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Association of Nurse-Physician Teamwork and Hospital Surgical Patient Mortality

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Abstract

Interest in the relationship between nurses and physicians has been increasing over the past few decades. Teamwork between the two disciplines was first studied in the 1970s and interest surged again in the 1980s, when evidence suggested that better teamwork saved more lives. This study presents a cross-sectional analysis linking 2006-2007 nurse survey data, hospital administrative data, and patient discharge data. The study sample comprised of 665 hospitals, 1,321,904 patients, and 29,391 nurses. Logistic regression models were used to assess the association between higher levels of nurse-physician teamwork and patient outcomes (30-day mortality and failure-to-rescue). Regression models were also used to examine whether any associations between nurse-physician teamwork and patient outcomes depends upon the level of other modifiable characteristics of hospital nursing (nurse staffing and education levels) in acute hospital settings. Final analysis revealed decreased odds of both 30-day mortality (OR = 0.943, 95% CI 0.930,0.958) and failure-to-rescue (OR = 0.939, 95% CI 0.925, 0.953) for surgical patients cared for in hospitals with better nurse reported nurse-physician teamwork, adjusting for hospital structural characteristics and patient characteristics. In addition, there was a significant interaction between nurse staffing and nurse-physician teamwork on surgical patient 30-day mortality, and failure-to-rescue rates. There was also a significant interaction between nurse education and nurse-physician teamwork on surgical patient 30-day mortality, and failure-to-rescue rates. Our analysis found a trend of decrease in odds of death and failure-to-rescue for hospitals with both higher nurse-physician teamwork scores and lower patient-per-nurse ratios. Similarly, there is a trend of a decrease in odds of death and failure-to-rescue in hospitals with higher nurse-physician teamwork scores and higher proportion of BSN educated nurses. In order for initiatives to improve interprofessional teamwork to have greater impact on patient outcomes, nurse staffing and nurse education need to be at sufficient levels.

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ASSOCIATION OF NURSE-PHYSICIAN TEAMWORK AND HOSPITAL SURGICAL PATIENT MORTALITY

DEDICATION

To my parents, Zhenqing Chen & Yuxing Kang, for all your love and support that made this possible.

"Systems awareness and systems design are important for health professionals, but they are not enough. They are enabling mechanisms only. It is the ethical dimensions of individuals that are essential to a system's success. Ultimately, the secret of quality is love. You have to love your patient, you have to love your profession, you have to love your God. If you have love, you can then work backward to monitor and improve the system."

--Avedis Donabedian: father of quality assurance and poet

(Best & Neuhauser, 2004)

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ABSTRACT

ASSOCIATION OF NURSE-PHYSICIAN TEAMWORK AND HOSPITAL SURGICAL PATIENT MORTALITY

Xiao Linda Kang

Matthew D. McHugh

Interest in the relationship between nurses and physicians has been increasing over the past few decades. Teamwork between the two disciplines was first studied in the 1970s and interest surged again in the 1980s, when evidence suggested that better teamwork saved more lives. This study presents a cross-sectional analysis linking 2006-2007 nurse survey data, hospital administrative data, and patient discharge data. The study sample comprised of 665 hospitals, 1,321,904 patients, and 29,391 nurses. Logistic regression models were used to assess the association between higher levels of nurse-physician teamwork and patient outcomes (30-day mortality and failure-to-rescue). Regression models were also used to examine whether any associations between nurse-physician teamwork and patient outcomes depends upon the level of other modifiable characteristics of hospital nursing (nurse staffing and education levels) in acute hospital settings. Final analysis revealed decreased odds of both 30-day mortality (OR = 0.943, 95% CI 0.930, 0.958) and failure-to-rescue (OR = 0.939, 95% CI 0.925, 0.953) for surgical patients cared for in hospitals with better nurse reported nurse-physician teamwork, adjusting for hospital structural characteristics and patient characteristics. In addition, there was a significant interaction between nurse staffing and nurse-physician teamwork on surgical patient 30-day mortality, and failure-to-rescue rates. There was

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CHAPTER 1 – INTRODUCTION

Problem

Millions of surgeries are performed each year at hospitals across the United States, with wide variations in mortality (Ghaferi, Birkmeyer, & Dimick, 2009). In the eye-opening *To Err is Human: Building a Safer Health System* report, the Institute of Medicine (IOM) estimated that there are 44,000 to 98,000 deaths annually due to medical errors in hospitals (Kohn, Corrigan, Donaldson, & others, 2000). An updated study using the IOM's estimation methods determined that the number of deaths per year due to preventable harms in hospitals in the United States was closer to 210,000 to 400,000 (James, 2013; Makary & Daniel, 2016).

Research shows that a better nurse work environment is essential to patient safety (Zwarenstein & Reeves, 2002) and teamwork is an important aspect of nurses' work environment. In 2008, the Joint Commission issued a sentinel event alert to warn organizations of the harms posed by a lack of teamwork among health care professionals (The Joint Commission, 2008). The IOM also highlighted the importance of interprofessional teamwork to patient safety and quality of care in numerous seminal reports (Institute of Medicine [IOM], 2001; Page & others, 2004; Richardson et al., 2000). Interprofessional teams—individuals from different disciplines, such as a nurse and a physician—working together could be the most effective strategy in dealing with challenging health care issues, according to the IOM's 2001 Committee on Quality of Health Care in America (IOM, 2001). An interprofessional approach enables providers to share expertise and perspectives to form common goals that improve patient outcomes

while combining resources (Barker, Bosco, & Oandasan, 2005). Despite such recommendations, there is still a lack of nurse-physician teamwork in health care due to social and structural barriers (Nair, Fitzpatrick, McNulty, Click, & Glembocki, 2012).

Previous research has heralded interprofessional teamwork as a way to improve patient outcomes (Baggs, Ryan, Phelps, Richeson, & Johnson, 1992; Baggs et al., 1999; Boyle, 2004; Knaus, Draper, Wagner, & Zimmerman, 1986; Mitchell & Shortell, 1997). However, prior research on the association between nurse-physician teamwork and patient outcomes has not adequately studied the impacts of and interactions with nursing organizational factors on a large, systematic level (Kalisch & Lee, 2011). The health care system has enormous complexity due to its complicated design and its nonlinear and dynamic nature (Lipsitz, 2012). Thus, a systematic approach is necessary to study the interactions of various components that can improve patient outcomes. Researchers have confirmed an association between nursing organizational characteristics, such as staffing and education, and better patient outcomes of mortality and failure-to-rescue (FTR), or death after the development of a complication, in the hospital setting (Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Aiken, Clarke, Cheung, Sloane, & Silber, 2003; Aiken, 2002).

While previous studies linked nurse-physician teamwork to patient outcomes (Baggs et al., 1992; Baggs et al., 1999; Boyle, 2004; Knaus et al., 1986; Mitchell & Shortell, 1997), few studies were done in more than 100 hospitals. No studies tested whether the effects of nurse-physician teamwork on patient outcomes are modified by nurse organizational factors (San Martín-Rodríguez, Beaulieu, D'Amour, & Ferrada-

Videla, 2005). This study reported here examined nursing organizational factors and nurse-physician teamwork's association with patient outcomes of 30-day mortality and FTR. An additional inquiry was made into whether organizational factors, such as nurse staffing and nurse education, are important in promoting nurse-physician teamwork, and if these factors have a moderating effect with patient outcomes.

The lack of research on nursing factors and interprofessonal teamwork is surprising, as registered nurses comprise the largest body of health care providers (Kazanjian, Green, Wong, & Reid, 2005; IOM, 2011). Nursing is pivotal in acute hospital settings, as nurses provide the most consistent presence to coordinate and influence direct care (Mitchell & Shortell, 1997). Nurses are key players in the health care team, coordinating to minimize duplications, communicating to decrease contradictions, and facilitating to organize the process of care (Ajeigbe, McNeese-Smith, Leach, & Phillips, 2013). In addition, nurses provide consistent and effective communication with patients and families to help relieve unnecessary anxieties, alleviate confusion, and offer support, information, and space for questions to improve the quality of care (Mechanic & Aiken, 1982).

While interprofessional teamwork is seen as key to improve quality and safety of patient outcomes, nurse-physician relationships are at the heart of health care teams (Yeager, 2005). Nurses and physicians interact in the labyrinthine organizations of hospital and health systems. The complexity in the delivery of health care stems from resource availability, administrative systems, technology factors, unit norms, system processes in making patient-care decisions, and relationships between co-workers

(Ebright, 2010). Such a convoluted system requires evaluations and interventions at the organizational level, such as individual hospitals; however, research is lacking in the area of nurse-physician teamwork, with a focus on how nursing organizational factors affect teamwork and patient outcomes.

Research Objectives and Hypothesis

This is a cross-sectional study using data from surveys of nurses from the states of New Jersey, Florida, California, and Pennsylvania, collected between 2006 and 2007. There are links between these data and the American Hospital Association (AHA) annual survey and patient discharge data from the same states and period as the nurse surveys.

The research objectives are to determine if there are associations between nurse-physician teamwork and patient outcomes (30-day mortality and FTR) and to determine whether any associations between nurse-physician teamwork and patient outcomes depends upon the level of other modifiable characteristics of hospital nursing (nurse staffing and education levels) in acute hospital settings.

Hypothesis: Patients in hospitals with higher levels of nurse-physician teamwork will have better outcomes compared to patients in hospitals with lower levels of nurse-physician teamwork. However, nurse-physician teamwork will have a greater impact on patient outcomes in hospitals with better nurse staffing and higher proportions of nurses with BSN degrees.

Summary

A growing body of evidence suggests that the complex interactions among patient, organizational, and human factors contribute to surgical morbidity and mortality

(Ghaferi et al., 2009). Research regarding the interactions of these nursing characteristics (staffing and education levels) shows an association with patient outcomes (Aiken et al., 2011). Unfortunately, research looking at these organizational and structural factors specifically contributing to and interacting with nurse-physician collaborative teamwork and patient outcomes is limited (Manser, 2009). Existing studies on this topic are limited in geography and size, with small health care provider samples from one unit, health system, or state (Baggs et al., 1992; Baggs et al., 1999; Boyle, 2004; Knaus et al., 1986; Mitchell & Shortell, 1997). The study reported here provides a more recent update and expansion to the often-cited studies of the 1980s and 1990s, which evaluated nurse-physician teamwork's association with patient outcomes. The study also tests whether nurse-physician teamwork's association with patient outcomes differs depending on nurse organizational factors. In addition, this large scale study of nurse-physician teamwork across hospitals in diverse geographic areas may help to establish the importance of the interactions of organizational factors with interprofessional teamwork and add to improvements in patient safety and health care quality.

CHAPTER 2 – BACKGROUND

Introduction

This study examines the association between nurse-physician teamwork and nurse staffing and education with outcomes for surgical patients. This chapter presents the conceptual model used to inform the study, discusses the literature reviewed for the processes described in the conceptual model, and concludes with a summary of the knowledge gaps and covariates chosen for inquiry in the study.

Definitions and Historical Context

This study uses terms such as patient safety, quality of care, and interprofessional teamwork, which may require definition. The Institute of Medicine defines quality of care as "the degree to which health services for individuals and populations increase the likelihood of desired health care outcomes and are consistent with current professional knowledge" ([IOM], 2001). Safety, as part of quality, is defined as "freedom from accidental injury and does not reside in a person, device or department, but emerges from the interactions of components of a system" (Kohn et al., 2000, p.57).

The terms teamwork and collaboration are used interchangeably in the research literature (Alberto & Herth, 2009). For this study, the term “teamwork” will be used, as it encompass the ideals of communication, cooperation and coordination –all underpinnings of optimal relationships among health care professionals (Kramer & Schmalenberg, 2005). Drinka and Ray (1986), in their study on interprofessional health care teams and balance of power dynamics, defined teams as “[people from] multiple health disciplines with diverse knowledge and skills who share an integrated set of goals

and who utilize interdependent collaboration that involves communication, sharing of knowledge and coordination of services to provide services to patients and their caregiving systems" (p. 44). These definitions are also reflected by the Interprofessional Education Collaborative Expert Panel (2011) in their development of core competencies for interprofessional collaborative practice, with the definition of interprofessional teamwork as "the levels of cooperation, coordination and collaboration characterizing the relationships between professions in delivering patient-centered care." The terms interdisciplinary, multidisciplinary, and interprofessional, which further describe teamwork, have evolved over time (Alberto and Hearth, 2009). Interdisciplinary was used the earliest during the 1970s and around the same time multidisciplinary began to appear in the literature, causing confusion with interdisciplinary as the two terms were used interchangeably (Alberto and Hearth, 2009). However, multidisciplinary is associated with independent or side by side work (Sternas, O'Hare, Lehman, & Milligan, 1999). Interprofessional teamwork refers to an expansion of multidisciplinary work, in which participants transcend disciplinary perspectives and weave together resources and tools to address problems. The term is further defined as "interactions of two or more disciplines involving professionals who work together, with intention, mutual respect, and commitments for the sake of a more adequate response to a human problem" (Harbaugh, 1994, p 20). The term "interprofessional practice and education" (IPE), which occurs when individuals "from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes" (Baker, 2010,

p. 7) has replaced the terms interdisciplinary and multidisciplinary in recent works (Nester, 2016).

