PATIENT ACUITY: CONCEPT CLARIFICATION AND PSYCHOMETRIC ASSESSMENT

by

CAITLIN W. BRENnan

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Dissertation Advisor: Barbara J. Daly, PhD, RN, FAAN

Frances Payne Bolton School of Nursing

CASE WESTERN RESERVE UNIVERSITY

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SCHOOL OF GRADUATE STUDIES

We hereby approve the thesis/dissertation of

Caitlin W. Brennan

Candidate for the Doctor of Philosophy degree*:

Barbara J. Daly, PhD, RN, FAAN
Patricia A. Higgins, PhD, RN
Katherine R. Jones, PhD, RN, FAAN
Elizabeth A. Madigan, PhD, RN, FAAN
Neal Dawson, MD

May 24, 2010

*We also certify that written approval has been obtained for any proprietary material contained therein.
Dedication

This dissertation is dedicated to my husband, Justin Brennan, and my parents, Barbara and Peter Winnen.
Table of Contents

Title Page ................................................................. i
Committee Signature Page ........................................... ii
Dedication ................................................................. iv
Table of Contents ............................................................ v
List of Tables ................................................................. viii
List of Figures ................................................................. ix
Acknowledgements ......................................................... x
Abstract ................................................................. xi

Chapter I: Introduction .................................................. 1

Introduction ................................................................. 1
Background ........................................................................... 1
Patient Acuity, the Nursing Shortage, and the Current Recession .... 3
Dissertation Purpose and Summary ........................................ 5

Chapter II: Patient Acuity: A Concept Analysis .................................. 7

Preface ............................................................................. 7
Abstract ................................................................. 8
Summary Statement .......................................................... 9
Introduction ........................................................................ 10
Data Sources .......................................................................... 12
Findings ............................................................................. 13

Identifying & Describing Attributes ........................................ 13
Non-Patient-Related Acuity ................................................ 14
Patient-Related Acuity ....................................................... 15
Provider-Related Acuity ...................................................... 17
System-Related Acuity ....................................................... 19

Discussion ......................................................................... 21

Study Limitations ............................................................ 21
Comparison of Attributes of Acuity ....................................... 21
Relationship between Severity and Intensity Attributes ............ 22
Proposed Definitions of Acuity Attributes ................................ 22
Linear versus Nonlinear Relationship .................................... 23
Units of Measurement ............................................................ 23
Theoretical Implications ...................................................... 24
Chapter III: A Meta-Review of the Relationship Between Nurse Staffing and Patient Outcomes

Chapter IV: The Oncology Acuity Tool: A Reliable, Valid Method for Measuring Patient Acuity for Nurse Assignment Decisions
List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Characteristics of Acuity Attributes and Subcategories</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>Holzemer’s Model Applied to the Concept of Patient Acuity</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>Units of Measurement for the Attributes of Acuity</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>Excluded Articles and Rationale</td>
<td>46</td>
</tr>
<tr>
<td>5</td>
<td>The Oncology Acuity Tool</td>
<td>68</td>
</tr>
<tr>
<td>6</td>
<td>Unit Nurse Demographics</td>
<td>69</td>
</tr>
<tr>
<td>7</td>
<td>Content Validity Nurse Demographics</td>
<td>69</td>
</tr>
<tr>
<td>8</td>
<td>Predictive Validity Results</td>
<td>70</td>
</tr>
<tr>
<td>9</td>
<td>Concurrent Validity Descriptive Results</td>
<td>70</td>
</tr>
<tr>
<td>10</td>
<td>Descriptive Results of One Month Data</td>
<td>71</td>
</tr>
<tr>
<td>11</td>
<td>Descriptive Data ANOVA Results</td>
<td>84</td>
</tr>
</tbody>
</table>
List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.</td>
<td>Flow Diagram of Study Selection Process</td>
<td>46</td>
</tr>
<tr>
<td>Figure 2.</td>
<td>Study Model of Acuity, According to Holzheimer’s Model for Health Care Research</td>
<td>71</td>
</tr>
<tr>
<td>Figure 3.</td>
<td>Holzheimer’s Model Modified for Use from a Complexity Science Perspective</td>
<td>78</td>
</tr>
</tbody>
</table>
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Patient Acuity: Concept Clarification and Psychometric Assessment

Abstract

by

CAITLIN W. BRENNAN

Despite rich data on the association between nurse staffing and patient outcomes, evidence regarding the number and combination of nursing resources that optimize patient outcomes is lacking. One method of determining nurse staffing is patient acuity measurements, but inconsistencies exist in how acuity is defined and measured. The purpose of this study was to clarify the concept of acuity, recommend a standardized definition of acuity, and assess the psychometric properties of the Oncology Acuity Tool (OAT), a patient acuity tool currently in use on an inpatient oncology unit.

Procedures included assessing inter-rater reliability (IRR), surveying expert oncology nurses for content validity, using a visual analog scale for concurrent validity, and assessing whether acuity scores predicted one of two acute events, patient falls and rapid response team consults, for predictive validity. Results demonstrated high inter-rater reliability (ICC=0.953, CI 0.914, 0.977; p<0.001), moderately strong concurrent validity (r=0.578, p=0.01), high content validity (70% of acuity items had an I-CVI ≥ 0.78; S-CVI=0.82; 84% of items had kappa statistics (k*) of good [k*=0.6-0.74] or excellent [k*>0.74]). Acuity scores during the shift of the acute event were significant predictors of rapid response team consults (OR=2.25, CI 1.45, 3.48; p<0.001), as were acuity scores during the shift prior to the acute event (OR=1.75, CI 1.21, 2.54; p=0.003).

These data indicate that the OAT is a psychometrically sound instrument that demonstrates high reliability and validity for measuring acuity prospectively in the
oncology inpatient population. These findings can be used in future research in oncology populations to test acuity as a structure and process variable in studies that examine the relationship between acuity-based staffing and patient outcomes. The methodology used in this study can be applied to the development of acuity tools in other populations and tests of the relationship between acuity-based staffing decisions and better patient outcomes.
Chapter I

Introduction

The concept explored in this dissertation is patient acuity. This chapter provides an overview of the dissertation research project, including identification of the problem, background on the concept of acuity and how it applies to the recent nursing shortage and the current economic recession, and the relationship between nurse staffing and patient outcomes. Three of the chapters in this dissertation were prepared as manuscripts to be submitted for publication, which is discussed in the “Dissertation Purpose and Summary” section below.

Background: Problem Identification

Medical errors and their effect on patient safety and the quality of care in hospitals in the United States was highlighted by two Institute of Medicine reports, “To Err is Human: Building a Safer Health System” and “Crossing the Quality Chasm: A New Health System for the 21st Century” (IOM, 2001a & 2001b). The latter report set forth six aims for patient care: that it is safe, effective, patient-centered, timely, efficient, and equitable (Kovner & Knickman, 2005, p. 540). Since then, health care providers, researchers, payors, legislators, and consumers have focused on how to define and measure quality, in order to minimize errors and maximize safety (Kovner & Knickman, 2005, p. 548-561).

Depending on the stakeholder’s perspective, the focus and methods used in accomplishing the goal of high quality care varies. A major factor affecting health care providers’ ability to ensure quality care of patients in hospitals is the balance between the supply of adequately-trained providers and the demands of patient care. Historically,
supply and demand have not been in balance due mostly to workforce shortages that cannot keep pace with increases in patient acuity and new services and technologies available to patients (Kovner & Knickman, 2005, p. 422). If various aspects of demand, such as patients’ presenting conditions, and supply, such as the availability of nursing staff, cannot be controlled in the short-term, the focus of improving quality must be on the processes that can be managed or manipulated (Chin & Muramatsu, 2003). A key process that can be manipulated is the assignment of nurses to patients, or the allocation of nurse resources to meet demands of patient care. The primary feature of the assignment process is the measurement of acuity. Thus, the problem addressed in this project is the need for a valid and reliable method to measure acuity.

**Background: Acuity**

A steady increase in patient acuity in the inpatient setting over the past two decades is well documented in the health sciences literature (Aiken, Clarke, & Sloane, 2002; Edel, 1995; Heinz, 2004). There are several contributors to the rise in acuity. Diseases such as diabetes, hypertension, congestive heart failure, and cancer that were difficult to treat and resulted in high rates of mortality in the past are currently able to be managed as chronic illnesses as a result of scientific advancements in the diagnosis and treatment of disease (Anderson & Knickman, 2005). The aging population is living longer in part because of healthier lifestyles as well as these advancements in technology (Clark & Normile, 2002). The managed care movement, subsequent reductions in hospital lengths of stay, and pressure on hospitals to implement cost-saving measures have shifted patient care services traditionally provided in hospitals to outpatient departments, surgical centers, and/or patients’ homes (Bordoloi & Weatherby, 1999;
Brown, 1999; Gourevitch, Caronna, & Kalkut, 2005; Heinz, 2004). The intersection of these phenomena is an increase in the number of hospitalized patients, especially elderly patients with multiple co-morbidities, who are more acutely ill when they are admitted to the hospital (Heinz, 2004).

**Patient Acuity, the Nursing Shortage, and the Current Recession**

The changes in technology, increase in life expectancy of the population, and restriction of inpatient care to the most acutely ill have coincided with the most recent nursing shortage (Fox & Abrahamson, 2009). The nursing shortage is attributed to multiple factors, including decreased enrollment in nursing programs, a shortage of nursing faculty, an aging nursing workforce, and issues related to recruitment and retention (Fox & Abrahamson, 2009; Heinz, 2004). Nurses on inpatient units are experiencing workload increases not only from the supply side (due to the current nursing shortage) but also from the demand side – patient care needs are more complex, due in part to the aforementioned increase in both patient acuity and new diagnostic and treatment capabilities (Unruh, 2003). Nurse managers are faced with the challenge of balancing nursing burnout and cost containment, given that nurses make up the largest portion of hospital labor costs (Buerhaus, 2010; Mullinax & Lawley, 2002). This situation of increased demand for nursing care services and a supply that cannot keep pace with the demand is expected to worsen as baby boomers age and the number of ill elderly increases (Buerhaus, Staiger, & Auerbach, 2000; Heinz, 2004). Most recently, as a result of the economic recession, demand for nurses has decreased as hospitals tighten their budgets, while the supply of nurses has increased as nurses work more hours or delay retirement in order to maintain a stable income for their families, thereby relieving
the shortage of nurses in the hospital setting in the short-term (Buerhaus, 2009).

Buerhaus (2009) also states that many economists have declared that the recession has ended and predicts that many RNs will exit the workforce as the economy stabilizes, thus increasing the demand for nurses and potentially leading to another nursing shortage if the number of new graduates cannot keep pace with demand.

The aforementioned increased demands on nursing staff, related to increasing complexity of illness of patients, in the context of a heightened focus on cost control efforts during the current recession, have increased the importance of having a reliable method to classify patients according to their acuity and allocate the available nursing staff accordingly. Accurate classification provides nurse managers with “objective evidence to support staffing and budgetary needs” and can assist in balancing the nursing workload, as well as serve as a template for collecting cost data (Mullinax & Lawley, 2002; Strickland & Neely, 1995, p. 13).

An initial review of the literature to assess the number of tools available to measure acuity and to evaluate the psychometric soundness of those tools revealed that there is a great deal of variability in how patient acuity is defined and measured, and in the purpose patient acuity measurement served in the clinical setting (Cusack, Jones, & Chisholm, 2004a; Cusack, Jones-Wells, & Chisholm, 2004b; Dorling, Field, & Manketelow, 2005; Jones, Cusack, & Chisholm, 2004; Urbanowicz, 1999; Van Slyck & Johnson, 2001; Walts & Kapadia, 1996). For example, one research team developed three versions of an oncology acuity tool for use in medical/surgical, bone marrow transplant, and critical care settings. Although they reported high inter-rater reliability ($r = 0.84-0.95$) and content validity ($r = 0.85-0.93$), it is unclear if acuity ratings were
conducted prospectively for staffing decisions or retrospectively to analyze cost data, or for some other purpose (Lovett & McMillan, 1993; Lovett, Reardon, Gordon, & McMillan, 1994; Marsee, Lovett, & McMillan, 1995). Of the tools that utilized acuity measurements for making staffing decisions, none reported reliability or validity ratings (Cusack, et al., 2004a; Cusack, et al., 2004b; Edel,1995; Jones, et al., 2004; Lacovara, 1999; Van Slyck & Johnson, 2001). Another disadvantage of the aforementioned acuity tools is that they were developed in the 1990s and are likely outdated for use in the current inpatient setting. Criticisms of patient acuity measurement for determining nurse staffing include potential biases of ratings (both the tendency of raters to inflate patient acuities in order to increase staffing and managers’ tendency to deflate ratings to decrease nurse staffing in an attempt to control costs) and weak predictive power of acuity tools in assessing staffing needs and personnel costs (DeGroot, 1994; Shaha & Bush, 1996; Strickland & Neely, 1995). Improvements in measurement tools’ reliability and validity can potentially reduce bias and enhance the tools’ predictive power (Waltz, Stickland, & Lenz, 2005).

**Dissertation Purpose and Summary**

The purpose of this dissertation is to clarify the concept of acuity and report the psychometric properties of the Oncology Acuity Tool (OAT) currently in use on a hematology/oncology/bone marrow transplant unit in an urban hospital in the Midwestern United States. Chapter II presents the first manuscript, “Patient Acuity: A Concept Analysis,” which clarifies the concept of patient acuity and proposes a definition of acuity within the context of Holzemer’s Model for Health Care Research (Holzem, 1994; Holzemer & Reilly, 1995). Chapter III presents the second manuscript, “A Meta-
Review of the Relationship Between Nurse Staffing and Patient Outcomes,” which describes the background of the relationship between nurse staffing and patient outcomes and the role of acuity within that relationship. Chapter IV presents the third manuscript, “The Oncology Acuity Tool: A Reliable, Valid Method for Measuring Patient Acuity for Nurse Assignment Decisions,” which reports the methods and results of the psychometric analysis of the OAT. Chapter V presents recommendations for future research, in terms of the implications for acuity measurement, outcomes research, theory and methods for future research, and policy formation.
Chapter II

Patient Acuity: A Concept Analysis

Preface

This chapter presents the first manuscript, which was accepted for publication on November 14, 2008. The manuscript addresses the need for concept clarification, which stems from variability in how the concept of patient acuity is defined, used, and measured in the health sciences literature. The manuscript explores the concept of acuity within the context of Holzemer’s Model for Health Care Research. Specific attributes of acuity and a definition of acuity are proposed. The full citation is:

Abstract

Aim: This paper is a report of a concept analysis of patient acuity.

Background: Patient acuity is a widely-used term in the health sciences literature, but often without specification of its exact meaning. Concept clarification is therefore needed to delineate the meaning of patient acuity.

Data Sources: A review of the Pubmed, CINAHL, MEDLINE, and PsychInfo databases for the keyword “acuity” in the title or abstract of papers in English language journals, as well as searches for the term “acuity” and “acute” in the Merriam-Webster and Oxford English Dictionaries were the data sources for this concept analysis. Papers were excluded if “acuity” was not present in the title or abstract. Publication dates of the literature included in the review ranged from 1974 to 2008.

Findings: The attributes of acuity are severity, intensity, and the pairing of acuity measurements with another concept. These attributes were organized according to Holzemer’s Outcomes Model for Health Care Research as patient-, provider-, or system-related. The sub-categories of attributes identified were physical, psychological, nursing care needs, workload, complexity, case-mix, patient classification systems, urgency/triage scales, and other uses.

Conclusion: Researchers are encouraged to specify which attribute of acuity they are studying and to develop measurement tools specific to that attribute, in order to move the science toward standardization of the concept of acuity and its measurement.

