Modeling Nursing Flowsheet Data for Quality Improvement and Research

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Introduction

1. Describe the relevance of flowsheet data for continuing business operations, quality improvement, and research.
2. Identify challenges in current use of flowsheet data to achieve the above perspectives.
3. Explore principles for consistent and reliable mapping of flowsheet data to clinical data models for continuing (secondary) use of the data.
4. Learn about national initiatives and how to get involved to apply the principles in additional health care settings.

Flowsheet

<table>
<thead>
<tr>
<th>Patient Care Summary</th>
<th>4/17/13</th>
<th>4/18/13</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0800</td>
<td>1200</td>
</tr>
<tr>
<td>Johns Hopkins Falls Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fall History</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Elimination</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Medications</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Patient Care Equipment</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Requires assistance or supervision</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unsteady gait</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Visual or auditory impairment affecting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Altered awareness of physical</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Impulsive</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lack of understanding of physical and</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Johns Hopkins Total Score</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Moderate Fall Risk Interventions</td>
<td>standard</td>
<td>standard</td>
</tr>
<tr>
<td>High Fall Risk Interventions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fall Risk - Meds</td>
<td>Analges...</td>
<td></td>
</tr>
<tr>
<td>High Acuity Falls Interventions</td>
<td></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)
Examples Use of Flowsheet Data

Quality Measures

- Fall Prevention
- Pressure Ulcer Prevention
- Pain Management
- Prevention Venous Thrombosis Embolism (VTE)
- Prevention Catheter Associated Urinary Tract Infections (CAUTI)
Research

- Predictive model for CAUTI – include GU flowsheets
- Prevention and prediction of complications of sepsis – vital signs, cognition, fluid balance
- Prediction of diabetic complications

Vision for Extending 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

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

MHealth / 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
Phase 1 – Initial Work

• Understand how data are documented, documentation requirements, and factors that influence documentation
• Observed nursing workflows, reviewed 30 charts, interviewed nurse managers
• 5 quality measures
  – Falls
  – Pressure ulcers
  – Pain management
  – CAUTI
  – VTE

Lessons Learned

• Data are entered over time period (multiple “columns”)
  – Timeliness of initial assessment – review more than one column
• What you see is what you get (charted)
  – Hidden (manual cascading) can result in missing data
• Data found on multiple screens/ database fields in the EHR
• Association between items not clear
  – Pain assessment > 0
  – Pain medication
  – Pain reassessment in 30 minutes
• Documentation inconsistencies (i.e. missing pain goals)
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 could more easily answer some questions (assessment every shift)
  - Can’t see deprecated measures or find multiple locations
- Interdisciplinary team was required to do the work
  - Clinical knowledge needed (Heparin flush vs. VTE prophylaxis)
  - EHR developer/ trainer
  - Data query skills

Lessons Learned

- CDR queries easier for some questions, only once you know how, where, when, and why charting is done
- 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
  - Currently left to each organization to define fields, values and workflows
  - Need standards to compare within multi-facility organizations and across other organizations
  - Limit locations for documentation of critical data
Phase 2

Data Source
Clinical Data Models - Flowsheets

- 10/20/2010 - 12/27/2013
- 66,660 patients
- 199,665 encounters
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

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 (n=827)
  - How to select/ combine that is generalizable
- Same FS measures can be in different groups/ templates
- Variations on names / value sets for FS measures
- 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
Developed Standardized Process

- Identify Clinical Data Model Topic
- Identify Concepts
- Map Flowsheets to Concepts
- Present
- Validate

Principles

- Determine spurious measures
  - Excluded measures < 10 patient encounters (should be larger)
- Scope project
  - 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
- Choose priorities - focused on quality measures, then other physiological measures, then behavioral health
Priorities - Physiological

- Cardiovascular
- Cognitive/Perceptual/Neuro
- Eating/Nutrition
- Gastrointestinal
- Genitourinary
- Medication
- Musculoskeletal
- Neurological
- Pain/Comfort
- Respiratory

Current Status

<table>
<thead>
<tr>
<th>Behavioral Health - Emotion</th>
<th>Musculoskeletal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Health - Cognition</td>
<td>Lines/Drains/Airways</td>
</tr>
<tr>
<td>Cardiac</td>
<td>Pain/Comfort</td>
</tr>
<tr>
<td>Cognitive/Perceptual/Neuro</td>
<td>Peripheral Neurovascular</td>
</tr>
<tr>
<td>Falls</td>
<td>Respiratory</td>
</tr>
<tr>
<td>Functional Status</td>
<td>Skin &amp; Pressure Ulcer</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Safety</td>
</tr>
<tr>
<td>Genitourinary/CAUTI</td>
<td>Specimen Collection</td>
</tr>
<tr>
<td>Height &amp; Weight</td>
<td>Vital Signs</td>
</tr>
<tr>
<td>Lines, Infusion and output</td>
<td>VTE</td>
</tr>
</tbody>
</table>
T/G/M – Excel Spreadsheet
Templates and groups show the context of use

