Diagramming Research Questions: A Multivariate Revelation!

Cathy Carlson, PhD, APRN, FNP-BC, RN-BC
Associate Professor
Northern Illinois University

Conflict of Interest Disclosure

• No Conflicts of Interest for ALL listed contributors.

• Cathy Carlson, PhD, APRN, FNP-BC, RN-BC
carlson@niu.edu

A conflict of interest is a particular financial or non-financial circumstance that might compromise, or appear to compromise, professional judgment. Anything that fits this should be included. Examples are owning stock in a company whose product is being evaluated, being a consultant or employee of a company whose product is being evaluated, etc.

• Taken in part from “On Being a Scientist: Responsible Conduct in Research”.

Objectives

1. To understand how a research problem can be diagrammed creating a concept map leading to a choice of a technique of multivariate analysis
2. To review fundamental research classification of research variables and their relationships
3. To understand the basic format of a research problem and the notation system used to represent its construction into a concept map.
4. Review of notation system and examples related to pain management research
5. To practice mapping several independent research problems from articles in Pain Management Nursing and predict the chosen technique of multivariate analysis
Story Time!

Levels of Measurement

• **Nominal**
  - Attributes are only named
• **Ordinal**
  - Attributes can be ordered
• **Interval**
  - Distance is meaningful
• **Ratio**
  - Absolute zero

Considered Quantitative Data

The Notation System

Circle

- Stands for a latent variable, which is a non-measured characteristic such as ‘quality’ or ‘anxiety’
  - OR
  - **PAIN**
The Notation System Cont……

Square or Rectangle

- Stands for a manifest variable, which is a directly measured characteristic
- Indicates a quantitative measurement level (interval or ratio-scale)
- For lower measurement levels, the rectangle is subdivided

The Notation System Cont……

Male

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Female

- Stands for a dummy variable with 2 categories such as gender with male/female
- A dummy variable with two categories is a variable which is coded as 0 and 1 where 1 gender is 0 and the other gender is 1
- In doing so, a dichotomous variable is artificially lifted to a higher level of measurement

The Notation System Cont……

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

- A variable with 3 categories

OR

- More with one less column than rows
The Notation System Cont……

- Line
  \[ X \longrightarrow Y \]
  - Stands for a statistical relationship between 2 variables that is not causal in nature

- Two Way Arrow
  \[ X \leftrightarrow Y \]
  - Stands, just like a \[ X \longrightarrow Y \] for a statistical relationship that is not conceived of in terms of cause and effect

The Notation System Cont……

- One-Way Arrow
  \[ X \rightarrow Y \]
  - Stands for a dependent relationship in terms of cause and effect

The Notation System Cont……

- Interaction
  - Stands for effect of interaction, which means the combined effect of 2 independent variables on the dependent variable
To Decide Which Statistical Analysis to Use:
• We follow a series of questions/subclassifications of data.

1. Is This a Dependent or Nondependent Technique?
• Is there an implied cause and effect relationship?
• The dependent variable must be specified
• The techniques are asymmetrical

Dependent or Nondependent?

**Dependent Techniques**
- Multiple regression
- Partial correlation
- Analysis of variance
- Analysis of covariance
- Discriminant analysis

**Nondependent Techniques**
- Factor analysis
- Cluster analysis
2. How Many Dependent Variables Are There?

<table>
<thead>
<tr>
<th>One Dependent Variable</th>
<th>Several Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multiple regression</td>
<td>• Multivariate multiple regression</td>
</tr>
<tr>
<td>• Analysis of variance</td>
<td>• Multivariate analysis of variance</td>
</tr>
<tr>
<td>• Analysis of covariance</td>
<td>• Multivariate analysis of covariance</td>
</tr>
<tr>
<td>• Discriminant analysis</td>
<td>• Multiple discriminant analysis</td>
</tr>
</tbody>
</table>