Keywords: concept analysis, acuity, case-mix, patient classification, nurse staffing, Outcomes Model for Health Care Research
Summary Statement

What is already known about this topic

- Patient acuity seems to be a well-used concept in the health sciences literature, but there is a lack of consistency in terms of how it is defined and measured.
- Nurse staffing based on patient acuity has the potential to be an efficient method of utilizing the available nurses during a global nursing shortage.

What this paper adds

- Exploring the concept of acuity within the context of Holzemer’s Outcomes Model for Health Care Research provides a theoretical basis for establishing the attributes of acuity.
- Specific attributes of the concept of acuity identified in this analysis are severity, intensity, and the pairing of acuity measurements with another concept.
- The proposed definition of patient acuity as a measure of the severity of illness of the patient and the intensity of nursing care that patient requires is clear and concise and provides the first step toward developing standardized measurements of patient acuity.

Implications for practice and/or policy

- Researchers are encouraged to be specific about which attribute of acuity is being studied, particularly when developing tools to measure patient acuity.
- Standardized definitions and measurements of patient acuity allow for future research on the relationships among acuity structures, processes, and outcomes.
• The effect of acuity-based nurse staffing decisions on various safety, quality, and cost outcomes is a topic for future research that has the potential to affect policy decisions in hospitals and long-term care facilities.

**Introduction**

The concept to be analyzed in this paper is patient acuity. On the surface, “patient acuity” seems to be a well-defined concept, given its common usage in the health sciences literature. For example, “rising patient acuity” has been cited often throughout the past three decades (Abbott, 2002; Aiken, Clarke, & Sloane, 2001; Alexander et al., 2003; Angeles & Barbone, 1994; Aylott, 2007; Belcher & Munjas, 1990; Bezyack, 1999; Chetney, 2008; Cobb & Cooley, 1988). In addition, many measurement tools exist that provide quantitative data on patient acuity, such as the Resource Utilization Group (RUG-III) classification system, the Acute Physiology, Age, Chronic Health Evaluation (APACHE III) instrument, the National Therapeutic Intervention Scoring System (NTISS), the Injury Severity Score (ISS), the Van Slyck & Associates Acuity System (VSA), and the Revised Easley-Storfjell Patient Classification Instrument (Anderson & Rokosky, 2001; Arling, Kane, Mueller, & Lewis, 2007; Bacchetta et al., 2006; Bond et al., 1993; Gray et al., 1992; Mayo & Van Slyck, 1999; Van Slyck, 1991). However, there is a lack of consistency in the literature in terms of how acuity is defined and measured.

The goal of this concept analysis is to assess the various usages of the term “acuity” and define it within the context of Holzemer’s Outcomes Model for Health Care Research (Holzemer, 1994). Holzemer’s model, based on Donabedian’s Structure, Process, and Outcomes Theory, suggests that structures of care influence processes of
care, which in turn influence outcomes (Holzemer and Reilly, 1995). Holzemer’s model stratifies structures, processes, and outcomes as patient-, provider-, or system-related.

Current issues facing nurse managers include ensuring adequate nurse staffing, in order to provide high quality care to patients, within the constraints of an aging population, a nursing shortage, and rising healthcare costs (Knickman and Snell, 2002; Lesser, Ginsberg, & Devers, 2003; Letvak and Buck, 2008; Seago et al., 2001). According to Holzemer’s Model, the concept of acuity can be considered a structure of care, in that it is a characteristic of the patient that, when measured, can be applied to nurse staffing decisions and thus also be considered a process of care. Nurse staffing decisions based on patient acuity have the potential to balance the nursing workload among available nurses, thus improving patient safety and quality, and potentially reducing costs, which are outcomes of care.

The current nursing shortage is a global issue that affects many nations (Abualrub, 2007; Baumann, 2006; Brady and Arabi, 2005; Doiron et al.; 2008; Gardulf et al., 2008; Haley et al., 2008; Kumar, 2007; Sapountzi-Krepia et al., 2008; Scribante and Bhagwanjee; 2007). With few viable short-term solutions, nurse managers must utilize the available nursing staff in the most efficient manner possible. Exploring the concept of acuity in the context of Holzemer’s model will provide a starting point for establishing the attributes and a standardized definition of patient acuity. Standardization will allow for comparisons of patient acuity across hospital units, institutions, geographical regions, and eventually internationally.

Before patient acuity can be studied, valid measurements are needed, which entails clarity about what is being measured. Despite frequent use of the term “acuity,”
the lack of consistency in defining and measuring it has led to an inability to compare acuity measurements across settings or examine the relationship between acuity and outcomes. Therefore, a concept analysis is warranted to provide clarification and move the evidence base toward standardized definitions and methods of measurement of acuity.

Morse’s concept clarification method will be used (Morse, 1995). She states that “occasionally a concept will appear to be ‘mature’ and well-described. Often there is an enormous body of literature on such a concept, including rich descriptions, clinical evidence, and quantitative instruments measuring the concept…[but] on closer reading, the concept is murky, and many competing implicit assumptions may be evident” (page 41). Morse (1995) recommends the following steps for concept clarification: conducting a literature review, content-analyzing the literature according to the underlying values, and identifying, describing, and comparing and contrasting the attributes and the rules of relation for each category.

**Data Sources**

Searches for the keyword “acuity” in the title or abstract of papers in English language journals were conducted in Pubmed, CINAHL, MEDLINE, and PsychInfo databases, as well as the Merriam-Webster and Oxford English Dictionaries. The searches resulted in a total of 1977 papers. All these papers (citations and abstracts) were exported into the EndNote reference management system, listed in alphabetical order, and printed with abstracts. No published reports of concept analyses of patient acuity could be located. Papers were included in the analysis if the title or abstract contained the term “acuity,” and were excluded if “acuity” was not present in the title or abstract. The rationale for excluding papers that lacked the term “acuity” in the title or abstract
was that no new information on the concept of acuity, its definition, and how it is measured was likely to be gained from such a paper. Papers were further categorized based on their quality. Newsletters or special reports were excluded from the analysis because less explicit information related to the concept of acuity could be gained from these papers. Publication dates for the reviewed literature ranged from 1974 to 2008.

Findings

Identifying and Describing Attributes

The 1996 Oxford English Compact Dictionary definition of “acuity” is “sharpness, acuteness” (Acuity, 1989). The definition of “acute” in relation to a disease is: “coming sharply to a crisis; severe not chronic”. In addition, the Merriam-Webster dictionary (Acuity, 2008) definition of acute includes:

“having a sudden onset, sharp rise, and short course (acute disease); being, providing, or requiring short-term medical care (as for serious illness or traumatic injury - acute hospitals, an acute patient); lasting a short time (acute experiments); ending in a sharp point, as being or forming an angle measuring less than 90 degrees (an acute angle); felt, perceived, or experienced intensely (acute distress); seriously demanding urgent attention (an acute emergency)”.

For the purposes of this concept analysis, these definitions of acuity and acute can be categorized, using Holzemer’s model, as non-patient-related, or patient-, provider-, or system-related. The main attribute of non-patient-related acuity is sharpness/keenness. Patient-related acuity attributes include onset, time-sensitive, and severity. Provider-related acuity includes the intensity attribute. Lastly, system-related acuity includes the process attribute of pairing acuity measurements with another concept. Subcategories within each attribute and their characteristics are described below and summarized in Table 1.
Non-Patient-Related Acuity

**Sharpness/Keenness.** The sharpness/keenness attribute of acuity includes subcategories of sensation, coming to a point/forming an angle, intellectual, and social.

**Sensation.** Retrieved papers that discussed acuity in relation to sensation included the following categories: auditory, olfactory, perceptual, proprioceptive, sensory, spatial, tactile, and visual. Visual acuity was the most common usage of acuity in relation to sharpness or keenness of sensation, followed by auditory acuity. Examples of studies related to visual acuity included descriptions of defined ranges of visual acuity, measures of corrected and uncorrected acuity, and effects of various treatments on visual acuity (Anuar and Ibrahim, 2007; Boltz, 1993; Shiraga et al., 1998). Papers that referred to auditory acuity often described animals’ abilities to locate sound in space (Bodson, Niersch, & Dehnhardt, 2007; Brown, Beecher, Moody, & Stebbins, 1978). Human auditory acuity was represented in a similar way, with a focus on localization acuity, as well as the effects of various treatments on auditory acuity (Catchpole, Mckeown, & Withington, 2004; Smith et al., 1989).

**Coming to a Point/Forming an Angle.** Papers that fit this description of acuity most often referred to repositioning or position sense acuity. The goal for these studies was to establish a quantitative measure of error in positioning joints, so as to promote range of motion, relieve pain, and develop diagnostic techniques and rehabilitation programmes for joint-related injuries (Asell, Sjolander, Kerschbaumer, & Djupsjobacka, 2006; Clark, Larwood, Davis, & Deffenbacher, 1995; Hjortskov, Hye-Knudsen, & Fallentin, 2005; Sjolander, Michaelson, Jaric, & Djupsjobacka, 2008).
**Intellectual.** With regard to intellectual acuity, most papers that used the term “mental acuity” referred to cognition and memory, rather than cleverness or sharp-wittedness. For example, strategies for assisting elders in maintaining mental capabilities as they age, medications to improve memory and/or concentration, and reduced mental acuity as a risk factor for injuries in older people were areas of research on mental acuity (Cherry and Reed, 2007; Sudilovsky, Turnbull, Croog, & Crook, 1988; Testa et al., 1998; Wootton et al., 1982). Reports of side effects of medications affecting mental acuity were also described (Adler, 1974).

**Social.** Social acuity was used to mean social awareness, sensibility, or keenness in having an ability to interact socially with others (Ambady, Laplante, & Johnson, 2001; Aube and Whiffen, 1996; Bernieri and Gillis, 1995).

**Patient-Related Acuity**

Papers referring to patient-related acuity included the following attributes: onset, time-sensitive, and severity.

**Onset.** Papers referred to acuity of onset in relation to onset of disease or timing of medication action, as in the treatment of asthma (Covar, Macomber, & Szefler, 2005; Keeffe and Otto, 2003; Lempert et al., 1998; Williams et al., 2001).

**Time-Sensitive.** The time-sensitive or temporal quality attribute of acuity was often used to describe hospital facilities to differentiate acute care hospitals from long-term care or rehabilitation facilities (Curtin, 2003; Curtin, 2007; Dlugacz et al., 2002; Doloresco, 2005; Ferguson-Pare, 1996; Gender, 1989).

**Severity.** The severity attribute includes subcategories physical and psychological.
**Physical.** The physical subcategory includes descriptions of overall severity or seriousness of illness, as well as inflammatory and injury acuity. Physiological measures of severity of illness include the aforementioned APACHE and ISS instruments as well as the Mortality Prediction Model (MPM), A Severity Characterization of Trauma (ASCOT), and the International Classification of Disease Injury Severity Score (ICISS) (Marcin and Pollack, 2007; Wickel, Cheadle, Mercer-Jones, & Garrison, 1997). Severity of illness has often been measured to assess differences between groups or to study the relationship between disease severity and other outcomes, such as mortality, organ failure, stress, and immunological competence (Cheadle & Spain, 2003; Davies, Tibby, & Murdoch, 2005; Harries, Danis, & Heatley, 1984; Kuo, Plotkin, & Johnson, 1998; Martin, 2001; Miller, Lewis, Nork, & Morley, 1996; Ratzinger, Burgdorf, Zelger, & Zelger, 2007; Sheean and Braunschweig, 2006; Wickel et al., 1997).

Papers referred to inflammatory acuity in terms of the extent or severity of the actual inflammatory process or in relation to a specific disease, such as chronic inflammatory bowel disease (Bamborschke, Wullen, & Beil, 1990; Loffler et al., 2006). Injury acuity was used for triage purposes in emergency departments (EDs) or for inter-hospital transport, for assessing differences between groups on various outcomes such as length of stay, morbidity/mortality, and costs, as well as the importance of accuracy when using diagnostic codes to capture injury acuity in research studies (Bard et al., 2006; Gabriel, Amadio, Ilstrup, 1997; Harrison, Thomas, & Wedel, 1997; Nufer and Wilson-Ramirez, 2004; Wright and Litaker, 1996).
Psychological. Papers referring to psychological acuity (including behavioral, crisis, and mental) used acuity to mean severity of psychological distress or disease (Bellus et al., 1996; Bonyenge, Lee, & Thurber, 2005; Hampton, 2007).

Provider-Related Acuity

Papers that referred to provider-related acuity fell under one main attribute: intensity. Most papers referred to intensity in terms of the care burden the patient brings to medical or nursing staff in terms of the time, skill, mental concentration, and surveillance required to meet patient needs. The intensity attribute of acuity has three sub-categories: nursing care needs, workload, and complexity.

Nursing Care Needs. Patient severity (seriousness) of illness often dictates nursing care needs and therefore the severity and intensity attributes of acuity are closely related (Huber & Craig, 2007; Shaha & Bush, 1996). Rather than seriousness, intensity can be thought of as the concentration or amount of nursing care or resources used by the patient (Adams & Johnson, 1986; Bernstein et al., 2002; Brisley et al., 2003; Burns & Carney, 1986; Cusack et al., 2004a; Gimbel, Tanabe, Yarnold, & Adams, 2004; Gray et al., 1992; Harris et al., 2004; Irvine et al., 2000; Kemp, Harris, & Comino, 2005; Lutjens, 1992; Lyons, Scheruble, Anderson, & Swartz, 1989; Sheedy, 1989; Sherman and Ryan, 1998). Papers often referred to nursing intensity in terms of the amount of time required to provide patient care (Adams & Duchene, 1985; Adams & Johnson, 1986; Dale & Mable, 1983; Detwiler & Clark, 1995; Hendrickson, Doddoto, & Kovner, 1990; McNeal, Hutelmyer, & Abrami, 1987; Schroeder, Rhodes, & Shields, 1984). Measures of nursing intensity included nursing hours per patient day and nursing intensity weights, or DRGs weighted by nursing care needs (Blegen, Vaughn, & Goode, 2001; Cimiotti, 2004).
Other terms for acuity that described nursing care needs included patient dependency, or the patient’s reliance on nurses for fulfillment of their needs (Harrison, 2004; Hurst, 2005).

Although many authors labeled the nursing care needs of the patient as nurse or patient intensity, several also referred to nursing care needs as patient severity, rather than using severity to mean the specific physiological or psychological subcategories of severity described above. Severity was often described in terms of nursing diagnoses and interventions or the type and amount of direct nursing care activities required (Adams-Wendling, 2003; Andro, Robertson, & Glandon, 1987; Blegen, Goode, & Reed, 1998; Brown, 1999; Brown & Gallant, 2006; Diers & Bozzo, 1997; Dirks, Lough, & Moungey, 1995; Dexter, Wachtel, & Epstein, 2006; Dexter & Rittenmeyer, 1997; Edel, 1995; Ferrant, 2004; Gross, Faulkner, Goodrich, & Kain, 2001; Harper & McCully, 2007; Hart, 1985; Hickey, 1987; Kim et al., 2007; Lacovara, 1999; Moss, O’Connor, & Windle, 1994; Parrinello, 1987; Shaha & Bush, 1996; Sovie, Tarcinale, Vanputee, & Stunden, 1985; Urbanowicz, 1999; Vanputte, Sovie, Tarcinale, & Stunden, 1985; Vaughan & MacLeod, 1985). Patient functional status and patient debility were also included in some descriptions of severity measures, in relation to provider-related acuity (Adams-Wendling, 2003; Curtin, 2003; Grohar, Myers, & McSweeney, 1986).

