Using Data Science to Influence Population Health
Session #NI3, February 19, 2017
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University of Minnesota School of Nursing
Speaker Introduction

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• DNP Specialty Coordinator, Nursing Informatics
• Affiliate faculty, Institute for Health Informatics
Conflict of Interest

Karen A. Monsen, PhD, RN, FAAN

Has no real or apparent conflicts of interest to report.
Agenda

• Population Health, Data Science, and the Voice of Nursing
• Robust nursing information
• Cutting edge methods
• Value of nursing
• Questions
Learning Objectives

• Outline how large, robust, well-coordinated data sets can be used to influence outcomes in populations
• Describe how pattern visualization and other data science methods can be used by nurses to affect outcomes
• Illustrate the importance and value of nurses in managing the care of patient populations
Population Health Value and Health IT

During this session you'll hear how nurses can use and analyze large data sets to influence outcomes in patient populations.

T: Treatment/clinical nursing data capture
E: Electronic data use in population health
P: Population management potential
S: Savings r/t improved data management
Part 1: Population Health, Data Science, and the Voice of Nursing
Population Health, Data Science, and the Voice of Nursing

• What is Population Health?

Population Health (or Total Population Health) is the health outcomes of a group of individuals, including the distribution of such outcomes within the group. It is an approach to health that aims to improve the health of an entire human population.

Experts offer different perspectives about referring to patient populations; some suggest we should use the term population health management.

Research using large datasets reflect patient populations; however, some may be population based if they capture an entire population of interest (e.g. all women of childbearing age in a jurisdiction).

Population Health, Data Science, and the Voice of Nursing

• What is Data Science?
• Leveraging technology in research design and methods
  • Inform hypothesis generation and testing
  • Able to handle large datasets
  • Requires teams of individuals with clinical domain expertise as methods and statistical skills

Image from Abdelbarre Chafik available at https://www.quora.com/What-is-data-science
Population Health, Data Science, and the Voice of Nursing

• What is the Voice of Nursing?

• In the 1960s and 70s, the advent of computerization in healthcare sparked a quest to codify nursing knowledge for purposes of giving voice to nursing in the EHR

• Implementation of standardized nursing languages in EHRs remains a national priority
Part 2: Robust Nursing Information
Robust nursing information

Nursing Data
Nursing Minimum Data Set

http://www.nursing.umn.edu/prod/groups/nurs/@pub/@nurs/documents/asset/nurs_71413.pdf

A minimum set of elements of information with uniform definitions and categories concerning the specific dimensions of nursing, which meets the information needs of multiple data users in the health care system.

- Client characteristics & outcomes
- Nursing assessments & interventions


Nursing Context Data
Nursing Management Minimum Data Set

http://www.nursing.umn.edu/icnp/usa-nmmds/

Core essential data needed to support the administrative and management information needs for the provision of nursing care. The standardized format allows for comparable nursing data collection within and across organizations.

- Nurse and health system characteristics
- Nurse and health system credentials

Recognized Nursing Terminologies
American Nurses Association

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Nursing Problem</th>
<th>Nursing Intervention</th>
<th>Nursing Outcome</th>
<th>Nursing Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NANDA (1992)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIC (1992)</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>NOC (1997)</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

The above three terminologies must be used together to obtain information about the nursing problem (diagnosis), intervention and outcome. The below terminologies all have terms for the nursing problem, intervention, and outcome.