Nurse and physician teamwork is the focus of this study on interprofessional teamwork, as nurses and physicians together make up the largest components of the health care system, and they are integral to the health care team (Keenan, Cooke, & Hillis, 1998). Historical and cultural stereotypes imbue the nature of nurse and physician relationships (Stein, Watts, & Howell, 1990; Sweet & Norman, 1995; Vega & Bernard, 2016). Gender roles in society have influenced the relationships between nurses and physicians throughout history, along with differences in power, perspective, education, status, and class (Salvage & Smith, 2000). The seminal report from Leonard Stein in the 1960s described the relationship of nurses and physicians as a game in which the relationship was hierarchical and careful management of actions was necessary in order not to disturb the hierarchy; it was necessary for nurses to avoid disagreement with physicians at all costs (Stein, 1967). In addition, the level and length of formal education required for each profession yielded status conflicts, as physicians had a longer formal education than nurses did (Raisler, 1974).

In the 1970s, shortly after Stein's report, promotion of better nurse-physician teamwork in health care started in the United States, although the idea had been around since the 1940s (Yeager, 2005). In the 1970s, the American Medical Association and American Nurses Association jointly supported the development of the National Joint Practice Commission with a mutual concern for increased patient loads with more cost constraints (Fagin, 1992). This was one of the first organizations to promote teamwork

between nurses and physicians, and it defined joint practice as "nurses and physicians collaborating as colleagues to provide team-focused patient care" (Martin & Coniglio, 1996, p. 311). Weiss and Davis (1985) defined collaborative practice similarly as "interactions between nurse and physician that enable the knowledge and skills of both professions to synergistically influence the patient care provided" (p. 299). With funding from the Kellogg Foundation, four demonstration hospitals tested interventions to promote collaborative practice showed nurses reports of better communication between nurses and physicians, improved nurse-patient relationships, and more time for patient care (National Joint Practice Commission, 1981). The evidence of the importance of interprofessional teamwork continued to grow and came to the forefront of health care services research, catapulted by the IOM's reports on patient safety and quality of care. The IOM's seminal report, *To Err is Human: Building a Safer Health System*, made the point that across organizations there is a "high premium placed on medical autonomy and perfection and a historical lack of interprofessional cooperation and effective communication" (Kohn et al., 2000, p. 165).

Review of Literature

> The IOM's report asserts that a comprehensive approach is needed and that: building safety into process of care is a more effective way to reduce error than blaming individuals … the focus must shift from blaming individuals for past errors to a focus on preventing future errors by designing safety into the system. (Kohn et al., 2000, p. 4-5)

By advocating systematic solutions to improve the quality of patient care, the IOM suggested that this will assist administrative units to better understand and eliminate the causes of human error in the hospital. As teamwork is a system-based intervention, more research into the interactions of modifiable nursing and hospital characteristics may result in finding facilitators of and barriers to teamwork. More importantly, while the IOM's *To Err is Human* report had galvanized health care systems to put initiatives such as rapid response teams into place, there is still much more work necessary to improve patient safety and quality of care (Aiken, 2005).

While existing studies on nurse-physician teamwork have not considered factors such as staffing and educational composition for nurses, the research has demonstrated the association of better nurse staffing with lower adverse patient outcomes (Aiken, 2002; Kovner & Needleman, 2003; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2001). An increase of one additional patient to a registered nurse's workload led to a 7% increase in mortality (Aiken, 2002); and an increase of 10% in the proportion of baccalaureate trained nurses in the workforce led to a 5% decline in mortality rate (Aiken et al., 2003), after adjustment for patient, hospital, and nurse characteristics.

The majority of published research literature on nurse-physician teamwork took place in intensive care units, or ICUs (Manser, 2009). The early pioneers (those who established the first intensive coronary care unit) of the critical care system, in describing the ICU, expressed the importance of negotiations between nurses and physicians:

> [It is] not an advanced system of medical practice based on electronics but an advanced system of nursing care. This system relied on the authority derived from the negotiations between nurses and physicians to provide better care to their critically ill patients. (Meltzer, Pinneo, & Kitchell as cited in Fairman & Lynaugh, 2000, p. 88)

While these early pioneers recognized the importance of nurse-physician teamwork, as well as the importance of the system of nursing care, not all subsequent studies examining the effect of nurse-physician teamwork on patient outcomes considered the organizational characteristics, especially those concerning nursing care.

Another well-known study, *The Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments* (SUPPORT), tried to improve the coordination of care and physician-patient communication for seriously ill, hospitalized patients by having research nurses report patient preferences to the physician, but this approach was not successful (Connors, et al., 1995). Dr. Bernard Lo, in an accompanying editorial to the study results, speculated that physicians may have found it too difficult to accept suggestions from nurses rather than respected colleagues:

> Improving the quality of care generally requires changes in the organization and culture of the hospital and the active support of hospital leaders … physicians will oppose changes they perceive as threatening [to their self-esteem, sense of competence, or autonomy]. In retrospect, was it wise to expect to improve care at the end of life without changing the organization and culture of the hospital? (Lo, 1995, p. 1636)

As Lo (1995) suggested, the SUPPORT follow-up study might have had different results if it had taken the organization and culture of hospitals into consideration. Researchers hypothesized that it is necessary to examine statistical interactions among nurse organizational characteristics, and nurse-physician teamwork, as both nurses and physicians in the work environment can contribute to problems in patient outcomes (McMahan, Hoffman, & McGee, 1994; Rosenstein & O'Daniel, 2005).

A review of the literature documenting potential impacts of teamwork between nurses and physicians on patient mortality produced mixed results. Systematic reviews that examined the relationship between organizational structures and adverse outcomes found an association between nurse-physician teamwork and lower mortality in some studies, while there was no association or effect in other studies (Kazanjian et al., 2005; Martin, Ummenhofer, Manser, & Spirig, 2010; Mitchell & Shortell, 1997; Tourangeau, Cranley, & Jeffs, 2006). Six studies specific to hospital settings found consistent and significant positive associations between increased nurse-physician teamwork and reduced patient mortality, whether using instruments directly studying nurse-physician teamwork or using questions about nurse-physician teamwork embedded within comprehensive instruments (Aiken, Smith, & Lake, 1994; Baggs et al., 1992; Baggs et al., 1999; Knaus et al., 1986; Lake, 2000; Mitchell, Armstrong, Simpson, & Lentz, 1989). Knaus et al. (1986) conducted a classic study of ICUs in 13 hospitals, and found an association between ICUs with reports of better coordination between nurses and physicians and lower-than-predicted mortality rates. Other studies in ICUs showed an association between higher levels of nurse-physician teamwork and lower-than-predicted

actual mortality rates, as well as lower rates of readmission to ICUs and mortality following ICU discharges (Baggs et al., 1999; Wheelan, Burchill, & Tilin, 2003).

However, three other studies found no such associations between nurse-physician teamwork and patient outcomes, whether through quasi-experimental designs or provider questionnaires (Koerner, Cohen, & Armstrong, 1985; Mitchell, Shannon, Cain, & Hegyvary, 1996; Shortell et al., 1994). Shortell et al. (1994), in contrast to Knaus's study, used a comprehensive nurse-physician survey that evaluated leadership, communication, coordination, and conflict management to collect data from 42 randomly chosen ICUs, but did not find an association with risk-adjusted mortality. Both Knaus and Shortell used risk adjustment for patients and hospital with uniform data collected from geographically diverse samples, yet produced contradictory results.

Conceptual Model

The conceptual framework that guides this study, the Quality Health Outcomes Model (QHOM), originates from Donabedian's structure-process-outcome model (Donabedian, 1966). Donabedian's model assumes a unidirectional relationship in which structure, or the context for delivery of care, affects process and outcomes (Donabedian, 1988). The QHOM replaces the linear aspects of Donabedian's framework. The QHOM considers four main constructs, system, intervention, client, and outcomes, and suggests there are feedback channels between the system, outcome, and intervention between the client; the intervention; and the outcome (Mitchell, Ferketich, Jennings, & American Academy of Nursing Expert Panel on Quality Health, 1998). The QHOM assumes no directional connection of intervention to outcome, as it proposes that system and/or client

characteristics mediate the outcome (Mitchell et al., 1998). Figure 1 presents a representation of the model adapted from QHOM.

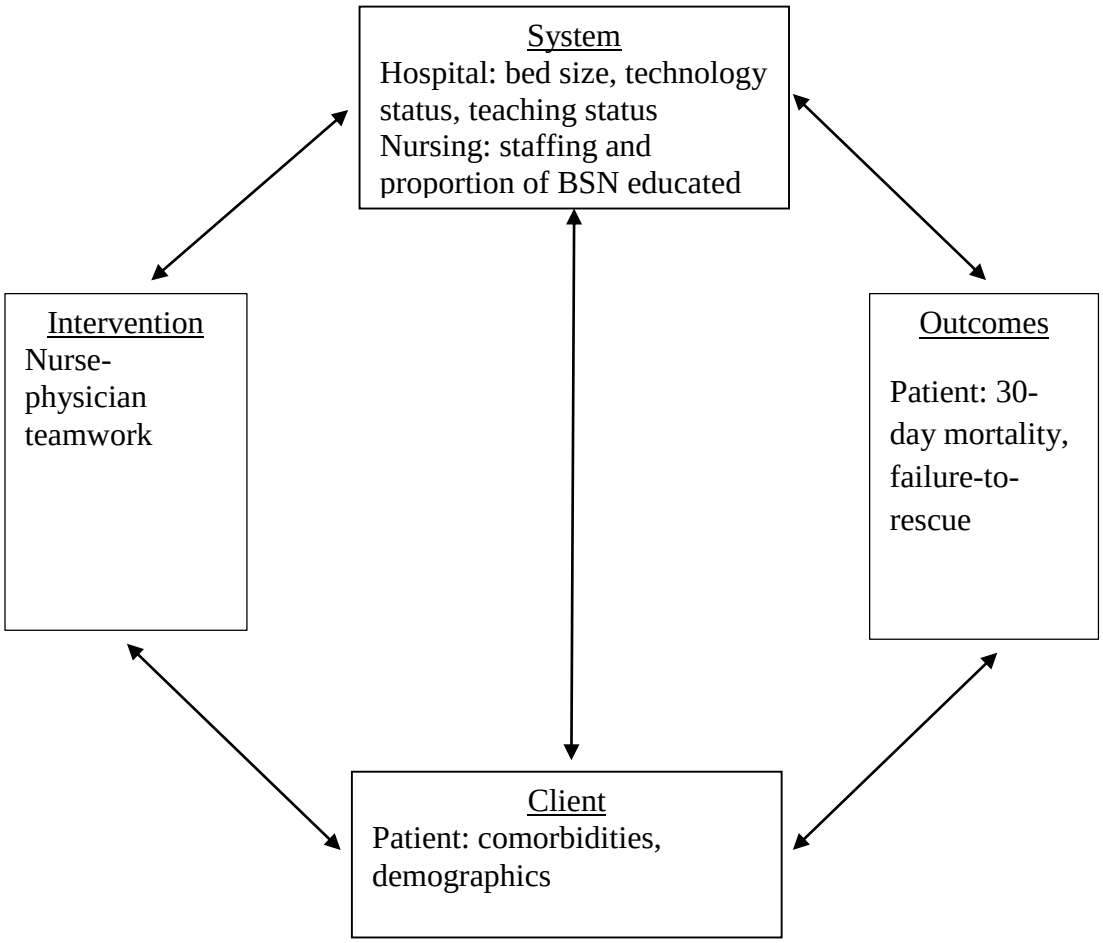


Figure 1. Adapted Quality Health Outcomes Model (Mitchell et al., 1998)

Intervention

Interventions in the QHOM refer to the direct and indirect clinical processes and procedures that correlate to the original process measures of care in Donabedian's framework (Donabedian, 1966). Interventions do not directly influence outcomes, but act through system and client characteristics. According to Mitchell et al. (1998), interventions are clinical processes and actions. In the context of this study, the nurse-

physician teamwork acts as the intervention, as previous literature indicates that the quality of this teamwork can effectively influence the quality of patient outcomes indirectly (Benner, 2007; Mitchell & Shortell, 1997). For instance, there is an association between failures in coordination and communication between nurses and physicians and excessive mortality rates in ICUs (Knaus et al., 1986). When team interaction is collaborative rather than hierarchical, each team member is able to speak up if there are safety concerns, and communication is both valued and rewarded. As a result, there will be more reports of accidents and near misses, improving the future of patient care (Knox & Simpson, 2004). As teams build trust and confidence, they exchange more information, resulting in more efficient real-time problem solving (Katzenbach & Smith, 1993).

System

The system in the QHOM includes the organizational characteristics of the hospital that relate to the structural measure of care in Donabedian's framework (Donabedian, 1966). For this study, the system features will include hospital characteristics—bed size, technology, and teaching status—and nursing characteristics, such as nurse staffing and nurse education levels.

Hospital Characteristics

The specific associations between hospital characteristics and nurse-physician teamwork is not clear, and has been little empirical work to understand it (Manojlovich & DeCicco, 2007; San Martín-Rodríguez et al., 2005). However, hospital structural characteristics do have an association with levels of teamwork among nurses. Previous

studies in this area have shown an association between staffing, skill mix, work experience, unit types, and hospital types and the level of nursing teamwork (Kalisch & Lee, 2009, 2011, 2013). In addition, hospital characteristics such as size, teaching status, and technology status also represent uncontrolled factors in patient outcomes. For instance, hospitals with higher technology also had lower adjusted mortality rates compared to those with lower technology status (Shortell et al., 1994).