**Workload.** The second sub-category of the intensity attribute of acuity is workload. Authors who referred to increased patient acuity also discussed an increase in nursing workload, in terms of the combined effect of reductions in patient lengths of stay and rising patient severity of illness (Aiken, Clarke, & Sloane, 2001; Baggerly & DiBlasi, 1996; Balstad & Springer, 2006; Chang, Kicis, & Sangha, 2007; Harrison, 2004; Hurst,
Workload was often described as an increase in demand for nursing services or skills and a measure of the nursing requirements to meet patient needs (Brewer, 2006; Stull & Vernon, 1986). “Workload intensity” was also a term used by several authors (Mamaril et al., 2007; Upenieks et al., 2007; Zupancic & Richardson, 1998).

**Complexity.** The final intensity attribute is complexity. Apart from amount and time, papers also focused on the complexity or level of difficulty of patients’ nursing and medical care needs (Boling, Buck, & Falls, 1999; Burke, 1998; Cervelli, 1997; Cowan, Walsh, & Homsi, 2002; Craig & Huber, 2007; Delisle, 2008; Fee, Weber, Maak, & Bacchetti, 2007; Finlayson, Watson, & Jacobs, 2003). The complexity subcategory captures the skill, concentration, and level of surveillance required of nurses and physicians to provide care to a patient or group of patients.

**System-Related Acuity**

System-related acuity has to do with the process of pairing acuity attributes with another concept. Subcategories of system-related acuity include case mix, classification systems, urgency/triage, and other uses.

**Case-mix.** Case-mix refers to the number of patients (cases) present on a hospital unit or in a nursing home who can be placed in the same category, based on care needs. A case-mix index represents the resource utilization (described in terms of time and costs) required by the average patient or nursing home resident in each category (Feng et al., 2008). In the USA, Medicare prospective payment and Medicaid reimbursement for nursing homes is based on case-mix using the RUGS-III system, which categorizes patients based on resource utilization for the purpose of reimbursement for services (Arling & Daneman, 2002; Fries et al., 1994). The categories may also be based on
DRGs, with the goal of stratifying patients by severity of illness or nursing care needs (Diers & Bozzo, 1997; Grogan et al., 2004; Weinstein et al., 1999). A criticism of this method is that other researchers have found no statistically significant correlation between intensity of care and DRGs (Adams & Johnson, 1986). Case-mix stratification can also be helpful in projecting or tracking outcomes such as productivity and resource use (Hubble, 1985; Tsen et al., 2002).

**Patient Classification Systems.** Patient classification systems (PCSs) such as the Perioperative Acuity Measurement System (POAMS) pair nursing costs with acuity (amount of care required) (Moss et al., 1994). The Computerized Severity Index-Classification for Nursing (CSI-CN) measures patient characteristics and therapies to determine amount of nursing resources needed and/or to determine nurse assignments (Buckle, Horn, & Simpson, 1991; Detwiler & Clark, 1995). PCSs are also used to predict or match staffing needs relative to patient needs (Edel, 1995; Gross et al., 2001; Harrison, 2004; Shaha, 1995; Shaha & Bush, 1996).

**Urgency/Triage Scales.** In ED settings, triage scales are often used to determine severity of illness and match the patient with the appropriate medical and nursing needs. Triage scales often categorize patients as non-urgent, urgent, or emergent (Boudreaux, Friedman, Chansky, & Baumann, 2004; Rogers, Delgado, & Simon, 2004; Simon, Ledbetter, & Wright, 1997). More recent triage scales, such as the widely-used Canadian Triage and Acuity System (CTAS) and a triage tool used in the USA, have moved to a 5-category scale to account for greater variability in severity of patients presenting in the ED (Atack, Rankin, & Then, 2005; Beveridge, 1998; Cooke, Watt, Wertzler, & Quan,
2006; Daniels, 2007; Darrab et al., 2006; Dong et al., 2007; Ekwall, Gerdtz, & Manias, 2008).

**Other uses of patient acuity measurements.** Patient acuity measurements can be used for a variety of other predictions, including morbidity and mortality, costs or charges of care, staffing, budgets, or for assigning patients to case managers (Adams & Duchene, 1985; Adams-Wendling, 2003; Detwiler and Clark, 1995; Ethridge, 1985; Finkler, 1985; Finkler, 1991; Huber & Craig, 2007; Marcin & Pollack, 2007).

**Discussion**

**Study Limitations**

An important limitation to this concept analysis is the limited number of papers published within the past five years. This analysis, which is based on the available literature, draws heavily on the great number of manuscripts published on acuity during the 1980s and early 1990s. These may not all be equally relevant in today’s healthcare climate. Conceptually, however, these papers provide historical context and allow for examination of the concept of acuity over time, which is applicable to concept clarification.

**Comparison of Attributes of Acuity**

The review of the literature revealed several attributes of acuity. Non-patient-related acuity is not applicable to the purposes of this paper, which is to clarify the concept of acuity in the context of Holzemer’s Model for Health Care Research. In terms of patient-related acuity, onset and timing are not applicable to nursing and nurse staffing. What matters more than whether the disease is short-course or chronic, and whether the patient is admitted to an acute care or rehabilitation facility, is the severity of
patient’s illness and intensity of their care needs. Therefore, the severity and intensity attributes are the most applicable attributes of acuity for the purposes of this paper.

**Relationship between Severity and Intensity Attributes**

The severity and intensity attributes of acuity are similar in many ways and overlap in their use in the literature. Severity and intensity were used interchangeably to mean amount, duration, or type of nursing care requirements posed by a specified group of patients. This is not surprising, since the two terms are synonyms – both can be used to mean “seriousness.” However, these main attributes must be defined and measured separately so as to avoid confusion and provide conceptual clarity. Definitions of each attribute are proposed here, according to Holzemer’s Model (Table 2). Because the goal of this paper is concept clarification, patient acuity as a structure and process will be addressed, but outcomes were omitted because they are beyond its scope.

**Proposed Definitions of Acuity Attributes**

The proposed definitions of acuity attributes are as follows: the severity attribute of acuity indicates the physical and psychological status of the patient, while the intensity attribute of acuity indicates the nursing care needs and the corresponding workload and complexity of care required by an individual patient or a group of patients. In this way, workload and complexity are derived from intensity (care needs), which is derived from patient severity of illness. Thus, patient acuity is a measure of the severity of illness of the patient and the intensity of nursing care that patient requires.

Setting-related acuity attributes are not included in the definition of acuity because they indicate the process of classifying acuity measurements in some way,
whether in the form of case-mix, triage, or some other categorization, rather than indicating what acuity is.

**Linear versus Nonlinear Relationship**

The relationship between the severity and intensity attributes of acuity can be both linear and non-linear. For example, one author stated that “higher acuity is directly proportional to intensity of care” (Spiegel, 2001, p. vi). This indicates that as patient severity of illness rises, so do the nursing care requirements. However, the relationship between severity and intensity may be dependent on the goals of treatment. For example, nursing care needs for a patient having a bone marrow transplant may increase in relation to the patient’s severity of illness if the treatment plan is based on curative care, as compared to one based on palliative care. The relationship between severity of illness and nursing intensity may be linear up until the patient decides not to undergo any further treatment, at which point nursing care needs may be greatly reduced while the severity of illness remains high. Similarly, patients who require long-term ventilation may have a complicated set of therapies and interventions in terms of nursing care, but their severity of illness has stabilized compared to a patient with high risk of respiratory distress who is not ventilated or requires short-term ventilation.

**Units of Measurement**

Another comparison that is helpful for clarifying the concept of acuity is by units of measurement. The patient- and provider-related attributes of acuity are summarized according to their units of measurement in Table 3 below. To avoid repetition, system-related acuity measures are excluded because they are often combinations of the patient- and provider-related measures already included in Table 3.
Theoretical Implications

Middle-range theories “focus on nursing concepts grounded in practice context…[and are] developed in concert with research questions directly linked to important practice problems”, according to Chinn and Kramer (2004, p. 37). They go on to explain that “[midrange theory] avoids a focus on methodology for methodology’s sake and shifts the focus to understanding nursing phenomena. Substantive theory can inform practice and lead to new practice approaches and factors that influence the outcomes desired in nursing practice” (Chinn & Kramer, 2004, p. 38). The definition of acuity and its attributes as applied to Holzemër’s Model proposed here can be considered the preliminary foundation for formulating a midrange theory to describe the relationships among patient-, provider-, and system-related constructs of the concept of acuity.

Conclusion

Recommendations for Research, Practice, and Policy

Because of the wide variation in use of the term patient acuity in health sciences research, the science of acuity measurement has stalled in past decades. Recommendations for researchers are to be specific about which attribute of acuity is being studied – patient-related severity of illness or provider-related intensity. In practice, the lack of continued use of the same measurement tool in several studies, especially those measuring the intensity attribute of acuity, may be a result of tool creators not being clear about which attribute of acuity they were measuring. As a result, these measurement tools are not particularly useful in the clinical setting. Development of measurement tools for acuity must be derived from a sound conceptual basis, in order
to establish their relevance and validity for a particular patient population. The combination of a standardized definition of acuity and valid and reliable measurements of it will allow for future research on the effects of acuity-based nurse staffing on safety, quality and cost outcomes. This research will have the potential to influence health policy decisions within and across hospitals and long-term care facilities.

**Theoretical Frameworks for Future Research**

Future research is needed to develop psychometrically sound patient acuity instruments. Once measurement tools are available, the addition of outcomes to Holzemer’s model and testing of the model as a midrange explanatory theory, in terms of relationships among acuity structures, processes, and outcomes, can occur. For example, acuity measurements derived from patient severity of illness and nursing intensity, which are used to make nurse assignments on each shift, have the potential to balance the nursing workload. The effect of this type of staffing model on patient and system outcomes, such as safety, quality and costs, is a topic for future research. These types of studies can be conducted in a variety of settings using standardized measures of acuity, in order to compare results in various populations, which will enhance the generalizability of study findings and move the science of acuity measurement forward. This concept analysis is a first step in providing clarity on the concept of acuity, so that next steps on researching this topic can be taken.

In conclusion, analysis of patient acuity through Holzemer’s model allows for categorization of the various attributes of patient acuity, which provides clarity to what we mean as researchers when we discuss patient acuity. Although there are system-level aspects of acuity in terms of the application of acuity measures to nurse staffing needs or
budgets etc, the status of the patient’s condition forms the basis for the rules of relation of
the concept of patient acuity. In other words, information about provider-related and
system-related acuity is derived from patient-related data. Conceptually, this is very
important for clarifying the definition of acuity and for developing accurate measures of
it.
# Tables

## Table 1. Characteristics of Acuity Attributes and Subcategories

<table>
<thead>
<tr>
<th>Acuity Attribute</th>
<th>Subcategories</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-patient-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharpness/Keenness</td>
<td>• Sensation</td>
<td>• Acting keenly on the senses</td>
</tr>
<tr>
<td></td>
<td>• Coming to a point/forming an angle</td>
<td>• Repositioning of joints to promote optimal range of motion</td>
</tr>
<tr>
<td></td>
<td>• Intellectual</td>
<td>• Cleverness; concentration/memory</td>
</tr>
<tr>
<td></td>
<td>• Social</td>
<td>• Sensibility, quick discernment</td>
</tr>
<tr>
<td>Patient-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset</td>
<td>None</td>
<td>Sharp rise or short course, as in disease/timing of pharmacologic action</td>
</tr>
<tr>
<td>Time-sensitive</td>
<td>None</td>
<td>Acute versus long-term care/rehabilitation services</td>
</tr>
<tr>
<td>Severity</td>
<td>• Physical</td>
<td>• Seriousness of illness/physiologic state</td>
</tr>
<tr>
<td></td>
<td>• Psychological</td>
<td>• Extent of inflammation/injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Seriousness of psychological distress/disease</td>
</tr>
<tr>
<td>Provider-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>• Nursing care needs</td>
<td>• Concentration/amount of nursing care required</td>
</tr>
<tr>
<td></td>
<td>• Workload</td>
<td>• Time needed to provide nursing care</td>
</tr>
<tr>
<td></td>
<td>• Complexity</td>
<td>• Dependence/reliance of patient on nursing staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Demand for nursing services/skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Level of difficulty of care needs</td>
</tr>
<tr>
<td>System-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pairing acuity</td>
<td>• Case-mix</td>
<td>• Number of patient (cases) that can be placed in the same category based on care needs</td>
</tr>
<tr>
<td>measurements</td>
<td>• Patient Classification Systems</td>
<td>• Pair amount of care required with costs, nursing resources; predict staffing needs</td>
</tr>
<tr>
<td>with some other</td>
<td>• Urgency/Triage Scales</td>
<td>• Determine severity of patient illness and match with medical/nursing needs</td>
</tr>
<tr>
<td>concept</td>
<td>• Other uses</td>
<td>• Prediction of morbidity/mortality, charges, budgets, case management needs</td>
</tr>
</tbody>
</table>

## Table 2. Holzermer’s Model Applied to the Concept of Patient Acuity

<table>
<thead>
<tr>
<th>Structure</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td></td>
</tr>
<tr>
<td>Severity</td>
<td>• Physical</td>
</tr>
<tr>
<td></td>
<td>• Psychological</td>
</tr>
<tr>
<td>Provider (Nurse)</td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>• Nursing care needs</td>
</tr>
<tr>
<td></td>
<td>• Workload</td>
</tr>
<tr>
<td></td>
<td>• Complexity</td>
</tr>
<tr>
<td>Setting (Institution)</td>
<td>Pairing acuity measurements with another concept</td>
</tr>
<tr>
<td></td>
<td>• Case-mix</td>
</tr>
<tr>
<td></td>
<td>• Patient Classification System</td>
</tr>
<tr>
<td></td>
<td>• Urgency/Triage Scales</td>
</tr>
<tr>
<td></td>
<td>• Prediction of Morbidity, Mortality, Budgets, Staffing, Costs</td>
</tr>
<tr>
<td>Acuity Attribute</td>
<td>Unit of Measurement</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Severity</strong></td>
<td></td>
</tr>
<tr>
<td>Acute Physiology, Age, Chronic Health Evaluation (APACHE)</td>
<td>Weighted score of physiologic status (vital signs &amp; lab values), age, and chronic health</td>
</tr>
<tr>
<td>Mortality Prediction Model (MPM)</td>
<td>Prediction score developed from five admission variables and eight additional variables obtained at 24 hours post-admission to Intensive Care Unit</td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Nursing Care Needs – Amount | • Count data regarding the number of activities or tasks completed for the patient during a 24-hour period  
• Nursing Intensity Weights (scale ranging from 1 to 5 based on nursing care needs; higher score indicates higher needs) | Adams and Duchene, 1985  
Cimiotti, 2004                  |
| Nursing Care Needs – Time | • Minutes required for specific direct and indirect care activities  
• Nursing hours per patient day (HPPD)                                                                                                                      | Jones et al., 2004  
Blegen et al., 1998            |
| Workload        | • Count data from a list of indicators of nursing care requirements  
• Based on HPPD/nursing requirements and severity of illness                                                                                               | Brewer, 2006  
Upenieks et al., 2007          |
| Complexity of Care | • Categorical measure based on primary diagnosis, other medical/surgical problems, current medications, medication changes, symptoms, nursing problems, non-pharmacologic interventions (no quantitative measure)  
• Categorical measure based on list of patient’s needs, interventions, and activities required of the case manager | Cowan et al., 2002  
Huber and Craig, 2007          |
Chapter III

A Meta-Review of the Relationship between Nurse Staffing and Patient Outcomes

Preface

This chapter presents the second manuscript for publication, which was submitted to *Medical Care Research and Review* on April 8, 2009. It is currently undergoing revisions recommended by the editors and will be resubmitted. This manuscript describes the background of the relationship between nurse staffing and patient outcomes and the role of acuity within that relationship. The first manuscript “Patient acuity: A Concept Analysis” specified the attributes of acuity according to Holzemer’s Model for Health Care Research, which is the conceptual model guiding this study, and proposed that staffing by acuity has the potential to efficiently allocate available nursing staff according to patients’ nursing care needs, and thus lead to improved patient outcomes. The second manuscript proposes that researchers focus on conducting theoretically sound, unit-based studies that test the effect of various structures and processes of nursing care on the enhancement of positive patient outcomes and avoidance or reduction of negative patient outcomes.
Abstract

This meta-review presents a comprehensive review of the state of the science of the relationship between nurse staffing and patient outcomes and suggests specific directions for future research. Holzemer’s Model for Healthcare Research served as the conceptual model by specifying the relationships between provider-related nurse staffing variables and patient-related outcomes. Meta-review methods followed Centre for Reviews and Dissemination recommendations, including a literature search in the CINAHL, Pubmed/Medline, Psychinfo, and Cochrane databases, quality assessments and data extraction of included articles. Two major themes arose from the 14 included reviews: variability in methods and overall inconsistency and inconclusiveness of results across primary studies. Our meta-review synthesizes the theoretical, methodological, and statistical issues that have contributed to the inconclusiveness of results across reviews. We recommend repetition of theoretically sound, single-unit studies, followed by gradual expansion to multi-site studies, to build the evidence-base for the relationship between nurse staffing and patient outcomes.

