



# **Normalizing Flowsheet Data for Continuing Use to Meet Multiple Clinical Quality & Research Needs**

Beverly A. Christie, DNP, RN

Bonnie L. Westra, PhD, RN, FAAN, FACMI



UNIVERSITY OF MINNESOTA



School of Nursing  
Driven to Discover<sup>SM</sup>

## **Additional Authors**

Steven G. Johnson, MS; Matthew D. Byrne, PhD, RN; Anne LaFlamme, DNP, RN; Connie W. Delaney, PhD, RN, FAAN, FACMI; Jung In Park, BS, RN; Lisiane Pruinelli, MSN, RN; Suzan G. Sherman, PhD, RN; Stuart Speedie, PhD, FACMI

## **Disclosure**

We have no relevant financial relationships with commercial interests

## **Acknowledgment**

This was supported by Grant Number 1UL1RR033183 from the National Center for Research Resources (NCRR) of the National Institutes of Health (NIH) to the University of Minnesota Clinical and Translational Science Institute (CTSI).

Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CTSI or the NIH.

The University of Minnesota CTSI is part of a national Clinical and Translational Science Award (CTSA) consortium created to accelerate laboratory discoveries into treatments for patients.

# Data Standardization

- [https://www.youtube.com/watch?v=g7D6pm\\_bLyU](https://www.youtube.com/watch?v=g7D6pm_bLyU)
- What are the key messages that are similar to documentation, particularly flowsheets?

# Introduction

- Value of continuing (secondary) use of EHR data
- Challenges and lessons learned with flowsheet data
- Process for post-hoc standardizing data (ideal is standardized during the EHR build)
- Examples of use of the data
- Importance of flowsheet data for quality improvement and research

# Vision

## Health Information Technology Strategic Framework For A Learning Health System

AIMS: Patient-centered, Safe, Timely, Effective, Efficient, Equitable

❖ INFORMED & EMPOWERED PATIENT

**RESULTS**

❖ ENHANCED VALUE

❖ IMPROVED CARE

❖ IMPROVED OUTCOMES

❖ SHARED KNOWLEDGE

### ACTIVITIES

Engage Consumers

Provide Care

Measure Quality

Improve and Innovate

Educate

Conduct Research

### BENEFICIARIES

Consumers

Patients

Providers

Payers

Public Health  
Professionals

Researchers

### A Learning Health System for



*Individuals*



*Population health*

DATA

Meaningful Use of Health Information Technology

Privacy and Security

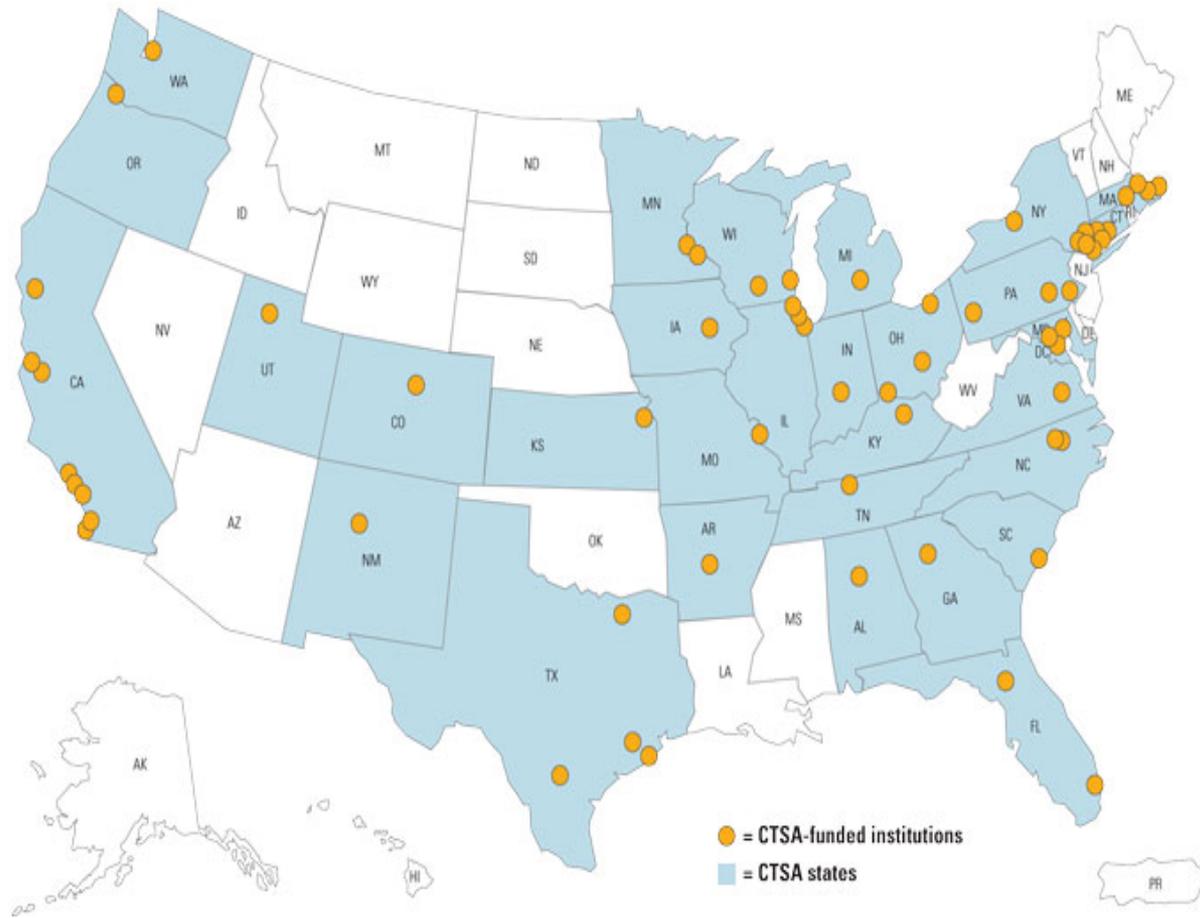
Policy and Technical Infrastructure

A system that is designed to:

- Generate and apply the best evidence for the collaborative health care choices of each patient and provider
- Drive the process of new discovery as a natural outgrowth of patient care
- Ensure innovation, quality, safety, and value in health care.

(Charter of the Institute of Medicine Roundtable on Value & Science-Driven Health Care)

