

HOSPITAL NURSING LINKED TO READMISSIONS
FOLLOWING TOTAL HIP AND KNEE ARTHROPLASTY

Karen B. Lasater

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Supervisor of Dissertation

Matthew D. McHugh, PhD, RN
Associate Professor of Nursing

Graduate Group Chairperson

Connie Ulrich, PhD, RN
Professor of Nursing

Dissertation Committee:

Linda H. Aiken, PhD, RN
Professor of Nursing and Sociology

Eileen V. Lake, PhD, RN
Associate Professor of Nursing and Sociology

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Karen Blanchette Lasater

DEDICATION

To my parents, who instilled a love for learning
To my husband, who inspired a dream

“Far and away the best prize that life has to offer
is the chance to work hard at work worth doing”
-Theodore Roosevelt

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ABSTRACT

HOSPITAL NURSING LINKED TO READMISSIONS FOLLOWING TOTAL HIP AND KNEE ARTHROPLASTY

Karen B. Lasater

Matthew D. McHugh

Hospital readmissions pose negative health risks for older adults and reflect low quality, high cost healthcare. Efforts to reduce readmissions have focused on disease-specific interventions that target patients during the transition from the hospital or in the post-acute care setting. Less attention has spotlighted the role of hospital nursing. Staff nurses represent an around-the-clock surveillance system that is well-positioned to recognize patients' physical and social needs that may contribute to a readmission. This cross-sectional secondary data analysis explored the association between the working conditions of hospital nurses – staffing and the practice environment – and 30 day readmissions among older adults following elective total hip and total knee arthroplasty. Data sources from 2005-2006 included patient administrative data, nurse survey data, and hospital organizational data. Nurse survey responses were aggregated to construct hospital measures of nurse staffing and the practice environment. The main outcome of interest was 30 day unplanned readmission. The analytic sample consisted of 112,018 Medicare patients electively undergoing either total hip or total knee arthroplasty, and 23,089 registered nurses working in 495 acute care hospitals in four states (CA, FL, NJ, PA). The sample was descriptively analyzed using cross-tabulations, Kaplan-Meier plots, and histograms. Multivariable logistic regressions estimated the effect of nurse staffing and the practice environment on 30 day readmission, adjusting for patient and hospital

covariates and accounting for clustering of patients within hospitals. The 30 day unplanned readmission rate was 5.6% and 5.7% for hip and knee patients, respectively. After adjusting for patient and hospital covariates, each additional patient was associated with an 8% increase in the patient's likelihood of readmission. Patients cared for in a better practice environment, as compared to a mixed or poor environment, had 13% lower odds of readmission; however, this relationship became insignificant once adjusting for nurse staffing. These findings reveal that a substantial percentage of older adults experience an unplanned rehospitalization following elective total hip and total knee arthroplasty. The evidence suggests that improving nurse staffing and the practice environment may be strategies for reducing readmissions among older adult orthopedic surgical patients.

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CHAPTER 1: INTRODUCTION

“The hospital environment should enable patients not disable, and expect their staff do the same. I didn’t realize the importance of staying active and not laying in bed the whole time. Do the people who work in the hospital know this?”

– Anonymous patient (Boltz et al, 2010)

The problem

Half of all hospitalized older adults experience profound negative consequences for their health and quality of life, above and beyond the reason for hospitalization (Boltz et al, 2012). A common outcome of hospitalization for older adults includes functional decline, which can onset as early as 48 hours from admission and result in increased morbidity and mortality (Boltz, Capezuti, & Shabbat, 2011; Boltz et al, 2012; Kortebein et al, 2008). Physical deconditioning is associated with prolonged recovery, with many patients never regaining pre-hospitalization functional capacity (Covinsky et al, 2003; Ponzetto et al, 2003). Each time an older adult is hospitalized, there is an increased probability for rehospitalization and a decreased likelihood of living independently in the future (Boltz, Capezuti, & Shabbat, 2011; Kortebein et al, 2008; Ponzetto et al, 2003). With one in every five older adults readmitted within 30 days after an initial hospitalization, preventing avoidable readmissions has the potential to improve the overall health and quality of life for older adults (Jencks, Williams, & Coleman, 2009; RWJF, 2013).

Preventing readmissions has been a focus of clinicians’ efforts for decades (Achté & Apo, 1967; Jenkins, Bermiss, & Lorr, 1953; Strauss et al, 1974; Wing, Denham, & Munro, 1959). However, with the enactment of the Affordable Care Act and the Hospital Readmission Reduction Program, initiatives to reduce readmissions have come to the forefront of public awareness. Today, readmissions are targeted by the Centers for

Medicare and Medicaid Services (CMS) and others, as an indicator of hospital quality. Hospitals are being held financially accountable for excessive readmissions.

Medicare – the primary third party payer for older adults – spends approximately one quarter of its annual outlay on inpatient hospital services (CBO, 2014). Of the \$139 billion spent on hospital services in 2013, Medicare spent approximately \$26 billion on readmissions (RWJF, 2013), \$17 billion of which are potentially avoidable (CBO, 2014; RWJF, 2013). Avoidable readmissions account for more than 12% of Medicare inpatient spending (CBO, 2014).

Since the Hospital Readmission Reduction Program was enacted, researchers have increased attention to understanding the incidence and risk factors for readmission, and to identifying strategies to reduce readmissions. While the causes of readmission are multifactorial and span from individual patient characteristics to environmental and system-level contributors, only a small portion of research has focused on the role of the most numerous healthcare providers – inpatient nurses. Hospital nurses’ proximity to patients and their care provision in the hospital make nurses instrumental in understanding the complexity of patient needs and well-positioned to identify and address issues that may precipitate a readmission following discharge.

Specifically, little is known about the role of hospital nurses, such as staffing and the practice environment, on reducing readmissions. Hospital nurses provide around-the-clock care at the patient’s bedside, which positions nurses as the primary surveillance system to identify and intervene on early warning signs or changes in patients’ clinical condition. When nursing care is stressed due to unmanageable staffing ratios, limited time resources prevent the nurse from providing complete and thorough care and

surveillance. The practice environment describes the social context where nurses provide care. Early studies suggest more favorable nursing characteristics are associated with reduced odds of readmission for some medical and surgical conditions (Ma, McHugh, & Aiken, 2015; McHugh & Ma, 2013).

However, to date, little is understood about how hospital nurses influence readmissions in older adults undergoing total hip and total knee arthroplasty (THA/TKA). THA/TKA is a common surgical treatment for arthritis, which is caused in part by normal wear and tear on joints related to aging and can be exacerbated by undue stress on joints due to obesity. Given an aging baby boomer generation and the rising incidence of obesity, the numbers of THA/TKA procedures are likely to increase over time (Kurtz et al, 2005). Approximately two-thirds of the 285,000 THA and 600,000 TKA that are performed annually in the United States, are paid for by Medicare (AAOS, 2014; Ong et al, 2006). These surgeries account for Medicare's largest procedural cost (Bozic et al, 2008). Estimates suggest that the 30 day readmission rate following THA/TKA is approximately 5%, in the Medicare population (Suter et al, 2014).

Readmissions following this common surgical procedure have gained increased attention among patients, third party payers, and providers, alike. Beginning in 2015, preventable readmissions following elective THA/TKA became the first surgical procedures to be targeted for financial penalization for hospitals that have worse than expected readmission rates (PPACA, 2010). As provider reimbursement becomes increasingly linked to patient outcomes, providers have a growing incentive to utilize evidence-based strategies to reduce readmissions. This study examines the association

between modifiable hospital nursing structural characteristics – staffing and the practice environment – and readmissions in older adults following elective THA/TKA.

Background

Nurses are the most numerous healthcare providers and spend a significant amount of time directly caring for hospitalized patients. Staff nurses are responsible for providing, overseeing, and coordinating the care of patients. For many hospitalized patients, nursing care includes assessment and management of signs and symptoms of the disease process and response to treatments, coordination of care between providers both inside and outside of the hospital, administration of medications and treatments, and education of the patient and their caregivers about self-care practices and disease management.

Older adults undergoing major orthopedic surgery require intensive care, particularly in the postoperative period. In the immediate postoperative period, patients are at risk for serious complications including infection, blood clots, pulmonary emboli, falls and prosthetic dislocation. During the days and weeks following surgery, patients require mobility assistance, physical rehabilitation, wound management, and ongoing education about self-care following a major joint replacement. For these patients, the role of the hospital staff nurse extends beyond the care provided in the hospital to include coordinating follow-up care after discharge and ensuring patients can safely transition to independent self-care activities.

Nurses' essential role in patient care is borne out by the fact that approximately one-third of inpatient hospital spending is allocated to nursing staff (Kane & Siegrist, 2002). It is well established that nurses are vital healthcare providers in ensuring the safe

and effective delivery of high quality healthcare. However, due to high patient demands and a lack of time, hospital staff nurses are often forced to prioritize patient care needs in such a way that patients frequently and unknowingly forfeit necessary nursing care (Kalisch, 2006; Kalisch, Gay & Williams, 2009). One recent study linked missed nursing care to an increased odds of patient readmission (Brooks Carthon et al, 2015).