Background

The association between nurse staffing and patient outcomes has been studied extensively over the past decade. Methods have varied from single-unit, case-control designs to multi-site, cross-sectional and longitudinal designs (Kane, Shamlivan, Mueller, Duval, & Wilt, 2007; Krauss, Evanoff, Hitcho, Ngugi, Dunagan, Fischer, et al., 2005). Nurse staffing data are often measured in hours per patient day (HPPD) or nurse-to-patient ratios. Although the California state legislature has signed into law minimum nurse-to-patient ratios, there is currently a lack of consensus on the appropriate level of
nurse staffing to promote optimum patient outcomes (Bergmann, 1999; Kovner & Heinrick, 2000).

In relation to patient outcomes, several initiatives have been established in the recent past. In 2003, the Agency for Healthcare Research and Quality (AHRQ) expanded on the original Healthcare Cost and Utilization Project quality indicators and released 27 Patient Safety Indicators that provide information on potential adverse events in hospitals (AHRQ, 2006). In 2004, the National Quality Forum published a consensus statement on nursing-sensitive patient-centered outcome measures, which included failure to rescue, prevalence rates for pressure ulcers, falls, restraints, and hospital-acquired infections (NQF, 2004a). Since 2002, the American Nurses’ Association (ANA) has been collecting unit-level data for its National Database of Nursing Quality Indicators (NDNQI) and many of the indicators have been endorsed by NQF (NDNQI, 2002a). Patient-level NDNQI indicators included patient falls, hospital-acquired pressure ulcers and infections, psychiatric physical/sexual assault, pediatric pain assessment cycle, pediatric peripheral IV infiltration, and use of physical restraints; nurse-level indicators included staff mix of registered nurses (RNs), licensed practical/vocational nurses (LPN/LVNs), and unlicensed assistive personnel (UAP), nursing care hours provided per patient day, RN education/certification, and RN survey data (Practice Environment and Job Satisfaction Scales) (NDNQI, 2002b). Building off of the work from NQF, in 2006 the Robert Wood Johnson Foundation (RWJF) created the Interdisciplinary Nursing Quality Research Initiative (INQRI), which provides funding for interdisciplinary research focused on linking new measures of the work of nurses to quality of care in hospitals (INQRI, 2007).
The efforts of these organizations highlight the vested interest from the public and private sectors in investigating the influence of nursing care on patient safety and quality of care in hospitals, but despite their recommendations variation in the measurement of nurse- and patient-level variables remains. This may be due in part to the fact that these recommendations and initiatives were recently released and there is lag time before they appear in the literature. Alternatively, four separate organizations (NQF, ANA, RWJF, and AHRQ) have set forth recommendations for nursing-sensitive measures, all of which are slightly different and thus slow progress toward standardization. Lastly, even in the presence of recommendations for standardized measures, researchers may not have control over or the ability to manipulate the data that are collected from large databases or discharge abstracts.

The following meta-review will synthesize published data from systematic reviews (SR) and reviews of the literature (ROL) on the relationship between nurse staffing and patient outcomes and provide recommendations for the direction of future research in this area.

**Conceptual Model**

Avedis Donabedian conceptualized a theoretical framework for assessing quality of care via the relationships among structures, processes, and outcomes of care (Donabedian, 2003, p. 46-47). Holzemer’s Model for Health Care Research, which was adapted from Donabedian’s theory, categorizes structures, processes, and outcomes as being patient-, provider-, or system-related (Holzemer & Reilly, 1995). Holzemer’s model was the conceptual model that guided this meta-review. Theoretically, provider-related structures (e.g., number of nurses available) and processes (e.g., nurse staffing
models) interact with patient- and system-related structures and processes, which in turn affect patient outcomes. Special attention was paid to whether review articles utilized a theoretical framework to guide the research.

Methods

Methods for this article were based on a recently published review of reviews and the Centre for Reviews and Dissemination (CRD) report on undertaking systematic reviews (van Dulmen, Sluijs, van Dijk, de Ridder, Heerdink, Bensing, 2007; CRD, 2001). A sequential series of steps were undertaken, including a literature search, development of inclusion and exclusion criteria, quality assessment of included reviews, and data extraction.

Literature Search

A literature search was conducted in the CINAHL, Pubmed/Medline, Psychinfo, and Cochrane databases for the search term “nurse staffing AND patient outcomes.” The search was limited to review articles published in the United States (U.S.) in English within the past twenty years. That rationale for limiting the search in this way is that the U.S. healthcare system is vastly different from that of other nations. Only hospitals in the U.S. were included in order to systematically compare results across reviews and rule out any differences that were due to variation in healthcare systems, nurse education structures, and/or the role of registered nurses. The search yielded 70 reviews.

Inclusion and Exclusion Criteria

The authors adapted van Dulmen’s “checklist for the inclusion and exclusion of reviews” for assessing relevance to the topic of nurse staffing and patient outcomes (van Dulmen et al., 2007). Articles were included in the meta-review if the following
inclusion criteria were met: the setting was acute care hospitals, the subject of the review was nurse staffing, the research question addressed the effect of nurse staffing on patient outcomes, and the review method was either a SR or ROL. SR articles needed to fulfill the following additional inclusion criteria: the literature search included an assessment of electronic databases with clearly stated search terms and search strategy, and the inclusion and exclusion criteria were clearly stated and applied to primary studies. SR or ROL articles that assessed only nurse-level or system-level outcomes, such as turnover, burnout, or cost, without assessing patient outcomes, were excluded.

**Data Extraction**

The first author reviewed each article for the aforementioned inclusion and exclusion criteria, conducted a quality assessment based on CRD recommendations, and categorized articles as SR or ROL (CRD, 2001). The second author reviewed 10% of the articles’ abstracts. One hundred percent inter-rater agreement was achieved. Three SR and 11 ROL articles met the criteria for inclusion in the analysis (Figure 1). The first author conducted data extraction for each article, which included re-verification of study eligibility and assessment of methodological quality, as well as listing of outcomes and their measurement, conclusions and recommendations for future research from each review. Table 4 lists the rationale for exclusion and reference for each excluded article.

**Results**

The 14 reviews concluded that a statistically significant association between nurse staffing and patient outcomes was demonstrated in many primary studies, which indicates a trend toward improved patient outcomes with increased nurse staffing. However, two major themes arose: variability in methods and overall inconsistency of results across
primary studies. Inconsistencies led authors of reviews to deem the evidence on the topic inconclusive. Authors were uncertain whether the inconsistency in findings was due to methodological variability or due to a true lack of a statistically significant association between nurse staffing and patient outcomes (Blegen, 2006, p. 119; Lake & Cheung, 2006, p. 671). Inconsistency and inconclusiveness of results have inhibited translation of findings into clinically meaningful recommendations, which has caused knowledge on this topic to stall in recent years.

Rather than repeating findings on specific nurse staffing and patient outcomes data, this meta-review will synthesize the review articles’ findings related to the reasons for inconsistency and/or inconclusiveness across primary studies, which have been categorized as being related to theory, research design, statistical analysis, or significance.

Theory

Establishing the theoretical basis for relationships among variables at the outset of a study is essential for providing clarity to the study’s purpose, findings, and policy recommendations at the study’s end (Polit & Beck, 2004, p. 49). Four articles presented a theoretical framework or discussed use of one for assessing the relationship between nurse staffing and patient outcomes (Kane et al., 2007; Lake & Cheung, 2006; Needleman, Kurtzman, & Kizer, 2007; Unruh, 2008), while 10 did not (Blegen, 2006; Curtin, 2003; Dimick, 2005; Garretson, 2004; Garrett, 2008; Heinz, 2004; Hugonnet et al., 2004; Hyun, Bakken, Douglas, & Stone, 2008; Lang, Hodge, Olson, Romano, & Kravitz, 2004; Mamaril, Sullivan, Clifford, Newhouse, & Windle, 2007). Lack of theoretical focus contributes to differences in variables and methods chosen across
primary studies, leading to inconsistency of and difficulty in interpretation of results (Lake & Cheung, 2006, p. 671).

**Research Design**

Three aspects of research design were identified as contributing to inconsistency and/or inconclusiveness of results across primary studies, including use of observational design, the unit of analysis on which the variables were measured, and limitations in the operationalization of nurse staffing variables.

**Observational Design.** Among the research designs available to investigators, the randomized controlled trial (RCT) is considered the highest level of evidence to support a causal relationship among the variables studied (Polit & Beck, 2004, p. 179-180). The effect of nurse staffing on patient outcomes does not lend itself to RCT methods and thus researchers are limited to observational and descriptive designs. Observational and descriptive designs can assess associations among variables, but evidence of association is not sufficient to establish causation (Kane et al., 2007, p. 97).

Despite several studies’ findings of statistically significant inverse correlations between nurse staffing and patient outcomes, observational designs do not allow researchers to conclude that increased nurse staffing causes improvements in patient outcomes (Kane et al., 2007, p. 96; Needleman et al., 2007, p. 17S). Results based on associative relationships are difficult to extrapolate into specific nurse staffing policy recommendations because it is unclear whether adding more nurses, not to mention the ideal number of nurses to add, rather than improving staffing along with a combination of other variables, will result in better patient outcomes, thus leading to inconclusive results.
**Unit of Analysis.** Another component of research design is determining the unit of analysis for both data collection and testing of variables, in this case, patient-, unit-, or hospital-level data. What is evident from these review articles is the trade-off between internal and external validity when selecting the unit of analysis for the variables being studied. For example, multi-unit and multi-hospital samples are strong on external validity, or generalizability to other settings, but weak on internal validity because the use of large databases for data collection results in the inability to manipulate the data, choose how variables are measured, or assure consistency in measurement (Kane et al., 2007, p. 93). Data are as good as the systems that collect them and investigators rarely have the opportunity to provide input on how the data are collected or manipulate the data within the already-established systems, thus reducing the ability to use standardized measures.

Alternatively, unit-based studies typically have strong internal validity because investigators can generally decide how to measure and collect data on the variables of interest, but weak on external validity because setting-specific differences make the results less generalizable, especially if the data come from a single unit or a single hospital (Heinz, 2004, p. 45). Inconsistencies across unit-level studies were also due to the use of uniquely-defined variables for each study in lieu of standardized definitions and the fact that data on patient outcomes were collected at different time points than nurse staffing information, making it difficult to interpret the impact of staffing changes on patient outcomes (Blegen, 2006, p. 110, 113; Hyun et al., 2008, p. 152). Unit-level data are often expensive and labor-intensive and there is difficulty obtaining data on patients who move from unit to unit during their hospital stay (Needleman et al., 2007, p.
18S). Thus, differences in the level of analysis of study variables was another contributor to inconsistency of results.

**Definitions of Nurse Staffing.** The dependent variables, patient outcomes, were fairly straight-forward for researchers to measure because outcomes were typically measured as rates of patient outcome events that occurred during a given time period. Nurse staffing, the independent variable, is more difficult to operationalize and authors used several different measures, including the proportion of nursing staff that consisted of RNs (skill mix) (Lang et al., 2004, p. 328); licensed hours or full-time equivalents (FTE) per patient day, RN proportion of licensed staff, number of patients assigned to specific nurses (Lake & Cheung, 2006); number of patients cared for by one nurse per shift, FTE per 1,000 patient days, FTE per occupied bed, HPPD, and quartiles of total nursing hours per patient day (Kane et al., 2007). In summary, nurse staffing was measured as either a nurse-to-patient or nurse-to-bed ratio, by hours of nursing care provided during a defined time period, or proportion of staff that consisted of RNs.

There are several limitations to measurement of nurse staffing in this manner. HPPD are averages, thus much information is lost in terms of the variability in staffing from unit to unit (Kane et al., 2007, p. 94). Hours also do not specify direct versus indirect patient care and vacation or sick time, or describe the mix of hours of care provided by RNs versus unlicensed personnel (Heinz, 2004, p. 49; Kane et al., 2007, p. 11). Neither ratios nor HPPD accounts for variation in patient acuity (severity of illness and/or nursing intensity) or for variation in RN education, experience, competence, and other variables such as burnout, dissatisfaction, and intention to leave, all of which potentially affect the quality of nursing care being provided to patients (Kane et al., 2007,
Blegen points out that “…it is difficult to translate specific hours or proportions for all nurses employed in the hospital as a whole to recommendations for staffing patient care units with direct care RNs” (Blegen, 2006, p. 107) and there is wide variation in how nurse staffing is defined and measured, which makes comparisons across studies difficult (Blegen, 2006, p. 109; Heinz, 2004, p. 45). The measures currently used are based on time or numbers of people, which do not capture what nurses do or how/why the roles of nurses affect patient outcomes. This lack of standardization across studies and overall paucity of richer variables that specifically describe the role of the nurse and the processes of care that contribute to improved patient outcomes are additional reasons why results from these reviews have been inconclusive.

Statistical Analysis

One of the statistical assumptions that must be met prior to use of regression analysis is that the independent variables vary in a linear fashion (Field, 2005). Lang, et al. (2004) noted that many primary study authors inappropriately utilized linear regression techniques on non-linear data, which has the unintended effect of inaccurately estimating the effect of nurse staffing on patient outcomes. Kane found that mortality decreased with improved nurse staffing, but in a non-linear fashion (Kane et al., 2007, p. 92). Methodologically, this means that prediction of number of lives saved or number of infections prevented, among other outcome variables, based on linear regression analyses will not be precise when estimated from nonlinear data, thus making policy and staffing recommendations from these data unclear.
Significance

One of the largest primary studies included data from 799 hospitals (Needleman, Buerhaus, & Mattke, 2002). With that large a sample size, one can expect statistical significance to occur with smaller effect sizes, at which point special attention to clinical significance needs to be paid. Results of primary studies often did not report clinical significance or effect size, the amount of change in patient outcomes that occurred as a result of changes in nurse staffing (Lang et al., 2004; Lake & Cheung, 2006, p. 673; Unruh, 2008, p. 65-66). When clinical significance was described, it was often in reference to the nurse staffing variable, rather than patient outcomes variables. For example, two review authors discussed that a 10% difference in staffing level paired with a “substantial change” in a patient outcome was deemed clinically significant, but the authors did not define what “substantial change” meant (Kane et al., 2007; Lang et al., 2004). Lack of specification of the clinical significance of results is another reason for the inability to provide clinically meaningful recommendations from results of studies.