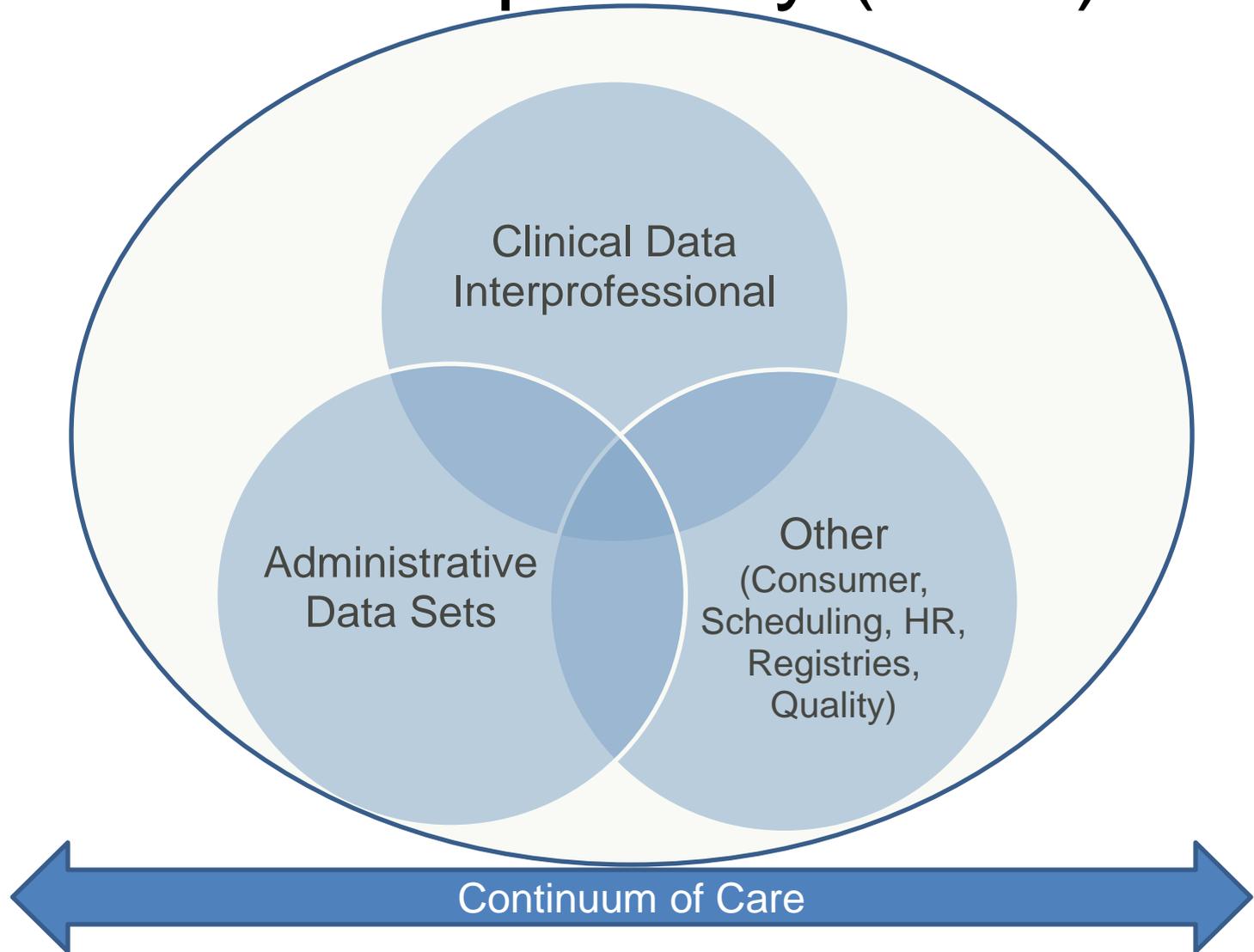
# Clinical and Translational Science Awards (CTSAs)



<http://www.ncats.nih.gov/research/cts/cts.html>;