Nursing Characteristics

Previous research has shown an association between lower patient-to-nurse ratios and higher proportions of BSN nurses in hospitals and lower mortality and FTR rates (Aiken, 2002; Cho, Ketefian, Barkauskas, & Smith, 2003; Duffield et al., 2011; Needleman et al., 2011). A difference in education levels between nurses and physicians may affect the balance of power (Alt-White, Charns, & Strayer, 1983). Researchers suggested that nurses with higher levels of education may gain more confidence and power, although this was not found to be the case (Alt-White et al., 1983). Nurse staffing has also been a major factor in patient outcomes and could also contribute to how much time nurses have for aspects of teamwork such as communication and coordination. A national survey of hospital nurses and chief nursing officers reveal that 93% of hospital nurses report major problems with having enough time to maintain patient safety, detect complications early and collaborate with team members (Buerhaus, Donelan, Ulrich, & Norman 2005).

Clients

Client characteristics pertain to demographics, patient health status, and other risk factors. This study adjusts for patient characteristics of age, gender, surgery types, and comorbidities for the four states of patient discharge data for risk adjustment (Elixhauser, Steiner, Harris, & Coffey, 1998). The use of risk adjustments level the playing field for mortality rates in order to account for differences in the health status of different groups of patients (Iezzoni, 2003).

Outcomes

The patient outcomes of this study are 30-day post-surgical mortality and failure-to-rescue.

Patient Outcomes

The IOM recommends interprofessional teamwork to improve patient safety in various reports (Kohn et al., 2000; Page et al., 2004). There are only a few studies on the specific impacts of nurse-physician teamwork on patient outcomes (Baggs et al., 1999; Boyle, 2004). These all have been ICU studies indicating that improving teamwork can reduce errors or adverse events relating to patient care (Osmon et al., 2004).

Mortality rates have been getting more attention since the Center for Medicare and Medicaid Services announced changes in reimbursement to value-based purchasing (Center for Medicare and Medicaid Services, 2011). Mortality rates have been the most frequently and commonly used measurements to compare quality of care across hospitals since measurements take place in the same way across institutions (Iezzoni, 2003; Silber, Williams, Krakauer, & Schwartz, 1992). Previous studies have also used mortality and

FTR rates to study the quality of nursing care in hospitals, and have reported lower rates of mortality with better nurse staffing and nurse work environment (Aiken, 2002; Park, Blegen, Spetz, Chapman, & De Groot, 2012). The 30-day post-admission mortality rate is a widely used benchmark, and research studies in ICUs have suggested that lower risk of death is associated with higher levels of nurse-physician collaborative teamwork (Baggs et al., 1999; Knaus et al., 1986; Wheelan et al., 2003).

Studies have also reported an association between FTR and nurse-to-patient ratios, nurse education levels, and nurse work environment (Clarke & Aiken, 2003; Friese, Lake, Aiken, Silber, & Sochalski, 2008; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995). Unit level study in a single health system also suggests that there is an association with nurse-physician teamwork with FTR rates (Boyle, 2004).

Summary

Patient safety and quality of care are systematic issues, and it is necessary to find systematic solutions. Other systematic characteristics, such as the culture of the hospitals, have associations with levels of nurse-physician teamwork (San Martín-Rodríguez et al., 2005), but no study to date has looked at the interaction between nursing organization characteristics, such as staffing and education, and nurse-physician teamwork on patient surgical mortality (Leppa, 1996). This supports a need for more investigations into the impact of these systematic determinants on nurse-physician teamwork.

CHAPTER 3 – METHODOLOGY

Design of Study

This is a retrospective, cross-sectional secondary data analysis. Several datasets were linked for this study: survey data of nurses from the four states of New Jersey, Florida, California and Pennsylvania from 2006-2007; data from the American Hospital Association Annual Survey (AHA); and administrative patient discharge data from the same four states from the same time period. The multi-state nurse survey includes the nurse-physician teamwork level, nurse demographics and nursing organizational characteristics. The AHA data provides structural characteristics of hospitals such as bed size, teaching status, and technology status. The patient discharge data includes patient demographics, comorbidities, and outcomes.

The Parent Study

The Multi-State Nursing Care and Patient Safety Study was completed by the Center for Health Outcomes and Policy Research (CHOPR) at the University of Pennsylvania (Aiken, principal investigator). The parent study measured nurses' demographic information, levels of education, reported work environment, work-load, nurse outcomes—burnout, job satisfaction, etc.—and assessments of patient safety (Aiken et al., 2011). A total of 272,783 surveys were sent out between 2006 and 2008 to a random sample of all actively licensed registered nurses in California, Pennsylvania, New Jersey, and Florida. A random sample of 40% of all active registered nurses was selected in California and Pennsylvania. A random sample of 25% of all active registered nurses was selected in Florida and a 50% random sample of nurses in New

Jersey. To decrease self-selection bias in case some hospitals refused to participate, surveys were sent to individual nurses' addresses provided from the state boards Nurses were asked to fill out location and name of their workplace if they were employed in a hospital, home care, or nursing home facility. This enabled the researchers to calculate nursing organizational factors such as staffing levels and proportion of BSNs, and also to link with hospital structural factors such as bed size, teaching, and technology status to better measure the impact of nurse work environment including nurse-physician teamwork. One aim of the parent study was to understand the insider perspective of the organization of work in hospitals from the nurses' view. As such, a large number of surveys were mailed out to nurses in an effort to include as many hospitals as possible indirectly through nurses (Smith, 2009).

A modified Dillman (2000) method of repeated surveys and postcards was used with an overall response rate of 35.4%; a random sample survey of non-responders was conducted to check for response bias. The non-responder survey included 650 nurses in the states of California and Pennsylvania, and was comprised of a shorter questionnaire with a financial incentive. The response rate to the nonresponder survey was 91% and other than differing demographics (sex, race, national origin), there were no differences in evaluations of this study's measures between the nurses who responded initially and those who failed to respond initially but responded to the non-responder survey (Smith, 2009).

Datasets

Multi-State Nursing Care and Patient Safety Study

The dataset from the Multi-State Nursing Care and Patient Safety Study includes data on more than 30,000 nurses who worked in adult non-federal acute care hospitals in the states of New Jersey, Pennsylvania, Florida, and California. The survey contains information on nurses' demographics, education level, work experience, workloads, job satisfaction, intent to leave, etc. In addition, the survey also contains the Practice Environment Scale of the Nursing Work Index Revised tool, measuring the state of nursing environment which has been validated and used in a variety of other studies.

American Hospital Association Annual Survey of Hospitals

The American Hospital Association conducts an annual survey and provides data on nearly 6,000 hospitals. The survey covers a wide range of topics, which include structural characteristics, facilities and services, number of staffed beds, staffing, and finances. The AHA annual survey was the source for information on size, technology, and teaching status of hospitals in our study.

Patient Discharge Databases

Patient discharge data for hospitals in the parent study are available from these independent state agencies from 2006-2007: California Office of Statewide Health Planning and Development (OSHPD); Florida Agency for Healthcare Administration; New Jersey Department of Health and Senior Services; and Pennsylvania Health Care Cost Containment Council (PHC4). These state databases include a facility identifier, a pseudo- patient identifier, patient demographics, admission information, principal and

secondary diagnosis and procedure codes (ICD-9-CM), payer, length of stay, discharge status (alive/dead) and destination, diagnosis-related group (DRG) assignment, and summary charges. Previously linked vital statistics data were used to identify patients who died within thirty days of admission post hospital discharge.

Sample

Hospital

This study used adult non-federal acute care hospitals that were included in the 2006-2007 American Hospital Association Annual survey in the states of California, Pennsylvania, New Jersey, and Florida, and had a minimum of 10 nurses that responded to the nurse survey. Previous studies have shown the reliability of survey measurements with at least 10 nurses per hospital (Aiken, et al., 2003). This study also used aggregation statistical tests (intra-class correlation) to ensure inter-rater reliability. There are 665 hospitals included in our sample.

Nurses

Nurses were included in this study if they (a) worked in an adult, non-federal, acute care hospital and (b) worked in direct patient care; 29,391 nurses are included in our sample. There were no exclusions in type of units worked as nurse-physician teamwork occurs in all types of units. The differences in geographic locations of nurses provided diverse, broad, and reasonable representation of nurses, hospital and patients in the United States (Aiken et al., 2010).

Patients

Patient data were used to measure outcomes. The following patient sample will be included: patients aged 18-90 years with Diagnosis Related Group for general, orthopedic, or vascular surgery, admitted between January 1, 2006 and December 2007 in California, Pennsylvania, and New Jersey, and between January 1, 2006 and December 31, 2007 in Florida (in order to be in the same timeframe as when the nurse surveys were distributed for these states). These surgical procedures were selected as they are performed in most general hospitals (Brooks-Carthon, Kutney-Lee, Jarrin, Sloane, & Aiken, 2012) and used in previous research (Silber, Rosenbaum, Zhang, & Even-Shoshan, 2007).

Variables

Main variable of interest

Level of nurse-physician teamwork was the main explanatory variable measured by the nurse-physician relations subscale in the Practice Environment Scale of the Nursing Work Index (Lake, 2002). The components of this subscale are as follows: (a) teamwork between nurses and doctors, (b) quality of relationships between physicians and nurses, and (c) degree of functional collaboration between nurses and physicians. Each question is measured on a Likert scale from 1 to 4 ranging from “strongly disagree” to “strongly agree”. To link with other datasets and measure organizational properties, the nurse-physician relations subscale was aggregated to the hospital level. The aggregated measurement of nurse-physician relations was categorized into three levels of low 25%, middle 50% and high 25% level for stratified comparison of patient outcomes.

Nurse work environment. The Practice Environment Scale of the Nursing Work Index (PES-NWI) developed from the Nursing Work Index (NWI) and Revised Nursing Work Index (NWI-R) (Aiken & Patrician, 2000; Lake, 2002). The validity and reliability of the PES-NWI have been tested and recommended by the National Quality Forum as a nurse-sensitive instrument to measure nurse work environment (Friese et al., 2008). The PES-NWI has 31 items with five dimensions of professional nursing practice: nurse participation in hospital affairs; nursing foundations for quality care; nurse manager ability, leadership and support of nurses; staffing and resource adequacy; and nurse-physician relations (Lake, 2002). Reviews of instruments measuring organization of nurses work found that the PES-NWI was the most promising instrument due to its theoretically relevant content, ease of use and wide dissemination (Lake, 2007) and content, construct, discriminant and concurrent validity (Bonneterre, Liaudy, Chatellier, Lang, & de Gaudemaris, 2008). This study will focus on the subscale of nurse-physician relations and aggregate it to the hospital level to link with other datasets.

The collegial nurse-physician relations subscale is part of the PES-NWI and the 3 item questions are also present in the NWI-R. Several studies reported significant associations from this particular subscale to quality of care outcomes (Gunnarsdóttir, Clarke, Rafferty, & Nutbeam, 2009; Kanai-Pak, Aiken, Sloane, & Poghosyan, 2008). Kanai-Pak et al. (2008) found that high burnout, poor-fair quality of care, and job dissatisfaction were 40% higher in hospitals where nurses had less satisfactory relations with physicians in 19 hospitals in Japan. Similarly, a study of 695 nurses in Iceland found that the individual subscale of collegial nurse-physician relations from the NWI-R

was a statistically significant predictor of nurse job satisfaction, burnout and nurse rated quality of patient care (Gunnarsdóttir et al., 2009).

Lake (2002) showed the validity of the overall PES-NWI with the 1985-1986 survey conducted by Kramer and Hafner (1989) on nurses in magnet and non-magnet hospitals. The composite collegial nurse-physician relations subscale showed moderate reliability at the individual level (Cronbach Alpha =.71) but robust average interitem correlation (.72) and ICC(1,k) (.86). Factor analysis with varimax rotation method showed the question "a lot of teamwork between nurses and doctors" as having the strongest association (0.65) followed by "physicians and nurses have good working relationships" (0.55) and "collaboration between nurses and physicians" (0.53) (Lake, 2002). However, factor analysis with oblimin with Kaiser normalization rotation method from the Iceland sample from Gunnarsdóttir et al. (2009) showed "collaboration between nurses and physicians" having the strongest association (0.81) followed by "physicians and nurses have good working relationships" (0.71) and "a lot of teamwork between nurses and doctors" (0.60). Further analysis for nurse-physician relations subscale is included in results section.

Nurse staffing. Survey responses from nurses include the questions "On the most recent shift/day you worked, how many patients were on your unit?" and "On the most recent shift/day you worked, counting yourself, how many RNs provided direct patient care?" Utilizing these questions, the number of patients divided by number of nurses on the unit were then aggregated to the hospital level. The mean number of patients cared for by nurses on the last shift for each hospital has been thought to better reflect how

patients are cared for in their hospitalization, as they may stay in more than one unit and be seen by more than one nurse (Aiken et al., 2002).