Discussion

The following discussion will focus on directions for future research, based on the results and recommendations of the 14 reviews. Recommendations are to focus on: 1) establishing the theoretical basis for the expected relationships between nurse staffing and patient outcomes; 2) developing and validating process of care variables, along with richer nurse staffing variables, that help explicate the relationship between structures and outcomes of care; 3) establishing strong internal validity of single-unit studies using standardized measures of all study variables; and 4) exploring new perspectives in
relation to promotion of positive patient outcomes and prevention of negative outcome occurrences. Examples of each recommendation are provided below.

Donabedian’s structure-process-outcomes theory (Donabedian, 2003) is the overarching theoretical framework for this meta-review. Of the systematic reviews that discussed theoretical frameworks, Kane (2007) and Lake (2006) described in great detail how structural variables such as nurse staffing affected the patient outcome variables, but there was a lack of focus on process variables. This is pervasive throughout the literature, as currently smoking cessation counseling is the only nursing-sensitive process measure with an established and validated evidence base as being connected to patient outcomes that has been endorsed by the National Quality Forum (NQF, 2004b).

Examples of nursing-level process of care variables are nursing workload and staff nurse care coordination, but there are few if any instruments available at this time that reliably and validly measure either concept (Unruh, 2008, p. 63; Lamb, 2008). Development and validation of these and other process variables are areas for ongoing and future research.

Structural variables that measure nurse staffing are currently limited to data in the form of hours or ratios. Rather than operationalizing nurse staffing as hours or ratios, future research should focus on a broader definition such as “nurse resources” that can be operationalized into both structure and process categories according to who the nurses are (education, years of experience, credentials, etc), what the nurses do or the specific actions they take that affect patient care (coordination, surveillance, critical thinking and decision-making), as well as how many are available. Tschannen and Kalisch (2009, p. 168) recently reported similar recommendations by proposing that future research focus on process variables, especially given that nurses are the coordinators of care who
monitor patients’ progress in hospitals and promote restoration of optimal patient functioning, and indicate the importance of nurse levels of education and experience to meet patient safety and outcome goals. Development of richer nurse staffing variables that capture more of “what nurses do” will assist researchers in determining how nurses contribute to the enhancement of patient safety and improvement of patient outcomes.

Holzemer’s Model for Health Care Research, based on Donabedian’s theory of quality of care, serves as the conceptual model for this meta-review and is appealing in this regard because of its specific focus on patient-, provider-, and system-related structures and processes that affect patient outcomes (Holzemer & Reilly, 1995). Mitchell’s Quality Health Outcomes Model incorporates Donabedian’s and Holzemer’s work and postulates that system- and client-specific characteristics mediate and moderate the relationship between interventions and outcomes (Mitchell & Lang, 2004, p. II-5). Donabedian’s theory and Holzemer’s and Mitchell’s models are examples of frameworks that provide the foundation for the theoretical basis of the relationship between nurse staffing and patient outcomes. Replication of studies that utilize these frameworks will enhance comparison of results across studies.

Future research should initially focus on limiting external validity in favor of internal validity through the design of unit-based studies that establish the evidence-base for the specific roles that nurse staffing variables play in affecting patient outcomes, while taking into consideration other structure and process variables. Lake provided an excellent example of the clarity that unit-based studies can provide in citing Krauss’ case-control study of nurse and patient dyads. Krauss demonstrated that the likelihood of a patient falling was 3 times higher for patients whose nurse was caring for 4 to 6 patients.
and was 7 times higher for patients whose nurse was caring for 7 or more patients, as compared to patients whose nurse was caring for 3 or fewer patients (Lake & Cheung, 2006, p. 673-674). The clinical significance is clear because patient and nurse staffing variables were both measured on the unit level, thus providing contextual relevance through focusing on staffing situations. Research designs that study only hospital-level data lose the specificity of what is occurring on the situation level on specific nursing units. Unit-based studies will allow researchers to isolate the variables that are clinically and statistically significant in a particular nursing care environment. Eventually, replication of highly internally valid unit-based studies can lead to larger, multi-unit, multi-site studies that balance internal and external validity and can be translated into meaningful policy recommendations.

There are several new perspectives that apply to future research in this area. One is focusing on positive patient outcomes, in terms of demonstrating the positive, protective, and preventive effects of nurse staffing on patient outcomes, rather than describing the negative effects on patient outcomes that occur with reduced nurse staffing (Blegen, 2006; Kane et al., 2007, p. 95). Mitchell’s Quality Health Outcomes Model focuses on five positive patient outcome categories that are hypothesized to be sensitive to nursing care, including achievement of appropriate self-care, demonstration of health-promoting behaviors, health-related quality of life, perception of being well cared for, and symptom management (Mitchell & Lang, 2004, p. II-5). This idea of selecting outcomes and working backwards to develop processes and structures of care that will promote positive outcomes and prevent negative outcomes is highlighted in the recently updated NQF initiative on the identification of “never events,” or preventable serious
adverse events and the promotion of safe practices for preventing patient harm (NQF, 2006). This is an opportunity for nurse researchers to isolate nursing interventions that enhance positive patient outcomes and prevent adverse outcomes and provide recommendations accordingly. In a way, these new perspectives move the research on this topic from that of effectiveness, or descriptions of the actual relationship between nurse staffing and patient outcomes in current healthcare settings, to that of efficacy, or exploring the ideal conditions under which the maximum benefits for patient care are achieved (Aday, Begley, Lairson, & Balkrishnan, 2004, p. 67).

Instead of researching the effect of increased nurse staffing on patient outcomes, which may be unrealistic given financial constraints during the current economic recession, another new perspective is to focus research efforts on efficient use of the available nursing staff (e.g., staffing assignments based on patient acuity). Research on this perspective will potentially provide clear policy recommendations for the utilization of nurses in inpatient settings and serve as another nursing-level process variable for testing the link between structures and outcomes of care.

**Conclusion**

We recommend repetition of theoretically sound, single-unit studies using standardized structure, process, and outcome variables followed by gradual expansion to multi-unit and multi-site studies, in order to build the evidence-base for the relationship between nurse staffing and patient outcomes, while taking into consideration other pertinent relationships. Cost-effectiveness and cost-benefit analyses, as well as exploration of similarities and differences among results from international settings, are important next steps after the initial development and validation of nursing-specific
structure and process variables. The end goal is to identify the variables and conditions that result in clinically and statistically significant improvements in patient outcomes and translate findings into realistic, practical, clear policy recommendations specific to various inpatient populations.
Tables & Figures

1. 70 review articles retrieved from electronic literature search. All abstracts were reviewed and categorized as being SR or ROL.

2. Full text of 12 included studies read and quality assessment conducted.

3. Full text of 16 unclear studies read.

Figure 1. Flow diagram of study selection process

Table 4. Excluded Articles and Rationale

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Rationale for Exclusion</th>
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<tr>
<td>Aiken, 2008; Aydin et al., 2004; Baernholdt &amp; Lang, 2007; Caton &amp; Klemm, 2006; Chang et al., 2006; Cho, 2001; Clarke, 2007; Diers &amp; Bozzo, 1997; Hall, 1997; Horn, 2008; Kutney-Lee &amp; Aiken, 2008; Lake, 2000; Lin &amp; Liang, 2007; Manojlovich &amp; Sidani, 2008; Needleman, 2008; Newbold, 2008; Peck et al., 1997; Riehle et al., 2007; Rischbieth, 2006; Shirey, 2006; Smith-Stoner &amp; Markley, 2007; Sochalski et al., 1997; Taylor, 2008; Van den Heede et al., 2007</td>
<td>Not a SR or ROL</td>
</tr>
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<td>Bolton et al., 2007; Charney &amp; Schirmer, 2007; Clegg et al., 2001; Duffy, 2002; Hwang &amp; Herndon, 2007; Joseph, 2007; Kollef, 1998; Rebmann, 2008; Ridley, 2008; Robnett, 2006; Srivastava et al., 2008; Storch, 2005</td>
<td>Did not focus on nurse staffing</td>
</tr>
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<td>Carayon &amp; Gurses, 2005; Currie et al., 2005; Curtin, 2007; Gerdtz &amp; Nelson, 2007; Richardson, 1999; Sheward et al., 2005; Shullanberger, 2000; Thungjaroenkul et al., 2007</td>
<td>Did not focus on patient outcomes</td>
</tr>
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<td>Ayre, Gerdtz et al., 2007; Cheung et al., 2008; Clarke et al., 1999; Duffield et al., 2006; Haesler et al., 2008; Lankshear et al., 2005; Schubert et al., 2005; Scott-Cawiezell &amp; Vogelsmeier, 2006; West et al., 2007</td>
<td>Setting was not U.S. or acute care</td>
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<td>Butler, et al., 2008</td>
<td>Pending completion</td>
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Chapter IV

The Oncology Acuity Tool: A Reliable, Valid Method for Measuring Patient Acuity for Nurse Assignment Decisions

Preface

This chapter presents the third manuscript to be submitted for publication to Nursing Research. This manuscript provides a brief summary of the background on acuity measurement, the methods and results of the dissertation study, which entailed a psychometric assessment of the Oncology Acuity Tool (OAT), as well as a discussion of the results and study limitations.
Abstract

Background: Nurse managers, hospital administrators, and legislators are seeking recommendations for the best methods for determining nurse staffing in inpatient settings, but evidence on the most effective strategies is lacking.

Objectives: The aim of this study is to assess the psychometric properties of the Oncology Acuity Tool (OAT), a patient acuity tool currently being used on an inpatient unit for determination of nurse assignments every shift.

Method: Inter-rater reliability and concurrent validity were assessed via surveys of current RN-users of the acuity tool and content validity data were collected from expert oncology nurses. Predictive validity data were collected by tracking patients who sustained either of two acute events.

Results: The OAT demonstrated high inter-rater reliability (ICC=0.953, CI 0.914, 0.977; p<0.001), moderately strong concurrent validity (r=0.578, p=0.01), high content validity (70% of acuity items had an item-level content validity index ≥ 0.78; scale-level content validity index=0.82; 84% of items had kappa statistics (k*) of good [k*=0.6-0.74] or excellent [k*>0.74]. Acuity scores during the shift of the acute event were significant predictors of one of the events (OR=2.25, CI 1.45, 3.48; p<0.001), as were acuity scores during the shift prior to the acute event (OR=1.75, CI 1.21, 2.54; p=0.03).

Discussion: These data indicate that the OAT is a psychometrically sound instrument that demonstrates high reliability and validity for measuring acuity prospectively in this inpatient population. Future research should focus on developing acuity tools for other inpatient populations and assessing whether acuity-based staffing decisions result in better patient outcomes, compared to other staffing models.
Key Words: Nurse's Practice Patterns, Hospital Nursing Staff, Health Services Needs and Demand
Recent patient safety initiatives have revealed high rates of errors in hospitals and have proposed six aims for patient care: that it is safe, effective, patient-centered, timely, efficient, and equitable (IOM, 2001a & b). These initiatives have motivated a variety of stakeholders, including health care providers, researchers, payors, legislators, and consumers, to focus their efforts on understanding the best methods for minimizing errors and maximizing safety, in order to achieve high quality, cost-effective care.

A major factor affecting health care providers’ ability to ensure quality care of patients in hospitals is the balance between the supply of adequately-trained providers and the demands of patient care. Historically, supply and demand have not been in balance, primarily related to workforce shortages. These shortages have been associated with increases in patient acuity and new services and technologies available to patients (Dumpe, Herman, & Young, 1998). Most recently, as a result of the economic recession, demand for nurses has decreased as hospitals tighten their budgets, while the supply of nurses has increased as nurses work more hours or delay retirement in order to maintain a stable income for their families, thereby relieving the shortage of nurses in the hospital setting in the short-term (Buerhaus, 2009). Buerhaus (2009) also states that many economists have declared that the recession has ended and predicts that many RNs will exit the workforce as the economy stabilizes, thus increasing the demand for nurses and potentially leading to another shortage if the number of new graduates cannot keep pace with demand.

Some aspects of supply and demand, such as patients’ presenting conditions and the availability of nursing staff, cannot be controlled in the short-term. Given this, the focus of improving quality must be the local processes that can be managed or
manipulated and the efficient use of available nurse resources (Chin & Muramatsu, 2003). A key process that can be manipulated is the assignment of nurses to patients, or the allocation of nurse resources to meet demands of patient care. A primary feature of the assignment process is the ability to accurately assess the demands of patient care in a quantitative manner, via the measurement of patient acuity. The problem addressed in this study is the need for a valid and reliable method to measure acuity, in order to test acuity as a process of care variable in future research that focuses on the effect of acuity-based staffing decisions on quality of care.

Background

A steady increase in patient acuity in the inpatient setting over the past two decades is well documented in the health sciences literature (Aiken, Clarke, & Sloane, 2002; Unruh, 2003). Nurses on inpatient units are experiencing workload increases from the demand side. Patient care needs are more complex, due to rising patient acuity and advances in diagnostic and treatment capabilities (Aiken, Clarke, & Sloane, 2002; Heinz, 2004). Although the number of employed nurses continues to rise, both overall and in hospital settings specifically, an aging nursing workforce and high turnover in hospitals are contributors to supply-side workload increases (Bureau of Labor Statistics, 2010). This situation of increased demand for nursing care services and a less stable supply to meet that demand is expected to worsen as baby boomers age and a significant portion of the RN workforce retires (Buerhaus, Staiger, & Auerbach, 2000). Increasing complexity of illness of patients in the context of the current nursing shortage and a heightened focus on cost control efforts highlight the importance of having a reliable method to allocate the
available nursing staff effectively and efficiently, which requires accurate assessment of acuity.

Several types of acuity tools have been proposed in the health sciences literature over the past three decades and their use varies widely. For example, acuity tools have been used for making budget projections, for analyzing hiring practices, and for tracking patients’ progress throughout an inpatient hospital stay (Van Slyck & Johnson, 2001). Historically, acuity tools have focused on the time required to complete nursing care activities (Adams-Wendling, et al, 2007; Chabot & Fox, 2005; Jones, Cusack, & Chisolm, 2004; Walts & Kapadia, 1996) or differences in nursing care needs by diagnosis-related group categories (Knauf, Ballard, Mossman, & Lichtig, 2006). Most authors have not reported reliability and validity assessments. Criticisms of the use of patient acuity for nurse staffing decisions have included concerns about the potential biases of ratings (both the tendency of raters to inflate patient acuities in order to increase staffing and managers’ tendency to deflate ratings to decrease staffing) and weak predictive power of acuity tools in assessing staffing needs and personnel costs (DeGroot, 1994; Shaha & Bush, 1996; Strickland & Neely, 1995). These criticisms can be addressed by conducting rigorous research that identifies the theoretical basis for use of acuity for staffing decisions, that clearly defines acuity, and that establishes the reliability and validity of tools that measure acuity.

For the purposes of this study, Brennan and Daly’s definition of acuity was used, which incorporates both a severity of illness attribute, reflecting the physical and psychological status of the patient, and an intensity attribute, reflecting the nursing care
needs and corresponding workload and complexity of care required by a patient or group of patients (Brennan & Daly, 2009).