Nurse-driven interventions like care coordination, patient education, and discharge planning are believed to effectively reduce readmissions (Coleman et al, 2006; Jack et al, 2009; Naylor et al, 2004; Naylor et al, 2011). However, to date, such evidence has largely been based on research pertaining to disease-specific nurse-initiated interventions, such as telephone follow-up for patients with congestive heart failure (Dudas et al, 2001; Wheeler & Waterhouse, 2006; Woodend et al, 2003), nurse practitioner-led transitional care models, which involve a nurse practitioner who is devoted to coordinating patient care across settings (Naylor et al, 2004; Naylor et al, 2011), and other team-based approaches focused on the hospital discharge process (Coleman et al, 2006; Jack et al, 2009; Naylor et al, 2011). While the effectiveness of many of these interventions have been demonstrated in randomized control trials (Ahmed, 2002; Coleman et al, 2006; Dudas et al, 2001; Jack et al, 2009; Naylor et al, 2004; Naylor et al, 2011; Wheeler & Waterhouse, 2006; Woodend et al, 2003), their effectiveness is less clear once implemented in practice (Hansen et al, 2011).

One hypothesis for this dissonance is the additional demands these interventions place on hospital nurses. These additional interventions may detract from the essential care that nurses deliver at the patient's bedside – care which is commonly missed due to lack of time (Kalisch, 2006; Kalisch, Gay & Williams, 2009). In addition to the lack of

evidence that disease-specific readmission reduction approaches are effective in practice, they require additional interventions beyond essential nursing care, and are overly narrow in focus; thus begging the question if there is a more effective and efficient way to reduce readmissions among at-risk populations (Dharmarajan et al, 2013).

Interventions that require additional providers or place additional demands on staff nurses should be considered a supplement, rather than a substitute for underlying systemic problems with care delivery. In other words, hospital nurse work conditions, including staffing and the practice environment, should be considered the essential building blocks to which these population and disease-specific interventions can be added. Every hospitalized patient receives nursing care; while only some patients receive targeted readmission reduction interventions.

System level investments in hospital nursing are associated with positive health outcomes. Additionally, increasing nurse staffing simultaneously improves various health outcomes for all hospitalized patients cared for by a nurse – unlike disease-specific approaches, which are narrowly focused on target populations. A system level approach to promoting positive health outcomes is supported by decades of research that demonstrate an association between more favorable staffing ratios, better practice environments, and more educated nursing staff and better outcomes. A large cross-sectional analysis of retrospective secondary data of general, orthopedic, and vascular surgery patients demonstrated that each additional patient per nurse was associated with 7% higher odds of mortality and failure-to-rescue – a measure of death in patients who experience a complication – within 30 days of admission (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002). A cross-sectional secondary data analysis of a similar patient

population in Pennsylvania hospitals found that patients cared for in a less favorable work environment had higher odds of mortality and failure-to-rescue. These findings suggest that hospitals exhibiting signals of nursing excellence, as measured by nurses' positive assessment of their work environment, are associated with better outcomes of care (Aiken et al, 2008). The proportion of hospital nurses with a baccalaureate degree has also been demonstrated to be associated with lower odds of mortality and failure-to-rescue. In a study of surgical patients, odds of mortality and failure-to-rescue decreased 5% for each additional 10% increase in the proportion of nurses within a hospital holding a baccalaureate degree (Aiken et al, 2003). These seminal studies are bolstered by numerous other studies across various patient populations (Kane et al, 2007; Kazanjian et al, 2005; Shekelle, 2013).

Far fewer studies have examined the effect of nursing on 30 day readmissions, yet early studies suggest that hospital nursing matters. For Medicare patients with heart failure, myocardial infarction, or pneumonia, one study demonstrated that the odds of 30 day readmission decreased for patients cared for by nurses working in more favorable practice environments and with better staffing ratios (McHugh & Ma, 2013). These findings were consistent in a study of general, vascular, and orthopedic surgical patients (Ma, McHugh, & Aiken, 2015). An analysis of nursing hours per patient day conducted at the unit level within a single institution showed that increasing investments in nurse staffing could be cost-beneficial through reductions in post-discharge hospital utilization (Weiss, Yakusheva, & Bobay, 2011). Increasing staffing in less well-staffed hospitals has the potential to reduce readmissions while being cost-beneficial to the hospital (Weiss, Yakusheva, & Bobay, 2011). These findings did not account for the CMS penalties for

worse than expected readmission rates, suggesting that cost savings could be greater than estimated in the study.

Significance

Understanding if and to what extent hospital nursing can influence patient readmission is significant for multiple stakeholders. With one in five discharged Medicare patients rehospitalized within 30 days (Jencks, Williams, & Coleman, 2009; RWJF, 2013), avoidable readmissions have become widely recognized as a signal of high cost, low quality care. Estimates suggest that with over 9 million Medicare hospitalizations annually, Medicare could realize \$17 billion in cost savings through eliminating avoidable readmissions (RWJF, 2013).

The Hospital Readmission Reduction Program is one of many programs in the Affordable Care Act, which constitute a new reimbursement paradigm – pay-for-performance. Pay-for-performance is a hypernym and umbrella term for the initiatives of the Affordable Care Act that aim to improve healthcare value through high quality outcomes at lower cost (James, 2012). For example, the Hospital Readmission Reduction Program allows CMS to financially penalize hospitals with worse than expected readmission rates, by withholding a fraction of the hospital's annual base CMS reimbursements. Other such programs are known as value-based purchasing, which gives CMS authority to incentivize hospitals, through financial penalties, to perform well on an a priori set of performance and outcome measures (James, 2012). Third party payers, beginning with CMS, are closely monitoring various indicators of hospital quality and withholding payment for poor performance and outcomes of care.

Understanding how hospital nursing impacts patient outcomes can help inform hospital administrators about the value of additional investments and the consequences of reduced investments in nursing. Hospitals have been known to make cost reductions to nursing resources during financially stressful times (Aiken, 2008), a practice that may increase in frequency as hospital budgets are further subjected to CMS reimbursement withholdings for poor performance on quality measures. With more robust evidence about the impacts of more favorable nurse staffing ratios and better practice environments, hospital administrators are better positioned to make a social and financial case for strategic investments in nursing.

This findings from this study may also have state and federal policy implications. More evidence on the far reaching effects of more favorable staffing ratios on numerous patient outcomes can help to substantiate policies that support better working conditions for nurses. One way policy can influence better nurse staffing in hospitals is through mandated staffing ratios. California is the first and only state to have implemented staffing laws, yet other states are considering similar legislation. Among the states analyzed in this study, California has the best staffing ratios, the lowest percent of hospitalized penalized, and the lowest average penalty (Table 3.1). Building a more robust evidence-base can support other states to more effectively lobby for safe staffing policies, such as mandated staffing ratios.

Additionally, readmission and the negative human consequences of hospitalization are important to patients and families, alike. Although the recent attention to readmissions has largely been driven by national policy efforts to reduce readmissions in an effort to drive down unnecessary spending, the human consequences of readmission

are profound. Functional decline and the potential for loss of independent living are concerning outcomes for older adults (Boltz, Capezuti, & Shabbat, 2011; Kortebein et al, 2008; Ponzetto et al, 2003). Today, there is public reporting of hospital performance on health outcomes through the Hospital Compare website. The website is publicly accessible and reports hospital readmission rates, among other quality indicators. Finally, healthcare providers assume an ethical responsibility for providing the best care possible for each individual, which makes understanding predictors of readmission an imperative for healthcare providers and the populations they serve.

Study overview

This study is a cross-sectional analysis of secondary retrospective data that used multiple linked datasets to build on existing literature about the effects of hospital nursing – staffing and the practice environment – on reducing the likelihood of readmission 30 days after discharge following elective THA/TKA

Specific aim

Aim: To examine the extent to which hospital nursing – staffing and the practice environment – are associated with odds of 30 day readmission in a Medicare population undergoing elective total hip and total knee arthroplasty.

Hypothesis 1: Patients undergoing elective total hip and total knee arthroplasty in hospitals with more favorable nurse staffing ratios and better practice environments will have lower odds of 30 day readmission, after controlling for patient and hospital characteristics.

Gaps

This study addressed a number of gaps in the existing literature. This is the first study to examine the impact of nursing on readmission in an older adult population undergoing elective THA/TKA. Of principal importance is the impact that this study's findings can have on the health outcomes of hospitalized patients. Prior research on reducing readmissions has offered disease-specific interventions, which are often narrowly targeted to a subset of the population. Attention to the structural characteristics of hospital nursing, such as staffing and the practice environment, may have the potential to impact health outcomes in this orthopedic surgical population and other hospitalized patients.

This study extends beyond describing readmissions among older adults undergoing THA/TKA and offers evidence for actionable strategies that hospitals can employ to reduce readmission rates among their vulnerable patients. Specifically, this study builds on research by Ma and colleagues (2015) to analyze older adults undergoing a particular orthopedic procedure that has timely policy and financial relevance for hospitals and insurers, alike.

Summary

Chapter 1 provided an introductory discussion of the questions to be explored in this study – the association of hospital nursing with 30 day readmission in a Medicare population undergoing elective THA/TKA. The background and significance section briefly explored the literature in this area and the social, financial and political importance of reducing readmissions following hospitalization. This study was a cross-

sectional analysis of retrospective data using multiple linked datasets to explore the association of nurse reports of staffing and practice environment with readmission.