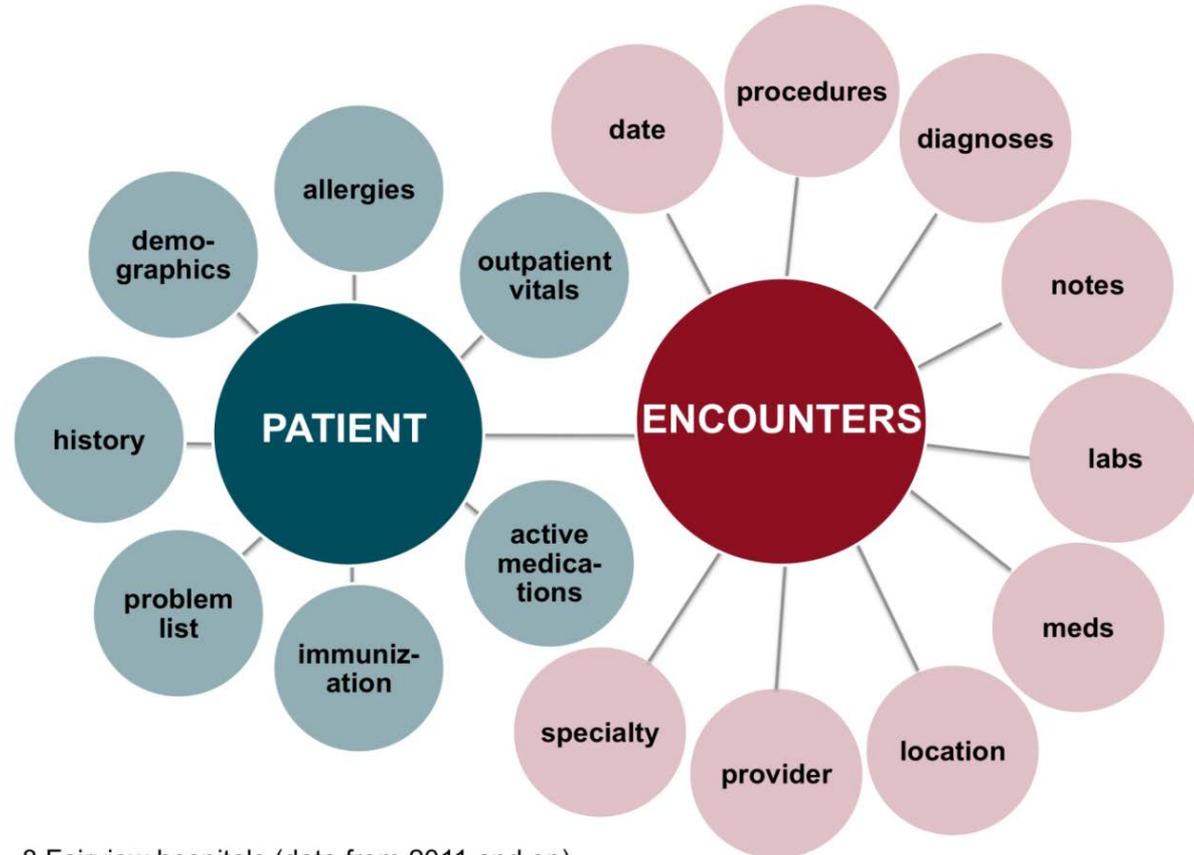
<https://www.ctscentral.org/>

# Vision for Extending Clinical Data Repository (CDR)



# Data Accessible to Researchers & QI Staff

- Cohort discovery & recruitment
- Observational studies
- Predictive Analytics



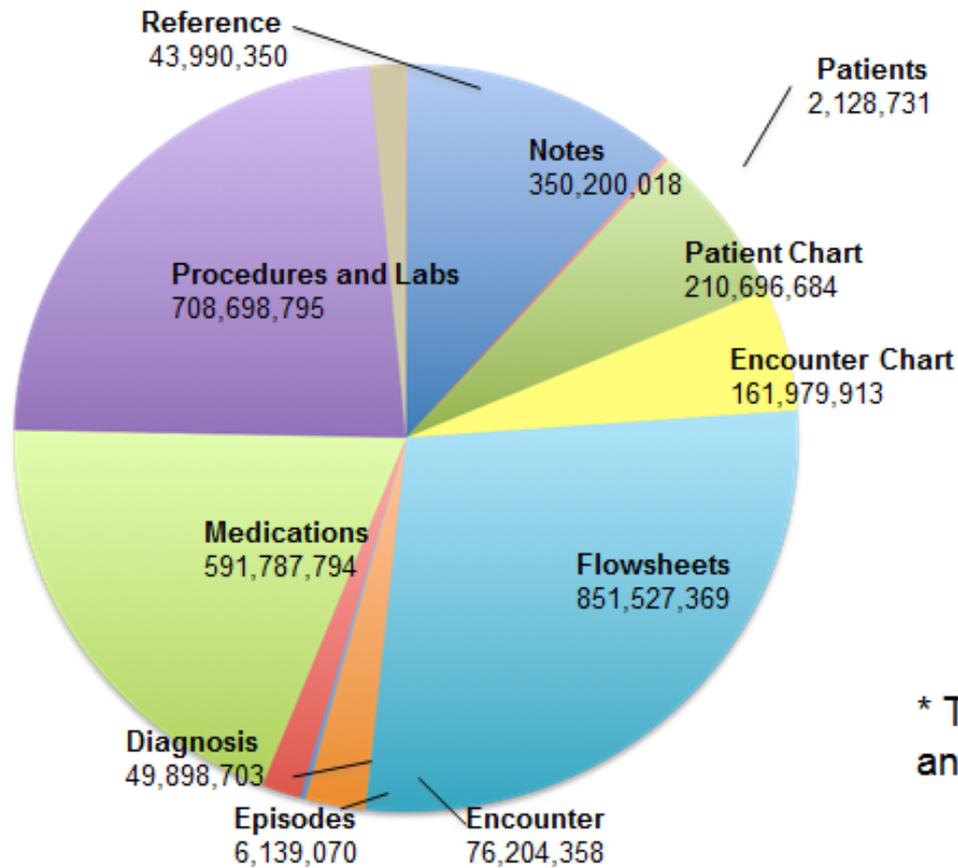
8 Fairview hospitals (data from 2011 and on)

40+ Fairview (from 2005) and UMP clinics (from 2011)

Data available to UMN researchers via the Academic Health Center Information Exchange (AHC-IE)  
2+ million patients

# UMN Health / Fairview Health Services (others in the future)

AHC-IE - acute & ambulatory clinical data  
2+ million patients  
4+ billion total rows of unique data



\* The number of patients and records changes daily

# Extend Data Types in Traditional CDR Flowsheet Data

- Purpose - Create usable research / quality improvement data from flowsheet measures beginning with five clinical conditions
  - Falls assessment
  - Pressure ulcer assessment & prevention
  - Pain management
  - Urinary catheter management
  - Venous thrombosis embolism (VTE) prevention
- Normalize data, mapping flowsheet measures and values to concepts – use LOINC/ SNOMED CT
- Organize concepts into an ontology
  - Display data in i2b2 for cohort discovery
  - Extend AHC-IE database with flowsheet data
  - Organize data for data delivery

# Pilot Project

- UMN Academic Health Center – Information Exchange (AHC-IE)
  - Adult Patient data - 10/20/2010 - 12/27/2013
  - Focus is primarily on inpatient flowsheet data
  - Total patients - 66,660 with 199,665 encounters
- The flowsheet data includes
  - Unique flowsheet measure names - 14,550
  - Flowsheet measure context of use is provided templates (like computer screen views) and groups
  - Unique template names - 562
  - Unique group names - 2,969
  - Total measure (data points) - 153,049,704

# Example Flowsheet

## Patient Care Summary

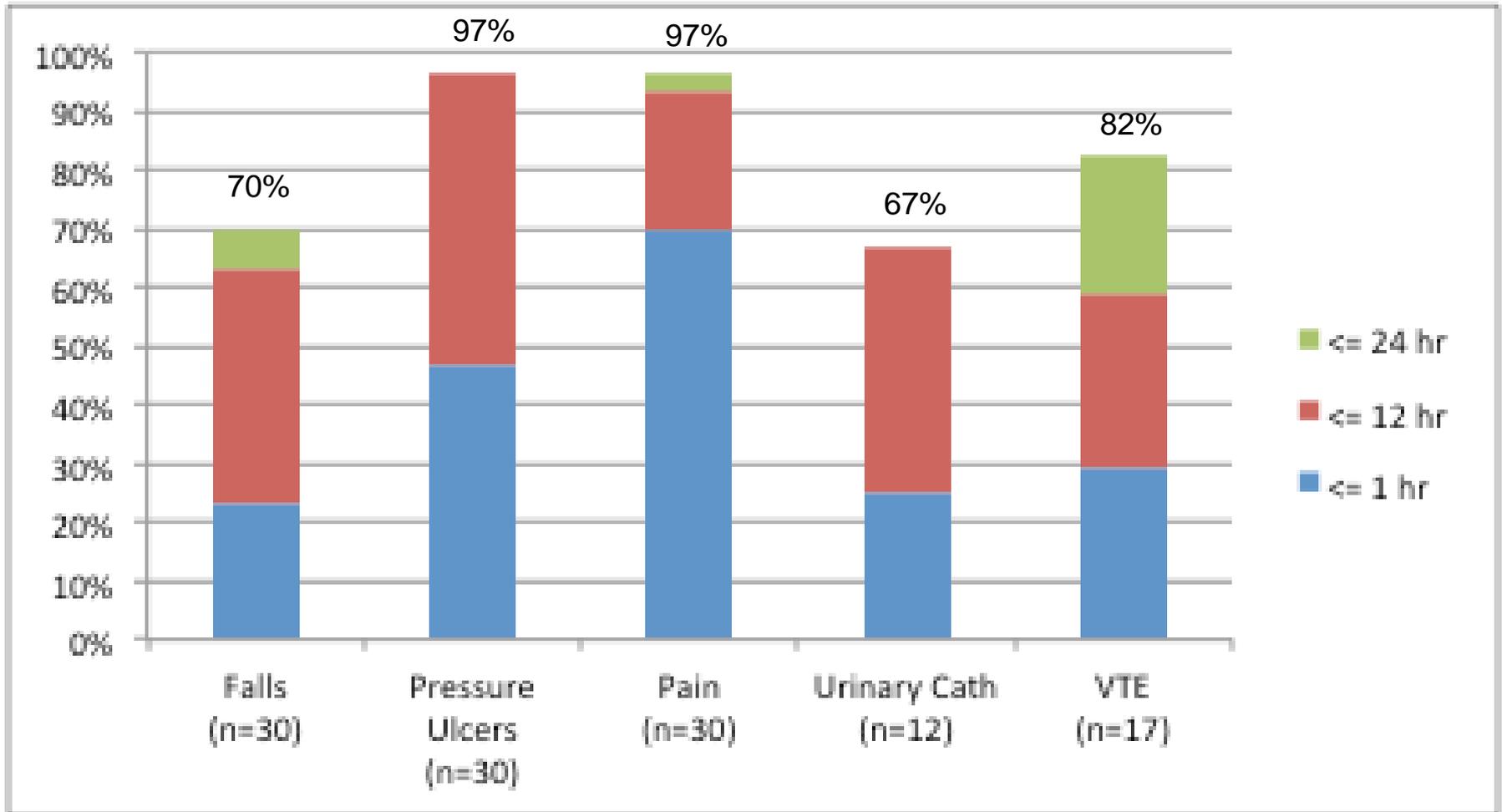
	4/17/13					
	0800	1200	1600	2000	0000	0400
<b>Johns Hopkins Falls Assessment</b>						
Age	1		1		1	
Fall History	0		0		0	
Elimination	2		2		2	
Medications	3		3		2	
Patient Care Equipment	2		2		2	
Requires assistance or supervision	2		2		2	
Unsteady gait	0		0		0	
Visual or auditory impairment affecting	0		0		0	
Altered awareness of physical	0		0		0	
Impulsive	0		0		0	
Lack of understanding of physical and	0		0		0	
Johns Hopkins Total Score	10		10		9	
Moderate Fall Risk Interventions	standard		standard		standard	
High Fall Risk Interventions						
<b>Safety Interventions (Adult)</b>						
High Fall Risk - Meds			Analges...			
High Acuity Falls Interventions					none	