**Purpose and Theoretical Background**

Holzemer’s Model for Health Care Research, based on Donabedian’s Structure, Process, Outcome Theory, served as the theoretical foundation of this study (Donabedian, 2003; Holzemer & Reilly, 1995). Nurse staffing decisions, made in part through the use of patient acuity measurements, have the potential to efficiently allocate available nursing staff according to patients’ nursing care needs, thereby balancing nursing workload, and thus theoretically leading to improved patient outcomes.

The overall purpose of this study was to determine the psychometric properties of the Oncology Acuity Tool (OAT), a patient acuity tool currently in use on an inpatient hematology/oncology/bone marrow transplant unit in a metropolitan hospital located in the Midwest United States. Specific research questions were: 1.) What is the inter-rater reliability of the OAT? 2.) What is the content and concurrent validity of the OAT? 3.) What is the predictive validity of the OAT, as measured by its relation to patient falls and acute event (“code white”) consultations? 4.) Are there statistically significant differences in acuity by patient diagnosis type (hematology, oncology, bone marrow transplant) or by shift (day, evening, night)?

The “code white” team, also known as a rapid response team (Shapiro, Donaldson, & Scott, 2010), is made up of intensive care unit nurses who can be called for a consult by any nurse or care provider who thinks his or her patient is unstable and may need additional interventions or treatments to prevent a full “code blue” (cardiac arrest) or to facilitate a controlled (versus emergent) transfer to the ICU. Diagnosis types refer
to patients with a non-cancerous hematologic disorder (sickle cell anemia or thrombolytic thrombocytopenic purpura), an oncology diagnosis (liquid or solid tumor without having received a bone marrow transplant), or recipients of a bone marrow transplant.

The study model presented in Figure 2 is an adaptation of Holzemer’s Model for Health Care Research and proposes that reliable and valid measurements of acuity will theoretically depict one or more of the attributes of acuity (patient- and/or nurse-related) identified by Brennan and Daly (2009), potentially provide the ability to assess differences in acuity by patient diagnosis and nursing shift, and predict patient outcomes (falls and code white consults). A dotted line surrounds “acuity-based nurse assignments” because this study does not test acuity as a process of care measure. Rather, the nurse-level process of matching acuity scores with the available nursing staff is standard practice on the unit where the study took place.

Methods

Setting & Acuity Tool

A group of staff nurses and nurse managers developed the patient acuity tool approximately twenty years ago as one aspect of determining nurse assignments every shift. A few informal inter-rater reliability assessments were conducted during the past twenty years, but no other psychometric testing has occurred and no reports have been published. During every shift, staff nurses use the acuity tool to rate each of their patients’ nursing care needs prospectively for the next eight-hour shift. Charge nurses use the acuity data to make nurse assignments for the next shift in a primary nursing model. The acuity tool underwent revisions in September, 2009 led by the unit’s acuity
committee, which is made up of staff nurses and advanced clinical nurses from the unit. Table 5 presents the revised acuity tool.

Acuity is measured by choosing the level of care (columns) required for each patient according to each nursing care dimension (rows). The levels of care hold a value of 0, 1, 2, or 3 points for each of 10 dimensions and the total acuity is an aggregate of the scores of each dimension. Each dimension is scored according to the highest level of demand. For example, if a patient possesses a care need in both the “2” and “3” columns for the safety dimension, the patient would receive 3 points for safety. Three out of the 10 dimensions have a range of only 0-2 points and thus the potential total acuity score for a patient ranges from 0 to 27 points, although most scores are in the 2 to 14 range. Higher acuity scores indicate more nursing care required, while lower acuity scores indicate less nursing care required for a specific patient during a given eight-hour shift.

Data Collection & Data Analysis Procedures

The study was approved by the hospital’s Cancer Center Institutional Review Board (IRB) in July, 2009. Because acuity data were linked to specific nurses and the data were not completely anonymous, informed consent of nurses was obtained. The researcher approached every nurse (N=51) employed on the unit (full-time, part-time, and PRN) during the study period and explained the study purpose and procedures and other consent form content. Nurses who were willing to participate returned consent forms and an anonymous demographics survey in locked boxes on the unit. Nurses who agreed to participate received a copy of their consent form and the original was kept on file in the researcher’s office. A waiver of informed consent for patients on the unit was obtained from the IRB.
SPSS version 17 and MedCalc version 11 were used for reliability analyses. SPSS version 17 was used for all validity analyses.

**Reliability.** Assessment of inter-rater reliability (IRR) focused on the consistency of acuity scores across nurse raters who evaluated the acuity of the same patient at the same time. In order to ensure that each rater had access to the same information, assessment of IRR occurred via case study format. Case studies created from actual patient data have been used in previous research, including for the assessment of IRR of a scale (Bowles, et al, 2009; Endicott, Tracy, Burt, Olson, & Coccaro, 2002).

The researcher wrote 25 case studies based in part on chart reviews of actual patients admitted on the unit. The case studies were reviewed by a senior nurse on the unit to verify that the cases were reflective of patients cared for in “real life” on the unit. Twenty randomly-selected nurses were asked to rate the acuity of 6 patient case studies prospectively for the next shift, in a similar fashion to how acuity is rated as standard practice on the unit. Nurses completed case studies for shifts they normally work, during a regularly scheduled work day during November, 2009. Nurses who participated were compensated for their time with a $5 gift card to the hospital coffee shop.

The researcher entered the data into SPSS and a research assistant entered a random sample of 10% of the cases in order to check data entry for errors. There was 97% agreement between the researcher’s and the research assistant’s entries and any errors found were corrected.

IRR of total acuity scores was assessed via an intraclass correlation coefficient (ICC), which has been recommended by Kottner and Dassen (2008, p. 1243) as an appropriate statistical test for assessing IRR of clinical measurements, as long as there is
adequate true variance in the subjects being rated. The range of acuity scores of the case studies were purposely written to achieve high variance across scores, with a range of 2 to 18 acuity points. Acuity scores were deemed reliable in this sample if the ICC was ≥ 0.7 (Walter, Eliasziw, & Donner, 1998).

Validity

Content Validity. The researcher surveyed a group of expert oncology nurses at a monthly meeting of the local chapter of the Oncology Nursing Society on September 16, 2009. Experts were given a definition of acuity and were asked to rate each intervention in the acuity tool as “not relevant,” “somewhat relevant,” “quite relevant,” or “very relevant” to the definition of acuity. Raters were asked to state their rationale for any items they rated “not relevant” or “somewhat relevant.” An item-level content validity index (I-CVI), a scale-level content validity index (S-CVI), and a modified kappa statistic (k*), to determine the probability of chance agreement, were calculated for the purposes of assessing content validity (Polit, Beck, and Owen, 2007). Recommended cut points for I-CVI and S-CVI scores are ≥ 0.78 and > 0.8 (Polit, Beck, & Owen, 2007, p. 467), respectively, and recommended evaluation of k* scores are fair (0.4-0.59), good (0.6-0.74), and excellent (>0.74) (according to Cicchetti & Sparrow, 1981 & Fleiss, 1981 as cited in Polit, Beck, & Owen, 2007, p. 467).

Predictive Validity. Similar to the approach used by others, predictive validity of the acuity tool was assessed by testing whether acuity scores predicted patient falls and patient code white events (Mathews, et al., 2008). Acuity scores can theoretically predict patient falls because as acuity scores rise and patients become more dependent on the nursing staff for mobility and activities of daily living, they are also at higher risk for
falling. In addition, fall rates were a clinical problem of interest on the unit where the study took place and thus we had the opportunity to study whether acuity scores predicted falls. For code white consults, theoretically, as patients’ acuity scores rise, their severity of illness and need for more intensive therapies increase and indicate the potential need for additional interventions, reflected in the need for a code white consult.

The researcher tracked patient falls and code white consults from November 1, 2009 through January 31, 2010. For every patient who sustained an event, two patients of similar diagnosis type (hematology, oncology, or bone marrow transplant) were randomly selected to serve as matches.

Logistic regression analyses were conducted with the patient event (fall, code white consult) as the dependent variable and the acuity score for the shift of the event and the acuity score during the shift prior to the event as the predictor variable in four separate regression models. No covariates were included in the models, as the purpose was to test predictive validity of the acuity tool, not to test a predictive model of all factors that influence falls and code white consults.

**Concurrent Validity.** Concurrent validity is the “ability to detect a statistical relationship between two instruments simultaneously measuring the same concept at the same time” (Higgins & Straub, 2006, p. 25). Data collection took place from January 1-March 8, 2010. Nurses were asked to rate each of his or her patients’ acuities on a visual analog scale (VAS), which served as a second instrument to measure patient acuity. These scores were compared to acuity ratings that were made on the acuity tool, according to standard practice on the unit. Statistical analysis occurred through
calculation of a Pearson r correlation between the acuity tool score and the VAS measure of acuity.

**Descriptive Data.** Acuity scores were collected for every shift for every patient admitted to the unit from January 1-31, 2010. Differences in patients’ first, lowest, and highest acuity scores, as well as differences between highest and lowest acuity scores, and total number of acuity scores, were assessed according to diagnosis type and shift via Analysis of Variance (ANOVA) tests. A Bonferroni correction was used for multiple group comparisons for diagnosis type and shift.

**Results**

**Sample/Demographics**

All 51 staff nurses agreed to participate. However, one nurse transferred to a position in the outpatient setting and another nurse was on a family medical leave of absence during the study period. Thus, the final sample consisted of 49 staff nurses, each of whom received a $20 gift card at the end of the study period as compensation for their time. Table 6 presents nurse demographic data. Patients admitted to the unit during the study period were age 18 years or older (adult population) with a length of stay ranging from 1-31 days. Patients without a hematology, oncology, or bone marrow transplant diagnosis who were admitted to the unit because no other bed was available in the hospital were excluded from the analysis because the acuity tool was not designed for non-cancer diagnoses.

**Inter-Rater Reliability**

As previously described, 20 randomly-selected nurses each rated the acuity of 6 patient case studies, which yielded between 4 and 6 acuity ratings for each of the 25 case
studies. Since raters for each case were selected at random, the ICC was calculated via a one-way random effects model. By default, both SPSS and MedCalc software are programmed to conduct listwise deletion for any case that has fewer than the highest number of replications of the measurement, which would have resulted in the deletion of all cases with fewer than 6 replications and a sample size of N=11 instead of N=25. Thus, the researcher randomly removed acuity scores from the database so that each of the 25 case studies had 4 replications of acuity scores to ensure that all 25 cases were included in the analysis. The ICC for IRR was 0.953 (0.914, 0.977), p<0.001.

Validity

Content Validity. A total of 17 experts completed surveys. One respondent was excluded from the analysis due to missing data. Another respondent was excluded because she is retired and the goal was to survey nurses currently working in the oncology specialty area. The final sample was N=15 expert raters. Nurse demographics for content validity are provided in Table 7. I-CVI ratings ranged from 0.46-1.0. Forty-five out of the 64 items (70%) in the acuity tool had an I-CVI ≥ 0.78. The S-CVI was 0.82. Kappa statistic results were as follows: 4 items (6%) were poor (k* of <0.4), 6 items (9%) were fair (k* of 0.4-0.59), 9 items (14%) were good (k* of 0.6-0.74), and 45 (70%) items were excellent (k* of >0.74).

Predictive Validity. Eleven patients sustained a fall and 26 patients had a code white consult during the study period. Mean acuity scores both during the shift of the event and the shift prior to the event for patients who fell were higher than patients who did not fall, but these differences did not achieve statistical significance (6.00 versus 5.55, p=0.295 and 6.30 versus 5.95, p=0.517). Mean acuity scores during the shift of the
event for patients who had a code white were significantly higher than mean acuity scores for non-code white patients (7.00 versus 5.38, \( p<0.001 \)). Mean acuity scores during the shift prior to the event for patients who had a code white were also significantly higher than mean acuity scores for non-code white patients (6.70 versus 5.43, \( p=0.001 \)). Table 8 presents the logistic regression results.

**Concurrent Validity.** Table 9 provides a summary of patient diagnosis type and shift data for concurrent validity. The final sample included 128 independent measurements of patient acuity (one rating per patient) collected on the VAS from all 49 nurses who consented to participate in the study, with each RN rating one to four patients. The Pearson \( r \) correlation between the score rated on the acuity tool and the VAS was 0.578 (\( p=0.01 \)). A Pearson \( r \) correlation was also run on 49 randomly-selected RN ratings (one rating per RN) of independent patients (one rating per patient) and the results were \( r=0.506 \) (\( p=0.01 \)).

**Descriptive Analysis**

One hundred and seventeen patients were admitted to the unit during the month of January, 2010. Descriptive data for first, highest, and lowest acuity scores, as well as differences between highest and lowest acuity scores, are presented in Table 10. Results from separate one-way ANOVA models are presented in the Appendix. BMT patients had significantly higher first acuity scores than hematology or oncology patients (6.30 versus 5.29, \( p=0.001 \); 6.30 versus 5.59, \( p=0.01 \)). BMT patients’ highest acuity scores were significantly higher than hematology or oncology patients (8.40 versus 6.75, \( p<0.001 \); 8.40 versus 6.88, \( p<0.001 \)). There was a statistically significant difference in patients’ lowest acuity scores by diagnosis type for the overall ANOVA analysis, but
multiple group comparison analyses demonstrated no significant difference among diagnosis groups (4.33 for BMT, 3.75 for hematology, 4.20 for oncology). BMT patients had significantly higher differences between the highest and lowest acuity ratings compared to hematology and oncology patients (4.07 versus 3.00, p<0.001; 4.07 versus 2.68, p<0.001). First acuity ratings on day shift were significantly higher than night shift (6.00 versus 5.45, p=0.051). There were no differences in highest acuity scores by shift (7.08 for day, 7.35 for evening, 7.26 for night). Lowest acuity ratings on evening shift were significantly lower than day shift (3.63 versus 4.42, p=0.018).

Discussion

These data indicate that the acuity tool is a psychometrically sound instrument that demonstrates high reliability and validity for measuring acuity prospectively in the hematology/oncology/bone marrow transplant inpatient population. Specifically, in relation to reliability, an ICC of 0.953 with a narrow confidence interval and a statistically significant p-value provides strong evidence of high IRR of the acuity tool. While the tool overall demonstrated content validity, some individual items did not reach our pre-determined cut-points. For example, 19 of the 64 possible interventions in the tool (30%) had I-CVI ratings of <0.78. Twelve of these items were acuity level “1” and 7 of these items were acuity level “2.” Similarly, 4 of the 64 items received a “poor rating” for k* (<0.4), of which 3 were acuity level “1” and 1 was acuity level “2.” Thus, experts perceived all of the level “3” acuity items and most of the level “2” items as relevant, but perceived some of the level “1” and “2” items, which represent more routine care needs, as less relevant to the definition of acuity. Experts’ rationale for items rated as “not relevant” or “somewhat relevant” included statements about the items not
being particularly complex or time-consuming, or that the items were not related to a serious safety issue, or that the items were part of daily duties or standard/expected nursing care. Although the definition of acuity provided to the raters included a general statement about nursing care needs of the patient, some of the experts perceived some of the routine nursing care items as not relevant to their understanding of acuity and perceived the items that reflected more complicated or complex care needs as more relevant to the definition of acuity. This indicates a discrepancy in how acuity is conceptualized by experts versus end-users of the tool. However, if the acuity tool is to capture all care needs, both routine and complex care needs must be included. One potential recommendation for modification of the OAT, or for future tools developed based on the OAT, is to eliminate the items that were deemed not relevant by experts during content validity assessment, condense the OAT into two columns instead of three, and give each patient a baseline of 2 acuity points to account for the “routine care” items. The end result is a more condensed, parsimonious tool that is better aligned with experts’ responses. This shortened instrument also would likely be associated with clinicians’ acceptance of the tool as reflecting both routine and complex care needs.