Chapter 2 describes the conceptual framework underlying the study and explores the empirical and clinical context that will be enhanced by the knowledge developed from this study. This chapter provides a review of the literature related to the effects of nursing on readmission for various patient populations, as well as a review of the literature on readmission for patients undergoing elective THA/TKA. The study outcomes and covariates are defined.

Chapter 3 describes the methodology for the study, including a description of the datasets and parent study, clearly delineated sample criterion, as well as an explanation of the statistical analytic plan for the specific aim. The measurement approach for the outcomes and covariates used in the study are described. In this section, there is a description of the Practice Environment Scale of the Nurse Work Index (PES-NWI) – an instrument used for measuring the practice environment. Lastly, Chapter 3 includes a brief discussion of the methodological limitations and assumptions, a data integrity plan, and issues related to human subjects including Institutional Review Board requirements.

Chapter 4 describes the findings of the study including descriptions of the patients, nurses, and hospitals, the results from the analysis of the specific aim and an extensive sensitivity analysis. Finally, Chapter 5 provides a discussion of the main findings in the context of previous literature findings. Limitations of the study, as well as implications for policy, practice, and future research are described.

CHAPTER 2: BACKGROUND AND SIGNIFICANCE

Introduction

Chapter 2 sets the context for the study. The conceptual framework, the Quality Health Outcomes Model, is introduced and its adaptation for use in this study is explained. Next, an integrated review of prior literature related to the associations of nursing and readmissions among various inpatient populations and readmissions among older adult patients undergoing THA/TKA are explored. Substantive gaps in knowledge that this study and future studies could address are identified. The social, financial, and political implications of the hypothesized study findings are described, lending credence to the significance of the study. Finally, the outcomes and covariates of interest are specified.

Conceptual framework

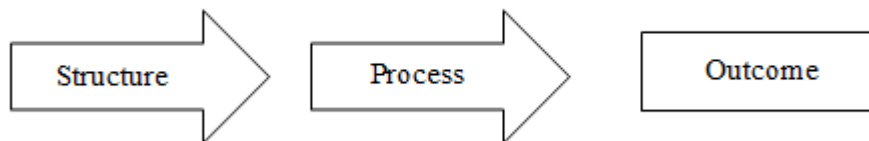
The Quality Health Outcomes Model provides the conceptual framework for this study. This model describes the relationships between four concepts: system, intervention, client, and outcome (Mitchell, Ferketich, & Jennings, 1998). The Quality Health Outcomes Model has previously served as an important framework in seminal nursing health services research (Mitchell & Lang, 2004).

The Quality Health Outcomes Model has iteratively emerged from another framework, Donabedian's structure process outcome model (Figure 2.1). Developed to evaluate and study the quality of care, Donabedian's model is composed of three dimensions: structure, process, and outcome (Donabedian, 1966). Each dimension consecutively affects the succeeding dimension (Donabedian, 1966). Structure is defined by the setting in which the process of care occurs. Structure includes variables such as

hospital size and teaching status. Nursing related structure concepts, for example, include staffing and the practice environment. The linear nature of Donabedian's structure process outcome model and the successive alignment of the three dimensions assume that the quality of the structure prescribes the quality of the outcome. For example if nurse staffing (structure) is poor, then the succeeding dimensions - delivery of care (process) and readmission (outcome) – will likely also be poor.

The process dimension is the dimension in which the act or practice of caregiving occurs and is concerned with *how* the care is delivered. The process dimension includes concepts such as how information is communicated between patient and provider and which interventions are performed. The process dimension directly affects the outcome (Donabedian, 1966). Outcomes can be either negative, such as readmission, or positive, such as patient satisfaction.

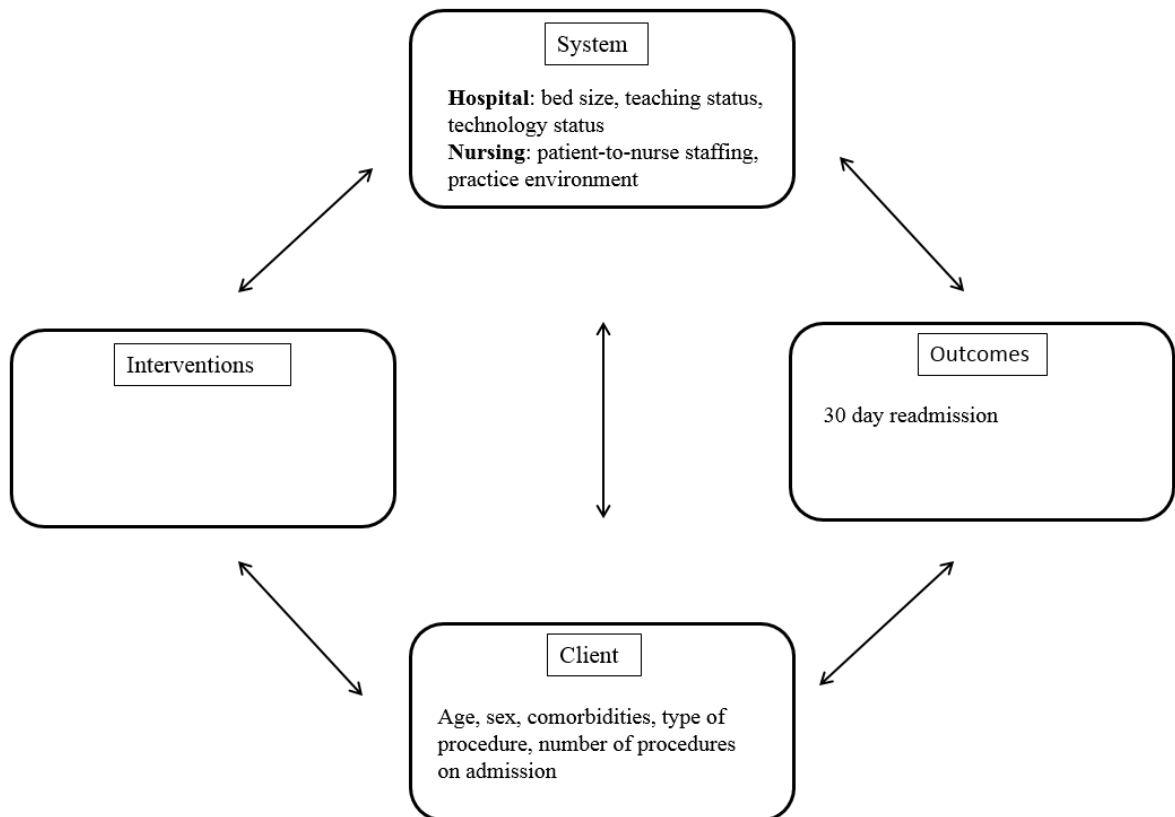
Figure 2.1. Donabedian's structure process outcome model



Although it is a commonly used model in the evaluation of healthcare delivery and quality, the linear and unidirectional nature of Donabedian's structure process outcome model may not accurately reflect the complexities of healthcare delivery. The process dimension encompasses multiple variables that require unpacking in order to appreciate the complexity of care. Such deficits of this model have aided in the development of another framework, the Quality Health Outcomes Model.

Unlike Donabedian’s structure process outcome model, the Quality Health Outcomes Model contains complex relationships using bi-directional arrows between concepts to represent the interrelationships in healthcare delivery (Figure 2.2). This complexity allows researchers to more readily test theoretical relationships, including patient outcomes that are sensitive to both nursing interventions and system characteristics. This has made the Quality Health Outcomes Model a popular theoretical model among some nurse health services researchers (Mitchell & Lang, 2004).

Figure 2.2. Theoretical framework adapted from the Quality Health Outcomes Model



The system is a concept that describes a range of organizational attributes, such as nurse staffing and hospital teaching status. In this study, multiple system attributes were explored. Figure 2.2 depicts how the Quality Health Outcomes model was adapted for use in this study. Within each concept, the variables of interest are listed. The primary

predictors of interest explored included nurse staffing and the practice environment. Hospital organizational features explored included: bed size, teaching status, and technology status. Other system level organizational attributes were explored in an extensive sensitivity analysis, which is detailed later in this chapter.

In the Quality Health Outcomes Model, the system concept is bi-directionally related to other concepts. Unlike the unidirectional arrows in Donabedian's structure process outcome model, the bi-directional arrows in this framework demonstrate how features in one concept reciprocally relate to features in another concept. For example, in this study I hypothesize that hospital nurse staffing (system) is associated with 30 day readmission (outcome). In light of the Hospital Readmission Reduction Program financial penalties, it could also be hypothesized that 30 day readmission rates (outcome) are associated with hospital revenue (system). This example illustrates how two concepts in the Quality Health Outcomes Model can be bi-directionally related.

Although the system concept is related to the intervention concept, the intervention concept was not specifically explored in this study. Generally, the intervention concept encompasses all of the care which nurses deliver to patients, as represented by the bi-directional arrow to the concept of client. The client or patient is conceptually defined as the person receiving the care intervention. The client could also be the family or support system of the person receiving care. While it may be theoretically and empirically important to understand the role of caregivers in preventing readmissions, the data available for this study limited such an analysis. Therefore, for the purposes of this study, I considered the client to be the patient. Client characteristics of interest in this study included age, sex, comorbidities, type of procedure, and number of

procedures during index admission. Other client characteristics were further explored in a sensitivity analysis, described later in this chapter. Although a mediation analysis was not conducted in this study, conceptually, the client is a mediating concept between interventions and outcomes of care. Theoretically, this means that the mediator variable (client) explains the relationship between the predictor variable (intervention) and the outcome variable (outcome).