- Capture clinical observations in cells (“flowsheet measures”)
- Columns represent points in time
- Categorized into Groups and Templates (screens)

# Phase 1 – Initial Work

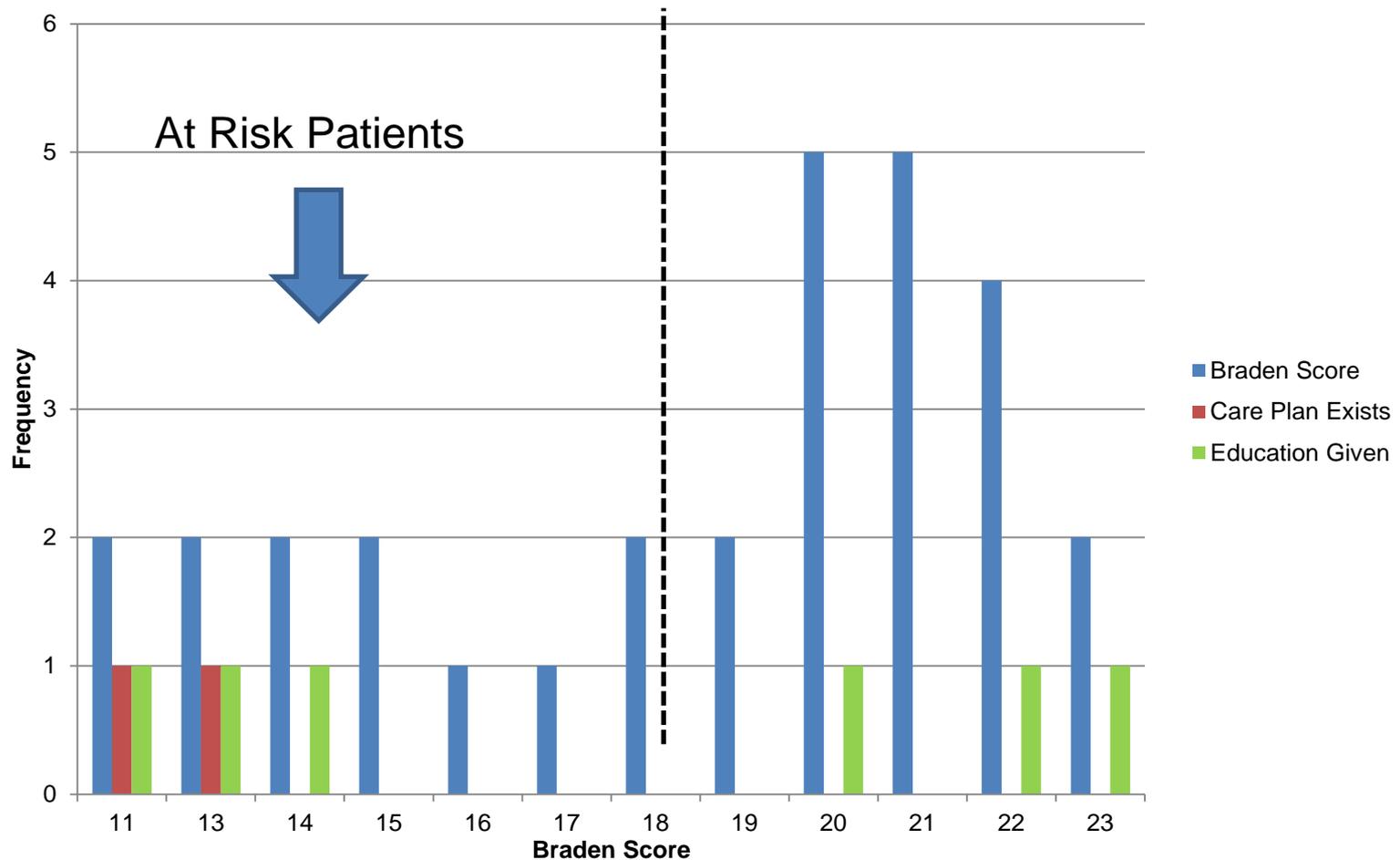
- Purpose: Understand how data are documented, documentation requirements, and factors that influence documentation
- Assessed quality measures – falls, pressure ulcers, pain management, CAUTI, VTE
- Observation of nursing workflows
- 30 chart reviews
- Interviews with nurse managers

# Timeliness of Assessments



# Pressure Ulcer Assessment & Prevention

## Care Plan and Education for At Risk Patients



# Lessons Learned

- Interdisciplinary team was required to do the work
  - Clinical knowledge needed (Heparin flush vs. VTE prophylaxis)
  - EHR developer/ trainer
  - Data query skills
- Data are entered over time period (multiple “columns”)
  - Timeliness of initial assessment – review more than one column
- Data found on multiple screens/ database fields in the EHR
- CDR queries easier for some questions, only once you know how, where, when, and why charting is done
- Association between items not clear
  - Pain assessment > 0
  - Pain medication
  - Pain reassessment in 30 minutes

# Lessons Learned

- Translation of documentation policy to database queries challenging
  - Finding data in multiple i.e. Pain MAR Exists, Lab INR, etc
  - Difficult to determine ongoing documentation required for high risk patients – a shift can be 8 or 12 hours
- CDR queries can audit more patients faster
- Clinical data model (ontology) needed to address specific user needs for data i.e. researcher's view of data
  - Map multiple similar flowsheets to 1 concept
  - Organize concepts logically for a clinical topic
- Standards needed for representing flowsheet data



What experience have you had  
with secondary use of flowsheet  
data?