Concurrent validity testing resulted in a moderate and statistically significant association between the two instruments. One reason why the correlation between the two instruments was not higher may be related to the range of possible scores of the two instruments. The VAS ranged from 0-100 and included the written anchors, “lowest acuity” and “highest acuity.” Most scores on the OAT range from 2-14. Some respondents wrote the patient’s actual acuity score, as rated on the OAT, on the VAS. For example, an acuity score of 4 would be represented by a drawing a line at or near the
20% mark on the VAS, but some respondents drew the line on the VAS at the 4% mark. Making the anchors of both tools the same or using only word anchors instead of numerical ones may avoid this difference in interpretation of scale in future studies.

Acuity was a statistically significant predictor of code white consults, but was not a significant predictor of falls in this sample. As acuity scores increased, the odds of requiring a code white consult doubled for both the shift of the event and the shift prior to the event, with narrow confidence intervals, and statistically significant p-values. This is consistent with the usual association of severity or instability of patient condition with the need for more intensive therapies and interventions, reflected in the need for a code white consult. Falls occurred much less frequently than code white events during the study period and the lack of statistical significance is likely due to a small sample size. It is reasonable to hypothesize that patients who have a higher severity of illness and higher intensity of nursing care needs are more at risk for falling because of increased dependence on nursing staff for activities of daily living such as ambulation and general mobility. However, there are a number of other variables that influence whether or not a patient falls, such as age, mental status, and side effects of medications, which are not captured in this acuity measure. Future studies that focus on acuity as a predictor of falls may achieve more accurate results by including other covariates in the model, in order to measure the variance explained by acuity versus other factors. In addition, rather than using acuity scores to predict falls, future studies could focus on total nurse workload (the sum of acuity scores for all the patients for whom a nurse is caring) as a predictor of patient falls, similar to the case control methods used by Krauss, et al. (2005).
For the descriptive analysis, in terms of diagnosis type, BMT patients rated statistically significantly higher than hematology and oncology patients for the first and highest acuity scores and for the difference between highest and lowest acuity scores. While statistical significance was achieved by a p-value of less than or equal to 0.05, it is important to consider the clinical significance of the magnitude of the difference among acuity scores. The mean difference in first acuity scores by diagnosis type was approximately one acuity point and mean differences for highest acuity scores were approximately 2 points apart, which are not necessarily clinically significant on the patient level, but may be clinically significant at the unit level, in terms of making nurse assignment decisions that balance the nursing workload. For example, if a nurse is taking care of three patients and each patient is two acuity points higher than the other patients on the unit, the nurse’s total workload is 6 points higher than the other nurses’ workload. Thus, clinical significance is assessed by considering acuity on the nurse level, not the patient level.

In terms of shift, first acuity scores were significantly higher during day shift, with a difference in 0.55 acuity points. Lowest acuity scores were significantly lower during the evening shift, compared to other shifts, with a difference of 1 acuity point, which may reach clinical significance in terms of balancing workload on the nurse level.

In summary, results from the descriptive analysis demonstrated that BMT patients rate higher on the acuity tool than other patients, which is not surprising, given that BMT patients have very high nursing care needs and high severity of illness. There were no major differences in acuity by shift, which indicates that nursing intensity is not necessarily shift-dependent. Thus these data support the premise that patient acuity is less
likely to depend on the shift or time of day, and more likely to depend on nursing care needs related to other factors, such as changes in severity of illness, side effects or adverse reactions, and goals of care.

Although day shift is typically viewed as a “busier” shift than the evening or night shift, the contributors to this perception may have more to do with activities such as physician rounds, consults from multiple services such as occupational and physical therapy, social work, etc, as well as patients traveling to and from the unit for diagnostic tests, which all represent potential interruptions in nurses’ workflow and occur less often during evening and night shift. Thus, the solution on day shift may include adding more transporters or secretarial staff, rather than more nurses, to offset some the “busy-ness” that these non-direct care activities create on the unit.

Significance

The results of this study can contribute to both research and policy formation. The findings from this study can be used as a model for developing tools to assess acuity in other populations, tailoring the specific acuity measures to unique features of other patient groups. In addition, this acuity tool can be used in other oncology populations to test acuity as a structure and process variable in future studies examining the number and combination of resources that lead to optimum patient outcomes, in the most cost-effective manner. In terms of policy, currently several state legislatures are considering appropriate nurse staffing as a topic for legislation (Bergmann, 1999; Kovner & Heinrick, 2000; ANA, 2009). Implementing such laws may be problematic for hospital administrators because there is little evidence on the most effective nurse staffing plan for optimizing patient outcomes and there are few evidence-based tools available to measure
patient acuity. The method used here to establish reliability and validity of an acuity measure, tailored to the appropriate population, can be used to provide a sound basis for resource allocation.

**Study Limitations**

There are a number of limitations to the study. This tool was only tested on one inpatient unit, in one patient population, which limits the external generalizability of the study results. Use of a case study format for testing IRR may not reflect the reliability among raters during “real life” situations on the unit. As noted, there was a small sample size for fall events, thus limiting predictive validity. In relation to content validity, the difference in conceptualization of acuity between expert raters and end-users is an artifact that should be addressed in future studies, perhaps by providing examples of acuity use to the expert users in addition to the definition of acuity.

**Conclusion**

The OAT is a psychometrically sound instrument that demonstrates high reliability and validity for measuring acuity prospectively every shift for nurse assignment decisions in the inpatient hematology/oncology/bone marrow transplant population. Future research should focus on developing similar acuity tools for other patient populations and testing acuity-based staffing as a process of care variable using Holzemer’s Model for Health Care Research. In subsequent studies researchers can assess whether acuity-based staffing decisions on the unit and hospital level result in better patient outcomes, compared to other staffing models. Results will potentially translate into more salient nurse staffing recommendations for nurse managers, administrators, and legislators.
### Table 5. The Oncology Acuity Tool

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching</strong></td>
<td>-Reinforcement teaching</td>
<td>-New teaching of procedures, chemo protocols, or significant medication changes.</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Discharge teaching</td>
<td></td>
</tr>
<tr>
<td><strong>Treatments and Skin Care</strong></td>
<td>-Single tube care: i.e. CVC, chest tube, foley, G-tube, drains</td>
<td>-multiple tubes from category 1</td>
<td>-Multiple packed dressings, including stage 3 and 4 pressure ulcers</td>
</tr>
<tr>
<td></td>
<td>-Contact precautions</td>
<td>-Trach care</td>
<td>-Severe skin GVHD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Tube feedings</td>
<td>-Multiple bed changes per shift</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Multiple dressing to same site per shift</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>-Falls precautions</td>
<td>-Neutropenia</td>
<td>-Restraint monitoring</td>
</tr>
<tr>
<td></td>
<td>-Chemo precautions</td>
<td>-Thrombocytopenia</td>
<td>-Mental status changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-CIWA ≥ 6</td>
<td>-CIWA ≥ 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Neuro checks q4hours</td>
<td>-Uncontrolled active bleeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Special Medications</strong></td>
<td>-Continuous or low-dose chemotherapy</td>
<td>-Vesicant chemo through CVC</td>
<td>-Vesicant chemo through peripheral IV</td>
</tr>
<tr>
<td></td>
<td>-Uncomplicated Amphotericin product</td>
<td>-Subsequent doses of IVIG, ATG, without reactions</td>
<td>-Chemotherapy or biological with frequent vital signs</td>
</tr>
<tr>
<td></td>
<td>-Anticoagulant drip</td>
<td>-High-dose Chemo</td>
<td>-1st dose IVIG, ATG</td>
</tr>
<tr>
<td></td>
<td>-PCA monitoring</td>
<td>-Amphotericin product with rigrors</td>
<td>-Insulin gtt with CS</td>
</tr>
<tr>
<td><strong>Condition Changes</strong></td>
<td>-Nausea</td>
<td>-Respiratory distress</td>
<td>-Potential Unit Transfer</td>
</tr>
<tr>
<td></td>
<td>-Known pain with analgesic control</td>
<td>-Pain of unknown etiology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Frequent VS post invasive procedure</td>
<td>-Acute hypotensive episode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-GI bleeding</td>
<td></td>
</tr>
<tr>
<td><strong>IV Medications</strong></td>
<td>-1 or 2 IV modules infusing</td>
<td>-3 or 4 IV modules infusing</td>
<td>-5 or more IV modules infusing</td>
</tr>
<tr>
<td><strong>Blood Products</strong></td>
<td>-Plasma, Cryo, or Platelets</td>
<td>-2 or more units of PRBCs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-4 or more units of Plasma</td>
<td></td>
</tr>
<tr>
<td><strong>Tubing Changes</strong></td>
<td>-Making or hanging 1-2 IV lines</td>
<td>-Making or hanging 3-4 IV lines</td>
<td>-Making or hanging 5 or more IV lines</td>
</tr>
<tr>
<td><strong>Blood Draws</strong></td>
<td>-CVC Blood draw, Mediport needle change</td>
<td>-Peripheral blood draw by RN (CSA levels Coags, cultures)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Peripheral IV start</td>
<td></td>
</tr>
<tr>
<td><strong>Psychosocial</strong></td>
<td>-Documented impaired coping</td>
<td>-RN participation in family meeting</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-End-of-life decision-making support</td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Unit Nurse Demographics

<table>
<thead>
<tr>
<th></th>
<th>Range, Mean, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=49</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>22-62, 32.68, 9.65</td>
</tr>
<tr>
<td>Years of formal education after high school</td>
<td>3-9, 5.59, 1.53</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, any location</td>
<td>&lt;1-40, 5.40, 7.48</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, this unit</td>
<td>&lt;1-24, 4.85, 5.54</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, in oncology</td>
<td>&lt;1-24, 5.27, 5.88</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>47 (96%)</td>
</tr>
<tr>
<td>Male</td>
<td>2 (4%)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Asian</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>45 (92%)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Associate Degree in Nursing</td>
<td>2 (4%)</td>
</tr>
<tr>
<td>Diploma in Nursing</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>Bachelor of Science in Nursing or other field</td>
<td>34 (69%)</td>
</tr>
<tr>
<td>Bachelor of Science in another field and entry to practice RN degree</td>
<td>8 (16%)</td>
</tr>
<tr>
<td>Master of Science in Nursing/Doctor of Nursing Practice</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Master’s Degree in another field</td>
<td>1 (2%)</td>
</tr>
</tbody>
</table>

Table 7. Content Validity Nurse Demographics

<table>
<thead>
<tr>
<th></th>
<th>Range, Mean, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=15</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>27-62, 45.79, 11.34</td>
</tr>
<tr>
<td>Years of formal education after high school</td>
<td>3-13, 5.79, 2.75</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, any location</td>
<td>3-40, 14.07,10.36</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, current position</td>
<td>1-9, 4.0, 3.4</td>
</tr>
<tr>
<td>Years worked full-time as a staff nurse, in oncology</td>
<td>3-27, 11.20, 7.03</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>15 (100%)</td>
</tr>
<tr>
<td>Male</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Race</td>
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</tr>
<tr>
<td>African American</td>
<td>2 (13%)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>13 (87%)</td>
</tr>
<tr>
<td>Education</td>
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</tr>
<tr>
<td>Associate Degree in Nursing</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>Diploma in Nursing</td>
<td>2 (13%)</td>
</tr>
<tr>
<td>Bachelor of Science in Nursing</td>
<td>8 (53%)</td>
</tr>
<tr>
<td>Master of Science in Nursing/Doctor of Nursing Practice</td>
<td>3 (20%)</td>
</tr>
<tr>
<td>Master’s Degree in another field</td>
<td>1 (7%)</td>
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### Table 8. Predictive Validity Results

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean, SD</th>
<th>p-value</th>
<th>OR, 95% CI</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td><strong>Falls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acuity – Shift of Event (N=33)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Fall (N=22)</td>
<td>4-9</td>
<td>5.55, 1.10</td>
<td>0.295</td>
<td>1.41 (0.74, 2.67)</td>
<td>0.30</td>
</tr>
<tr>
<td>Fall (N=11)</td>
<td>5-9</td>
<td>6.00, 1.27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acuity – Shift Prior to Event (N=30)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Fall (N=20)</td>
<td>4-10</td>
<td>5.95, 1.43</td>
<td>0.517</td>
<td>1.21 (0.69, 2.12)</td>
<td>0.51</td>
</tr>
<tr>
<td>Fall (N=10)</td>
<td>4-9</td>
<td>6.30, 1.25</td>
<td></td>
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<tr>
<td><strong>Code White Consults</strong></td>
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<td></td>
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<tr>
<td>Acuity – Shift of Event (N=76)</td>
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<td></td>
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</tr>
<tr>
<td>Non-Code White (N=50)</td>
<td>3-9</td>
<td>5.38, 1.12</td>
<td>&lt;0.001</td>
<td>2.25 (1.45, 3.48)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Code White (N=26)</td>
<td>4-11</td>
<td>7.00, 1.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acuity – Shift Prior to Event (N=76)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Code White (N=47)</td>
<td>3-9</td>
<td>5.43, 1.33</td>
<td>0.001</td>
<td>1.75 (1.21, 2.54)</td>
<td>0.003</td>
</tr>
<tr>
<td>Code White (N=23)</td>
<td>4-10</td>
<td>6.70, 1.71</td>
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### Table 9. Concurrent Validity Descriptive Results

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<thead>
<tr>
<th></th>
<th>N=128</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematology</td>
<td>18 (14%)</td>
<td></td>
</tr>
<tr>
<td>Oncology</td>
<td>76 (59%)</td>
<td></td>
</tr>
<tr>
<td>Bone Marrow Transplant</td>
<td>34 (27%)</td>
<td></td>
</tr>
<tr>
<td>Shift During which Survey was Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night ➔ Day</td>
<td>28 (22%)</td>
<td></td>
</tr>
<tr>
<td>Day ➔ Evening</td>
<td>54 (42%)</td>
<td></td>
</tr>
<tr>
<td>Evening ➔ Night</td>
<td>46 (36%)</td>
<td></td>
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</tbody>
</table>
Table 10. Descriptive Results of One Month Data

<table>
<thead>
<tr>
<th></th>
<th>N=117</th>
<th>Mean, SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Acuity Score</td>
<td>5.70, 1.12</td>
<td>6.0</td>
<td>3-9</td>
<td></td>
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<td>Difference between highest and lowest acuity scores</td>
<td>4.07, 1.76</td>
<td>4.5</td>
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Figure 2. Study Model of Acuity, According to Holzheimer’s Model for Health Care Research
Chapter V

Recommendations for Future Research

There are a number of recommendations for future research based on the results of this study, which will be discussed according to implications for acuity measurement, outcomes research, theory and research methods, and policy.

Acuity Measurement

Several recommendations for future research pertain to the measurement of acuity, ranging from development of acuity tools on the unit level for specific patient populations to the incorporation of acuity tools into the electronic health records (EHR).

An initial goal of unit-level research should be to develop patient acuity tools specific to the patient population of each unit. Similar to the OAT, the indicators of importance within the categories of nursing care (e.g., teaching, special medications, condition changes, etc) and their corresponding levels of intensity (1, 2, 3 points, etc), will need to be decided for each population. Suggested methods to begin this initiative are the use of action research methods, focus groups/interviews, or other qualitative methods. Clinicians must be involved in the process of developing the indicators within the acuity tool in order for the tool to be clinically meaningful, useful, and relevant to their practice.