The outcome of care that was of interest in this study was 30 day unplanned readmission following elective THA/TKA. The arrow from outcomes to the system was not explored, but has important implications for future research related to readmissions. With the implementation of pay-for-performance under the Affordable Care Act, patient outcomes will result in either monetary rewards or penalties to systems based on the desirability of outcomes (PPACA, 2010). The outcomes of care will directly affect the financial inputs to the system.

Lastly, the bi-directional arrow between the system and client demonstrates that the two concepts act as mediators of the effect of the intervention on the clinical outcome. Thus, the system and the client never operate independently of the other. The system explains part of the relationship between the intervention and the outcome.

Background

Overview

The following section provides a background of existing knowledge related to readmissions in a Medicare population undergoing THA/TKA. The review begins with the historical interest in readmissions, and then focuses specifically on readmissions

following THA/TKA. The various definitions of THA/TKA readmissions are described, as well as the reasons for and incidence of readmission following THA/TKA.

The remainder of this chapter includes a review of the various patient and hospital characteristics that are commonly risk adjusted for in the THA/TKA readmission literature. Hospital nursing (staffing and practice environment) has, to my knowledge, not been studied for its effect on readmissions in patients following THA/TKA. The effect of these features will be discussed in the context of other studies of readmission in different patient populations. As mentioned in the preceding chapter, nurse education has been associated with many patient outcomes, yet evidence of an association between education and readmissions is less clear. A discussion about why nurse education was not included as a primary predictor of interest in this study is elaborated.

Readmission

The study of readmissions initially became popular in the 1950s. During this time, the psychiatric population – specifically, patients with schizophrenia – were the focus of readmission research. In the mid to late 20th century, more than half of discharged patients with schizophrenia experienced rehospitalizations (Achté & Apo, 1967; Jenkins, Bermiss, & Lorr, 1953; Strauss et al, 1974; Wing, Denham, & Munro, 1959).

After the introduction of CMS in 1965 and the resulting rise in healthcare spending, concerns about frequent readmissions in the older adult population surfaced. In a seminal study of hospital readmissions in the Medicare population, it was found that the 60 day readmission rate for all Medicare admissions was 22% (Anderson & Steinberg, 1984). Moreover, Medicare was estimated to be spending approximately \$8 billion in 1984 dollars on readmissions (Anderson & Steinberg, 1984).

Clinical concerns about avoidable readmissions spurred researchers' interest in reducing readmissions, yet policy lagged until 2010 with the passage of the Affordable Care Act. The Hospital Readmission Reduction Program payment reform, a provision in the Affordable Care Act, allows CMS to withhold a percentage of base CMS reimbursements for hospitals with worse than expected readmission rates for certain medical and surgical conditions. In 2012, the first penalties were targeted at all-cause readmissions following an admission for congestive heart failure, acute myocardial infarction, or pneumonia. In 2015, THA/TKA and chronic obstructive pulmonary disease joined the list.

Total hip and total knee replacements are a relatively new orthopedic surgery, with the first procedures performed in 1960 and 1968, respectively (AAOS, 2014). Today, more than 285,000 THA and 600,000 TKA are performed annually in the United States (AAOS, 2014) – of which, Medicare pays for approximately two-thirds (Ong et al, 2006). The popularity of these procedures and their expense to Medicare have made THA/TKA the target of CMS reimbursement penalties for worse than expected readmission rates, beginning in 2015 (CMS, 2014). In response to these pay-for-performance policy initiatives, hospital administrators are increasingly interested in understanding how to reduce readmissions following these procedures. The following describes the current knowledge on readmission following THA/TKA, as well as the predictors of readmission following hospital admissions in medical and surgical populations.

Definition

Despite a significant and growing body of research on hospital readmissions, the literature lacks a consistent definition of what temporally distinguishes a hospitalization as a readmission. The majority of studies that examine readmissions in a THA/TKA population define a readmission event as a hospitalization occurring within 30 or 90 days from discharge; however, the timeframe in the literature ranges from 28 days (Cullen, Johnson, & Cook, 2006; Khan et al, 2012) to 180 days after discharge (Riggs et al, 2010).

The time from discharge to rehospitalization is important for defining a readmission event. CMS has determined a readmission within 30 days of discharge to be the timeframe for measuring hospital care quality (Suter et al, 2014). This decision appears arbitrary and lacks strong empirical evidence to suggest a reasonable timeframe for measuring hospital care quality. Although researchers and hospital administrators have argued that a 30 day timeframe extends beyond a hospital's capacity to control patient outcomes (Vaduganathan, Bonow, & Gheorghide, 2013), CMS continues to use this measure as the basis for withholding reimbursements under the Hospital Readmission Reduction Program.

In addition to defining a timeframe that constitutes a readmission, CMS also distinguishes between planned and unplanned readmissions in the THA/TKA population. The first study to attempt to differentiate planned and unplanned readmissions did so using clinical reasoning (Jencks, Williams, & Coleman, 2009). An unplanned readmission may or may not be avoidable, but is theoretically indicative of poor care quality. A planned readmission is theoretically indicative of good care quality. For example, it is clinically reasonable to believe that a readmission following THA/TKA for

inpatient rehabilitation is planned because rehabilitation is typically warranted following an intensive orthopedic surgery, and can be scheduled in advance. On the other hand, a readmission for shortness of breath due to pulmonary emboli is likely unplanned.

Pulmonary embolism is an acute and potentially fatal event for which there are prophylactic measures. Another study defined unplanned readmissions as “any subsequent admissions through the emergency department within 180 days of the index admission” (Riggs et al, 2010), thereby assuming that emergency department visits are by definition, unplanned events.

The THA/TKA Readmission Technical Report, which is prepared for CMS by a study team at the Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) and validated by the National Quality Forum, outlines an algorithm (Figure 3.1) to identify a planned versus unplanned readmission in the calculation of a hospital’s THA/TKA readmission rate (Suter et al, 2014). A planned readmission is believed to be an indicator of good care quality – such as a planned follow-up appointment for postoperative care. An unplanned readmission is one that could have potentially been avoided and is therefore indicative of poor quality care, such as the development of a postoperative infection (Suter et al, 2014). To my knowledge, there have been no studies in which researchers distinguish between a planned or unplanned readmission using the algorithm set forth in the THA/TKA Readmission Technical Report (Figure 3.1). This study used the readmission algorithm to distinguish between planned and unplanned readmissions. Unplanned readmission was the outcome of interest in this study.

Reasons

Identifying the reasons for readmission is important for understanding how to reduce the incidence of readmission in the future. In studies of patients undergoing THA, the main reasons for readmission were found to be more often related to medical issues than surgical issues. Among the most common medical reasons for readmission after THA are pneumonia, dehydration and renal dysfunction, deteriorating mobility, congestive heart failure, cardiac dysrhythmias, osteoarthritis, acute myocardial infarction, and diabetes (Khan et al, 2012; Vorhies et al, 2012). The literature lacks consensus about whether the most common medical causes are more likely to be cardiac or pulmonary in nature (Schairer et al, 2014; Vorhies et al, 2011). Common surgical reasons for readmission in THA include dislocation of the prosthesis, surgical site infection, wound disruption, and postoperative hematoma (Cullen, Johnson, & Cook, 2006; Pugely et al 2013; Saucedo, 2014; Schairer et al, 2014). Reasons for readmission following TKA are more likely related to surgical issues, such as surgical site infection, cellulitis, and arthrofibrosis (Schairer, Vail, & Bozic, 2014). A recent study found surgical site infection to be the most common reason for unplanned readmission following THA/TKA (Merkow et al, 2015). Overall, there appears to be no definitive consensus across the literature regarding the principal reasons why patients are readmitted following THA/TKA. This study will describe the top ten most common reasons for readmission for both THA and TKA.

Incidence

THA/TKA are among the most common inpatient procedures in the Medicare population (CDC, 2014; Kocher et al, 2013). Yet readmissions following THA/TKA are relatively uncommon, as a percentage of procedures, when compared with readmission rates for medical conditions, such as congestive heart failure (1 in 4), acute myocardial infarction (1 in 5) and pneumonia (1 in 6) (Krumholz et al, 2009; McHugh & Ma, 2013). Estimates from the literature find that 30 day readmission rates for THA and TKA range from 4-12% and 4-6%, respectively (Cullen, Johnson, & Cook, 2006; Khan et al, 2012; Mahomed et al, 2003; Merkow et al, 2015; Schairer, Vail, & Bozic, 2014; Zmistowski et al, 2013). This wide variation in reported readmission rates may be explained by trends over time. THA readmission rates steadily declined from 1991 to 2006, followed by a sudden increase in 2007 and 2008, which has been attributed to increasing patient complexity and reductions in length of stay (Cram et al, 2011). A similar study of the change in TKA readmissions over time also contributed reductions in length of stay to increases in readmission over time (Cram et al, 2012).

The estimates across the literature are generally consistent with CMS estimates of a combined THA/TKA readmission rate of 5.4% (Suter et al, 2014). With approximately 885,000 THA/TKA procedures performed each year, nearly 50,000 patients are unnecessarily readmitted annually (AAOS, 2014).