3. What is the Level of Measurement of the Dependent Variable?

<table>
<thead>
<tr>
<th>Quantitative</th>
<th>Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multiple regression</td>
<td>• Discriminant analysis</td>
</tr>
<tr>
<td>• Partial correlation</td>
<td></td>
</tr>
<tr>
<td>• Analysis of variance</td>
<td></td>
</tr>
<tr>
<td>• Analysis of covariance</td>
<td></td>
</tr>
</tbody>
</table>

4. What is the Level of Measurement for the Independent Variables?

• Most of the techniques used most frequently require quantitative measures
• Analysis of variance allows for nominal-level measures
• If there is a combination of levels of measurement, analysis of variance becomes analysis of covariance
Level of Measurement of Independent Variables

**Nominal**
- Analysis of Variance

**Quantitative**
- Multiple regression
- Partial correlation
- Discriminant analysis

**Mixed**
- Analysis of Covariance

---

5. Is the Structure Additive or Interactive?

- Linear models, by design, treat the effects of the independent variables as additive.
- In contrast, analysis of variance allows for the examination of interactions between independent variables.

---

Additive or Interactive Structure

**Additive Structure**
- Multiple regression
- Partial correlation
- Discriminant analysis
- Factor and cluster analysis
- Multidimensional scaling

**Interactive Structure**
- Analysis of variance
- Analysis of covariance
- Multivariate analysis of variance
- Multivariate analysis of covariance
6. Are the independent variables orthogonal?
   • Geometric interpretation
     - Perpendicular = no relationship
   • Consequences of nonorthogonality = multicollinearity
     - Means the independent variables are highly correlated
   • Most techniques assume orthogonality
     - Techniques exist that force orthogonality

7. Is the starting point a Problem-Variable or a Problem-Relation?
   • Most dependent techniques fall in the problem-variable category
   • Problem-relation is looking at the influence of the independent variable on the dependent variable
     • Questionable causality = spurious

Starting Point

<table>
<thead>
<tr>
<th>Problem-Variable</th>
<th>Problem-Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple regression</td>
<td>Partial correlation analysis</td>
</tr>
<tr>
<td>Analysis of variance</td>
<td>Other advanced versions</td>
</tr>
<tr>
<td>Analysis of covariance</td>
<td></td>
</tr>
<tr>
<td>Discriminant analysis</td>
<td></td>
</tr>
</tbody>
</table>
8. Are there distinct hierarchical steps?

One Hierarchical Step
- Multiple Regression

Several Hierarchical Steps
- Path analysis
- Partial correlation analysis
- Others

9. Are the Variables Latent or Manifest?

- Latent variables
  - Not directly measured
  - Theoretical Constructs
  - Represented by manifest (measured) variables in groups of 2 or more
  - The relationship between manifest and latent variables is nondependent

- Techniques with latent variables
  - Factor analysis
  - Canonical correlation analysis
  - Multidimensional scaling

Multivariate Analysis

- Many statistical techniques focus on just one or two variables
- Multivariate analysis (MVA) techniques allow more than two variables to be analysed at once
  - Multiple regression is not typically included under this heading, but can be thought of as a multivariate analysis
Analysis of Variance (ANOVA)

Let's Look at an Example

- Are there differences in pain intensity 24 hours after a THA based on gender, race, and educational level?
What if We Added Weight to the Independent Variables?

Multiple Regression Analysis

Let’s Look at an Example

- Do age, anxiety, and # of comorbidities improve the ability to predict pain intensity 48 hours after a THA?
Multiple Regression Analysis

Factor Analysis

Let’s Look at an Example
Process

• Read the sections given to you in your handout.
• Quickly go through the 9 questions discussed previously
• Sketch your diagram
• Compare your sketch to your handout to identify the statistical method used
  • Then we will compare notes and discuss

Article #1
Article #2

[Blank]

Article #3

[Blank]

Thank you for your time and attention!

[Blank]
Handouts for Concurrent Session 4A

Diagramming Research Questions: 
A Multivariate Revelation!