Nurse education. Nurses provide the answer to the question of highest degree attained in the survey. A dummy variable is created with "1" coded as those with having at least a BSN and "0" coded as not having at least a BSN. Previous studies have shown that the proportion of baccalaureate prepared nurses at the hospital level have associations with various patient outcomes (Aiken et al., 2003; Kutney-Lee, Sloane, & Aiken, 2013). Again the proportion of nurses with BSN degrees was aggregated to the hospital level to link to other datasets.

Percent of Nurses in Medical/Surgical and Intensive Care Unit (ICU) Settings. In order to account for hospitals with differences in staffing due to differences in unit settings, the logistic regression models included the percent of nurses in each hospital who reported working in Medical/Surgical and ICUs during their last shift.

Hospital characteristics

Bedsize. Hospitals are classified by the following categories according to their size: small (i.e.<=100 beds), medium (i.e. 101 – 250 beds), and large (>250 beds).

Teaching status. Hospitals are categorized according to the teaching capacity. Those without postgraduate trainees are non-teaching hospitals; hospitals with a 1:4 or smaller trainee-to-bed ratio are minor teaching hospitals; those with greater than a 1:4 trainee-to-bed ratio are major teaching hospitals.

Technology level. Hospitals that are capable of supporting open-heart surgery and/or major transplants are called high-technology hospitals. The rest are non-high technology hospitals.

Patient outcomes and characteristics for risk adjustment

Outcomes

Mortality and failure-to-rescue will be used because they are critical patient outcomes that have been investigated in numerous studies and can be objectively measured (Needleman et al., 2011; Park et al., 2012; Aiken et al., 2008).

30-day mortality. Discharge files linked with vital statistics indicate if patients died within 30 days of admission and whether patients died outside the hospital. This measure is preferable to inpatient mortality because there can be delayed effects of poor care during hospitalization after discharge.

Failure-to-Rescue. Silber and colleagues first defined FTR in 1992 although the definition has since been refined to "death within 30 days of admission for patients who have suffered a complication while in the hospital" (Clarke & Aiken, 2003; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995b; Silber et al., 1992). This measurement of FTR is more highly associated with provider characteristics than complications and 30-day mortality rates (Silber & Rosenbaum, 1997). According to Silber and colleagues, patients' characteristics such as age and comorbidities explain more of the variations in 30-day mortality than do hospital characteristics (Silber, Rosenbaum, & Ross, 1995a).

Calculation of FTR uses the same numerator as mortality rates; however, rather than including the entire patient sample, the denominator of FTR only uses patients who

had complications (Silber et al., 2007). Mortality and complication rates are associated with patient characteristics, but FTR rates are associated with hospital characteristics that are under the control of hospital management, such as organization of nursing care (Silber et al., 2007). For nursing care in hospitals, FTR is an appropriate benchmark to use because FTR rates are a barometer of a hospital's ability to rescue a patient when complications develop, and nurses can intervene when patients' conditions worsen (Needleman & Buerhaus, 2007).

Risk Adjustment

Appropriate risk adjustments are needed when studying relationships of mortality and FTR with other variables (Iezzoni, 2003). Differing patient characteristics, such as age, gender, and primary conditions, should all be controlled for, and co-morbidities should be used for risk adjustment (Iezzoni, 2003).

Patient demographics. Age was measured as a continuous variable while gender was assigned a dummy variable with 1=male and 0=female. These demographics have an influence on patients' risk for different outcomes (Aiken et al., 2002; Aiken et al., 2008; Aiken et al., 2011). Older adults, especially those older than 90 years of age, have higher risk of early mortality due to less adaptability to the stress of surgeries and postoperative complications (Hamel, Henderson, Khuri, & Daley, 2005; Massarweh, Legner, Symons, McCormick, & Flum, 2009). Women tend to have longer life expectancies than men, and overall risk of mortality increases with age (Seifarth, McGowan, & Milne, 2012). While older black and white patients have different mortality and complication rates in general, orthopedic, and vascular surgery (Brooks-

Carthon et al., 2012), this study did not adjust for race/ethnicity, as the disadvantage in putting race/ethnicity into the model is that it might adjust unequal treatments away for hospitals that actually do treat racial minorities differently.

Medical comorbidities. Comorbidities are important to control for as they have been long recognized as potential confounders of mortality (Schneeweiss, 2000). The comorbidity risk adjustment approach developed by Elixhauser and colleagues (Elixhauseret al., 1998) was applied in a modified form for this study. Of the 29 comorbidities identified in the original Elixhauser method, fluid and electrolyte disorders and coagulopathy have been shown to be miscalculated with complication (Glance, Dick, Osler, & Mukamel, 2006). The Elixhauser comorbidity risk adjustment has been shown to have better discrimination than other approaches using administrative data (Elixhauser et al., 1998), utilized with surgical patients (Volpp et al., 2007), or validated for use with ICD-9 coding (Li, Evans, & Faris, 2008). The superiority of the Elixhauser comorbidity risk adjustment approach versus Deyo et al. adaptation of the Charlson Comorbidity Index has also been demonstrated in mortality risk models (Stukenborg, Wagner, & Connors, 2001). Based on existing studies, a 180 day look-back period to previous hospitalization was used to distinguish between comorbidities and complications (Aiken et al., 2011; Aiken et al., 2002).

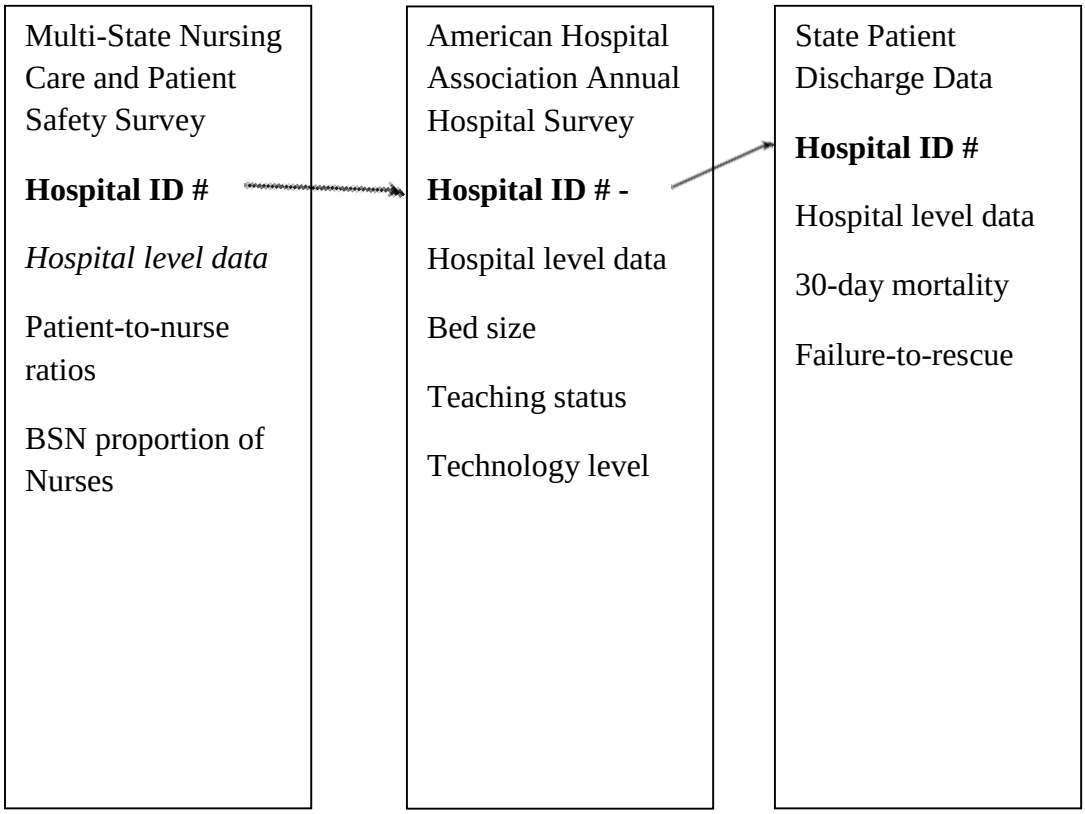
Surgery types. Patients' surgical procedures were provided by the DRG codes and a set of 48 dummy variables were used to indicate surgery type, a method validated in previous literature (Aiken et al., 2002).

Data Analysis

Procedures

Data was organized and inspected for missing data and dummy variables were derived when necessary. Datasets were linked by hospital identification numbers (Figure 2) and statistical significance was set at $p<.05$. Variables used in this study are shown in Appendix A, table 15.

Figure 2. Data Linkage



Research objective:

To determine the association between quality of nurse-physician teamwork and patient outcomes (30-day mortality and failure-to-rescue), while controlling for patient demographics, comorbidities, and hospital structural factors (hospital size, technology level, teaching status). Also determining whether nurses and physicians teamwork and outcomes depends on other modifiable nursing organizational factors (nurse staffing and education) in acute hospital settings.

Hypothesis: Better patient outcomes will be found in hospitals with higher levels of nurse-physician teamwork, better nurse staffing, and higher percentages of nurses with BSN degrees.

A logistic regression was used as the first model for the dichotomous outcomes of 30-day mortality and FTR. This model estimated the bivariate (unadjusted) relationship between the outcome and the predictors of interest (nurse-physician teamwork, patient to nurse ratios, and nurse education). The outcome variables of 30-day-mortality and FTR were measured at the patient level.

The next step was to use multiple logistic regression to control for patient and hospital characteristics that can influence the occurrence of the outcomes. Each of the predictor variables of interest was modeled separately to show the extent of their impact on the outcome.

Then a model that combined all the predictor variables of interest was run to estimate the influence each variable had on the outcomes. Furthermore, multicollinearity tests were done to determine whether predictors are highly correlated. Myers (1990)

suggested that a variance inflation factor (VIF) value greater than 10 is a cause for concern for multicollinearity in a regression analysis.

Finally a model to test whether the effects of nurse-physician teamwork on patient outcomes is conditional on nurse staffing and nurse education was used. The effects of nurse-physician teamwork were stratified into low (lowest quartile), middle (second and third quartiles), and high (highest quartile) levels were shown with varied patient-to-nurse workload ratios on patient outcomes similar to the study by Aiken et al., (2011).

Clustering of patients in hospitals was accounted for using the Huber-White sandwich estimator (Huber, 1967; White, 1980; Williams, 2000). There are concerns that patients treated by the same physicians and nurses working in the same hospital tend to share similar characteristics with their respective peer groups. If ignored, these common characteristics could lead to an underestimation of standard errors (SE), so a robust standard error adjustment needs to be used for better estimation (Greenfield, 1999). Goodness of fit of the models will be calculated to see how well the models predict the outcomes. The Hosmer-Lemeshow test was used, where a value greater than 0.5 predicts the outcome better than chance (Hosmer, Lemeshow, & Cook, 2000).

Human Subjects

This study of patients and nurses in CA, FL, NJ, and PA hospitals is based on secondary deidentified human subjects' data in the form of administrative data and primary nurse survey data. This research is covered under University of Pennsylvania protocol number 821602 (see appendix). As such this study poses no risk to patients or nurses.

Human Subjects Involvement

Patients: The study population includes de-identified administrative records on patients who have been hospitalized in general acute care hospitals in CA, FL, NJ, and PA and have undergone general, orthopedic, or vascular surgery.

Nurses: The study population is composed of a random sample of deidentified registered nurses who are actively licensed and residing in the states of CA, FL, NJ, and PA.

Potential Risks

Patients: This study poses no risk to patients. All patient data have been purged of identifying codes and assigned unique pseudo identifiers by state agencies that are coded uniquely to specific requests. All data will be stored on a secure research server in the School of Nursing at the University of Pennsylvania.

Hospitals: In order to avoid issues with hospital reputation standings, hospitals' names will not be used from working analytic files and will remain unreported in study findings. Findings will only be reported in the aggregate.

Potential Benefits of the Proposed Research

This study has the potential to advance understanding of the factors associated with nurse-physician collaborative teamwork in the care of surgical patients and inform policy and education reform in improvement of patient care.

CHAPTER 4 – RESULTS

The objective of this study was to examine the association of nurse-physician teamwork with patient outcomes (mortality and FTR) and the interactions with organizational factors (nurse staffing and nurse education). The hypothesis was that hospitals with better staffing ratios would strengthen nurse-physician teamwork's correlation on patient outcomes, or rates of patient mortality and FTR.

Nurse-Physician Relations Subscale Analysis

Table 1 shows exploratory factor analysis of the items in the PES-NWI subscale nurse-physician relations in the in our study sample of nurses. This shows how strongly each item loads on the factor (ideally above .6). The factor loading calculated by the varimax rotation method (indicating that factors are independent of each other) is consistent and within range of the studies mentioned above.

Table 1. Results of Exploratory Factor Analysis of Selected Items of the Nursing Work Index

Subscale and Items	Loading
Collegial Nurse–Physician Relations	
A lot of teamwork between nurses and doctors.	0.83
Physicians and nurses have good working relationships	0.76
Collaboration between nurses and physicians.	0.82

Table 2 provides information on the reliability of the individual items, which are strong to very strong (.78-.85). The average interitem correlation also is robust, with ICC (1,k) of greater than .6 (ideally >.5).