Risk adjustment

Risk adjustment is important for allowing meaningful comparisons to be made between different groups (Iezzoni, 2013). In a perfectly randomized study, risk adjustment would not be necessary because the groups for comparison would be alike on

all observable and unobservable attributes. However, in a cross-sectional study of existing data, it is necessary to account for the observable attributes that differ among the comparison groups, using risk adjustment (Iezzoni, 2013).

In this study, a number of patient and hospital characteristics are controlled for through risk adjustment. The following section discusses which patient and hospital characteristics are commonly adjusted for in the literature. While the risk adjustment for the analysis of the specific aim will be guided by the THA/TKA Readmission Technical Report, a sensitivity analysis of additional variables will be informed by the literature. The THA/TKA Readmission Technical Report will serve as the guide for sample selection and risk adjustment for regression models to ensure the findings of this study are relevant to hospitals at risk for CMS reimbursement penalties.

Patient characteristics

Age

The current literature on THA/TKA readmissions as well as the THA/TKA Readmission Technical Report consistently adjusts for patient age, finding that older age is associated with an increase in a patient's odds of readmission (Hu, Gonsahn, & Nerenz, 2014; Pugely et al, 2013; Tsai et al, 2013; Whittle et al, 1993; Zmistowski et al, 2013). This relationship makes intuitive sense because with age comes increased frailty and comorbidity. However, another study found no significant effect of age on readmission (Schairer, Vail, & Bozic, 2014). Patient age was controlled for in this study.

Sex

The current literature on THA/TKA readmissions as well as the THA/TKA Readmission Technical Report consistently adjusts for patient sex. The effect of sex on readmission varies across studies, with some studies finding no association between readmission and sex (Schairer, Vail, & Bozic, 2014). However, the majority of study findings agree that being male is a stronger predictor of readmission, than being female (Hu, Gonsahn, & Nerenz, 2014; Pugely et al, 2013; Singh et al, 2013; Tsai et al, 2013; Zmistowski et al, 2013). It is unclear why male sex is a greater predictor of readmission; however, one theory suggests that males tend to hold off seeking necessary medical care such that once males present for treatment, they are sicker than their female counterparts. Males may also engage in greater risk-taking behavior which could put them at risk for falls or other adverse events related to self-care management. Patient sex was controlled for in this study.

Comorbidities

Adjusting for patient acuity or comorbidities allows for valid comparisons of patients across outcomes. Although studies have used a range of risk adjustment techniques to account for comorbidities, such as a Charlson score, Elixhauser risk adjustment, or selecting relevant or common comorbid conditions, studies consistently find that patients with more comorbidities are at higher risk for readmission (Khan et al, 2012; Mahomed et al 2003; Riggs et al, 2010; Saucedo et al, 2014; Schairer et al, 2014; Schairer, Vail, & Bozic, 2014). Another method of adjusting for patient acuity is the American Society of Anesthesiologist score which was also shown to be positively

associated with odds of readmission for THA/TKA patients (Bini et al, 2009; Pugely et al, 2013). Patient comorbidities, as detailed in the THA/TKA Readmission Technical Report, were controlled for in this study.

Type and number of procedures

In a review of the literature, no prior studies were found to adjust for the type (THA vs. TKA) or number of procedures. Although no research strongly suggests that THA patients compared to TKA patients are more or less likely to be readmitted, the THA/TKA Readmission Technical Report adjusts for procedure type. The number of procedures may be a meaningful predictor of readmission, based on the theory that an individual recovering from multiple surgeries on the same admission may be more likely to experience a complication warranting readmission. The THA/TKA Readmission Technical Report adjusts for the number of THA/TKA procedures on the index admission. Therefore, both the type and number of procedures were controlled for in this study.

Discharge destination

Where patients convalesce following a hospital discharge is associated with their odds of readmission following THA/TKA. Studies find that patients discharged to skilled nursing facilities have higher odds of readmission, even after adjusting for patient acuity and frailty (Bini et al, 2009; Schairer et al, 2014). This is a well-described finding across patient populations (Tsai et al, 2013). Although, to my knowledge, no reasons for this finding have been hypothesized and tested in the literature, patients admitted to a skilled

nursing facility may be at higher risk of readmission because skilled nursing facilities have no disincentive to readmit a patient at the earliest warning signs of a potential issue (Mor et al, 2010).

Zmistowski and colleagues (2013) find that patients who are discharged to inpatient rehabilitation have higher odds of readmission, while another study reports opposing findings (Riggs et al, 2010). These findings may be the result of patients in inpatient rehabilitation being readmitted prematurely at the earliest warning sign of a potential issue, or as a result of the positive impacts rehabilitation can have on postoperative THA/TKA patients, such as mobility and strength training. It is also unclear to what extent discharge destination is a proxy measure for patient acuity, the complexity of the procedure, or the quality of care during the hospitalization.

Discharge destination is not included as a variable for risk adjustment in the THA/TKA Readmission Technical Report because discharge destination is a factor of the structure of the healthcare system and patients' comorbidities (Suter et al, 2014). Geographic variation in the availability of providers and practice patterns make discharge destination an unreliable factor on which to risk adjust (Suter et al, 2014). However, in keeping with prior literature, discharge destination was controlled for in a sensitivity analysis.

Length of stay

Much of the evidence suggests that longer lengths of stay in the hospital for patients following THA/TKA are associated with higher odds of readmission (Jencks, Williams, & Coleman, 2009; Riggs et al, 2010; Saucedo et al, 2014; Schairer et al, 2014;

Schairer, Vail, & Bozic, 2014; Zmistowski et al, 2013). Yet some studies find no association between length of stay and readmission (Mnatzaganian et al, 2012), while others find that shorter lengths of stay increase the risk for readmission (Heggestad, 2002). In sum, the association between length of stay and readmission remains unclear.

Length of stay is a complicated measure to risk adjust for when assessing hospital care quality. A patient's length of stay is a factor of (1) the patient's severity of illness and (2) the amount of care received. While it is appropriate to risk adjust for patient severity of illness, to allow for a more fair comparison of hospital quality, adjusting for the amount of care delivered may be correlated with hospital quality and performance, which is likely to be correlated with patient health outcomes. It is often unclear whether the length of stay is appropriate or inappropriate for any individual patient; therefore, it can be difficult to determine whether or not the hospital is treating patients efficiently. Because it is unclear if it is appropriate to adjust for length of stay, and because it is not risk adjusted for in the THA/TKA Readmission Technical Report, length of stay was controlled for in a sensitivity analysis.

Race/Ethnicity

Race/ethnicity is commonly adjusted for in the literature on THA/TKA readmissions; however, studies lack agreement about how race affects a patient's likelihood of experiencing a readmission. Mahomed and colleagues (2003) find that whites have higher odds of readmission as compared with blacks. Other studies find that blacks have higher odds of readmission as compared with whites (Hu, Gonsahn, & Nerenz, 2014; Jencks, Williams, & Coleman, 2009; Zmistowski et al, 2013).

Race/ethnicity is not risk adjusted for in the THA/TKA Readmission Technical Report, and was therefore not be adjusted for in the analysis of the specific aim. Rather, race/ethnicity was controlled for in a sensitivity analysis.

Socioeconomic status

Socioeconomic status, a measure of an individual's income, education, and employment status (Green, 1970), is a predictor of health outcomes, including a patient's risk of readmission and surgical mortality (Birkmeyer et al, 2008; Weissman, Stern, & Epstein, 1994). However, it is less clear whether, in the context of risk for readmission, socioeconomic status acts as a proxy for other factors that may influence readmissions, such as social support systems. In an effort to measure social support, Hu and colleagues (2014) accounted for the effect of marital status on likelihood of readmission, and found that patients who are unmarried have higher odds of readmission compared with patients who are married. This analysis assumes that marriage is correlated with increased social support. In another study, no significant relationship was found between readmission and measures of social support including marital status, living situation, and availability of help at home (Weissman, Stern, & Epstein, 1994).

Income alone has been found to be associated with readmissions, such that people with a lower income have higher odds of readmission following THA (Mahomed et al, 2003; Weissman, Stern, & Epstein, 1994). Income data is not typically reported in medical records, making this information difficult to obtain. One study used the receipt of supplemental security income as a proxy for low-income status (Jencks, Williams, & Coleman, 2009). Area-based measures of income created through geo-coding can be used

to link a patient's address with Census data (Brooks Carthon, 2012; Diez Roux et al, 2001); however, this approach is limited in areas with greater socioeconomic heterogeneity (NQF, 2014). Another proxy for measuring individual income status that is more often reported in patient health data is Medicaid eligibility. Medicaid eligibility or dual eligible status for the Medicare population has been verified as a valid indicator of low-income status (NQF, 2014). However, this measure is not without disadvantages, such as the variation in income among the Medicaid and dual eligible population (NQF, 2014). Uninsured patients are also less likely to be readmitted; however, this could be related more to the desire to avoid the financial cost of accessing healthcare, rather than the health status and needs of the individual (Weissman, Stern, & Epstein, 1994).

Education – a component of the socioeconomic status measure – is not well documented in patient health data (NQF, 2014). In theory, patients with higher educational attainment are less likely to be readmitted. Health literacy and the ability to navigate the healthcare system can positively impact a patient's ability to provide self-care as they transition from the hospital.

