Visualization Techniques for Nursing Research

Visualizing Data Patterns of Interest to Nursing
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University of Minnesota School of Nursing
Acknowledgments

• University of Minnesota Center for Nursing Informatics
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• Omaha System Data Collaborative
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• All research teams and co-authors
Visualization Better Science: Anscombe’s Quartet

• Four sets of data that have the same means, variances, correlation, and linear fit.

Visualize Nursing Data to:

• Make data interpretable in real time
• Or make data interpretable for research
• Uncover new associations
• Generate hypotheses for further testing
• Depict findings

http://www.transperfectlegal.com/solutions/forensic
Data for Visualization

• Standardized, structured data are essential
  • May be categorical (boxes) or continuous (lines)
  • Other data types must be pre-processed to create either categorical or continuous data
  • Relationships among variables should be known and specified
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

Development of Nursing and other Clinical Terminologies


Magic of the Omaha System

Classification & Measurement (Categorical) (Continuous)

- Classification creates the palate for painting meaningful pictures
  - simple, taxonomic structure
  - pre-defined relationships

Created by Karen Monsen in cmaptools
Visualization Easy: Quick Accessible Software

• Tableau
• Excel
• D3
• SPSS
• R
• SAS
• ArcGIS
• Python

Microsoft Excel Insert Chart Menu
This figure created in Excel shows how heat maps (A), pie charts (B), bar charts (C), bubble charts (D), and Venn diagrams (E) can be used to display categorical data.
Interventions and S/sx by Problem

- Mental health
- Income
- Pain

Problems with intensive interventions compared to s/sx

Created by Karen Monsen in Excel

Which do you prefer?

Bar chart

Dot plot

More interventions than s/sx

More s/sx than interventions

Most s/sx and interventions

created by Karen Monsen in Excel

Blue = strengths – Most common
Red = challenges – Less common
Green = needs – Fewest

Most challenges = Mental health, Vision, Nutrition, and Sleep
Most needs = Income
Weighted Mean Knowledge Gain for MCH & Elders

MCH show greater gains in health literacy vs. elders
Both MCH and Elders show gains in health literacy after intervention
Unique groups exist within MCH and Elders


Created by Michelle A. Mathiason in Excel
Nurses provide care differently depending on policy and/or client needs

- Compared to Basic, Wound Care
  - Includes TGC
  - Greater numbers of S, CM, and TP

This figure created in Excel shows how heat maps (A), Scatterplot (B), Line graphs (C), Control Chart (D), Boxplot (E), and Histograms (F) can be used to display continuous data.
Few mothers had SBDH scores of 0 – most had 1 or more. Minorities cannot have SBDH scores of 0.
Problems stabilize differentially after intervention – Caretaking/parenting and Pregnancy do not stabilize because of continuous need for developmental teaching, guidance, and counseling. Other problems (Mental health, Income, Family planning, Abuse, Substance use) stabilize more rapidly after intervention.
Multi-series Line Graphs

Improvement in KBS over time for individuals with diabetes in rural Mexico after regular visits in important problems: Physical activity, Medication regimen, and Health care supervision

Outcome evaluation demonstrated that knowledge, behavior, and status ratings improved significantly ($p < .001$).

Examples of problem-specific changes over time are shown for Health care supervision, Physical activity and Medication regimen problems.

Erika Lozada-Perezmitre, María Magdalena Sotomayor MSN, CCRN; María de la Luz Bonilla-Luis MSN, RN; Beatriz García-Solano DRN, NR; Lisiane Pruinelli, MSN, RN; Karen A. Monsen, PhD, RN, FAAN. (2014). Improving Outcomes of Diabetes Mellitus Type 2 Patients in Rural Mexico through Educational Home Care Services. H3IT, Washington DC
Streamgraphs

Intervention patterns show numbers of interventions by problem over time. Patterns differ by nurse and patient needs. Tailoring interventions shows quality care.

• Using Data Visualization to Detect Nursing Intervention Patterns


Created by Era Kim in d3
Sometimes categorical data may be displayed using methods usually used with continuous data.

Excel offers these recommended charts when selecting bar chart option to show differences in distribution of males and females in the sample. Which charts show this best?
Parallel Coordinates: Relating Nurses, Risk, Problems, Interventions, and Outcomes

Parallel coordinates allows comparison of numerous variables on multiple y-axes across the x-axis. Line graphs are connecting the variables and do not show patterns over time.

This was instrumental in discovering the ‘nurse effect’ in relationship to client outcomes.


Created by Jessica Peterson in R
Seeing is Believing!

A version of parallel coordinates looking at patterns in outcomes by problem and race/ethnicity. After intervention we see improvement in health literacy and change in patterns outcomes by race – nursing intervention takes away health disparities

- Shows the complexity of the problem
- Provides convincing evidence of the outcome
- Demonstrates value of care

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

Best outcome – Postpartum
Most challenging – Mental health

Stratified by race/ethnicity
Lines cross – pattern reflects problem


Created by Karen Monsen in Excel
Sunbursts combine categorical and continuous data

- 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

A version of pie charts that combine categories (problems = colored sections) and (signs/symptoms = tabs) and measures (KBS = shading, 1=brighter to 5=darker)
Patterns identified a hidden group with higher needs.

Heat Map DYI: Excel Conditional Formatting Functions

• Highlight data, Select conditional formatting – color scales – color(s) of your choice

Bonus: how to create a heat map in Excel
Heat Map - Patterns

Distribution of the sample is shown in first column
Other columns reveal different patterns from which we generated hypotheses

<table>
<thead>
<tr>
<th>SDH 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>
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Created by Karen Monsen in Excel
Heat Maps: Mental Health

Adherence Outcome ($N=247$, 167 with higher and 80 with lower) vs Ulcer Development Outcome ($N=233; 210$ without ulcers, 23 with ulcers)

- The work was supported in part by the National Institutes of Health, National Institute of Nursing Research Award #R01NR012237.
- The parent study is registered at clinicaltrials.gov (NCT01509599).

Mental health predicted better adherence and also less wound development.

Three variables appeared to be related to both adherence and wound development outcomes: MH 8, MH 9, MH 10.

Created by Michelle A. Mathiason in Excel.
**Heat Map: Intervention Analysis**

Nurses’ scope of practice reflects the total intervention scope
Mental health interventions predominate across the continuum of care

<table>
<thead>
<tr>
<th>Term</th>
<th>All</th>
<th>Nurse</th>
<th>Provider</th>
<th>Social worker</th>
<th>Psychologist</th>
<th>Chaplain</th>
<th>Music-therapist</th>
<th>Massage-therapist</th>
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<th>Admission to hospital</th>
<th>Admission to hospice</th>
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Created by Karen Monsen in Excel

“never trust summary statistics alone; always visualize your data” – Alberto Cairo  
https://www.autodeskresearch.com/publications/samestats
Visualization for Nursing Data

• Put your data to work
  • Make pictures
  • Identify patterns
  • Generate hypotheses
  • Test them to see if they are true

• Try it – your research will be better if you do!
Thank you! Questions?

• mons0122@umn.edu


• Erika Lozada-Perezmitre, María Magdalena Soriano-Sotomayor MSN, CCRN; María de la Luz Bonilla-Luis MSN, RN; Beatriz García-Solano DRN, NR; Lisiane Pruinelli, MSN, RN; Karen A. Monsen, PhD, RN, FAAN. (2014). Improving Outcomes of Diabetes Mellitus Type 2 Patients in Rural Mexico through Educational Home Care Services. H3IT, Washington DC.