<table>
<thead>
<tr>
<th>ID</th>
<th>Template</th>
<th>Group</th>
<th>FS Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>670030</td>
<td>CPM S12 ADULT PATIENT CARE SUMMARY</td>
<td>609141</td>
<td>601888</td>
</tr>
<tr>
<td>601888</td>
<td>CPM S12 GRP PCS PERIPHERAL NEUROVASCULAR (ADULT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>602961</td>
<td>CPM S12 ROW AS PERIPHERAL NEUROVASCULAR WDL. [WDL DEFINITION...]</td>
<td>Peripheral Neurovascular WDL</td>
<td></td>
</tr>
<tr>
<td>601280</td>
<td>CPM S12 ROW AS PERIPHERAL NEUROVASCULAR WDL. [WDL DEFINITION...]</td>
<td>Peripheral Neurovascular WDL</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Display Name</th>
<th>Value Type</th>
<th>Choices</th>
<th>Number Measures</th>
<th>Dates Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Patient Care Summary</td>
<td>8</td>
<td>Ex; Ex.; No New; WDL; ex; w; wdl;</td>
<td>765,123</td>
<td>10/21/10 – 12/5/13</td>
</tr>
<tr>
<td>Peripheral Neurovascular WDL</td>
<td>8</td>
<td>Ex; Ex.; No New; WDL; no new; w;</td>
<td>108,235</td>
<td>10/26/10 – 12/27/13</td>
</tr>
<tr>
<td>Peripheral Neurovascular WDL</td>
<td>8</td>
<td>Ex; Ex.; WDL; w;</td>
<td>101,728</td>
<td>10/22/10 – 10/15/13</td>
</tr>
</tbody>
</table>

Just Measures - Excel
Ontology Development Process

- Select clinical topics important for intended audience
- Create separate spreadsheet for clinical topics i.e. i.e. skin, pain, vital signs
  - Each person on the team took 1 topic at a time
- Develop list of concepts for each topic from research questions, clinical guidelines and literature for a clinical topic

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Display Name</th>
<th>Value Set (* indicates set drawn from actual data)</th>
<th>Measure Code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Problems Present (Venous Thromboembolic Disease)</td>
<td>*none, acute pain, situational response, embolism lead to tissue ischemia/infarction, other (see comments), (null)</td>
<td>600525</td>
</tr>
<tr>
<td>General</td>
<td>Problems Assessed (Venous Thromboembolic Disease)</td>
<td>all; acute pain, embolism leading to tissue ischemia/infarction</td>
<td>606680</td>
</tr>
<tr>
<td>Conditions/ Symptoms</td>
<td>Peripheral/Neurovascular Conditions/Symptoms</td>
<td>*alteration in sensation, cold hands/feet, numbness, tingling, none, edema, varicosities, change in limb circulation, abdominal aortic aneurysm (repaired), venous thromboembolic diseases, other (see comments), (null)</td>
<td>605988</td>
</tr>
<tr>
<td>Conditions/ Symptoms</td>
<td>Peripheral/Neurovascular Signs/Symptoms</td>
<td>*numbness lower extremity(s), numbness upper extremity(s), edema, denies, change in circulation lower extremity(s), change in circulation upper extremity(s), change in color lower extremity(s), change in color upper extremity(s), change in sensation, cold feet, cold hands, tingling upper extremity(s), tingling lower extremity(s), calf tenderness, other (see comments), (null)</td>
<td>677093</td>
</tr>
</tbody>
</table>
Ontology Development Process

• Use Excel spreadsheet “templates/groups/measures”
  – Search for concepts to find matching flowsheet measures i.e. pressure ulcer
  – Copy flowsheet measures to new spreadsheet in previous slide
• 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
• Copy related flowsheet measures for these into your spreadsheet
• Continue until no additional flowsheet measures found

Ontology Development Process

Organize the concepts for the clinical topic into hierarchy – not too deep if possible

– 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 flowsheet measures 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
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)
### Example Measures – Pressure Ulcers