Cathy Carlson, PhD, APRN, FNP-BC, RN-BC 
Associate Professor 
Northern Illinois University
### Variable Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="circle.png" alt="Circle" /></td>
<td>Stands for a latent variable, which is a non-measured characteristic such as ‘quality’ or ‘anxiety.’</td>
</tr>
<tr>
<td><img src="square.png" alt="Square" /></td>
<td>Stands for a manifest variable, which is a directly measured characteristic. A square or rectangle indicates a variable of quantitative measurement level (interval or ratio-scale). For lower measurement levels, the rectangle is subdivided as explained below.</td>
</tr>
<tr>
<td><img src="two-category.png" alt="Two-Category" /></td>
<td>Stands for a dummy variable with 2 categories such as gender with male/female. A dummy variable with two categories is a variable which is coded as 0 and 1 where 1 gender is 0 and the other gender is 1. It does not matter which category (male/female) is assigned the 0 or the 1 score for it is merely the intention to ‘calculate’ with the numerical values 0 and 1. In doing so, a dichotomous variable is artificially lifted to a higher level of measurement.</td>
</tr>
<tr>
<td><img src="three-category.png" alt="Three-Category" /></td>
<td>A variable with 3 categories</td>
</tr>
<tr>
<td><img src="non-causal.png" alt="Non-Causal" /></td>
<td>Stands for a statistical relationship between 2 variables that is not causal in nature.</td>
</tr>
<tr>
<td><img src="non-causal.png" alt="Non-Causal" /></td>
<td>Stands, just like a non-causal, for a statistical relationship that is not conceived of in terms of cause and effect.</td>
</tr>
<tr>
<td><img src="dependent.png" alt="Dependent" /></td>
<td>Stands for a dependent relationship in terms of cause and effect.</td>
</tr>
<tr>
<td><img src="interaction.png" alt="Interaction" /></td>
<td>Stands for effect of interaction, which means the combined effect of 2 independent variables on the dependent variable.</td>
</tr>
</tbody>
</table>
Multiple regression analysis (convergent causal structure)

Analysis of variance (ANOVA) (the interactive structure)

Analysis of covariance (ANCOVA) (interactive structure)

Partial correlation analysis (spurious or indirect causality)
Discriminant analysis (discriminant structure)

Canonical correlation analysis (the canonical structure)

Factor and cluster analysis (latent structure)

Multidimensional scaling (latent structure of similarities)
Multivariate multiple regression
(convergent causal structure
two or several times)

Multivariate analysis of variance
(interactive structure two or
several times)

Multivariate analysis of covariance
(interactive structure two or several times)

Multiple discriminant analysis
(discrimination structure with more
than two population groups)
Prior Conditions Influencing Nurses’ Decisions to Adopt Evidence-Based Postoperative Pain Assessment Practices

Abstract:
Over the past 30 years, postoperative pain relief has been shown to be inadequate. To provide optimal postoperative pain relief, it is imperative for nurses to use evidence-based postoperative pain assessment practices. This correlational descriptive study was conducted to identify factors, termed prior conditions, that influenced nurses’ decisions to adopt three evidence-based postoperative pain assessment practices. A convenience sample of nurses who cared for adult postoperative patients in two Midwestern hospitals were surveyed, and 443 (46.9%) nurses responded. The previous practice and innovativeness of nurses were supportive of adoption of the three practices. Nurses felt that patients received adequate pain relief, which is unsupportive of adoption of the three practices because there is no impetus to change. Nurses who perceived the prior conditions as being supportive of adoption of pain management practices used multiple sources to identify solutions to clinical practice problems, and those who read professional nursing journals were more likely to have adopted the three practices and were more innovative. The number of sources used to identify solutions to clinical practice problems, previous practices, and innovativeness were predictive of nurses’ adoption of the three evidence-based postoperative pain assessment practices. Nurses need to be encouraged to use multiple sources, including professional nursing journals, to identify solutions to clinical practice problems. Innovative nurses may be considered to be opinion leaders and need to be identified to promote the adoption of evidence-based postoperative pain assessment practices. Further exploration of the large unexplained variance in adoption of evidence-based postoperative pain assessment practices is needed.