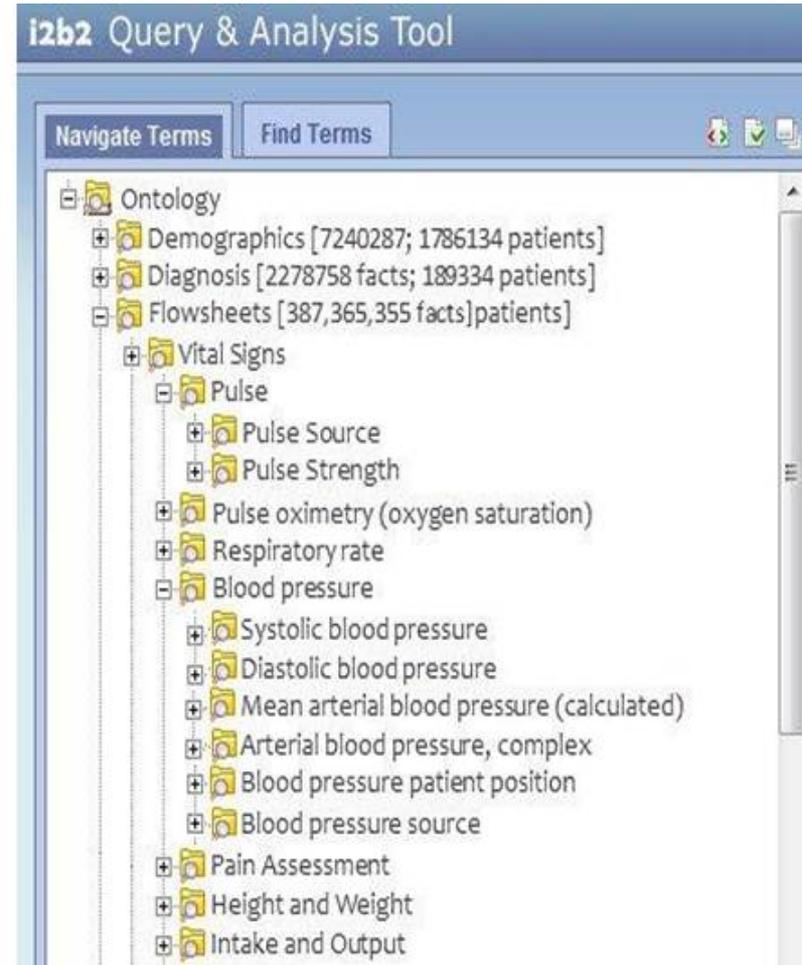
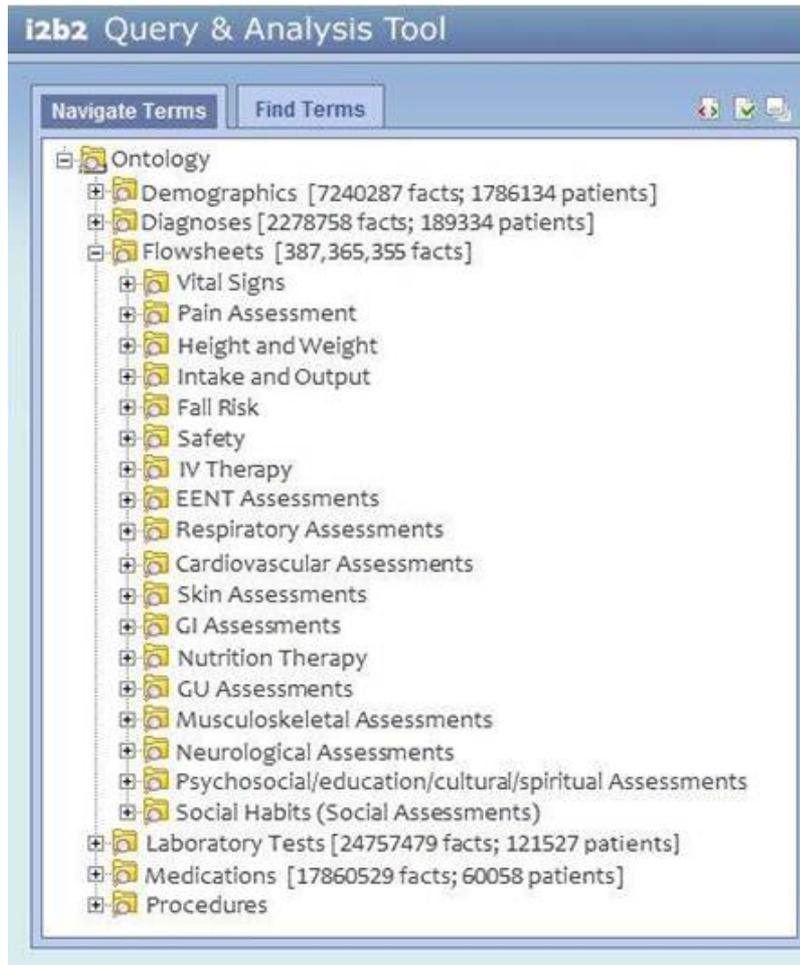
# Phase 2



# Purpose

- Develop a repeatable process for organizing flowsheet data to address quality and research questions
  - Create common (clinical) data models
    - Identify concepts i.e. pressure ulcers and map flowsheet data
  - Map concepts to standardized terminology
    - LOINC & SNOMED CT
  - Use steps in process to develop open source software to semi-automate mapping process

# Proposed Ontology for Cohort Discovery i2b2



Warren JJ, Manos EL, Connolly DW, Waitman LR. Ambient Findability: Developing a Flowsheet Ontology for i2B2. *Proc 11th Int Congr Nurs Informatics*. 2012 Jan;2012(1):432.

# Current Organization by Others

- Exported templates (T)/ groups (G)/ measures (M) to i2b2
  - Removed spurious build measures
  - Used hierarchical clustering data mining to combine similar groups –renamed groups
    - Then clustered groups into similar templates
  - Disregarded T, G, or M if  $\leq 35$  patient encounters

# Challenges

- Templates are top-level categories – how to select/combine that is generalizable
  - 562 templates – need organizing framework
- Same flowsheet measure can be in different groups/templates
- Variations on names / value sets for similar concepts
- Researcher must know data-entry model in order to locate information if using T/ G/ M
- Some data are deprecated and may be missed after an upgrade
- Our approach: develop an ontology (Common/ clinical data models)

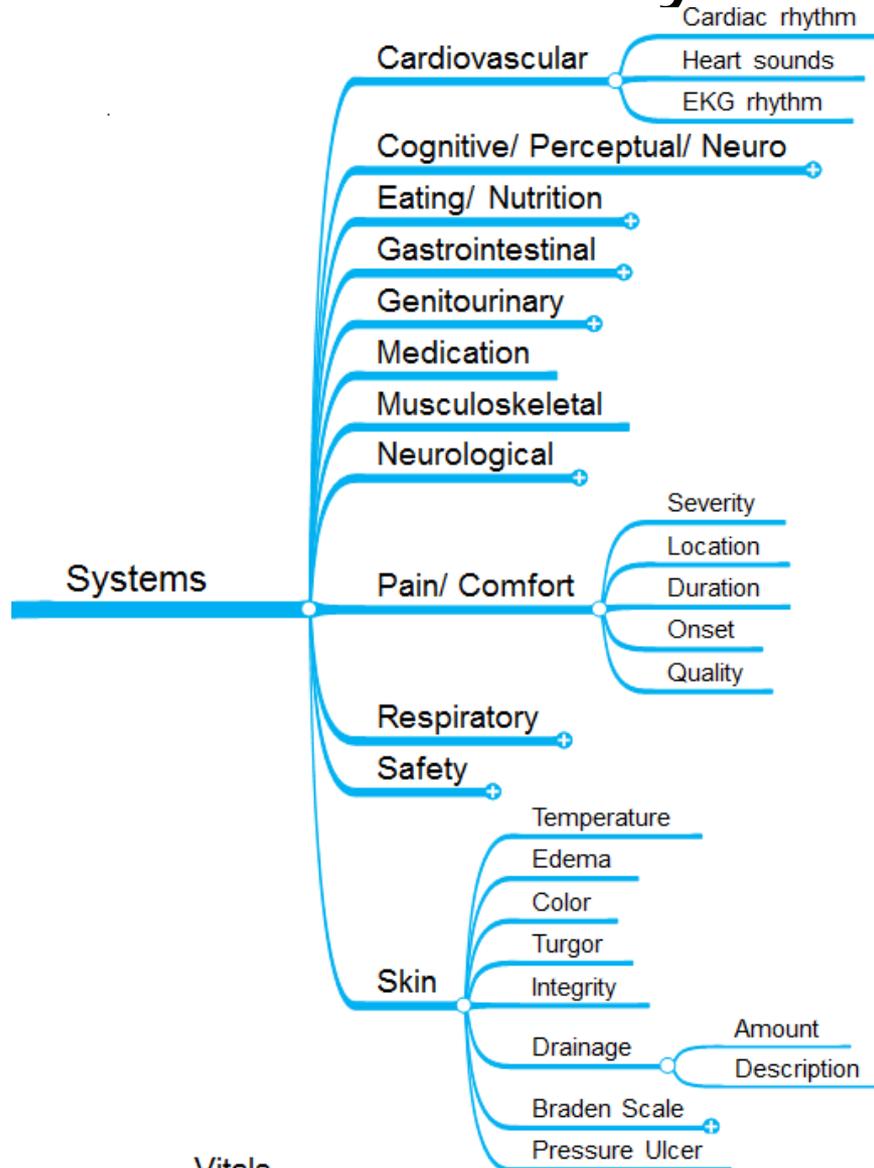
# Created 2 Excel Resources

- Templates – Groups – Flowsheet Measures
  - Data base and display names
  - Counts actual use of flowsheet measures by patient/  
patient encounters
    - Some flowsheets only linked to templates or nothing
  - Templates and groups show the context of use – Adult transitional care, Adult patient care summary, Review of Systems (GI/ GU)
- Just Measures
  - Counts of documentation for flowsheets regardless of context
  - Answer type – numerical, date, categorical
  - Value sets i.e. pain location

