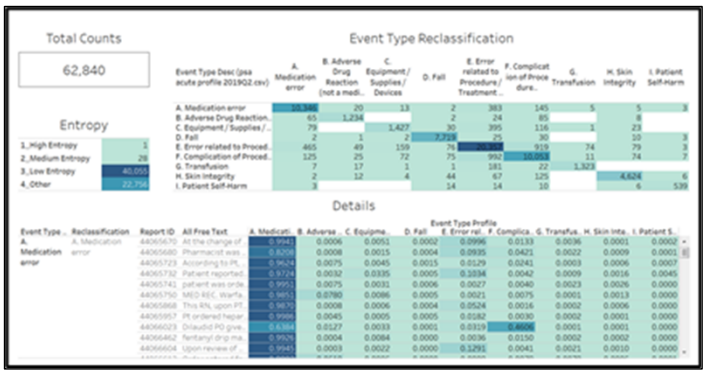
Profile



Identify if multiple categories match an event to identify unique patterns.

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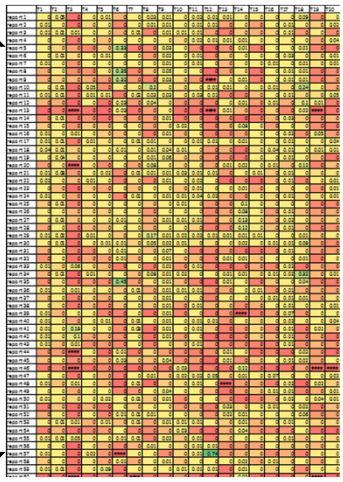
Report Profiles

General Event Type categories

Reports



Apply supervised and unsupervised approaches to identify reports with multiple factors.

	Text	Fall	Medication	Health IT
Report 1	“side effects of medication”	0	0.9	0
Report 2	“patient fell from bed”	0.9	0	0
Report 3	“patient fell while on new medication”	0.7	0.3	0

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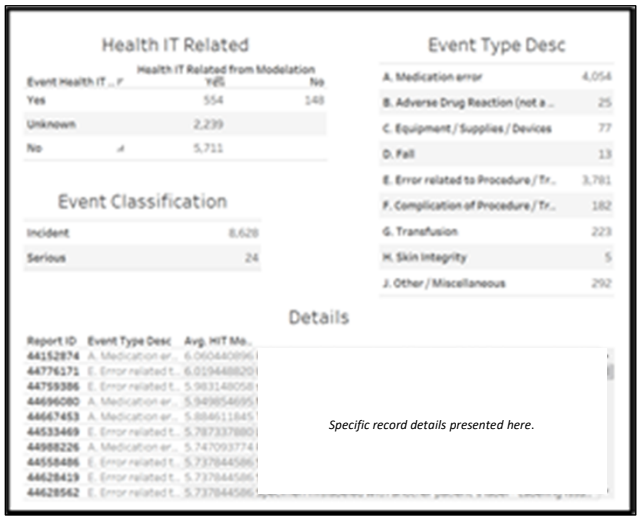
Health IT



Identify health information technology related events given a free-text description.

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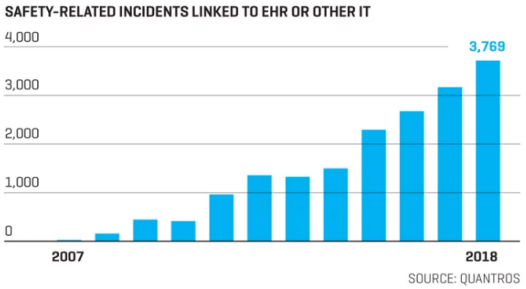
Example: Health IT Reports



Difficulty Identifying Health IT Issues

- Identifying health information technology (health IT) related reports is challenging:
  - Rarely specific event type categories for health IT
  - Reporters don't always recognize IT contributions
- How can we better detect health IT reports?

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Identifying Health IT Events

- Using natural language processing to identify health IT related events from free text descriptions
  - 1.7m reports
  - Develop a simple model that can be easily applied to determine which safety events may be health IT related
- A health IT hazard is a characteristic of any health IT application or its interactions with any other health care system (e.g. the people, equipment and workspaces) that increases the risk that care processes will be compromised and patients harmed. (Walker)

Fong, A., Adams, K. T., Gaunt, M. J., Howe, J. L., Kellogg, K. M., & Ratwani, R. M. (2018). Identifying health information technology related safety event reports from patient safety event report databases. *Journal of biomedical informatics*, *86*, 135-142.