Once the tool has been developed, psychometric assessments of each tool should be conducted to establish reliability and validity. The methods presented in Chapter IV can serve as a template. In addition, statistical techniques such as Bland Altman plots, mountain plots, and Deming regression, which are used to determine the reliability of diagnostic tests, can be used to assess newly developed acuity tools. Traditional
psychometric methods from the social sciences use correlation as the basis of determining reliability, which is useful as a starting point for determining whether the scores are associated with each other and the strength and direction of the association, but does not provide information on the magnitude of difference among ratings. Correlations reported in conjunction with Bland Altman plots, which measure the degree of concordance among raters, will provide a more robust picture of reliability of acuity tools. As for validity, Receiver Operating Characteristic (ROC) curves may be helpful for establishing additional evidence for the predictive capabilities of acuity tools, in terms of the ability of acuity scores to discriminate between true and false positives for specific patient events, as has been conducted in previous research focused on whether severity scores predict specific outcomes (El-Solh, Alhajhusain, Abou Jaoudem, Drinka, 2010). Acuity measurement is a unique combination of the social and clinical sciences, in the sense that it is a latent concept that is clinically meaningful for balancing workload as well as for predicting patient events. Thus, reliability assessments in future research would serve as a link between social science methods focused on psychometric soundness of the instrument and clinical science metrics of sensitivity, specificity, and magnitude of difference.

In an effort to make acuity ratings less dependent on characteristics of the nurse raters and to make the completion of acuity scores less time-consuming for nurses, automated versions of acuity tools that are incorporated into hospital electronic health records (EHR) are needed. The majority of the acuity indicators in the OAT are objective data that could be extracted directly from the EHR. The less objective items, such as teaching and psychosocial needs of the patient, could be built into the EHR as specific
check-boxes that nurses select in order to document the activities they completed for the patient that shift or for what remains a patient need for the next shift. In this way, rating acuity would link documentation. In its current form, with acuity ratings separated from the health record, documentation is completed based on what is required for the health record, not necessarily what is pertinent to acuity measurement. By linking the health record with acuity scores, researchers can more accurately capture the less objective acuity indicators.

Another area of EHR-based acuity measurement is the potential for building acuity-related alerts into the system. Results from studies that identify the acuity items that are most predictive of specific patient events, perhaps via ROC curve analyses, could be used to build alert systems that flag the particular acuity item, or combination of items, when it reaches the range that is predictive of the event. The patient would be flagged as being “at risk” for the specific event and the nurse would be prompted to carry out specific activities to prevent the event from occurring. Researchers could test whether these built-in alerts reduce the occurrence of the specific patient events.

**Outcomes Research**

Once reliable and valid measurements of acuity are available, ideally via electronic mechanisms, they can be used for hospital-wide staffing decisions and for outcomes research on the effectiveness of acuity-based staffing.

Hospital-wide nurse staffing plans based on patient acuity measurements would lead to more efficient allocation of nursing staff because staffing decisions would occur based on more objective measurements of the nursing care needs of each patient, instead of the current practice of allocation of staff by patient census and the number of nurses
available on each unit. Matching the available nurses with patients’ acuities theoretically should result in higher quality care because higher acuity patients would deliberately be given more nursing care. In order for hospital-wide nurse staffing decisions based on acuity to be effective, the acuity measurements on one unit must be comparable to those on another unit. For example, an oncology patient with an acuity rating of “11” must be equal to the workload of a heart failure patient with an acuity rating of “11.” Future research should include a mechanism for ensuring that scores are comparable across units. Hospital-wide staffing decisions made by acuity scores may be enhanced through the use of a nursing “float pool,” which is a group of nurses cross-trained to work in multiple hospital units. As health care becomes more and more technologically advanced and specialized, unit-based nurses feel less and less comfortable “floating” to other units because they are less up-to-date on the medications and methods of treating various types of patients outside their “home” unit. Not only does a float pool allow nurse managers more flexibility in filling gaps in staffing needs, it also ensures that patients are receiving care from a nurse who has received extra training, which has the potential to improve quality of care. A future study that focuses on the combined effect of hospital-wide acuity-based staffing decisions with use of a float pool of nurses on quality and cost outcomes would be beneficial.

In addition to matching demand for nursing care with the supply of available nurses, staffing by acuity on the hospital level would potentially reduce costs. First, staffing by acuity would potentially reduce the use of overtime pay because staffing needs could be filled by float nurses or other nurses in the hospital coming from lower-acuity units, instead of being filled by nurses on high acuity units working overtime.
Second, if patients are purposefully given more nursing care when their demand for care increases, the added nursing care on higher acuity days may result in a decreased likelihood of negative outcomes and in the promotion of positive patient outcomes, thereby reducing costs. The main theoretical premise behind staffing by acuity is that by allocating more nursing care to the higher acuity patients, nurses have more time to monitor and intervene and subsequently prevent complications and adverse events. There are several other factors that could confound the relationship between staffing by acuity and patient outcomes such as nursing education, nursing burnout/exhaustion, nurse-physician collaboration, the culture of the unit or hospital, use of mandatory overtime, and documentation burden. Any one of these factors, or some combination of them, could contribute to patient outcomes in positive and negative ways. Future research on whether staffing by acuity reduces costs should explore the extent to which other factors contribute to the relationship between nurse staffing and patient outcomes.

**Theory & Methods**

The application of Complexity Science (CS) theories and methods may be helpful for conceptualizing the multitude of factors that potentially affect patient outcomes in the inpatient setting, within the context of a modified version of Holzemer’s Model for Health Care Research. CS and the study of complex adaptive systems (CAS) focus on the interactions of multiple agents within systems and the resulting interdependent effects those interactions have on the agents involved (Heylighen, Cilliers, & Gersherson, 2007). The inpatient environment can be considered a CAS with a number of agents interacting with one another on a daily basis. Thus, CS lends itself to research assessing quality of
care in hospitals, and the effect of nursing care on patient outcomes in particular (Hugonnet et al., 2004, p. 332; Anderson & McDaniel, 2008).

As was summarized in Chapter III, much of the research conducted on the relationship between nurse staffing and patient outcomes has been unsuccessful in providing adequate recommendations for practice and policy. This may be due in part to the fact that these studies have followed the traditional research paradigm, which involves reducing this CAS down to its individual parts, measuring those parts, and attempting to predict patient outcomes based on the independent contribution of those parts, which ignores the impact of interactions and relationships among agents on outcomes. CS provides an opportunity to view the hospital setting as a whole greater than the sum of its parts, as a CAS that possesses emergent properties, or characteristics and qualities that emerge as a result of the relationships and interactions among people within it, that cannot be detected when it is broken down into its parts.

At first glance, researching nurse staffing and patient outcomes from a CS perspective, in which the CAS of the inpatient environment is studied as a whole, seems like an insurmountable task. Figure 3 presents a modified version of Holzemer’s Model that incorporates CS principles. This version of Holzemer’s model proposes an initial list of the structures, processes, and outcomes variables of importance in previous studies that investigated the relationship between nurse staffing and patient outcomes. There are no arrows in this model, which allows the researcher to look for patterns in relationships across variables, recognize that there will be variation from unit to unit in variables of importance and that these relationships may be nonlinear, in that small changes in one variable may result in large changes in another variable that is unexpected (Goldberger,
2006). The aim of CS is not to establish the external validity, or generalizability, of results, as it is in other types of research designs, because the factors of importance may vary from hospital to hospital and from unit to unit. Rather, the approaches and methods used to discover the variables of importance for improving patient safety and quality on individual units and hospitals may be generalizable to other settings.

Figure 3. Holzemer’s Model Modified for Use from a Complexity Science Perspective

In terms of research design and methods, measurement of nurse staffing is currently limited to data in the form of hours or ratios. Future research should focus on a broader definition such as “nurse resources” that can be measured as both structure and process categories according to who the nurses are (education, years of experience, credentials, etc), what the nurses do or the specific actions they take that affect patient care (coordination, surveillance, critical thinking and decision-making), as well as how
many are available. There are few if any instruments available at this time that reliably and validly measure nurse-level process variables (Unruh, 2008, p. 63; Lamb, 2008). The case study approach is one example of a CS method that lends itself to research that generates richer structure and process variables that capture the nursing contribution to enhancement of patient safety (Anderson, Crabtree, Steele, & McDaniel, 2005; Forbes-Thompson, Leiker, & Bleich, 2007). In addition to identifying RN-level variables, the case study approach may also be helpful in gleaning which unit-, and system-level variables matter the most on specific units because this approach takes into consideration the context of care, such as how relationships among staff or leadership styles of managers impact patient outcomes.

Social Network Analysis (SNA) and computational modeling/simulation are two statistical techniques that allow for nonlinearity when exploring relationships within CAS. SNA provides data on the interrelationships among individuals that can be used as indicators of organizational culture or functioning within a hospital unit (Lurie, Fogg, & Dozier, 2009). SNA can be a useful tool for indentifying “high connector” RNs, or those who are the most interrelated with others on the unit, and examining whether these RNs’ patients fare better in terms of quality and safety.

A variety of software packages offer computational modeling programs that allow for the simulation of events via computerized algorithms (Clancy & Delaney, 2005). These statistical techniques provide researchers with the ability to test the influence of various inputs and processes on the paths taken by agents in a simulated environment, as well as the outcomes that occur based on those decisions, before attempting to make
changes in the “real world.” Computational modeling of select variables from Figure 3 is a promising statistical approach to analyzing health care quality.

Positive deviance is another CS principle that can be applied to this area of research. Positive deviance occurs when people fare better than the expected results of the group to which they belong because of specific characteristics or strategies that person possesses that led to a positive outcome (Lindberg, Nash, & Lindberg, 2008, p. 284). For example, bone marrow transplant patients are at high risk of contracting central line infections because they are neutropenic after chemotherapy, but not all bone marrow transplant patients end up with central-line infections. Important lessons can be learned from studying which characteristics or strategies contribute to the positive deviants’ successful evasion of the negative outcome.

Bradley et al. (2009) provide specific steps for applying positive deviance principles to health care quality research. In addition, as mentioned in the meta-review, some studies have focused on the positive, protective, and preventive effects of nurse staffing on patient outcomes, rather than describing the negative effects on patient outcomes that occur with reduced nurse staffing (Blegen, 2006; Kane et al., 2007, p. 95). Code white consults are an example of a positive outcome, in that there are potential improvements in patient safety and quality of care with increases in these consults, as compared to falls rates, which are an example of a negative outcome whose incidence we aim to reduce. This is an opportunity for nurse researchers to isolate nursing interventions that promote positive deviance, in an effort to enhance positive patient outcomes, decrease the likelihood of negative outcomes, and to provide recommendations accordingly. As proposed in the meta-review, this type of research may be most effective
if conducted on the unit level, with unit-specific measures of patient-, nurse-, and unit-level structures and processes that promote positive patient, nurse, and unit outcomes and prevent negative ones.

One additional proposal for future research in this area is the development of “bundles” or checklists of variables from Holzemer’s Model that make the most significant contributions to promoting quality and patient safety (Resar, et al, 2005; Winters, et al, 2009). Rather than this bundle or checklist being standardized, the CS perspective informs us that the indicators of importance may vary among hospitals and among individual units within hospitals. Rather than focusing on standardization, centralization of research on the topic should be the priority. Similar to current reporting of National Database of Nursing Quality Indicators (NDNQI) data, hospitals could start reporting data to a centralized database that include patient-, unit-, and system-level indicators, not only for structures of care, but also for processes and outcomes. Researchers could use the database to analyze data from individual hospitals and units and provide reports on the bundles of variables that made the largest difference in patient outcomes. This would allow researchers to tailor recommendations to each unit and hospital.

Policy

The results of this study and future ones can contribute to policy formation on both the state and national level. Currently, several state legislatures are considering appropriate nurse staffing as a topic for legislation. California was the first state to sign into law minimum nurse-to-patient ratios, but a lack of consensus on the appropriate number of nurses to promote optimum patient outcomes remains (Bergmann, 1999;
Kovner & Heinrick, 2000). Thirteen states (CT, FL, IL, MA, MI, NV, NY, OH, OR, PA, RI, TX, WA) are currently considering, or have recently passed, legislation that requires hospitals to form a nurse staffing committee made up of direct care nurses that establishes a nurse staffing plan for the hospital (ANA, 2009). Six states (IL, ME, MI, NY, OH, PA) require that the nurse staffing plan take into consideration patient acuity measurements (ANA, 2009). On the federal level, the Registered Nurse Safe Staffing Act of 2007 was introduced in the 110th Congress and proposed that hospitals that receive Medicare funding put in place nurse staffing plans that incorporate measurement of nursing acuity, but it did not become law (H.R. 4138, 2007). Passage and implementation of such laws may be problematic for hospital administrators because there are few evidence-based tools available to measure patient acuity and there is a lack of evidence regarding the most effective nurse staffing plan for optimizing patient outcomes. Future research should focus on being able to translate results into recommendations for state and federal legislatures.

Other federal legislation pertinent to this area of research is the Patient Protection and Affordable Care Act, which was signed into law on March 23, 2010 and includes the creation of The Center for Quality Improvement and Patient Safety (part of the Agency for Healthcare Research and Quality). One initiative of this new Center will be to fund “research on health care delivery system improvement and the development of tools to facilitate adoption of best practices that improve the quality, safety, and efficiency of health care delivery services. Such support may include establishing a Quality Improvement Network Research Program for the purpose of testing, scaling, and disseminating of interventions to improve quality and efficiency in health care” (H.R.
The aforementioned centralized database of quality indicators, as well as research on the comparative effectiveness of various nurse staffing models on patient, nurse, and organization outcomes, including cost outcomes, are areas for future research that match the priorities of this new Center.

Conclusion

A number of recommendations for future research have been proposed, ranging from a focus on acuity measurement, to theory and methods, to policy. The overarching theme of these recommendations is that traditional research methods and statistical analyses should be augmented by perspectives from other disciplines, such as the application of CS principles to frame how we think about and find solutions to providing high quality care, as well as the use of various statistical techniques such as SNA, computational modeling, Bland Altman plots, and ROC curve analyses, for rank order discrimination, to allow us to accurately measure the variables of interest in the CAS of the hospital. Incorporating these perspectives into research on quality and patient safety will be important for improving clinical significance and for formulating more salient policy recommendations for nurse managers, hospital administrators, and legislators. The inability to make such recommendations is a major short-coming of research in this area conducted under the traditional research paradigm. The proposed recommendations for future research, especially those that apply CS principles to this area, have the potential to fill gaps in the literature and advance the state of the science on health care quality and patient safety.
## Appendix

**Table 11. Descriptive Data ANOVA Results**

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<th>p-value</th>
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<td>7.235</td>
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<td><strong>First Acuity Score by Shift</strong></td>
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<td>0.051 (Day &amp; Night)</td>
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<td>Night: N=65 (56%)</td>
<td>4.12, 0.94</td>
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Bibliography


http://www.nursingworld.org/mainmenucategories/ANAPoliticalPower/State/Stat
eLegislativeAgenda/StaffingPlansandRatios_1.aspx

classification instrument. Western Journal of Nursing Research, 23, 56-71.

research: The view from complexity science. Qualitative Health Research, 15,
669-85.


Andro, R. J., Robertson, S. & Glandon, G. L. (1987). Financial implications of an acuity-
based periodic staff adjustment model. Nursing Management, 18(10), 21-25.

Angeles, T. & Barbone, M. (1994). Infiltration and phlebitis: Assessment, management,


104


Mitchell, P. H., & Lang, N. M. (2004). Framing the problem of measuring and improving healthcare quality: Has the quality health outcomes model been useful? *Medical Care, 42*(2 suppl), II4-11.


Urbanowicz, J. A. (1999). An evaluation of an acuity system as it applies to a cardiac catheterization laboratory... modified EMERGE system. *Computers in Nursing, 17*, 129-134.