# Ontology Development Process

- Select clinical topics important for intended audience & create separate spreadsheets for each
- Develop list of concepts for each topic from research questions, clinical guidelines and literature for a clinical topic

# Priorities - Physiological



# Ontology Development Process

- Use Excel spreadsheet
  - “Templates/groups/measures”
    - Search for concepts to find matching flowsheet measures (i.e. pressure ulcer) to populate spreadsheet
    - Flowsheet measures often are part of a group of related assessments/ interventions
    - Search groups of measures for additional concepts (i.e. pressure ulcer stage, healing status)
    - Continue until no additional flowsheet measures found

# Ontology Development Process

Organize the concepts for the clinical topic into hierarchy

- Pain

- Pain Rating Scale (multiple methods)

- Pain rating 0-10

- FLACC

- » Face - FLACC Pain Rating

- » Legs - FLACC Pain Rating: Activity

- » Activity - FLACC Pain Rating

- » Cry - FLACC Pain Rating: Activity

- Pain Risk Factors

# Ontology Development Process

Combine similar concepts that have similar value sets

flo_meas_id	DISP_NAME	val_type_c	Value Set
673797	Pain Rating (0-10)	8	0;1;10;2;3;4;5;6;7;8;9;
301130	Pain Rating 2	8	0;1;10;2;3;4;5;6;7;8;9;
301180	Pain Rating 3	8	0;1;10;2;3;4;5;6;7;8;9;
3040110432	Pain Rating: Rest	8	0;1;10;2;3;4;5;6;7;8;9;
3040110433	Pain Rating: With Activity	8	0;1;10;2;3;4;5;6;7;8;9;
7060860	Pain Rating 4	8	1;10;2;3;4;5;6;7;8;9;
3040100517	0-10 Pain Scale	8	0;1;10;2;3;4;5;6;7;8;9;
6183	Pain Rating 7	8	0;2;3;4;7;
7060910	Pain Rating 5	8	1;10;2;3;4;8
675152	Pain Rating	8	0-->no pain;2-->mild pain;4-->moderate pain;6-->moderate-severe pain;8-->severe pain;
671197	Pain Rating	8	0;0-->no pain;10-->excruciating pain;2-->mild pain;4;4-->moderate pain;6-->moderate-severe pain;8-->severe pain;

# Ontology Development Process

- Consensus process
- Validated by a second investigator
  - Find any new flowsheet measures?
  - Agree with match between concept name and flowsheet measures?
- Team reviews findings by second investigator

# Start Small (Scope Project)

- Excluded measures
  - < 10 patient encounters (should be larger)
- Excluded templates (some concepts had different meanings and specialized measures)
  - OB, Peds, Newborn, NICU, Behavioral Health
  - Specialized Data Collection
    - Apheresis Peripheral Blood Progenitor Cell Collection Record
    - Card Nuclear Medicine Studies Worksheet
- Focused on quality measures, then other physiological measures

# Example Research Question

- “How many patients have pressure ulcers?”
- Two measures record answer

ID	DISPLAY NAME	VALUE SET	NUMBER MEASURES
673124	(R) Pressure Ulcer Present	no;other (see comments);yes;	13487
602938	[R] Pressure Ulcer Present	no;other (see comments);suspected;	40922

- Created two concepts:
  - Pressure Ulcer Present (confirmed)
  - Pressure Ulcer Present (suspected)

# Example - Pressure Ulcer Ontology

Concepts for pressure ulcer scattered across the EHR depending on patient level of care:

- 96 pressure ulcer related measures
- Organized into ontology with 84 concepts
- Measures appeared on 72 templates
- Each concept appeared on average of 12 templates
- One concept on 28 templates (Braden Score)