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Model Development Process

- Manually coded ~ 5,000 reports
  - 2,435 Likely and 2,852 Unlikely
- Multiple modeling approaches, with unigram as the best performing

Features	50	100	150	200	250	300	350	400	450	500	550	600
duplicate	2.8	2.7	2.5	2.6	2.7	2.3	2.2	2.4	2.5	2.8	2.9	3.1
mismatch	2.2	1.8	1.4	1.4	1.3	1.5	1.5	1.5	1.5	1.4	1.5	1.6
computer	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.3	1.3	1.5	1.5
prescription	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.4	1.3	1.3
incorrect	1	0.9	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
system	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.8
label	0.9	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.8
enter	0.8	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.8	0.9	0.9
order	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.8
schedule	0.7	0.8	0.7	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.9	0.9
administer	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5
dose	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
give	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4

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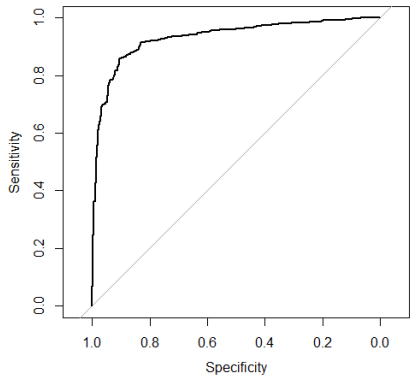
Model Performance



303 Likely (L)
982 Unlikely (U)
95 Need more info

Exclude "Need more information"

	Predicted L	Predicted U
True L	263 (87%)	40 (13%)
True U	122 (12%)	860 (88%)

Specificity: 0.88
Sensitivity (Recall): 0.87

AUC: 0.93
Precision: 0.68

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Model Application

- Applied the model to a database of reports (regardless of event type category)
- Identified 16x more health IT reports than traditional classification methods
- Enables identification of more health IT contributing factors

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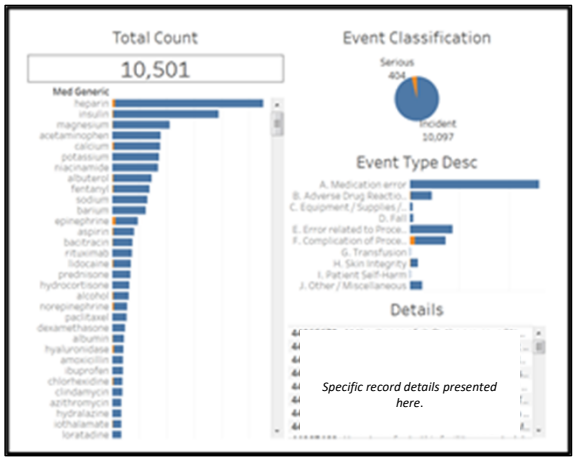
Medication



Identify medication names any report and map to drug libraries.

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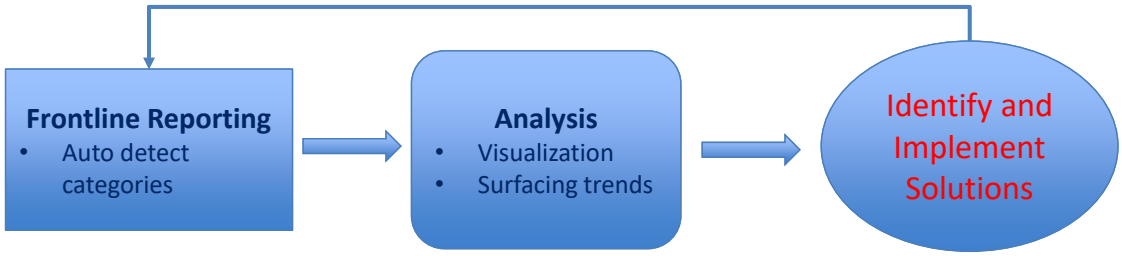
The Future of Reporting and Analysis



Opportunities

- Reduce reporting burden
  - Automatically categorize free text
- Ease analysis challenges
  - Surface patterns and trends
- Semi-automate tracking of intervention effectiveness

Limitations

- Interface design
- Updating models
- Demonstrating value
- Solution development

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Current Efforts

- Developing a prototype application to support report analysis:
  - Intuitive search
  - Visualization
  - Algorithms
- Actively seeking sites to pilot test the tool
  - No data sharing required

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Questions

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Thank you!

Contact: Jessica.L.Howe@medstar.net
Human Factors Research Scientist & Systems Safety Specialist

It's how we treat people.

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