Table 2. Reliability Indices for the Nurse–Physician Relations Subscale of the PES-NWI

	Individual level	Hospital Level		
	Cronbach's Alpha	Average Interitem Correlation	ICC 1	ICC (1,k)
A lot of teamwork between nurses and doctors.	0.782	0.803	0.051	0.669
Physicians and nurses have good working relationships	0.847	0.840	0.050	0.662
Collaboration between nurses and physicians.	0.796	0.877	0.054	0.679

Table 3 provides additional details on correlation of items on this subscale, demonstrating that they are moderately correlated (.66-.74). The common variance, which indicates variance in each item shared by common factors (ideally above .5), and specific variance, which indicates that the variance unique to each variable and not explained by other influences, are also tabulated. A specific variance value of 1 indicates that the variable has no common factor component, while 0 indicates the variable is entirely determined by common factors.

Table 3. Pearson Correlations Among Items and Variance Components of Nurse–Physician Relations Subscale of the PES-NWI

				Proportion of Variance	
Item	1	2	Loading	Common	Specific
1. A lot of teamwork between nurses and doctors.	--		0.83	0.48	*0.30*
2. Physicians and nurses have good working relationships	0.66	--	0.75	0.42	*0.43*
3. Collaboration between nurses and physicians.	0.74	0.64	0.82	0.47	*0.33*

Characteristics of the Sample

Table 4 shows descriptive characteristics of the hospitals in the study, general, vascular and orthopedic surgery patients discharged from hospitals, and nurses surveyed in the study hospitals. California has the largest percentage of the study hospitals (41%), patients (41%) and nurses (33%) of the four states. Florida has a quarter of the study hospitals (25%), the second largest percentage of patients (27%) but the least percentage of nurses (20%) among the four states. Pennsylvania also has nearly a quarter of the study hospitals (23%), a large percentage of patients (22%) and a quarter of the nurses (25%) in the study. New Jersey has the least percentage of the study hospitals (11%) and patients (11%) but nearly a quarter of the nurses (22%) in the study. Hospitals in the study varied in nursing characteristics, with a quarter of the hospitals having a patient-to-nurse ratio of 4 or less and around 20% having a patient-to-nurse ratio of 7 or more. Fewer than 20% of hospitals have a nursing workforce where more than 50% of their nurses are BSNs. The hospitals were grouped by quality of nurse-physician teamwork scores into categories of "good", for the top 25 percent of hospitals in the study, "mixed", for the middle 50 percent, and "poor", for the bottom 25 percent.

Table 4. Characteristics of Hospitals, and Proportions of Patients and Nurses			
	No. (%) Hospitals (n=665)	No. (%) Patients (n=1,321,904)	No. (%) Staff Nurses (n=29,391)
Nurse Staffing (Patient/Nurse)			
4 or fewer	175 (26.3)	356,258 (27.0)	7,337 (25.0)
5	214 (32.2)	496,735 (37.6)	11,893 (40.5)
6	142 (21.4)	277,003 (21.0)	6,555 (22.3)
7	76 (11.4)	119,485 (9.0)	2,266 (7.7)
8 or more	58 (8.7)	72,423 (5.5)	1,340 (4.6)
Nurse-Physician Relations			
Poor (>2.78)	196 (29.5)	324,226 (24.5)	11,004 (37.4)
Mixed (2.78-3.03)	296 (44.5)	653,152 (49.4)	8,368 (28.5)
Good (>3.03)	173 (26.0)	344,526 (26.1)	10,019 (34.1)
Nurse Education (% BSN)			
0-19	67 (10.1)	61,056 (4.6)	1,237 (4.2)
20-29	133 (20.0)	232,831 (17.6)	5,053 (17.2)
30-39	188 (28.3)	367,335 (27.8)	8,332(28.4)
40-49	146 (22.0)	321,697 (24.4)	7,403 (25.2)
>50	131 (19.7)	338,985 (25.6)	7,366 (25.1)
Location			
California	271 (40.8)	535,977 (40.6)	9,493 (32.30)
Pennsylvania	153 (23.0)	287,629 (21.8)	7,315 (24.89)
Florida	168 (25.3)	359,888 (27.2)	6,328 (24.89)
New Jersey	73 (11.0)	138,410 (10.5)	6,255 (21.53)
Bed Size			
<100	100 (15.1)	66,275 (5.0)	1,493 (5.1)
101-250	300 (45.3)	418,155 (31.6)	8,961 (30.5)
>250	264 (39.6)	837,205 (63.3)	18,923 (64.4)
Technology			
Not high tech	403 (60.7)	527,726 (39.9)	12,160 (41.4)
High tech	261 (39.3)	793,909 (60.1)	17,217 (58.6)
Teaching Status			
None	352 (53.0)	594,337 (45.0)	12,580 (42.8)
Minor	266 (40.1)	544,843 (41.2)	12,434 (42.3)
Major	46 (6.9)	182,455 (13.8)	4,363 (14.9)
Numbers in categories may not add up to total number due to missing values.			

Table 5 further describes the characteristics of the nurses in the study. The average age of staff nurses is 44.8 years, with a standard deviation of 10.8 years. Almost all (93.2 %) of the nurses are female, and a majority (57.3%) of nurses hold degrees lower than a bachelor's degree. Around a quarter of nurses (23.6%) reported the last unit they worked in was an ICU and 17.5% reported their last unit was a medical/surgical unit.

Table 5. Characteristics of Nurses in Study

Nurse Characteristics	Staff Nurses (N= 29,391)
Age (years), mean (SD)	44.9 (10.7)
Female, n (%)	27,267 (93.2)
Nurse Education, n (%)	
Diploma	5,261 (18.8)
Associates	10,744 (38.5)
Bachelors	11,070 (39.7)
Masters	830 (3.0)
Doctorate	8 (0.03)
Unit Type, n (%)	
Medical/Surgical Unit	4,167 (17.5)
Intensive Care Unit	5,634 (23.6)

Numbers in categories may not add up to total number due to missing values.

Table 6 provides information and summary on patient demographics, surgical, and diagnostic categories. Patients with complications represented 34% of all patients, or 454,564 out of 1,321,904 patients. Average age of all patients was around 60, while patients with complications tended to be older (64). Patient with complications tended to have a higher percentage of being transferred (2.1%) and death within 30 days of admission (4.8%) than patients without complications (0.8% and 0.4%). Patients without complications were significantly younger (58.2), with less transfers (6,488), less percentages of death within 30 days of hospital admission (0.4%), and larger percentage presented for orthopedic surgery (56.2%) than patients with complications. The most common type of surgery was orthopedic surgery (Musculoskeletal System & Connective Tissue) in all patients and those with complications (52.3% and 44.9%).

Table 6 also provides a summary of patient comorbidities identified with the 27 Elixhauser comorbidities evaluated. Hypertension was the most prevalent comorbidity in both populations (all patients=48%; patients with complications=53%). The average number of comorbidities was 2.2 (SD=1.3) in all patients, while patients with complications had a slightly higher rate at 2.53 (SD=1.5). All the Elixhauser comorbidities except obesity were present significantly less frequently for patients without complications than for patients with complications.

Table 6. Characteristics of Surgical Patients				
	All patients (n = 1,321,904**)**	Patients With Complications (n = 454,564)	Patients Without Complications (n = 867,340)	*P* - value
	No. (%)	No. (%)	No. (%)	
Male	570,846 (43.2)	211,907 (46.6)	358,939 (41.4)	<0.001
Age (years), mean (SD)	60.2 (17.5)	64.2 (16.7)	58.2 (17.6)	<0.001
Transferred status	15,890 (1.2)	9,402 (2.1)	6,488 (0.8)	<0.001
Death within 30 days of admission	25,514 (1.9)	21,807 (4.8)	3,707 (0.4)	<0.001
Major Surgical Category				
General Surgery (MDC 6,7,9,10)				
Digestive System disease and disorders (6)	279,503 (21.9)	108,529 (24.8)	170,974 (20.4)	<0.001
Hepatobiliary System diseases and disorders (7)	143,411 (11.2)	48,220 (11.0)	95,191 (11.3)	<0.001
Diseases and disorders of the skin, subcutaneous tissue & breast (9)	45,457 (3.6)	17,457 (4.0)	28,000 (3.3)	<0.001
Endocrine, Nutritional, Metabolic Diseases & Disorders (10)	71,031 (5.6)	20,179 (4.6)	50,852 (6.1)	<0.001
Orthopedic Surgery (MDC 8)	668,639 (52.3)	196,646 (44.9)	471,993 (56.2)	<0.001
Musculoskeletal System & Connective Tissue				
Vascular Surgery (MDC 5)	70,021 (5.5)	46,991 (10.7)	23,030 (2.7)	<0.001
Circulatory system diseases and disorders				
Congestive heart failure	69,700 (5.3)	45,483 (10.0)	24,217 (2.8)	<0.001
Valvular disease	61,830 (4.7)	28,621 (6.3)	33,209 (3.8)	<0.001
Pulmonary circulation disorders	14,100 (1.1)	10,720 (2.4)	3,380 (0.4)	<0.001

Peripheral vascular disorders	59,563 (4.5)	34,542 (7.6)	25,021 (2.9)	<0.001
Hypertension	639,698 (48.4)	240,515 (52.9)	399,183 (46.0)	<0.001
Paralysis	18,685 (1.4)	10,673 (2.4)	8,012 (0.9)	<0.001
Other neurological disorders	55,704 (4.21)	36,070 (7.9)	19,634 (2.3)	<0.001
Chronic pulmonary disease	193,499 (14.6)	84,537 (18.6)	108,962 (12.6)	<0.001
Diabetes, uncomplicated	198,805 (15.0)	74,308 (16.4)	124,497 (14.4)	<0.001
Diabetes, complicated	44,600 (3.4)	27,961 (6.2)	16,639 (1.9)	<0.001
Hypothyroidism	124,916 (9.5)	45,023 (9.9)	79,893 (9.2)	<0.001
Renal failure	64,749 (4.9)	42,300 (9.3)	22,449 (2.6)	<0.001
Liver disease	30,500 (2.3)	14,335 (3.2)	16,165 (1.9)	<0.001
Peptic ulcer disease (excluding bleeding)	868 (0.1)	426 (0.1)	442 (0.1)	<0.001
Aids	2,172 (0.2)	1,070 (0.2)	1,102 (0.1)	<0.001
Lymphoma	5,941 (0.5)	2,807 (0.6)	3,134 (0.4)	<0.001
Solid tumor without metastasis	15,384 (1.1)	7,507 (1.7)	7,877 (0.9)	<0.001
Metastatic cancer	42,227 (3.2)	21,798 (4.8)	20,429 (2.4)	<0.001
Rheumatoid arthritis/collagen vascular diseases	31,296 (2.4)	11,873 (2.6)	19,423 (2.2)	<0.001
Obesity	114,295 (8.7)	39,162 (8.6)	75,133(8.7)	0.359
Weight loss	23,565 (1.8)	18,519 (4.1)	5,046 (0.6)	<0.001
Blood loss anemia	21,957 (1.7)	11,750 (2.6)	10,207 (1.2)	<0.001
Deficiency anemias	183,412 (13.9)	86,248 (19.0)	97,164 (11.2)	<0.001
Alcohol abuse	31,499 (2.4)	16,022 (3.5)	15,477 (1.8)	<0.001
Drug abuse	18,739 (1.4)	8,884 (2.0)	9,855 (1.1)	<0.001
Psychoses	25,542 (1.9)	12,333 (2.7)	13,209 (1.5)	<0.001
Depression	96,261 (7.3)	35,677 (7.9)	60,584 (7.0)	<0.001

Comorbidities per patient, mean (SD)	2.22 (1.3)	2.53 (1.5)	1.4 (1.3)	<0.001

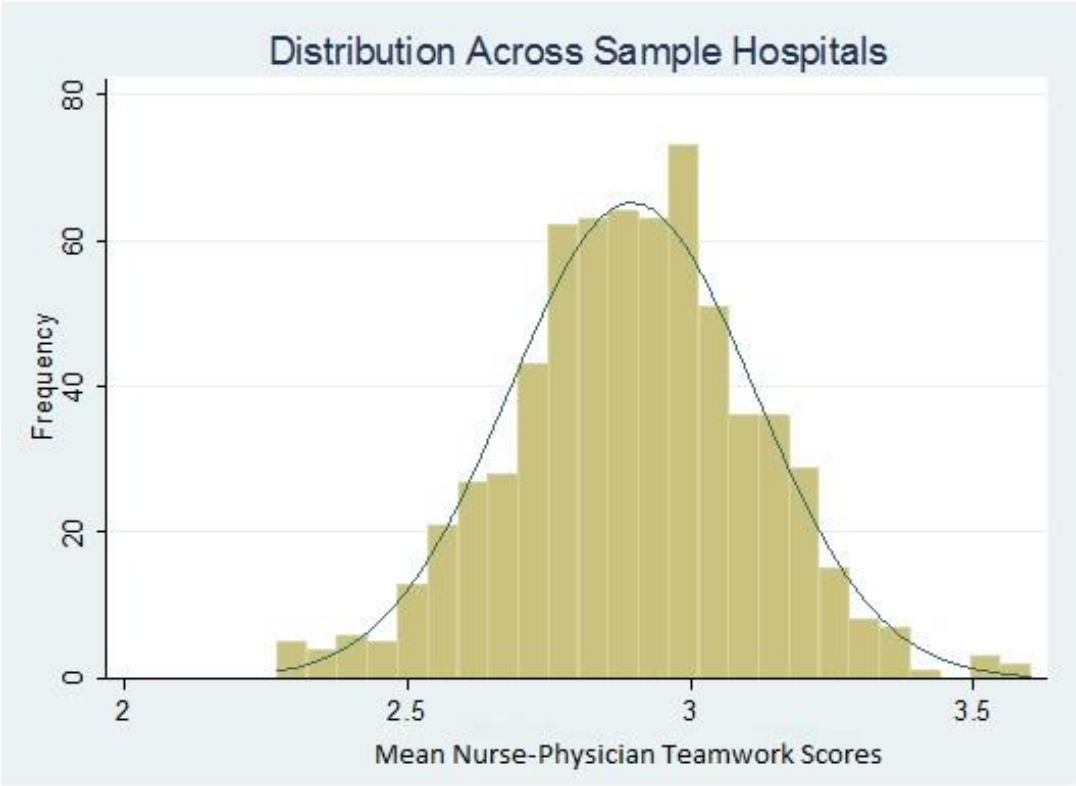


Figure 3. Distribution of Nurse-Physician Teamwork Scores across Study Hospitals.