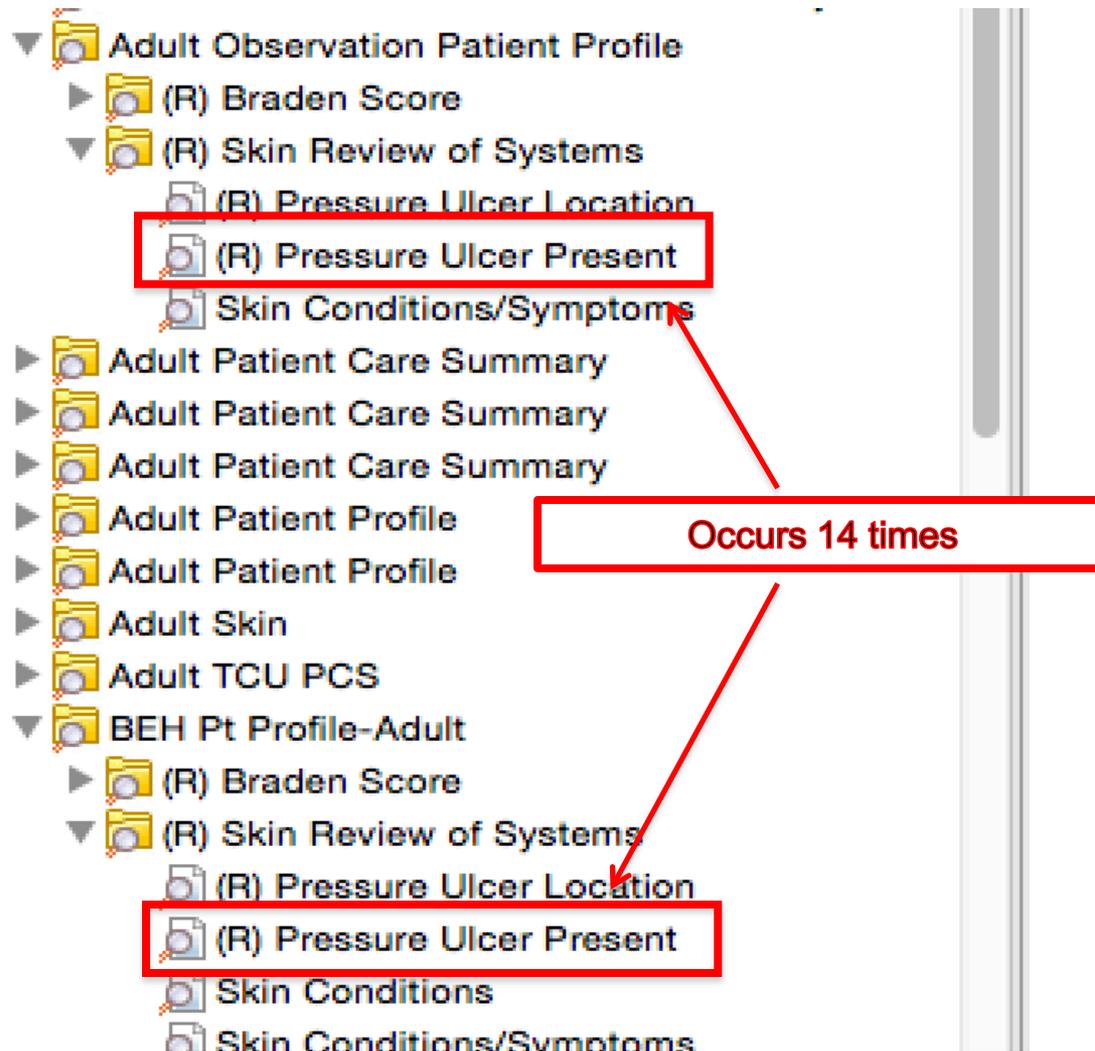
# Example Pressure Ulcer Measures

ID	MEASURE NAME	DISPLAY NAME	VALUE SET	NUMBER
303830	R PRESSURE ULCER LOCATION	LOCATION	Abdomen, arm, back, breast, buttocks, etc.	1780
605393	R PRESSURE ULCER DRAINAGE	DRAINAGE AMOUNT	Copious, large, moderate, none, other	23925
303870	R PRESSURE ULCER DRAINAGE COLOR	DRAINAGE COLOR, CHARACTERISTICS	Black, brown, clear, clots, creamy, green, odor	4256
303860	R PRESSURE ULCER SITE ASSESSMENT	WOUND BASE	Black, erythema, blanchable, non- blanchable	46218

# Value Sets Help Determine Similarity

ID	MEASURE NAME	VALUE SET
3040130300	R IP <i>SKIN INTEGRITY</i>	Blanchable erythema;Bruising;Dark purple area;Diaper rash;Dry/itchy;Flakey;Fragile;Hives;Intact;Intact except incisions/lines;Necrotic (black);Non-blanchable erythema;Non-intact (see wound assessment);Other (see comments);Rash;Weeping;int;itchy around IV tape;
601810	CPM S12 ROW AS <i>SKIN INTEGRITY</i> (ADULT, OB, PEDIATRIC	abrasion;blister;body piercing;burn(s);cracked;cut(s);cyst;drain/device;ecchymosis;erosion;excoriation;fragile;inci;incision;incision(s);intact;itchy;mass;other (see comments);petechiae;pressure ulcer;pressure ulcer(s);ra;rash;rash(s);scab;scar;skin tear;subcutaneous emphysema (specify);tattoo;wound;
600146	CPM S12 ROW AS <i>SKIN INTEGRITY</i> (NICU, NEWBORN)	abrasion;blister;cracked;ecchymosis;erosion;excoriation;incision;intact;mass;other (see comments);petechiae;pressure ulcer;rash;scab;scar;

# Template / Group / Measure Navigation in i2b2 Workbench

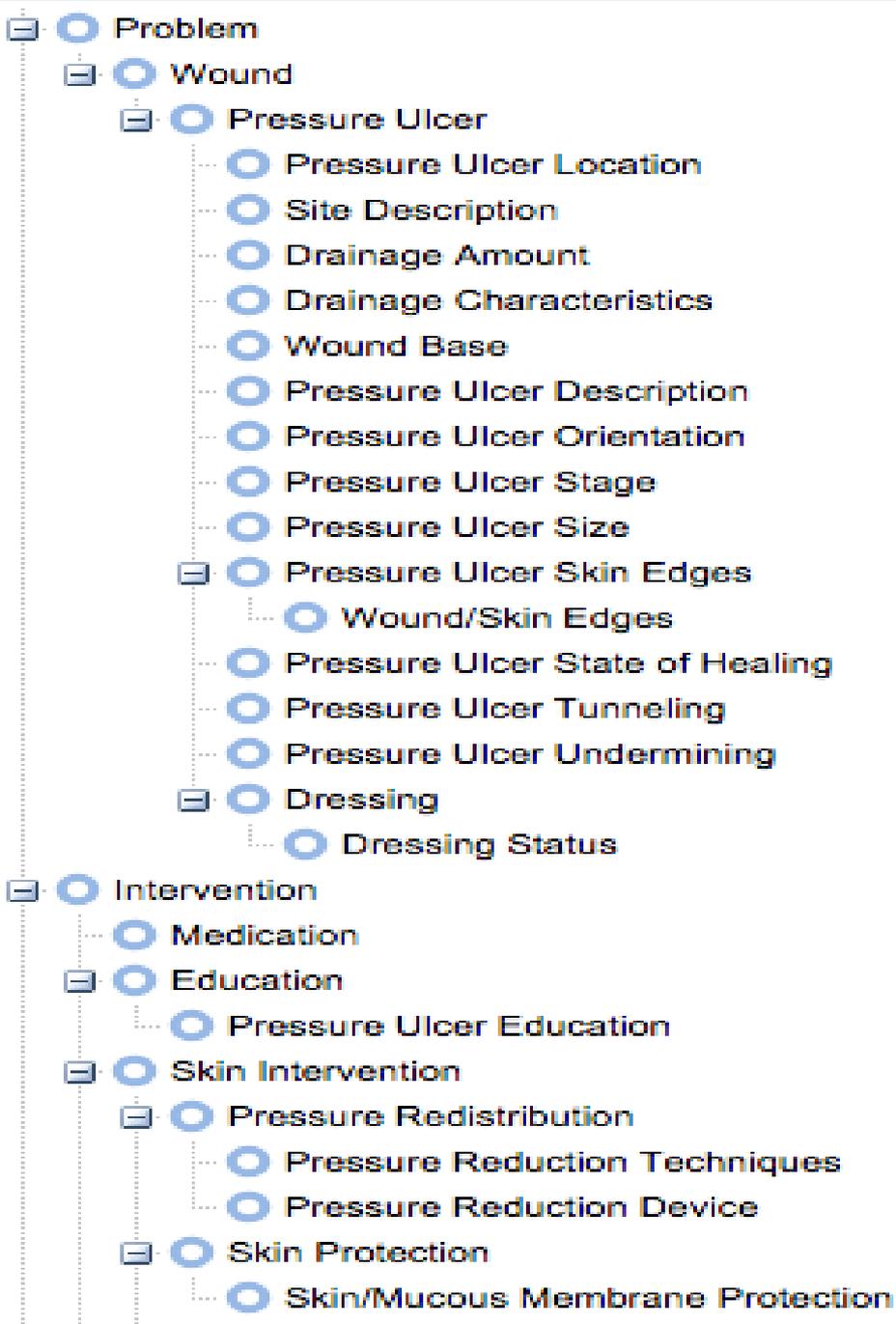


# Ontology Based Navigation

- Peri-wound Assessment
- ▼ Pressure Ulcer Present
  - Pressure Ulcer Present (confirmed)
  - Pressure Ulcer Present (suspected)
- Pressure Ulcer Problems Assessed
- Pressure Ulcer Problems Present
- Skin Area Inspected