© 2010 by the American Society for Pain Management Nursing

Unrelieved pain experienced by postoperative patients has been documented in several studies beginning over 30 years ago (Cohen, 1980; Marks & Sachar, 1973; Swiwanakul et al., 1985). The findings from these studies indicate that pain...
that unsatisfactory relationships led to a lack of cooperation and inadequate prescription of analgesic medications. Collegiate and collaborative relationships between nurses and physicians are important when nurses implement EBPPAP, communicate the findings, or discuss options for pain interventions (Casciu et al., 2003; Miaskowski, 2004; Van Nickerk & Martin, 2003a, 2003b). Unsatisfactory professional relationships between nurses and physicians may lead to inadequate pain relief for their patients.

METHODS

Research Design
A correlational, descriptive, cross-sectional survey research design was selected for this study. A survey format was used to elicit nurses’ perceptions of prior conditions, their level of adoption of EBPPAP, and descriptions of characteristics of nurses who care for adult postoperative patients.

Research Questions
1. Are there relationships among the prior conditions and: 1) level of adoption of EBPPAP, and 2) selected characteristics of a group of nurses, including age, gender, highest level of nursing education, years of nursing practice, current specialty certification, number of nursing journals regularly read, sources used to identify solutions for clinical practice problems, and plan to advance into a higher level nursing position in the future?
2. Do prior conditions related to nurses’ pain management practices improve the ability to predict their level of adoption of EBPPAP?

Population and Sample
A convenience sample of all nurses caring for adult postoperative patients in two hospitals in the Midwest was surveyed, resulting in a sample pool of 945 nurses. The entire sample pool was invited to participate, and the present sample consists of those who returned the survey booklets.

Protection of Human Subjects
The participants were given a written explanation of this study. No formal consent form was used, because completion of the questionnaires implied voluntary consent. The research protocol was reviewed by the Research Utilization Committee for both hospitals to ensure protection of human subjects. There was no coding of participants. Only aggregate data were reported, thus providing anonymity for participants.

Instrumentation
In addition to an explanation of the study, the survey questionnaire included 56 items in three sections: a demographic data questionnaire, Carlson’s Prior Conditions Instruments (CPCIs) developed by the investigator (Carlson, 2008), and the Postoperative Pain Assessment Nursing Practice Questionnaire (PPA NPQ) revised for this study from Brett’s (1986) NPQ. There was also an area for respondents to write comments.

Demographic Data Questionnaire. Eight characteristics of nurses contained in the demographic questionnaire were chosen according to generalizations made by Rogers’ (2003) model. Rogers identified characteristics that differentiate earlier adopters from later adopters. For example, earlier adopters of innovations have higher educational levels and socioeconomic status (Rogers). In addition, earlier adopters have a greater desire for upward social mobility and have greater exposure to mass media and interpersonal communication channels (Rogers). Therefore, variables collected included the highest level of nursing education, years of nursing practice, current specialty certification, and affirmation of a plan to advance to a higher level nursing position in the future. Additional variables that represented the communication behavior of nurses included the number of nursing journals regularly read and number of sources used to identify solutions for clinical practice problems. The sources used to identify solutions for clinical practice problems included nursing personnel in the nurses’ work environment, nursing supervisors, nursing staff educators, other personnel (e.g., physicians, pharmacists), nursing personnel from other organizations, nursing research journals, clinical specialty nursing journals, general nursing journals, textbooks, university nursing faculty, clinical conferences, research conferences, newsletters, the internet, and professional nursing organizations.

Gender is not addressed by Rogers’ generalizations, but Rogers posited that earlier adopters are no different from later adopters in age. Age and gender are standard variables collected in nursing research and were included in this study.