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Nursing Problem</th>
<th>Nursing Intervention</th>
<th>Nursing Outcome</th>
<th>Nursing Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC (HHCC) (1992)</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PNDS (1997)</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>ICNP (2000)</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Interdisciplinary Terminologies

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Nursing Problem</th>
<th>Nursing Intervention</th>
<th>Nursing Outcome</th>
<th>Nursing Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNOMED-CT (1999)</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SNOMED-CT Nursing Subset</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOINC (2002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omaha System (1992)</td>
<td></td>
<td>x</td>
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<td></td>
</tr>
</tbody>
</table>

Robust nursing information

The Omaha System (Martin, 2005)

Problem Classification Scheme
- Environmental
- Psychosocial
- Physiological
- Health Related Behaviors

Intervention Scheme
- Client Specific Information
- Target
- Category

Problem Rating Scale for Outcomes
- Knowledge
- Behavior
- Status

Problems
- have unique
- used for documenting

standardized terms
- which are
- Codes

1=lowest, 5=highest

Robust nursing information

• 2010: Dean Delaney invited the Omaha System Partnership for Knowledge Discovery and Healthcare Quality within the University of Minnesota Center for Nursing Informatics
  – Scientific teams
  – Affiliate members
  – Data collaborative
# Prototype Dashboard of SBDH Data for a Single Patient

(copyright Kesler & Monsen, 2016)

<table>
<thead>
<tr>
<th>KBS</th>
<th>Signs/Symptoms</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Substance Use" /></td>
<td>Date of last visit: 7/15/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Circulation" /></td>
<td>Date of visit: 7/15/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Mental Health" /></td>
<td>Date of visit: 6/5/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Sleep and Rest Patterns" /></td>
<td>Date of visit: 6/5/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Bowel Function" /></td>
<td>Date of visit: 3/8/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Communication with Community Resources" /></td>
<td>Date of visit: 6/5/16</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Medication Regimen" /></td>
<td>Date of visit: 7/15/16</td>
<td></td>
</tr>
</tbody>
</table>

- **Substance Use**
  - Knowledge: 3
  - Behavior: 4
  - Status: 5

- **Circulation**
  - S- coping skills – adaption techniques
  - CM- durable medical equipment – acquire needed equipment
  - TGC- anatomy/physiology – disease process
  - TP- medication administration – appropriate for age/condition

- **Mental Health**
  - Narrowed to scattered attention focus
  - Irritable/Agitated/Aggressive
  - Difficulty managing stress
  - Somatic complaints/fatigue

- **Sleep and Rest Patterns**

- **Bowel Function**

- **Communication with Community Resources**

- **Medication Regimen**
Prototype Dashboard of SBDH Data for a Patient Population (copyright Kesler & Monsen, 2016)
Part 3: Cutting Edge Methods
Using Data Visualization to Detect Client Risk Patterns

- Documentation patterns suggest a comprehensive, holistic nursing assessment.
- The presence of mental health signs and symptom tends to be associated with more problems and worse outcomes.

Key:
- Colors = problems
- Shading = risk
- Rings = Knowledge, Behavior, and Status
- Tabs = signs/symptoms

Using Data Visualization to Detect Nursing Intervention Patterns

Key:
- Colors = problems
- Shading = actions (categories)
- Height = frequency
- Point on x-axis = one month

Cutting edge methods

PHN Signature Styles?
Data Quality Issue vs. Signature?
Heatmap Visualization of SBDH Index

<table>
<thead>
<tr>
<th>SBDH Item Subgroups</th>
<th>Proportion of the sample (N=4263)</th>
<th>Income</th>
<th>Mental health</th>
<th>Abuse</th>
<th>Substance use</th>
</tr>
</thead>
<tbody>
<tr>
<td>married (n=914)</td>
<td>0.07</td>
<td>0.17</td>
<td>0.09</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>minority (n=2435)</td>
<td>0.20</td>
<td>0.32</td>
<td>0.35</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>low/no income (n=2812)</td>
<td>0.32</td>
<td>0.36</td>
<td>0.34</td>
<td>0.33</td>
<td>0.26</td>
</tr>
<tr>
<td>able to buy only necessities (n=340)</td>
<td>0.35</td>
<td>0.11</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>difficulty buying necessities (n=374)</td>
<td>0.14</td>
<td>0.07</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>sadness/hopelessness/decreased self-esteem (n=691)</td>
<td>0.14</td>
<td>0.07</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>loss of interest/involvement in activities/self-care (n=194)</td>
<td>0.29</td>
<td>0.23</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>difficulty managing stress (n=51)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>assaulted verbally (n=129)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
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<tr>
<td>fear/hypervigilant behavior (n=38)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>consistent negative messages (n=60)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>assaulted sexually (n=88)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>well/bruises/burns/other injuries (n=34)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>abuses alcohol (n=10)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
<tr>
<td>smokes/uses tobacco products (n=48)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.23</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Cutting edge methods

Data-Driven Intervention Clusters

Relationships between four intervention grouping/clustering methods for wound care.