<table>
<thead>
<tr>
<th>ID</th>
<th>MEASURE NAME</th>
<th>DISPLAY NAME</th>
<th>VALUE SET</th>
<th>NUMBER MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>303830</td>
<td>R PRESSURE ULCER LOCATION</td>
<td>Location</td>
<td>Abdomen;Arm;Back;Breast;Buttocks;Chest;Coccyx;Ear;Elbow;Face;Finger*(Comment<em>which</em>one);Foot;Forehead;Hand;Head;Heel;Hip;I ... k;Nose;Occipital<em>region;Other</em>(Comment);Pannus;Penis;Perineum;Sacrum;Scrotum;Shoulder;Spine;Toe*(Comment<em>which</em>one);Wrist;</td>
<td>1780</td>
</tr>
<tr>
<td>605393</td>
<td>CPM S12 ROW PRO PRESSURE ULCER LOCATION (ADULT, OB)</td>
<td>Pressure Ulcer Location</td>
<td></td>
<td>26483</td>
</tr>
<tr>
<td>3040111184</td>
<td>R IP PRO PRESSURE ULCER LOCATION</td>
<td></td>
<td>978</td>
<td></td>
</tr>
<tr>
<td>303870</td>
<td>R PRESSURE ULCER DRAINAGE AMT</td>
<td>Drainage Amount</td>
<td>Copious;Large;Moderate;None;Other*(Comment)</td>
<td>23923</td>
</tr>
<tr>
<td>303860</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>303880</td>
<td>R PRESSURE ULCER SITE ASSESSMENT</td>
<td>Wound Base</td>
<td>Black;Erythema, blanchable;Erythema, non-blanchable;Cyanotic;Erythema;Fissure; ...</td>
<td>46218</td>
</tr>
<tr>
<td>30401300167</td>
<td>R PRESSURE ULCER DESCRIPTION</td>
<td>Description</td>
<td></td>
<td>1320</td>
</tr>
<tr>
<td>303840</td>
<td>R PRESSURE ULCER ORIENTATION</td>
<td>Orientation</td>
<td>Anterior;Bilateral;Distal;Lateral; Left;Medial;</td>
<td>1212</td>
</tr>
<tr>
<td>30401300166</td>
<td>R PRESSURE ULCER STAGING</td>
<td>Staging (WOCN)</td>
<td>Deep tissue injury;Indeterminate;NA;Stage I;II;III;IV;unstageable;</td>
<td>1155</td>
</tr>
<tr>
<td>601525</td>
<td>CPM S12 ROW PRO PRESSURE ULCER STAGE (ADULT, OB, PEDIATRIC)</td>
<td>Pressure Ulcer Stage</td>
<td>Stage I;Stage II;Stage III;Stage IV;other (see comments);</td>
<td>282</td>
</tr>
<tr>
<td>30401303000</td>
<td>R IP SKIN INTEGRITY</td>
<td>Integrity</td>
<td>Blanchable erythema;Bruising;Dark purple area,Diaper rash;Dry;Itchy;Flakey;Fragile;Hives;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>
<td>505529</td>
</tr>
<tr>
<td>601310</td>
<td>CPM S12 ROW AS SKIN INTEGRITY (ADULT, OB, PEDIATRIC)</td>
<td>Skin Integrity</td>
<td>abrasion;blister;body piercing;burn(s);crack;</td>
<td>86097</td>
</tr>
<tr>
<td>600146</td>
<td>CPM S12 ROW AS SKIN INTEGRITY (NICU, NEWBORN)</td>
<td>Skin Integrity</td>
<td>abrasion;blister;cracked;ecchymosis;erosion;</td>
<td>23437</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 SKIN INTEGRITY</td>
<td>Blanchable erythema;Bruising;Dark purple area,Diaper rash;Dry;Itchy;Flakey;Fragile;Hives;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 SKIN INTEGRITY (ADULT, OB, PEDIATRIC)</td>
<td>abrasion;blister;cracked;ecchymosis;erosion;excoriation;incision;intact;mass;other (see comments);petechiae;pressure ulcer;pressure ulcer(s);ra;rasp;ra;scab;scar;skin tear;subcutaneous emphysema (specify);tattoo;wound;</td>
</tr>
<tr>
<td>600146</td>
<td>CPM S12 ROW AS SKIN INTEGRITY (NICU, NEWBORN)</td>
<td>abrasion;blister;cracked;ecchymosis;erosion;excoriation;incision;intact;mass;other (see comments);petechiae;pressure ulcer;rasp;scab;scar;</td>
</tr>
</tbody>
</table>
Next Steps

- Validate mappings entire data set
- Add unique UMN Concept ID at the appropriate level of granularity
- Map concepts to LOINC/ SNOMED CT
- Look at each value type and determine the strategy for how data will be represented in i2b2
- Begin integrating validated measures into i2b2
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

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.
Clinical and Translational Science Awards (CTSAs)


Nursing Knowledge:
2015 Big Data Science Conference

June 3 – 5, 2015

Demonstrating the Value of Sharable and Comparable Nurse-generated Data

z.umn.edu/bigdata
Conclusion

- 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

Questions?