Employment status/occupation is the third component of the socioeconomic status measure. However, like education, this information is difficult to obtain from patient health data (NQF, 2014). Weissman and colleagues (1994) found that patients working in unskilled occupations were more likely to be readmitted. Again, it is unclear whether employment status and occupation are proxy measures for individual characteristics that may influence an individual's health outcomes. Employment status is positively correlated with income, and occupation may be related to literacy.

Patient socioeconomic status is not adjusted for in the THA/TKA Readmission Technical Report and was therefore not adjusted for in this study. Rather, a patient level measure of socioeconomic status was controlled for in a sensitivity analysis.

Hospital characteristics

Bed size

Studies comparing readmission rates across hospitals often control for a number of hospital characteristics, including bed size. In theory, larger hospitals are more likely to have a greater volume of patients and therefore perform surgical procedures more frequently. The more experienced providers are with a particular procedure, the more likely patients are to have positive health outcomes. On the other hand, larger hospitals are more likely to attract sicker patients, which may negatively impact hospital performance on outcome measures. As described later in this section, the findings pertaining to the relationship between patient volume and outcomes in surgical patients are mixed. Specifically, one study found the larger hospitals were more likely to be penalized under the Hospital Readmission Reduction Program penalties (Joynt & Jha, 2013); while an earlier study by the same researchers, found that smaller hospitals had higher readmission rates (Joynt & Jha, 2011). In sum, the relationship between hospital bed size and readmission, is not well defined. Hospital bed size was controlled for in this study.

Teaching status

Teaching hospitals are defined by the presence or absence of medical fellows and/or residents providing medical care within a hospital. Little research has looked at the

relationship between a hospital's teaching status and patient readmission rates; however, some evidence suggests that teaching hospitals are associated with higher readmission rates and are more likely to be penalized under the Hospital Readmission Reduction program (Joynt & Jha, 2013; Press et al, 2013). Teaching hospitals tend to be located in urban cities, close to medical universities. They tend to be large in size, which provides medical trainees with an opportunity to get experience in a range of clinical fields. The association between teaching hospitals and greater readmissions may be an effect of the acuity of patients who are attracted to large, urban hospitals. Hospital teaching status was controlled for in this study.

Technology status

Hospital technology status is defined by a hospital's capacity to perform open-heart surgery and/or major organ transplantation. High technology hospitals also tend to be large, urban, teaching hospitals, which attract a case mix of patients that are on average, sicker and more clinically complex. Little research has directly examined the association of hospital technology status on readmissions; however, theory suggests that high technology hospitals would be associated with higher readmissions. Hospital technology status was controlled for in this study.

Geographic location

The geographic location of hospitals may be associated with a patient's risk for readmission; however, little research examines this direct association. As previously mentioned, urban hospitals are more likely to be larger, teaching hospitals with high

technology status – and therefore, more likely to attract sicker, more clinically complex patients. Rural hospitals, on the other hand, are more commonly smaller community hospitals. Hospital geographic location was controlled for in a sensitivity analysis.

Caseload volume

The volume-outcome relationship has been well researched; yet studies exploring the effect of surgeon and hospital volume on readmission reveal mixed findings. No relationship between volumes and readmission outcomes was found in a study of TKA patients (Judge et al, 2006). However, the same study did find that high-volume trusts in England's National Health Service were associated with lower readmission rates for THA (Judge et al, 2006). To the contrary, another study in Finnish hospitals reported conflicting findings with evidence that lower volume trusts had lower readmission rates (Mäkelä et al, 2011). Another study found no association between hospital volume and readmissions following surgery, but a positive association between high-volume and mortality (Goodney et al, 2003). Interestingly, a study of mortality following abdominal aortic aneurysm repair found the relationship between lower patient mortality in high-volume hospitals was contingent upon better nurse staffing in those hospitals (Wiltse Nicely, Sloane, & Aiken, 2012). This suggests that if a volume-outcome relationship exists in this postsurgical population, it may be correlated with hospital nurse work conditions. In sum, there is no consensus across the literature on the effect of hospital caseload volume on readmissions. The effect of hospital nursing on readmission was tested at various hospital caseload volumes in a sensitivity analysis.

Ownership type

There is little evidence to suggest an association between a hospital's ownership status and patient readmission outcomes. While one study found that not-for-profit performed better on readmission rates as compared with government-owned hospitals (Joynt & Jha, 2011), there is little theory or a robust empirical evidence-base to support any strong associations. Hospital ownership type was controlled for in a sensitivity analysis.

Socioeconomic status profile

In addition to patient socioeconomic status, a hospital's socioeconomic status profile, may explain some of the relationship between nursing and postsurgical readmission. Some hospitals have been described as disproportionate share hospitals (DSH), a definition used by the CMS to provide additional payments to hospitals serving a significant percentage of individuals insured through Medicaid. A study by Blegen and colleagues (2011) used DSH status to identify safety-net hospitals. Although the average staffing ratios were not significantly different between safety-net and non-safety-net hospitals, patients in safety-net hospitals were more likely to have poorer outcomes, including higher rates of mortality (Blegen et al, 2011). This study suggests, that despite adjusting for nurse staffing, hospital and patient characteristics, patients who receive care in a hospital with higher proportions of low socioeconomic status might be at greater risk for adverse outcomes.

However, studies vary in how they define safety-net hospitals. Safety-net hospitals have been identified based on the amount of uncompensated care provided, the

caseload of Medicaid patients, or other hospital characteristics such as being a public or teaching hospital (McHugh, Kang, & Hasnain-Wynia, 2009). Although no single best approach to defining a safety-net hospital has been identified, the method for identifying a safety-net hospital varies across the literature, leading to mixed findings about the impact of safety-net status on health outcomes (McHugh, Kang, & Hasnain-Wynia, 2009). For this study, a hospital's socioeconomic status profile was calculated based on the proportion of study patients within the hospital with a low socioeconomic status. Hospital socioeconomic status profile was controlled for in a sensitivity analysis.

Magnet® designation

In response to a nursing shortage in the 1980s, a study was conducted by the American Academy of Nursing to attempt to entice people to pursue a career in nursing (McClure et al, 1983). This study identified organizational features of certain hospitals that were best able to recruit and retain nurses during the nursing shortage. These hospitals were described to have “magnet-like” properties as a result of their low nurse turnover rates and high nurse satisfaction (McClure et al, 1983). Beginning in 1994, the American Nurses Credentialing Center (ANCC) began awarding hospitals that met specified criteria demonstrating nursing excellence as Magnet® designated hospitals (ANCC, 2014). Magnet® designation has been considered a proxy measure for hospitals with exceptional nurse practice environments.

A large and growing body of research suggests that better nurse work environments are associated with positive patient outcomes and reductions in mortality and readmission (Aiken, Smith, & Lake, 1994; Aiken et al, 2008; Aiken et al, 2011; Ma,

McHugh, & Aiken, 2015; McHugh & Ma, 2013). Magnet® designation is often used by researchers who do not have a direct measure of the nurse practice environments. In other words, Magnet® designation is a proxy for a direct measure of the practice environment. Although this study uses a direct measure of the practice environment, as measured by the PES-NWI, adjusting for each hospital's Magnet® designation status in a sensitivity analysis ensures that the direct measure of the practice environment is appropriately and fully accounting for hospital working conditions.

Surgical care improvement project process measures

Surgical care improvement project process measures are hospital quality performance measures included as one of the value-based purchasing programs among the pay-for-performance initiatives in the Affordable Care Act. Hospital postsurgical readmission rates have been found to be only weakly correlated with performance on surgical care improvement project measures (Tsai et al, 2013). The authors hypothesized that this finding may be due to the modest variation in hospital surgical care improvement project measure performance. A prior study of surgical care improvement project process measure performance revealed no significant association with surgical site infection (Garcia et al, 2012). Given this evidence, these measures may not be a highly valid quality measure for predicting patient health outcomes. Nevertheless, the measures do hold valid theoretical weight in the relationship of hospital care and postsurgical readmission. Therefore, as part of a sensitivity analysis, the hospitals' performance on surgical care improvement project measures were controlled for in a sensitivity analysis.

Nursing characteristics

The following section describes hospital nursing characteristics – staffing and practice environment – which were the primary predictors in this study. These features of hospital nursing have been consistently shown to be associated with various patient health outcomes, including readmission (Kane et al, 2007; Kazanjian et al, 2005; Shekelle, 2013; Ma, McHugh, & Aiken, 2015; McHugh & Ma, 2013; Weiss, Yakusheva, & Bobay, 2011).

Staffing

Registered nurses in the hospital are responsible for the ongoing surveillance of changes in patient status in response to medications, treatments, and disease progression. In a sense, hospital nurses are an around-the-clock surveillance system that is essential for detecting early warning signs of patient decompensation and intervening in order to prevent or ameliorate an adverse event. Patients undergoing elective orthopedic surgeries are generally healthy since they are deemed medically stable to undergo a major surgery. However, even the healthiest patients are at risk for complications in the postoperative period. Complications can be quick in onset and fatal, requiring rapid and intelligent response to prevent worsening. Some potentially fatal complications progress slowly overtime, but have subtle early warning signs, such as infection. Other complications, such as physical deconditioning, occur over time when patients are not frequently assisted and encouraged to ambulate. Whether postoperative complications progress quickly or slowly, the nurse is often the first healthcare provider to identify a change in

the patient condition and initiate a response. For many complications, a response, or lack thereof, can mean the difference between life and death for a postoperative patient.