Figure 3 shows that the distribution of nurse-physician teamwork scores varied across the 665 study hospitals from 2.27 to 3.6. There is a mean of 2.90 with a standard deviation of 0.22 in this figure, showing that there are variations across hospitals.

Table 7. Pearson Correlations between Nurse-physician Teamwork, Nursing Organizational Characteristics and Hospital Characteristics in Study Hospitals

	1. Nurse-Physician Teamwork	2. Nurse Staffing	3. Nurse Education	4. Teaching Status	5. High Technology	6. Bed Size
1. Nurse-Physician Teamwork	---					
2. Nurse Staffing	-0.31***	---				
3. Nurse Education	0.23***	-0.34***	---			
4. Teaching Status	0.11***	-0.10***	0.24***	---		
5. High Technology	0.07***	-0.11***	0.17***	0.21***	---	
6. Bed size	0.04***	-0.05***	0.30***	0.37***	0.44***	---

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 7 the Pearson correlation analysis, which showed that there was moderate correlation (moderate meaning values between 0.3 to 0.7 or -0.3 to -0.7) of nurse-physician teamwork scores with nurse staffing levels, and weak correlation (weak meaning values 0 to 0.3 or 0 to -0.3) with other hospital characteristics. All correlations were significant at the $p<0.001$ levels and an analysis of Spearman correlation produced similar results.

Table 8 describes the characteristics of hospitals according to quartiles of the hospital levels of nurse-physician teamwork. Significant differences across hospitals include location and bedsize. Compare to other states, California had greatest percentage of hospitals in the top 25% of teamwork scores while Florida had the lowest percentage of hospitals in the top 25% of teamwork scores and largest percentage in the bottom 25% of teamwork scores. Hospitals with less than 100 beds were twice as likely to be represented in the top quartile as the bottom quartile. Teaching and technology status of the hospitals did not make a significant difference in variation of scores of nurse-physician teamwork.

Table 8. Hospital Characteristics by Categories Of Nurse-Physician Teamwork Levels (N=665)

	All	Bottom 25% (n=167)	Middle 50% (n=332)	Top 25% (n=166)	*P* - value
Hospital Characteristic					
Nurse-Physician Teamwork, Mean (SD)	2.91 (0.19)	2.64 (0.10)	2.90 (0.08)	3.15 (0.09)	<0.001
State, No. (%)					<0.001
California	271	38 (14.0)	130 (48.0)	103 (38.0)	
New Jersey	73	21 (28.7)	38 (52.1)	14 (19.2)	
Florida	168	60 (35.7)	92 (54.8)	16 (9.5)	
Pennsylvania	153	48 (31.4)	72 (47.0)	33 (21.6)	
Bed Size, No. (%)					<0.001
≤100	100	22 (22.0)	37 (37.0)	41 (41.0)	
101-250	300	88 (29.3)	144 (48)	68 (22.7)	
>250	264	57 (21.6)	151 (57.2)	56 (21.2)	
Technology Status, No. (%)					0.031
Not High Tech	403	111 (27.5)	185 (45.9)	107 (26.6)	
High Tech	261	56 (21.5)	147 (56.3)	58 (22.2)	
Teaching Status, No. (%)					0.033
Nonteaching	352	91 (25.9)	171 (48.6)	90 (33.5)	
Minor	266	73 (27.5)	134 (50.3)	59 (22.2)	
Major	46	3 (6.5)	27 (58.7)	16 (34.8)	
Numbers in categories may not add up to total number due to missing values.					

Table 9 shows that there were significant variations across the quartiles of the hospital levels of nurse-physician teamwork in the patient outcome measures of 30-day mortality and FTR. Most notably patients at hospitals in the top 25 percentile of nurse-physician teamwork hospitals had lower 30-day mortality rates (1.7%) than patients at hospitals in the bottom 25 percentile of nurse-physician teamwork hospitals (2.2%). Similarly, patients in the top 25 percentile of nurse-physician teamwork hospitals had lower FTR rates (4.8%) than patients in the bottom 25 percentile of nurse-physician teamwork hospitals (6.3%).

Table 9. General, Orthopedic, and Vascular Surgical Patient Outcome Distribution by Categories of Nurse-Physician Teamwork (N=1,321,904)

	All	Bottom 25% (n=167)	Middle 50% (n=332)	Top 25% (n=166)	*P* - value
Nurse-physician Teamwork, mean (SD)	2.91 (0.19)	2.64 (0.10)	2.90 (0.08)	3.15 (0.09)	
Outcome					
30-day Mortality, No. (%)					
All Surgery^	25,514 (1.9)	5,878 (2.2)	14,106 (2.0)	5,530 (1.7)	<0.001
General	12,212 (2.2)	2,789 (2.4)	6,765 (2.2)	2,658 (1.9)	<0.001
Orthopedic	7,601 (1.1)	1,779 (1.3)	4,113 (1.1)	1,709 (1.0)	<0.001
Vascular	5,701 (7.9)	1,310 (8.5)	3,228 (8.0)	1,163 (7.0)	<0.001
Failure-to-Rescue, No. (%)					
All Surgery^	25,514 (5.6)	5,878 (6.3)	14,106 (5.6)	5,530 (4.8)	<0.001
General	12,212 (6.0)	2,789 (6.3)	6,765 (6.2)	2,658 (5.3)	<0.001
Orthopedic	7,601 (3.7)	1,779 (4.5)	4,113 (3.6)	1,709 (3.2)	<0.001
Vascular	5,701 (11.7)	1,310 (12.6)	3,228 (11.9)	1,163 (10.3)	<0.001
Complication, No. (%)					
	454,564 (34.4)	116,379 (35.0)	224,592 (34.1)	113,593 (34.4)	<0.001
All Surgery^	202,220 (36.2)	54,313 (37.6)	98,248 (36.1)	49,659 (35.0)	<0.001
General	203,802 (29.5)	48,784 (29.0)	102,356 (29.1)	52,662 (30.7)	<0.001
Orthopedic	48,542 (67.01)	13,282 (67.3)	23,988 (66.6)	11,272 (67.6)	0.028
Vascular					

Analysis of Research Objective

Tables 10 and 11 indicate the effects of adding different confounders to the model in a step wise fashion. Although the effects of our main factor of interest, nurse-physician teamwork, decreased on both outcomes with the addition of each set of confounder variables, the effects were still significant at $p<0.001$ for all models. For the models on 30-day mortality, the unadjusted model shows an odds ratio (OR) of 0.898 with confidence interval (CI) of 0.887 to 0.909 translating to a 10% less likelihood of death for patients for every increase in standard deviation of nurse-physician teamwork score. The model for failure-to-rescue has a similar result, the unadjusted model shows an odds ratio (OR) of 0.906 with confidence interval (CI) of 0.895 to 0.917 translating to around 9% less likelihood of death for patients for every increase in standard deviation of nurse-physician teamwork score. For both patient outcomes models adjusted with patient characteristics, hospital characteristics and staffing and nurse education the OR is 0.950 so a 5% less likelihood of death and failure-to-rescue for patients for every increase in standard deviation of nurse-physician teamwork score.

Table 11 shows that there were an interaction effects between both nurse staffing and nurse-physician teamwork and nurse education and nurse-physician teamwork. The significance of these interaction terms indicated the presence of a modifier effect with nurse staffing and nurse education on nurse-physician teamwork. For the models with interaction of nurse staffing and nurse-physician teamwork, the effect of one standard deviation increase on nurse-physician teamwork score was roughly a 5% decrease in likelihood of death and FTR for patients. The interaction term for nurse education and

nurse-physician teamwork was at OR = 0.946 ($p<0.001$) translating to the effect of one standard deviation increase on nurse-physician teamwork score was roughly a 5% decrease in likelihood of death and FTR for patients.

Table 10. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse-Physician Teamwork, Nurse Staffing, Nurse Education and Interactions on Patient Outcomes

	Odds Ratios from Models for Patient Mortality				
	Unadjusted (Bivariate)	Adjusted with patient characteristics/ comorbidities	Adjusted with patient characteristics/ comorbidities and hospital characteristics	Adjusted with patient and hospital characteristics and staffing	Adjusted with patient and hospital characteristics and staffing and nurse education
Nurse-physician teamwork (OR, CI)	0.898*** [0.887,0.909]	0.929*** [0.917,0.942]	0.943*** [0.930,0.958]	0.949*** [0.936,0.964]	0.950*** [0.939,0.967]
Staffing (OR, CI)				1.038*** [1.026,1.051]	1.028** [1.016,1.041]
Nurse Education (OR, CI)					0.936*** [0.922,0.951]
	Odds Ratios from Models for Failure-to-Rescue				
Nurse-physician teamwork (OR, CI)	0.906*** [0.895,0.917]	0.925*** [0.912,0.937]	0.939*** [0.925,0.953]	0.946*** [0.931,0.960]	0.950*** [0.936,0.964]
Staffing (OR, CI)				1.040*** [1.027,1.052]	1.029*** [1.016,1.042]
Nurse Education (OR, CI)					0.932*** [0.917,0.947]

* p<0.05, ** p<0.01, *** p<0.001

Table 11. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse-Physician Teamwork, Nurse Staffing, Nurse Education and Interactions on Patient Outcomes

Odds Ratios from Models for Patient Mortality		
	Fully adjusted with patient and hospital characteristics and staffing and nurse education and interactions jointly	Fully adjusted with patient and hospital characteristics and staffing and nurse education and interactions jointly
Nurse-Physician Teamwork (OR, CI)	0.952*** [0.938,0.966]	0.946*** [0.932,0.961]
Staffing (OR, CI)	1.040*** [1.027,1.053]	1.030** [1.017,1.042]
Nurse Education (OR, CI)	0.939*** [0.924,0.953]	0.929*** [0.914,0.944]
Staffing X Nurse-Physician Teamwork Interactions	1.024*** [1.015,1.033]	
Nurse Education X Nurse-Physician Teamwork Interaction		0.976*** [0.963,0.989]
Odds Ratios from Models for Failure-to-Rescue		
Nurse-Physician Teamwork (OR, CI)	0.947*** [0.933,0.961]	0.946*** [0.932,0.961]
Staffing (OR, CI)	1.043*** [1.029,1.056]	1.030** [1.017,1.042]
Nurse Education (OR, CI)	0.935*** [0.920,0.950]	0.929*** [0.914,0.944]
Staffing X Nurse-Physician Teamwork Interactions	1.028*** [1.019,1.038]	
Nurse Education X Nurse-Physician Teamwork Interaction		0.976*** [0.963,0.989]
* $p<0.05$, ** $p<0.01$, *** $p<0.001$		

Table 12 shows more succinct models with different associations of the independent variables of interest with 30-day mortality and FTR. Staffing is centered on the mean while nurse-physician teamwork is continuous and in standard deviation units, and nurse education is also standardized and reflects a 10% increase in proportion of BSN nurses by standard deviations. The first row shows the unadjusted models of the association of independent variables individually with mortality and FTR. The next rows show the independent variables adjusted simultaneously on the outcomes of interest with patient and hospital characteristics controlled for in the models. The table shows that all variables had significant effects in all models, indicating better nurse-physician teamwork, lower patient-to-nurse ratios, and higher percentages of BSN nurses decreased the odds of mortality and FTR. For nurse staffing in an unadjusted, or bivariate, model, there is a 5% chance of mortality with each unit of increase of patient-to-nurse ratio. The odds ratio drops down to a factor of 1.028 in a fully adjusted logistic regression model. These results are similar in the failure-to-rescue outcome. In nurse education, an unadjusted model shows a decrease in the odds on patents dying by the odds of 0.94, or 6%. In the fully adjusted model, the factor is 0.936, which is still around 7%. This is similar in the failure-to-rescue model.