Occurs only in 2 places

# Pressure Ulcer Ontology



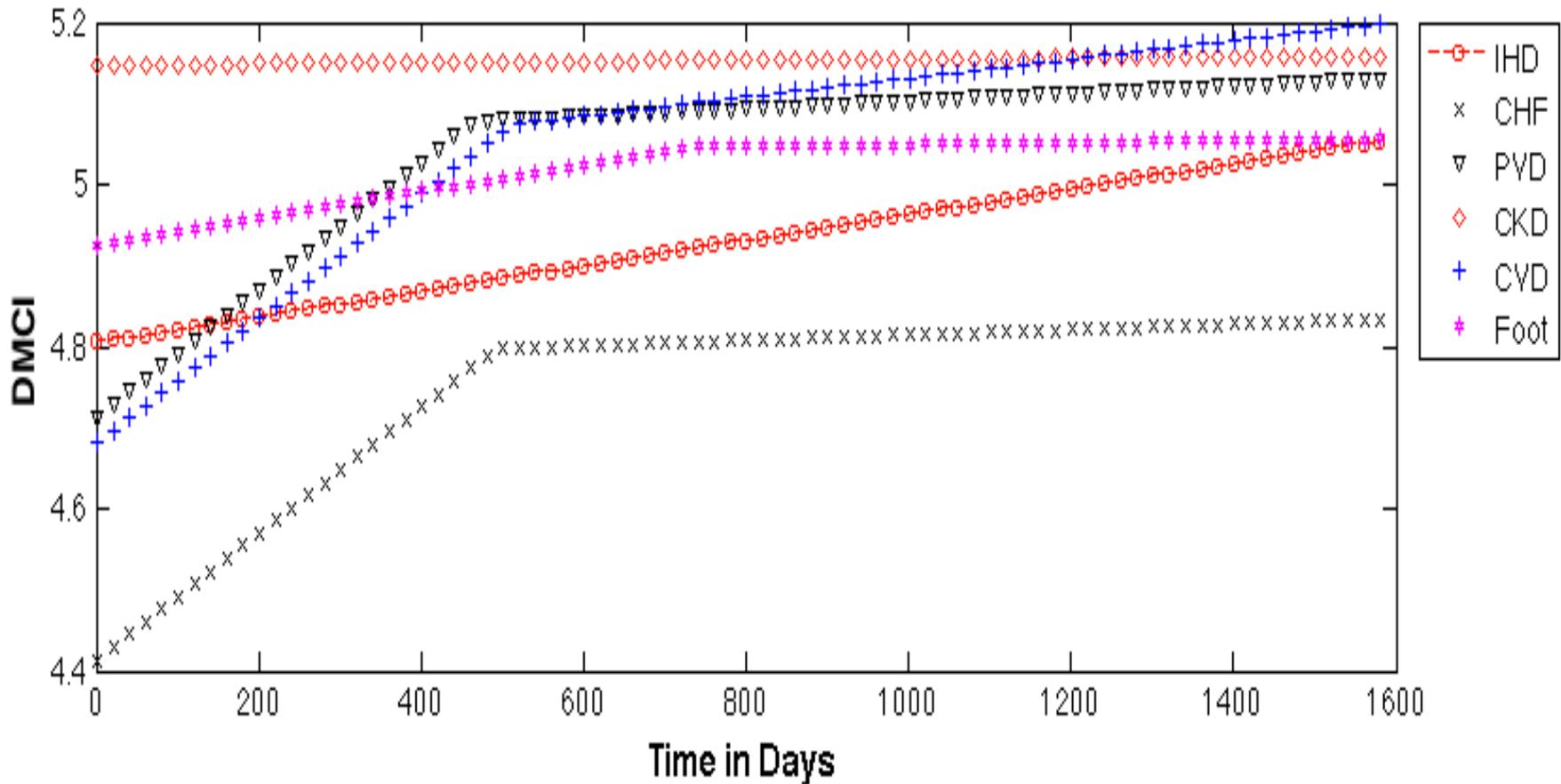
# Challenges

- When to combine similar measures
  - Same concept and value set -> combine
  - Same concept different value set -> unclear
    - Union of value sets?
    - Choice list combined with free text?
- Mapping to standard terminology
  - How to map all 56,965 values (answers)
- What is the cut off for number of flowsheets uses over time? (>10)



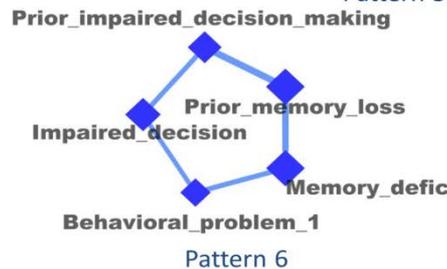
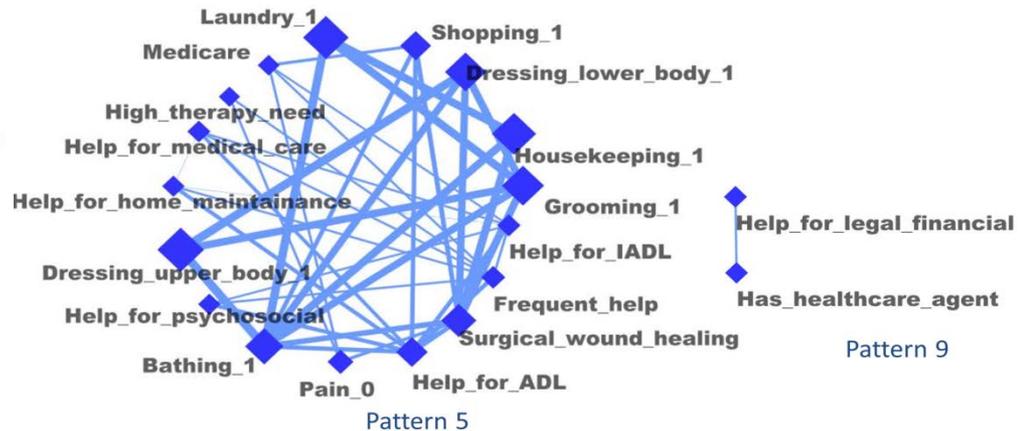
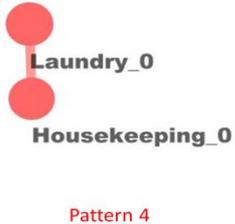
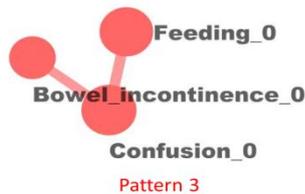
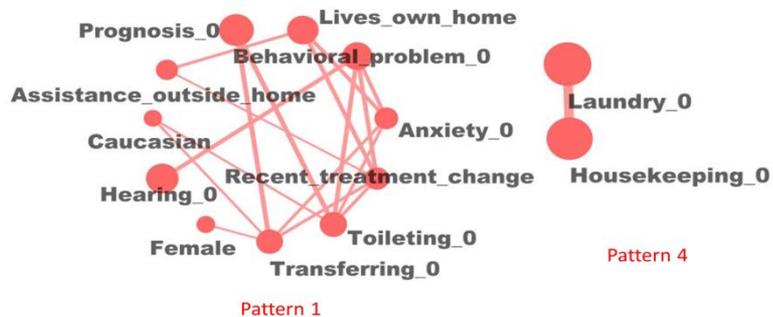
# Examples of Research

# Index of Predictors Associated with Complications of Diabetes



Health status trajectory for specific subpopulations

# Clusters Associated with Improvement in Ambulation



# Focus on Sepsis

- Predict morbidity and mortality for patients with severe sepsis/ septic shock
- Determine compliance with Surviving Sepsis Campaign guidelines
- Identify unique clusters of patient characteristics and guidelines for discovering new knowledge to prevent poor outcomes
- Include flowsheet data assessments and interventions
  - Vital Signs
  - Cognition, fluid balance
  - Other

# Discussion

- Flowsheet data is important to map for extending the clinical data in CDRs
  - 34% of all observations
- Manual mapping is difficult - we need to automate
- Flowsheet data important for quality indicators and for discovering new knowledge to predict and improve patient outcomes

# Conclusions

- Flowsheet data is important for research, quality reporting and quality improvement
- Organizing as template / group / measure is difficult to navigate
- An ontology organizes concepts better
- Automated mapping is needed



# Discussion & Questions?