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

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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

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)

https://www.ctsacentral.org/
Vision for Extending Clinical Data Repository (CDR)

- Clinical Data Interprofessional
- Administrative Data Sets
- Other (Consumer, Scheduling, HR, Registries, Quality)

Continuum of Care
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

<table>
<thead>
<tr>
<th>Johns Hopkins Falls Assessment</th>
<th>0800</th>
<th>1200</th>
<th>1600</th>
<th>2000</th>
<th>0000</th>
<th>0400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall History</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elimination</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medications</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient Care Equipment</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requires assistance or supervision</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsteady gait</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual or auditory impairment affecting</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Altered awareness of physical</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impulsive</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of understanding of physical and</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johns Hopkins Total Score</td>
<td>10</td>
<td>10</td>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate Fall Risk Interventions</td>
<td>standard</td>
<td>standard</td>
<td>standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fall Risk Interventions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Safety Interventions (Adult)

<table>
<thead>
<tr>
<th>High Fall Risk - Meds</th>
<th>Analges…</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Acuity Falls Interventions</td>
<td>none</td>
</tr>
</tbody>
</table>

- 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

- Falls (n=30): 70%
- Pressure Ulcers (n=30): 97%
- Pain (n=30): 97%
- Urinary Catheter (n=12): 67%
- VTE (n=17): 82%
Pressure Ulcer Assessment & Prevention

Care Plan and Education for At Risk Patients

At Risk Patients

Frequency

Braden Score

11 13 14 15 16 17 18 19 20 21 22 23

Braden Score
Care Plan Exists
Education Given
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
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 ≤ 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)
• 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

Created 2 Excel Resources
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

Cardiovascular
- Cardiac rhythm
- Heart sounds
- EKG rhythm

Cognitive/Perceptual/Neuro

Eating/Nutrition

Gastrointestinal

Genitourinary

Medication

Musculoskeletal

Neurological
- Severity
- Location
- Duration
- Onset
- Quality

Pain/Comfort
- Temperature
- Edema
- Color
- Turgor
- Integrity
- Drainage
- Amount
- Description
- Braden Scale
- Pressure Ulcer

Respiratory

Safety

Systems

Vital...
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

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

<table>
<thead>
<tr>
<th>ID</th>
<th>DISPLAY NAME</th>
<th>VALUE SET</th>
<th>NUMBER MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>673124</td>
<td>(R) Pressure Ulcer Present</td>
<td>no;other (see comments);yes;</td>
<td>13487</td>
</tr>
<tr>
<td>602938</td>
<td>[R] Pressure Ulcer Present</td>
<td>no;other (see comments);suspected;</td>
<td>40922</td>
</tr>
</tbody>
</table>

• 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)
<table>
<thead>
<tr>
<th>ID</th>
<th>MEASURE NAME</th>
<th>DISPLAY NAME</th>
<th>VALUE SET</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>303830</td>
<td>R PRESSURE ULCER LOCATION</td>
<td>LOCATION</td>
<td>Abdomen, arm, back, breast, buttocks, etc.</td>
<td>1780</td>
</tr>
<tr>
<td>605393</td>
<td>R PRESSURE ULCER DRAINAGE</td>
<td>DRAINAGE AMOUNT</td>
<td>Copious, large, moderate, none, other</td>
<td>23925</td>
</tr>
<tr>
<td>303870</td>
<td>R PRESSURE ULCER DRAINAGE COLOR</td>
<td>DRAINAGE COLOR, CHARACTERISTICS</td>
<td>Black, brown, clear, clots, creamy, green, odor</td>
<td>4256</td>
</tr>
<tr>
<td>303860</td>
<td>R PRESSURE ULCER SITE ASSESSMENT</td>
<td>WOUND BASE</td>
<td>Black, erythema, blanchable, non-blanchable</td>
<td>46218</td>
</tr>
</tbody>
</table>
### Value Sets Help Determine Similarity

<table>
<thead>
<tr>
<th>ID</th>
<th>MEASURE NAME</th>
<th>VALUE SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>3040130300</td>
<td>R IP <strong>SKIN INTEGRITY</strong></td>
<td>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;</td>
</tr>
<tr>
<td>601810</td>
<td>CPM S12 ROW AS <strong>SKIN INTEGRITY</strong> (ADULT, OB, PEDIATRIC)</td>
<td>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;</td>
</tr>
<tr>
<td>600146</td>
<td>CPM S12 ROW AS <strong>SKIN INTEGRITY</strong> (NICU, NEWBORN)</td>
<td>abrasion; blister; cracked; ecchymosis; erosion; excoriation; incision; intact; mass; other (see comments); petechiae; pressure ulcer; rash; scab; scar;</td>
</tr>
</tbody>
</table>
Template / Group / Measure

Navigation in i2b2 Workbench

- Adult Observation Patient Profile
  - (R) Braden Score
  - (R) Skin Review of Systems
    - (R) Pressure Ulcer Location
    - (R) Pressure Ulcer Present
  - Skin Conditions/Symptoms
- Adult Patient Care Summary
- Adult Skin
- Adult TCU PCS
- BEH Pt Profile-Adult
  - (R) Braden Score
  - (R) Skin Review of Systems
    - (R) Pressure Ulcer Location
    - (R) Pressure Ulcer Present
  - Skin Conditions
  - Skin Conditions/Symptoms

Occurs 14 times
Ontology Based Navigation

Occurs only in 2 places
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?