Carlson’s Prior Conditions Instruments. The CPCIs were used to measure nurses’ perceptions of factors influencing decisions to adopt pain assessment practices (Carlson, 2009). The CPCIs were composed of a set of four instruments with a total of 30 items. The Previous Practice instrument contained eleven items, the Felt Needs/Problems and Innovativeness instrument contained six items each, and the Norms of the Social System instrument contained seven items. The CPCIs have shown preliminary evidence of internal consistency reliability and construct validity (Carlson, 2008).
When completing the CPQIs, respondents were asked to mark item responses on a 5-point Likert scale ranging from 1 (never or disagree strongly) to 5 (almost always or agree strongly). After recoding of reversed items, item responses for each instrument were summated and a mean was calculated. Higher scores indicated more support of the adoption of EBPPAP and lower scores less support. A mean adoption score of 0-1.49 indicated that the prior condition was “unsupportive,” 1.5 to 2.49 that the prior condition was “somewhat unsupportive,” 2.5 to 3.49 that the prior condition was “neither unsupportive nor supportive,” 3.5 to 4.49 that the prior condition was “somewhat supportive,” and 4.5 to 5.0 that the prior condition was “very supportive” of the adoption of pain management practices.

Postoperative Pain Assessment Nursing Practice Questionnaires. The PPA-NPQ was adapted from Brett’s (1986, 1987) NPQ and Greene’s (1997) Nursing Practice: Issues in Pain Management Questionnaire. The PPA-NPQ contained brief descriptions of three postoperative pain assessment practices: 1) systematic assessment of patient’s pain (NP1); 2) assessment of patient’s patient-controlled analgesic (PCA) device use (NP2); and 3) acceptance of patient’s report of pain (NP3). Experts in nursing education and pain management nursing practices confirmed content validity of the PPA-NPQ. Internal consistency reliability by Brett (1986) resulted in a Cronbach alpha coefficient of 0.82. Subsequent studies using the NPQ or a variation indicated the overall internal consistency reliability coefficients remained above 0.70 (Barta, 1992, 1995; Coyle & Sokop, 1990; Greene, 1997; Rutledge, Greene, Mooney, Nail, & Ropka, 1996).

In the PPA-NPQ, six questions were asked after a brief description about each pain assessment nursing practice innovation. One point was given if the respondent answered “yes” to one or more of the first four questions related to whether the respondent had knowledge of the practice. A second point was added if the respondent answered “yes” to the fifth question that asks if the assessment practice should be used. Another point was added if the respondent answered “yes” that he or she used the practice “sometimes,” or another 2 points were added if the respondent answered “yes” that he or she used the practice “always.” Therefore, the maximum score possible for each practice was 4 (range 0-4).

Higher scores on the PPA-NPQ reflect that the level of practice adoption is more extensive. A mean adoption score of 0 to 0.49 indicates the respondent was unaware of the practice, 0.5 to 1.49 indicates awareness, 1.5 to 2.49 indicates persuasion to use the practice, 2.5 to 3.49 indicates that the respondent sometimes implements the practice, and 3.5 to 4.0 indicates that the respondent always implements the practice.
Pain Catastrophizing, rather than Vital Signs, Associated with Pain Intensity in Patients Presenting to the Emergency Department for Pain

Phoebe R. Block, MA, Beverly E. Thorn, PhD, ABPP, Shweta Kapoor, MBBS, PhD, and Jessica White, BA

The present study examined the relationships among self-reported pain intensity, vital signs, pain catastrophizing, and state anxiety in patients presenting to the ED for acute pain, exacerbations of chronic pain, and acute pain with concurrent, unrelated chronic pain. Both pain catastrophizing and state anxiety were hypothesized to be better predictors of pain intensity than vital signs. Finally, exploratory analyses were conducted to examine and identify any differences in the relationship between pain intensity, vital signs, and psychological factors in individuals presenting to the ED with acute pain, exacerbations of chronic pain, or acute pain with concurrent chronic pain.