Part 4: The Value of Nursing
Examining the Value of Nursing by Comparing Intervention Modeling Approaches for Elderly Home Care Patients

Examining the Value of Nursing for Hospitalization Outcomes Using Logistic Regression

- Too little care may result in hospitalization when patients have more intensive needs
  - Frail elders are more likely to be hospitalized if they have low frequencies of four skilled nursing intervention clusters
  - Policy implications: advocate for additional care at home to avoid re-hospitalization

Examining the Value of Nursing Using a Logistical Mixed-effects Model with Nursing Data

• How do nurses and interventions contribute to variability in patient and population health?
  
• Nurse (17%)
• Client (50%)
• Problem (17%)
• Intervention (17%)
  
  • Client age was significantly positively associated with knowledge benchmark attainment in all models

\[
Y_i \sim \text{Bernoulli}(\theta_i), \text{ where}
\]

\[
\log(\theta_i) - \log(1 - \theta_i) = \beta_0 + \beta_1 \text{Age} + U_i
\]

\[
U_i \sim N(0, \sigma^2).
\]

This research is partially supported by the National Science Foundation under grant # SES-0851705, and by the Omaha System Partnership. Monsen, K. A., Chatterjee, S. B., Timm, J. E., Poulsen, J. K., & McNaughton, D. B. (2015). Factors explaining variability in health literacy outcomes of public health nursing clients. Public Health Nursing, 32(2), 94-100.
Examine the Value of Nursing Using Generalized Estimating Equations for Cohort Comparison

- Mothers with intellectual disabilities have twice as many problems as mothers without intellectual disabilities
- Receive more public health nursing service
  - Twice as many encounters and interventions
- **Show improvement in all areas**
  - Do not reach the desired health literacy benchmark in Caretaking/parenting
- Policy implications: allocate sufficient funding for services

Examining the Value of Nursing for Health Literacy Using Pattern Comparison Pre- and Post-Intervention

- Knowledge scores across problems over time
- Pre-intervention, patterns by race/ethnicity - Post-intervention, patterns by problem

Benchmark = 3

Examining the Value of Nursing for Women of Childbearing Age Related to SBHD

All subgroups show improvement

Outcomes worsen, interventions increase

This research was supported by the National Institute of Nursing Research (Grant #P20 NR008992; Center for Health Trajectory Research). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Nursing Research or the National Institutes of Health. Monsen, K. A., McNaughton, D. B., Savik, K., & Farri, O. (2011). Problem stabilization: A metric for problem improvement in home visiting clients. Applied Clinical Informatics, 2, 437-446
Value of nursing

Examining the influence of Interprofessional Services for Adults with Complex Health Problems

Correlations
- Knowledge, behavior, and status are positively correlated (p<.001)
- Signs/symptoms and interventions are positively correlated (p=0.002)

Patterns
- As interventions increase, KBS ratings increase
- As signs/symptoms increase, KBS ratings decrease
Population Health, Data Science, and Health IT

During this session we heard how nurses can use and analyze large data sets to influence outcomes in patient populations.

T: Treatment/clinical nursing data capture is a critical first step

E: Electronic nursing data use in population health is feasible and desirable

P: Population management potential is beginning to be realized

S: Savings r/t improved data management must be measured over the long term
Questions

• For further information please contact me at mons0122@umn.edu

• Reminder: please complete online session evaluation - thank you!