The more patients a nurse cares for, the less time a nurse is able to spend with each individual patient which inhibits the nurse's capacity to recognize the subtle early warning signs of patient decompensation. Heavier nurse workloads can also influence the nurse's capacity to perform other essential nursing care tasks, such as the timely administration of medications, education related to self-care and disease management, and ambulation. Failure to perform these essential nursing care tasks can compromise the safety of patients, both within the hospital and beyond discharge.

Patients undergoing THA/TKA require ongoing mobility assistance, pain management, wound management, and education about self-care following a major joint replacement. The more patients a nurse cares for, the less time a nurse is able to spend providing thorough and in-depth care to each individual patient. Specifically, for patients following THA/TKA, nurses must tailor education and care instructions to each patient individually. Some patients may have support systems to help them perform activities of daily living when they return home, while other patients may require additional assistance from home health aides, registered nurses, and/or physical therapists. It is essential for hospital nurses to learn about each patient's individual needs in order to ensure that the patient can safely transition from the hospital to home.

With over two decades of research on nurse staffing, researchers consistently find that more favorable nurse staffing ratios positively impact patient outcomes (Kane et al, 2007; Kazanjian et al, 2005; Shekelle, 2013). Across the literature and in various patient populations, more favorable nurse staffing has been found to be associated with

reductions in patient mortality and a number of adverse patient events, including readmission (Kane et al, 2007). In a study of adult patients admitted for general, orthopedic, and vascular surgeries in 168 hospitals, each additional patient per nurse was associated with 7% higher odds of mortality (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002). Using unit level analysis, Needleman and colleagues (2011) examined patient exposure to nurse staffing when the unit was staffed below and at the staffing target. Staffing below the unit target was found to be associated with increased mortality (Needleman et al, 2011). The effect of more favorable staffing levels has also been shown to attenuate the odds of unplanned readmission and in-hospital mortality in a cardiac surgical population (Diya et al, 2011). A study by Ma and colleagues found every additional surgical patient per nurse increased the odds of readmission by 3% (Ma, McHugh, & Aiken, 2015).

Other studies have examined the association in medical patients. An analysis of national claims data for patients in all United States hospitals categorized nursing staffing into quartiles and found that patients discharge from hospitals in the lowest staffing quartile experienced higher readmission rates compared with patients discharged from hospitals in the highest staffing quartile (Joynt & Jha, 2011). These findings were further supported in a study of 375,681 patients with a primary diagnosis of congestive heart failure, acute myocardial infarction, or pneumonia, in 412 hospitals. Each additional patient in the nurse's average workload was associated with 7%, 6%, and 9% higher odds of readmission for congestive heart failure, pneumonia, and acute myocardial infarction patients, respectively (McHugh & Ma, 2013). Another study found that hospitals with more favorable staffing ratios were less likely to face CMS readmission penalties as

compared with hospitals with less favorable staffing ratios (McHugh, Berez, & Small, 2014).

Practice environment

In addition to having the time to perform essential nursing care tasks, the social context in which nurses work can impact the amount and quality of care nurses are able to deliver. The nurse practice environment describes this social context as the perceived role nurses have within their institution (Lake, 2002). It includes the relationships nurses have with other healthcare providers, including physicians and their direct supervisors (Lake, 2002). A positive social context in which nurses are able to effectively communicate with other providers can influence the care process and patient outcomes. A growing body of research finds that hospitals with better work environments are associated with fewer adverse patient outcomes.

When the clinical resources needed to perform nursing tasks are readily available, positive collegial relationships among physicians and nurses exist, and nurses experience clinical and political autonomy in hospital affairs, then nurses are better positioned to provide high quality care. Formally referred to as the practice environment, the organizational culture and resources available to nurses have been found to have predictive validity for patient outcomes, including readmission (Ma, McHugh, & Aiken, 2015; McHugh & Ma, 2013).

An early study of the practice environment matched 39 “magnet” hospitals known for good nursing care with 195 control hospitals and found that, controlling for hospital characteristics, patients in the “magnet” hospitals experienced a 7.7% lower mortality

rate than the control hospitals. After adjusting for patient characteristics in the “magnet” and control hospitals, the results remained significant, with the “magnet” hospitals, known for better nursing care, experiencing a 4.6% lower mortality rate (Aiken, Smith, & Lake, 1994). These findings were replicated in a study of surgical patients in 168 Pennsylvania hospitals using the PES-NWI to measure the nurse practice environment. In conjunction with more favorable nurse staffing and higher proportions of baccalaureate educated nurses, better nurse practice environments were associated with lower 30 day mortality rates (Aiken et al, 2008). A later study demonstrated the moderating relationship of the practice environment on the nurse staffing effect on 30 day mortality such that the effect of decreasing nurse workloads was greater in hospitals with better practice environments (Aiken et al, 2011).

The practice environment’s effect on readmission outcomes is less well understood. One study of medical patients found that patients cared for in the best practice environments compared with the poorest, experienced 7%, 6%, and 10% lower odds of 30 day readmission for congestive heart failure, acute myocardial infarction, and pneumonia, respectively (McHugh & Ma, 2013). A study of general, vascular, and orthopedic surgical patients, found that patients cared for by nurses working in better work environments had 3% lower odds of readmission (Ma, McHugh, & Aiken, 2015). A systematic review of ten studies revealed that a lack of standardized measures and methodological rigor prevents a clear understanding of the influence of the practice environment on readmissions (Ma, Shang, & Stone, 2014). This study attempts to build on previous findings of an association between readmission and the practice environment to bolster the evidence.

Education

Nurse education, or the hospital proportion of nurses holding a bachelors degree, is associated with various health outcomes. A rigorous body of empirical evidence suggests that hospitals with lower proportions of bachelors degree nurses are linked with poorer patient outcomes (Aiken et al, 2012; Aiken, Clarke, & Sloane, 2002; Blegen et al, 2013; Estabrooks et al, 2005; Kendall-Gallagher, et al 2011; Kutney-Lee, Sloane, & Aiken, 2013; Needleman et al, 2006; Tourangeau, Cranley, & Jeffs, 2006; Yakusheva, Lindrooth, & Weiss, 2014a).

The association of nurse education with readmission is less well understood. McHugh and Ma (2013) explored the relationship of nurse education and readmission in Medicare patients with congestive heart failure, acute myocardial infarction, and pneumonia but did not find a statistically significant relationship for patients with congestive heart failure or acute myocardial infarction. For patients with pneumonia, patients had 3% lower odds of readmission for each 10% increase in the hospital proportion of nurses with a bachelors degree (McHugh & Ma, 2013). Another study of readmissions among surgical patients found no effect of nurse education (Ma, McHugh, & Aiken, 2015). Because prior evidence does not suggest a robust effect of nurse education on readmissions, nurse education was not examined as a primary predictor of interest in this study.

Summary

While the effects of nurse staffing and practice environment on postsurgical outcomes including mortality and failure-to-rescue are well understood, much less is known about their effects on postsurgical readmissions. To my knowledge, this study was

the first to examine how hospital nursing is associated with readmissions in Medicare patients following elective THA/TKA.

Significance

Social

Hospitalization is a significant event for patients and their families. In an attempt to understand the patient experience of hospital readmission, the Robert Wood Johnson Foundation published a report, *Hospital Readmissions from the Inside Out: Stories from Patients and Health Care Providers*, which tells the stories of 16 readmitted patients (RWJF, 2013). Although patients believed their readmission event to be a unique experience, common themes emerged from the patient stories. Many patients felt they were discharged from the hospital prematurely and many did not understand their discharge instructions or felt their care instructions were too vague (RWJF, 2013). Many patients were concerned about being home alone upon discharge and reported they did not have a support system when they returned home (RWJF, 2013). One patient recounted his emotions about being home alone on the first night after being discharged, “I was real nervous; I didn’t know if I would make it. I thought this might be it” (RWJF, 2013). These vignettes reveal the difficulty of transitions for patients following hospitalization.

The hospitalization itself, as well as the transition from the hospital are emotionally, mentally, and physically taxing for many older patients. Insufficient education about self-care management, care coordination, and post-discharge support exacerbate the difficulties patients face upon hospital discharge (RWJF, 2013). Older adult patients can be especially frail and deconditioned when leaving the hospital, making

activities of daily living more difficult to accomplish (Kortebein, 2009). An inability to perform activities of daily living, such as preparing meals and basic self-care like taking medications, put these patients at risk for readmission.

Financial

The CMS quality initiative to reduce costly and avoidable readmissions has fundamentally complicated hospital administrators' financial incentives. Hospital administrators are now forced to grapple with a perverse financial incentive to earn additional money for the second hospital stay of a readmitted patient, or prevent readmissions and avoid CMS withholding a small fraction of reimbursements for all Medicare patient stays (Burton, 2012; Joynt et al, 2014). As the readmission penalties increase annually, the ambiguity of this decision for administrators may evaporate.