Table 12. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse Staffing, the Nurse-Physician Teamwork, and Nurse Education on Patient Mortality and Failure-to-Rescue

Odds Ratios from Models for Patient Mortality			
	Nurse-Physician Teamwork	Nurse Staffing	Nurse Education
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	0.898*** (0.874-0.921)	1.045*** (1.023-1.067)	0.940*** (0.917-0.964)
Fully Adjusted	0.943*** (0.930-0.958)	1.028** (1.007-1.049)	0.936*** (0.909-0.964)

	Nurse-Physician Teamwork	Nurse Staffing	Nurse Education
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	0.906*** (0.881-0.931)	1.043*** (1.020-1.067)	0.934*** (0.911-0.958)
Fully Adjusted	0.939*** (0.925-0.953)	1.029** (1.007-1.051)	0.932*** (0.903-0.962)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Tables 13 and 14 further describe the details of the interaction terms on patient outcomes. The top panel confirms that nurse staffing and education have a modifying effect on nurse-physician teamwork. Table 13 shows that while high nurse-physician teamwork scores lowers the odds of death and failure-to-rescue in hospitals, the effect is most pronounced in better staffed hospitals. The effects of nurse-physician teamwork scores are virtually nil in hospitals of poor staffing, or those hospitals with 2 patients per nurse above the mean. The effects of nurse-physician teamwork score in the best of hospitals staffed at 2 patients per nurse below the mean decreases the odds of mortality and failure to rescue by around 10%. The effects of nurse education had similar effects with nurse-physician teamwork on patient outcomes. While better nurse-physician teamwork lowers the odds of death and failure-to-rescue in hospitals across the ranges of proportions of BSN educated nurses, the effects of nurse-physician teamwork in hospitals that had 20% less BSN educated nurses below the mean had only 1% in decrease of odds on mortality and failure-to-rescue, whereas in hospitals with 20% more BSN educated nurses above the mean, nurse-physician teamwork decreased the odds of mortality and failure-to-rescue by roughly 9%. Higher proportions of BSN educated nurses at the hospital improved the impact of nurse-physician teamwork on patient outcomes, as 30-day mortality and failure-to-rescue had higher odds ratios rates with nurse-physician teamwork when education level decreased.

Additional analysis were also done to include the additional four questions (Physicians hold nurses in high esteem. Physicians respect nurses as professionals. Physicians recognize nurses' contributions to patient care. Physicians value nurses' observations and judgments.) to potentially add more details to the 3 original questions on the Nurse-

Physician Relations Subscale. The results of these analysis are included in the tables in Appendix B and Appendix C. The overall analysis of the expansion of items showed similar results in exploratory factor analysis models and regression models for patient outcomes.

Table 13. Odds Ratios Indicating (a) the Effect of Staffing in Various Nurse-Physician Teamwork, and (b) the Effect of the Nurse-Physician Teamwork at Various Staffing Levels

(a) When Nurse-Physician Teamwork is:	The Odds Ratio Indicating the Effect of Staffing is:	
	On Mortality	On Failure-to-Rescue
Two standard deviations below the mean	0.992	0.987
One standard deviation below the mean	1.016	1.014
At the mean (2.9)	1.024*	1.028*
One standard deviation above the mean	1.064*	1.072*
Two standard deviations above the mean	1.090*	1.102 *

(b) When the Hospitals Patient-to-Nurse Ratio is:	The Odds Ratio Indicating the Effect of the Nurse-Physician Teamwork is:	
	On Mortality	On Failure-to-Rescue
Two patients per nurse above the mean	0.997	1.000
One patient per nurse above the mean	0.974*	0.973
At the mean (5.3)	0.951*	0.947*
One patient per nurse below the mean	0.929*	0.920*
Two patients per nurse below the mean	0.908*	0.896*

* Denotes odds ratio significant at 0.05 level

Table 14. Odds Ratios Indicating (a) the Effect of Staffing in Various Nurse-Physician Teamwork, and (b) the Effect of the Nurse-Physician Teamwork at Various Education Levels

(a) When Nurse-Physician Teamwork is:	The Odds Ratio Indicating the Effect of BSN education is:	
	On Mortality	On Failure-to-Rescue
Two standard deviations below the mean	0.984	0.981
One standard deviation below the mean	0.966*	0.963*
At the mean (2.9)	0.982*	0.976*
One standard deviation above the mean	0.931*	0.929*
Two standard deviations above the mean	0.914*	0.912 *

(b) When the BSN education level is:	The Odds Ratio Indicating the Effect of the Nurse-Physician Teamwork is:	
	On Mortality	On Failure-to-Rescue
20% increase above the mean	0.915*	0.913*
10% increase above the mean	0.932*	0.929*
At the mean (40%)	0.954*	0.946*
10% decrease below the mean	0.967*	0.963*
20% decrease below the mean	0.986	0.981

* Denotes odds ratio significant at 0.05 level

CHAPTER 5 – DISCUSSION

The purpose of this study was to determine the association between nurse-physician teamwork and patient outcomes. An additional hypothesis was that the effects of nurse-physician teamwork on patient outcomes would differ in hospitals with different levels of nurse organizational outcomes.

This chapter begins with a discussion of the study's main findings concerning nurse-physician teamwork and nurse organizational factors and effects on outcomes of 30-day mortality and FTR. Then a discussion of the limitations is presented. Lastly, implications and recommendations for future research are discussed.

Main Findings

The results of this study confirm previous studies that found higher nurse-physician teamwork to be associated with lower patient mortality rates in hospitals (Baggs et al., 1999; Knaus et al., 1986; Wheelan et al., 2003). However, there are numerous differences from prior studies. Previous studies were all conducted in ICUs (Baggs et al., 1999; Knaus et al., 1986; Wheelan et al., 2003), while this study was conducted at the hospital level. While some previous studies used the higher than predicted mortality rate (Knaus et al., 1986; Wheelan et al., 2003) for patient outcomes, this study used FTR and 30-day mortality rates. Measures of teamwork were collected through questionnaires completed by staff members but some studies used nurses and physicians (Baggs et al., 1999; Wheelan et al., 2003), while others used unit medical or nursing directors (Knaus et al., 1986). Different questionnaires were used for all studies.

More importantly, at the time of writing, this is the first study to document how nursing organizational factors modify nurse-physician teamwork's association with surgical patient outcomes. Initial analysis confirmed the hypothesis of that nurse-physician teamwork, nurse staffing, and nurse education levels all had impacts on the patient outcomes of 30-day mortality and FTR. An in depth analysis reveals a trend of a decrease in odds of deaths for hospitals with both higher nurse-physician teamwork scores and lower patient per nurse ratios for both patient outcomes.

The hospital level analysis of nurse-physician teamwork and nurse staffing levels showed that in hospitals with higher patient to nurse ratios, the nurses reported lower perceptions of nurse-physician teamwork. Nurse education level also had an impact on nurse-physician teamwork, as the data showed that hospitals with higher percentages of BSN educated nurses tend to have significantly higher levels of nurse-physician teamwork ($p<0.001$).

The impact of nurse education level on nurse-physician teamwork documented here is different than an earlier study looking at factors that predict more nurse-physician teamwork(Alt-White et al., 1983), which found no statistically significant relationship between nurse-physician teamwork and educational preparation of the nursing staff. In that study, data was gathered through questionnaires completed by nurses, but the study population was a single hospital. A contribution of baccalaureate nursing education to improved teamwork may not have been present in that specific hospital, but it appears to be a broad phenomenon present in many of the hospitals in this wider population.

Implications

Policy makers, educators, and leaders in the health care system acknowledge the importance of interprofessional teamwork, but the majority of these programs have focused on factors other than nursing variables that contribute to interprofessional teamwork (IOM, 2010; Martin et al., 2010). There have been numerous initiatives and programs implemented to improve teamwork. Missing from all these initiatives is the recognition that nurse staffing and education levels contribute to optimization of patient centered team based health care.

At the policy level there have been systematic efforts to improve teamwork, coordination, and communication for better patient care and safety. Unfortunately there are still variations in levels of teamwork across hospitals despite policies initiated to improve teamwork. The Affordable Care Act (ACA) promotes coordination of patient care across the health care system with Accountable Care Organizations (ACOs) and Patient-Centered Medical Homes (PCMHs). These efforts by the ACA put an emphasis on the integral role of interprofessional teams (Nester, 2016). The environment in ACOs and PCMHs strongly encourage teamwork among interprofessional teams to improve patient outcomes (Nester, 2016). In addition, efforts to improve teamwork among health care providers, such as those of The Joint Commission, require organizations to create code of conduct to discourage and deal with non-disruptive behaviors for patient safety (Nadzam, 2009). *The Future of Nursing: Leading Change, Advancing Health* report from the IOM recommends "for nurses to lead and diffuse collaborative improvement efforts" (IOM, 2011). Other reports from the Institute of Medicine also recognize the

"positive impact that interprofessional teamwork can have on key dimensions of organizational performance" (IOM, 2015). Prioritizing interprofessional teamwork and teamwork by health care policy makers and regulators should continue but recognition of other essential components, such as nursing organizational factors, needs to occur to sustain changes in IPE. Policies focused on improving nurse staffing and setting standards on nurse educational levels should be employed. Minimum registered nurse to patient ratio requirements, such as those mandated in California, can lead to better nurse and patient outcomes (Aiken et al., 2010). In addition, the IOM's *The Future of Nursing: Leading Change, Advancing Health* report also recommends the proportion of nurses with baccalaureate degrees be increased up to 80 percent by 2020 (IOM, 2011).

For educators, reforms are underway in promotion of interprofessional education. The National Center for Interprofessional Practice and Education at the University of Minnesota was formed in 2012 by a unique public-private partnership between a governmental agency (United States Department of Health and Human Services, Health Resources and Services Administration) and private foundations (Josiah Macy Jr. Foundation, the Robert Wood Johnson Foundation, the Gordon and Betty Moore Foundation). The National Center's mission is to support evaluation, research, data, and evidence for the field of IPE. In 2009, six national education associations representing schools of health care professions formed the Interprofessional Education Collaborative, with the goal to advance interprofessional learning to help prepare future health care professionals to enhance team-based care. Later, in 2011, the Interprofessional Education Collaborative Expert Panel was convened. One action of the panel was to form core

competency domains of interprofessional education, which included learning objectives geared towards communication and teamwork. Another educational advancement in promoting team-based care is the evidence based training program, TeamSTEPPS (Team Strategies and Tools to Enhance Performance and Patient Safety), developed by the Agency for Healthcare and Research Quality and the Department of Defense (King et al., 2008). These programs are all important, but they can also benefit from recognizing the importance of optimal nursing organizational factors to team-based care.

At the hospital organizational levels, programs have been initiated to improve teamwork between nurses and physicians. However, there still needs to be a focus on improving nursing care factors in order to create an environment that is conducive to improving teamwork in hospital settings. Recent initiatives at the Veterans Health Administration, such as the patient aligned care team (PACT), have come to address the need for coordination and teamwork within team based care for patients (Gilman, Chokshi, Bowen, Rugen, & Cox, 2014; Piette et al., 2011; Rugen et al., 2014). Interprofessional teamwork is a hallmark of successful organizations (Naylor, 2011) and also part of the Magnet Recognition programs for hospitals (Kramer, Schmalenberg, & Maguire, 2010).

This study adds to evidence of the value of investing resources into improving factors to better nurse staffing and hiring nurses with BSN education (Kutney-Lee et al., 2013). Healthcare policy makers, educators, and hospital administrators looking for improvements in nurse-physician collaborative teamwork and ultimately patient care and

safety should keep in mind improvement in nurse organizational factors as a systematic strategy (Stone et al., 2007).

Limitations and Opportunities for Future Research

This study adds to the literature, being the first of its kind to test for interactions of nursing organizational factors with nurse-physician teamwork in relationship to patient outcomes. There do seem to be strong associations of lower nurse to patient ratios and lower nurse-physician teamwork with increased mortality, as work environments with staff shortages can create extra stress leading to communication breakdowns (Flicek, 2012). Researchers hypothesized that staffing adequacy contributes to the ability of team members to take time to communicate, develop teamwork, and help one another when needed (Kalisch & Lee, 2013). There were correlations of lower nurse education levels with lower nurse-physician teamwork and worse patient outcomes, raising the possibility that some physicians may question nurse competence and indicating that the lack of uniformity of nurse education decreases communication among health care providers (Baggs & Schmitt, 1988).

The study used cross-sectional data and thus we cannot determine causality between the factors studied. The time frame of the study data is also a limitation, as health care reform has taken place since 2006-2007. However programs to improve interprofessional teamwork have been ongoing since the 1970s, and this study presents a snap shot view into the continuous process of improvements in teamwork. Also, the study is limited to adult surgical patients, and may not be applicable in other populations, although other studies in ICUs (Baggs et al., 1999) and emergency departments (Ajeigbe

et al., 2013) have shown similar results. Also limited is the study's focus on nurse-physician teamwork as the expanse of the health care system also involves other health care professionals that need to be taken into account. In addition, the study is limited to nurses' perception of interprofessional teamwork and future studies should include the physicians' perceptions as well. Longitudinal research on impact of staffing and education on nurse-physician teamwork on patient outcomes is needed to establish the links seen in this study. Qualitative research is also recommended for developing an understanding of how nurse organizational factors link to nurse-physician teamwork and patient outcomes. Future studies should also be done in other patient populations to make generalizations possible and broaden the understanding of the impact of interactions between nursing factors and nurse-physician teamwork on patient outcomes. As improvements in nurse organizational factors and training in interprofessional teamwork require additional resources, studies into the return on investment in the form of improved patient outcomes are also needed (Lutfiyya, Brandt, & Cerra, 2016). As The Joint Commission estimates that nearly 60% of medical errors are direct results of communication breakdown (Woods, 2006), research into factors that can sustain improvements in interprofessional teamwork is worth the investment.