METHODS
Design, Participants, and Procedures
In this cross-sectional study, a convenience sample of 158 adults was recruited from an urban ED in the
southeastern United States between September 2012 and February 2014. Eligible patients were age 19 years or older and presenting to the ED with a primary complaint of pain (i.e., acute pain or exacerbation of chronic pain). Individuals with life-threatening conditions, HIV-related pain, or cancer-related pain were excluded from the study. The institutional review boards of the Druid City Hospital and the University of Alabama approved this study.

Triage nurses identified potentially eligible participants, informing these individuals of the opportunity to participate in a research study. Eligible individuals interested in study participation were approached by a research assistant after being transferred to an examination room. After administering a self-report measure of demographic characteristics, pain, catastrophizing, state anxiety, and pain. Participants were compensated $10 for their time and effort. After participants were discharged from the ED, a research assistant obtained their vital signs at triage, pain intensity rating at triage, and the final diagnosis for their ED visit by reviewing the participants’ electronic medical records.

**Measures**

Demographic and clinical data were obtained through a self-report demographics questionnaire and from participants’ electronic medical records. Participants provided their age, sex, race/ethnicity, years of education, location of pain complaint, duration of pain complaint, and type of pain complaint (i.e., acute pain or exacerbation of chronic pain). Participants presenting to the ED for acute pain with concurrent, unrelated chronic pain, also reported the location and duration of their chronic pain.

After participants’ ED discharge, a research assistant extracted the following information from the participants’ electronic medical records: vital signs at triage (i.e., systolic blood pressure [SBP], diastolic blood pressure [DBP], respiratory rate [RR], and heart rate [HR]), pain intensity rating at triage, and the final diagnosis for their ED visit. Pain intensity rating at triage was self-reported using an 11-point numerical rating scale (NRS), ranging from 0 (no pain) to 10 (worst pain imaginable). Mean arterial pressure (MAP) was calculated using triage SBP and DBP values (Mcewan et al., 2006).

Pain catastrophizing was measured using the Pain Catastrophizing Scale (PCS). The PCS is a 13-item, self-report measure focusing on the thoughts and feelings individuals may have when they are experiencing pain (Sullivan, Bishop, & Pivik, 1995).

The PCS provides a total pain catastrophizing score as well as three subscale scores of rumination, helplessness, and magnification. Individual items are rated on a scale from 0 (not at all) to 4 (all the time). Example items include “I feel I can not stand it anymore” (helplessness subscale), “I keep thinking about how much it hurts” (rumination subscale), and “I become afraid that the pain may get worse” (magnification subscale).

Total PCS scores range from 0 to 52, with higher scores indicating higher levels of pain catastrophizing. Among clinical samples of chronic pain, patients’ PCS scores greater than 30 (75th percentile of a chronic pain sample) indicate clinically significant levels of pain catastrophizing (Sullivan et al., 1995). Chronic pain patients with clinically significant levels of pain catastrophizing are particularly likely to experience adjustment difficulties and to progress poorly in rehabilitation programs (Sullivan, Stanish, Waite, Sullivan, & Tripp, 1998). High internal consistency and reliability have been demonstrated (Osman et al., 1997), and in the present study, the Chronbach’s alpha for the PCS was .92.

Participants’ state anxiety during their ED visit was assessed using the State-Trait Anxiety Inventory-State Subscale (STAI-S) (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI-S is a 20-item, self-report measure of state or current anxiety. Individual items are rated from 1 (not at all) to 4 (very much so), producing total scores ranging from 20 to 80. Example items include “I feel tense” and “I feel jittery.” High scores indicate higher levels of state anxiety, and scores greater than 39–40 suggest clinically significant levels of anxiety. Adequate reliability and validity have been demonstrated for the STAI-S, and it is widely utilized in various clinical and research settings to measure state anxiety (Julian, 2011; Knight, Wad-Manning, & Spears, 1983). In the present study, the Chronbach’s alpha from the STAI-S was .90.