Conclusion

Nurses and physicians have common goals to provide quality health care and ensure patients' safety. Within the health care system, many changes are also occurring and teamwork is an essential key to providing effective and safe patient care (Manser, 2009). This study adds to the evidence base that nurse organizational factors including

staffing and education can increase interprofessional teamwork and add to improvements in patient outcomes. In order to improve teamwork, the factors of nurse staffing and education need to be adequate.

The contribution of this study fits into the recommendations from the National Center for Interprofessional Practice and Education on finding the essential factors needed for sustainable Interprofessional Education and Collaborative Practice changes (Lutfiyya et al., 2016). The analysis of the interaction of nursing factors with nurse-physician teamwork is the start of looking into conditions that can improve interprofessional teamwork and in turn, quality and safety for health care systems in the future. A thorough understanding of how these factors interact can inform policy, practice, and education.

APPENDIX A

Table 15. Variables Used in the Study.

Independent Variable	Data source	Level	Measurement
Nurse-physician teamwork	Multi-state nurse survey	Hospital	Ordinal 0 = Low quartile = bottom 25% 1 = Medium quartile = middle 50% 2 = High quartile = top 25%
Controls			
Staffing	Multi-state nurse survey	Hospital	Continuous, derived, average patient-to-nurse ratio
Education	Multi-state nurse survey	Hospital	Continuous, proportion of BSN or higher
Hospital bed size	AHA	Hospital	Ordinal 0 = Small 1 = Medium 2 = Large
Hospital teaching status	AHA	Hospital	Ordinal 0 = Non 1 = Minor 2 = Major
Hospital technology level	AHA	Hospital	Dichotomous 0 = Low 1 = High
Age	Surgical patients' discharge data	Individual	Continuous
Gender	Surgical patients' discharge data	Individual	Dichotomous 0 = Female 1 = Male
Surgery types	Surgical patients' discharge data	Individual	Dichotomous, 48 dummy variable codes
Elixhauser co-morbidities	Surgical patients' discharge data	Individual	Dichotomous, 27 selected co-morbidities
Patient outcomes			
30-day mortality	Surgical patients' discharge data	Individual	Dichotomous 0 = living after 30 days of admission 1 = death within 30 days of admission

Failure-to-rescue	Surgical patients' discharge data	Individual	Dichotomous 0 = alive after complication within 30 days of admission 1 = death after complication within 30 days of admission

APPENDIX B EXPLORATORY ANALYSIS OF EXPANDED NURSE-PHYSICIAN RELATIONS SUBSCALE

Table 16 describes the potential expansion of the nurse-physician relations subscale to include more detail of nurses' perceptions of physicians' treatment and attitudes towards nurses. This ties into the forces of Magnetism of interdisciplinary relationship that's part of the Magnet Recognition Program©. Table 4 is analogous to table 1 explained above showing exploratory factor analysis with strong loading on the factor.

Table 16. Results of Exploratory Factor Analysis of Selected Items of the Nursing Work Index on the Nurse-Physician Relation Expanded scale

Subscale and Items	Loading
A lot of teamwork between nurses and doctors.	0.83
Physicians and nurses have good working relationships.	0.77
Collaboration between nurses and physicians.	0.84
Physicians hold nurses in high esteem.	0.84
Physicians respect nurses as professionals.	0.87
Physicians recognize nurses' contributions to patient care.	0.84
Physicians value nurses' observations and judgments.	0.83

Table 17. Reliability Indices for the subscale Expanded Nurse–Physician Relations Subscale of the PES-NWI

	Individual Level	Hospital Level		
	Cronbach's Alpha	Average Interitem Correlation	ICC 1	ICC2
A lot of teamwork between nurses and doctors.	0.932	0.856	0.051	0.669
Physicians and nurses have good working relationships	0.937	0.871	0.050	0.662
Collaboration between nurses and physicians.	0.932	0.861	0.054	0.679
Physicians hold nurses in high esteem.	0.932	0.853	0.058	0.706
Physicians respect nurses as professionals	0.929	0.851	0.055	0.693
Physicians recognize nurses' contributions to patient care.	0.931	0.856	0.043	0.634
Physicians value nurses' observations and judgments	0.932	0.856	0.047	0.656

Table 17, similar to table 2 provides information on the reliability of the individual items and seems to be strong to very strong (.929-.937) and greater than that of table 2. The average interitem correlation also is robust along with ICC (1,k) of greater than .6 (ideally >.5).

Table 18 seems to be similar to table 3 with additional details on correlation of items, which were moderately correlated (.64-.77). The common variance which indicates variance in each item shared by common factors (ideally above .5) and specific variance indicate that the variance that's unique to each variable that are not explained by the other items in the factor (1 indicates there variable has no common factor component, 0 indicates variable is entirely determined by common factor). Although the additional questions 4-7 have lower specific scores than those in table 3 (0.24-0.30).

Table 18. Pearson Correlations among Items and Variance Components of the Expanded Nurse–Physician Teamwork of the PES-NWI

Pearson Correlations Between Items								Proportion of Variance	
Item	1	2	3	4	5	6	Loading	Common	Specific
1. A lot of teamwork between nurses and doctors.	--						0.83	0.63	0.30
2. Physicians and nurses have good working relationships	0.67	--					0.77	0.54	0.40
3. Collaboration between nurses and physicians.	0.74	0.65	--				0.84	0.63	0.30
4. Physicians hold nurses in high esteem.	0.70	0.64	0.70	--			0.84	0.64	0.29
5. Physicians respect nurses as professionals	0.71	0.66	0.73	0.77	--		0.87	0.69	0.24
6. Physicians recognize nurses' contributions to patient care.	0.69	0.65	0.69	0.71	0.73	--	0.84	0.64	0.29
7. Physicians value nurses' observations and judgments	0.68	0.67	0.69	0.68	0.72	0.74	0.83	0.63	0.30

APPENDIX C ADDITIONAL ANALYSIS

Tables 19 and 20 show the effects of nurse-physician teamwork on patient mortality and FTR stratified across quartiles of nurse staffing ratio. These tables illustrate the effects of nurse staffing on nurse-physician teamwork as patient to nurse staffing ratio increases the effects of nurse-physician teamwork lessens and change from significant ($p<0.05$) to not significant. More in depth analysis are shown in the next section.

Table 19. Odds Ratio of Nurse-Physician Teamwork on 30 day mortality in Adult Surgical Patients, Stratified by Staffing, Fully Adjusted Model

	Patient to Staff Nurse Ratio (Mean, SD)			
	All (5.28, SD: 1.32)	Better 25% (3.86, SD: 0.40)	Medium 50% (5.23, SD: 0.47)	Poor 25% (7.24, SD: 1.17)
Nurse-physician teamwork, OR (95% CI)	0.954*** (0.930,0.978)	0.915*** (0.885,0.963)	0.954** (0.900,0.996)	0.981 (0.947,1.017)

* p<0.05, ** p<0.01, *** p<0.001

Table 20. Odds Ratio of Nurse-Physician Teamwork on FTR in Adult Surgical Patients, Stratified by Staffing, Fully Adjusted Model

	Patient to Staff Nurse Ratio (Mean, SD)			
	All (5.28, SD: 1.32)	Better 25% (3.86, SD: 0.40)	Medium 50% (5.23, SD: 0.47)	Poor 25% (7.24, SD: 1.17)
Nurse-physician teamwork, OR (95% CI)	0.951*** (0.926,0.977)	0.907*** (0.860,0.956)	0.952** (0.918,0.988)	0.985 (0.939,1.032)

* p<0.05, ** p<0.01, *** p<0.001

However, Table 21.shows a step by step regression model of the expanded nurse-physician teamwork scale with similar results to the original nurse-physician teamwork scale.

Table 22 with the expanded nurse-physician teamwork scale showed slightly less effect of the interaction terms than the non-expanded nurse-physician teamwork scale, although still statistically significant ($p<0.05$). The nurse staffing and nurse-physician teamwork interaction term was 1.022 versus 1.024 for the 3 item nurse-physician teamwork scale and the nurse education and nurse-physician teamwork interaction term was 0.982 versus 0.976 for the 3 item nurse-physician teamwork scale

Table 23 shows the effects of the independent variables unadjusted and fully adjusted individually which also has similar results to the original nurse-physician teamwork scale.

Table 24 shows the effects of the expanded nurse-physician teamwork scale with nurse staffing levels on patient outcomes which also has similar results to the original nurse-physician teamwork scale.

Table 21. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse-Physician Teamwork Expanded, Nurse Staffing, Nurse Education and interactions on Patient Mortality

Odds Ratios from Models for Patient Mortality					
	Unadjusted (Bivariate)	Adjusted with patient character-istics/ comorbidities	Adjusted with patient character-istics/comor-bidities and hospital characteristics	Adjusted with patient and hospital character-istics and staffing	Adjusted with patient and hospital character-istics and staffing and nurse education
Nurse-physician teamwork expanded (OR, CI)	0.909*** [0.898, 0.920]	0.941*** [0.929, 0.954]	0.946*** [0.933, 0.959]	0.952*** [0.939, 0.966]	0.957*** [0.944, 0.971]
Staffing (OR, CI)				1.039*** [1.026, 1.051]	1.029** [1.016, 1.041]
Nurse Education (OR, CI)					0.936*** [0.922, 0.951]
Odds Ratios from Models for Failure-to-Rescue					
Nurse-physician teamwork expanded (OR, CI)	0.918*** [0.907, 0.930]	0.940*** [0.927, 0.952]	0.942*** [0.928, 0.955]	0.948*** [0.935, 0.962]	0.953*** [0.940, 0.968]
Staffing (OR, CI)				1.040*** [1.027, 1.052]	1.029*** [1.016, 1.042]
Nurse Education (OR, CI)					0.932*** [0.917, 0.947]
* p<0.05, ** p<0.01, *** p<0.001					

Table 22. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse Physician Teamwork Expanded, Nurse Staffing, Nurse Education and interactions on Patient Mortality		
Odds Ratios from Models for Patient Mortality		
	Fully adjusted with patient and hospital characteristics and staffing and nurse education and interactions jointly	Fully adjusted with patient and hospital characteristics and staffing and nurse education and interactions jointly
Nurse physician teamwork expanded (OR, CI)	0.955*** [0.941,0.969]	0.954*** [0.940,0.968]
Staffing (OR, CI)	1.038*** [1.025,1.051]	1.029** [1.017,1.042]
Nurse Education (OR, CI)	0.939*** [0.924,0.953]	0.934*** [0.920,0.949]
Staffing X Nurse Physician Relations Interactions	1.022*** [1.013,1.031]	
Nurse Education X Nurse Physician Relations Interaction		0.982** [0.969,0.995]
Odds Ratios from Models for Failure to Rescue		
Nurse physician teamwork expanded (OR, CI)	0.950*** [0.936,0.964]	0.950*** [0.936,0.965]
Staffing (OR, CI)	1.041*** [1.027,1.054]	1.030** [1.017,1.042]
Nurse Education (OR, CI)	0.935*** [0.920,0.950]	0.930*** [0.916,0.945]
Staffing X Nurse Physician Relations Interactions	1.026*** [1.017,1.035]	
Nurse Education X Nurse Physician Relations Interaction		0.982** [0.969,0.995]

Table 23. Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse Staffing, the Nurse-Physician Teamwork Expanded, and Nurse Education on Patient Mortality and Failure-to-Rescue

Odds Ratios from Models for Patient Mortality			
	Nurse-physician Teamwork Expanded	Nurse Staffing	Nurse Education
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	0.909*** (0.885 0.933)	1.045*** (1.023-1.067)	0.920*** (0.891-0.951)
Fully Adjusted	0.957*** (0.935-0.980)	1.029** (1.008-1.050)	0.936*** (0.909-0.964)
Odds Ratios from Models for Failure-to-Rescue			
	Nurse-physician Teamwork Expanded	Nurse Staffing	Nurse Education
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	0.918*** (0.893-0.945)	1.043*** (1.020-1.067)	0.914*** (0.884-0.945)
Fully Adjusted	0.953*** (0.929-0.978)	1.029** (1.007-1.051)	0.932*** (0.904-0.962)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 24. Odds Ratios Indicating (a) the Effect of Staffing in Various Nurse-Physician Teamwork Expanded, and (b) the Effect of the Nurse-physician Teamwork at Various Staffing Levels

(a) When Nurse-Physician Teamwork is:	The Odds Ratio Indicating the Effect of Staffing is:	
	On Mortality	On Failure to Rescue
Two standard deviations below the mean	0.994	0.989
One standard deviation below the mean	1.016	1.014
At the mean	1.038*	1.041*
One standard deviation above the mean	1.060*	1.068*
Two standard deviations above the mean	1.083*	1.096 *

(b) When the Hospitals Patient-to-Nurse Ratio is:	The Odds Ratio Indicating the Effect of the Nurse-physician Teamwork is:	
	On Mortality	On Failure to Rescue
Two patients per nurse above the mean	0.997	1.000
One patient per nurse above the mean	0.975*	0.975
At the mean	0.955*	0.950*
One patient per nurse below the mean	0.935*	0.926*
Two patients per nurse below the mean	0.915*	0.903*

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

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