In the second year of implementation, 2,217 hospitals across the country experienced a readmission penalty (Burton, 2012). In total, these hospitals forfeited more than \$280 million in Medicare reimbursements (Rau, 2013). While this amount is only 0.3% of total Medicare reimbursements made to hospitals annually, the penalties are expected to become more severe over time, placing more hospital revenue at stake (Rau, 2013). After the third year of penalties, 2,610 hospitals were penalized, totaling approximately \$428 million in fines (Rau, 2014). Although data suggest national readmission rates are dropping on average, the penalties increased to 3% of base CMS reimbursements during fiscal year 2015 (Rau, 2014).

To date, it remains unclear whether the financial incentives are encouraging hospitals to provide higher quality care. Between the first and second years of

implementation, the average national penalty decreased from 0.42% of base CMS reimbursements to 0.38% (Rau, 2013). The average penalty in the third year of implementation was 0.68%, slightly less than double the penalties from the prior year (Rau, 2014). It is too early to know if changes in the average penalty are the result of actual care improvements, or modifications in the readmission penalty criteria made by CMS, such as the inclusion of more clinical conditions in the risk adjustment and more refined criteria to differentiate planned and unplanned readmissions (Rau, 2013). Only 129 hospitals which were penalized in the second year were able to avoid a penalty in the third year (Rau, 2014).

Hospitals are unnecessarily forfeiting a portion of reimbursement. Understanding how modifiable characteristics of hospital nursing affect readmission rates is fundamental to understanding the economic interplay of pay-for-performance incentives and investments in hospital nursing.

Political

The enactment of the Affordable Care Act in March 2010 has brought heightened attention to the link between avoidable hospital readmissions and healthcare costs as a signal for poor quality care. Historically, this health reform legislation and the pay-for-performance initiatives, mark the first time that payers are legally able to reimburse providers based on the quality of care, rather than the volume of care delivered.

The first year of implementing the Hospital Readmission Reduction Program began in October 2012. In the initial year of implementation, CMS withheld up to 1% of base CMS reimbursements for those hospitals that had worse than expected readmissions

rates. Expected readmission rates are risk standardized based on the hospital's case mix index as measured by patient demographics (age and sex) and comorbidities (CMS, 2014). In a report to Congress in 2011, CMS stated their aim to reduce readmissions by 20% by the end of 2013, which would result in the prevention of 1.6 million avoidable rehospitalizations and \$15 billion in savings to CMS (Kocher & Adashi, 2011).

Beginning in October 2012, the readmission penalty applied to all cause 30 day readmissions for Medicare beneficiaries with a principal index admission diagnosis of congestive heart failure, acute myocardial infarction, or pneumonia. In the first year of the program, readmission penalties were set for as much as 1% of annual base CMS reimbursements, with penalties increasing to 2% and 3% in fiscal year 2014 and 2015, respectively (CMS, 2014). Beginning in fiscal year 2015, penalties for 30 day unplanned readmissions for THA/TKA, as well as chronic obstructive pulmonary disease, took effect (CMS, 2014).

This study directly addresses modifiable nursing predictors of unplanned 30 day readmission for Medicare patients following elective THA/TKA. Understanding the extent to which nursing contributes to reductions in the likelihood of readmission, can guide hospital administrators and policymakers to more appropriately invest in nursing resources.

Outcome

The outcome of interest in this study was 30 day unplanned readmission. The 30 day readmission outcome was pragmatically chosen based on the Hospital Readmission Reduction Program penalty. In a study of older adult surgical patients, readmission was found to be associated with measures of surgical care quality, including mortality (Tsai et

al, 2013). A meta-analysis of inpatient care quality and 30 day readmission concluded that readmissions are associated with substandard inpatient care quality (Ashton et al, 1997). In a sensitivity analysis, 10 day unplanned readmission was also studied given the common criticism that 30 days from discharge is too far to accurately assess hospital quality (Joynt & Jha, 2012; Vaduganathan, Bonow, & Gheorghiade, 2013).

Covariates

The patient level covariates to be examined in this study were chosen a priori based on the risk adjustment measures used in the THA/TKA Readmission Technical Report, which is prepared for CMS by a study team at the Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) (Suter et al, 2014).

Patient level covariates included: age, sex, comorbidities, type of procedure, and number of procedures during admission. Hospital level covariates were included to risk adjust for differences across hospital characteristics. Hospital level covariates in this study included: hospital size, teaching status, and technology status. Hospital level primary predictor variables of interest were used to test the effects of nursing on the odds of readmission. These nurse covariates included: staffing and the practice environment. Other covariates adjusted for in a sensitivity analysis included patient level covariates: discharge destination, length of stay, race/ethnicity, socioeconomic status; and hospital level covariates: geographic location, caseload volume, ownership type, socioeconomic profile, Magnet® designation, surgical care improvement project performance measures.

Summary

In Chapter 2, the conceptual framework, the Quality Health Outcomes Model, was introduced and the relationships tested in this study were described. A review of the literature on readmissions and nursing elucidated the gaps that this study addressed. The social, financial, and political significance of this research was argued. Finally, the outcome and the covariates of interest in this study were described. In the chapters to follow, Chapter 3 describes the methods of the study, an explanation of the parent study, the datasets, the sample, and the analytic plan for the specific aim and the sensitivity analysis; Chapter 4 describes the study findings; and Chapter 5 contains a discussion of the main study findings as well as study limitations, implications, and areas for future inquiry.

CHAPTER 3: METHODS

Introduction

This section addresses the methodological aspects of the study, which aimed to understand the effects of nursing on the likelihood of 30 day readmission for older adults undergoing elective THA/TKA. After a general overview of the study methodology, this chapter describes the parent study from which the nurse survey data was collected, the hospital, nurse, and patient datasets, the procedure for identifying the study sample, and the plan for measuring variables of interest. The analytic plan for the specific aim and sensitivity analysis as well as the methodological limitations and assumptions are discussed. Finally, the concern for and attention to issues related to data integrity and human subjects are addressed.

Overview

This study was a cross-sectional analysis of three 2005-2006 secondary data sources including an annual hospital administrative survey, a survey of nurses, and patient data related to hospitalizations. The hospital administrative survey provided data on hospital characteristics including bed size, teaching status, and technology status. The nurse survey provided demographic data about the nurses as well as nurse reports of staffing and the organizational climate in which the nurse worked. The patient data included patient demographic data as well as diagnoses and procedures during each hospitalization. Three additional data sources were used in the sensitivity analysis: United States Census data, Hospital Compare Surgical Care Improvement Project data, and ANCC Magnet® designation data.

Parent study

The nurse survey data was retrieved from the parent study, the Multi-State Nursing Care and Patient Safety Study survey. The parent study was conducted in 2006, led by Principal Investigator, Dr. Linda Aiken, at the Center for Health Outcomes and Policy Research (CHOPR) at the School of Nursing at the University of Pennsylvania. Prior to data collection, the University of Pennsylvania Institutional Review Board approved the parent study. The data from this study are securely maintained at CHOPR.

Random sampling of a percentage of registered nurses in California (40%), Florida (25%), New Jersey (50%), and Pennsylvania (40%) were surveyed using a modified Dillman approach in which nurses received mailed surveys to their home addresses (Dillman, 1978; Dillman, 2000). These states were a convenience sample based on funding, but they represent nearly one-quarter of the national population and are geographically diverse (U.S. Census Bureau, n.d.). All surveys were mailed in 2005-2006, with the exception of surveys mailed to nurses in Florida, which were mailed in 2007-2008. In total, 272,783 surveys were mailed, with 106,532 surveys mailed to California nurses, 49,385 surveys mailed to Florida nurses, 52,545 surveys mailed to New Jersey nurses, and 64,321 surveys mailed to Pennsylvania nurses. Surveys were mailed to the nurses' home address, which was obtained from his/her state board of nursing. Mailing to the nurses' home, rather than their place of employment, helped to reduce hospital selection bias, which was a potential threat to the study's validity (Aiken et al, 2011). Hospitals with poor nurse working conditions or poor patient outcomes may have discouraged nurses from answering the survey, thereby biasing the sample. This

approach prevented hospitals from influencing whether or not nurses at their hospital responded to the survey.

The nurses received a mailed survey that could be completed with a pencil and paper or on a secured website. Each survey was labeled with a unique barcode and number. Returned surveys were then scanned with these unique identification numbers and no other personal information, thus maintaining the confidentiality of the survey respondents. The nurses were asked to identify the name and location of the hospital, homecare agency, or nursing home in which they were employed. This allowed responses from nurses who reported working in the same facility to be aggregated to create facility level measures (Aiken et al, 2011).

The overall response rate was 39% (Aiken et al, 2011). A follow-up survey involving double sampling was conducted to determine if and to what extent response bias was present in the sample of responders (Smith, 2008). Response bias, a term used to describe the cognitive biases that influence whether a survey recipient will participate, can weaken the validity of the findings. To ensure there was no response bias in the original survey, a follow-up study of 1,300 non-responders in California and Pennsylvania from the original survey was conducted. These non-responders were mailed a shortened survey, a modest monetary incentive, and received telephone reminders to complete the survey. This follow-up survey achieved a 91% response rate. Although there were demographic differences between those who responded to the original survey (responders) and those who responded to the follow-up survey (non-responders), such as age, years of experience, and race/ethnicity, there were no differences in the nurse

reported measures of interest to this study, such as nurse reports of staffing (Smith, 2008).

Data sets

Multi-State Nursing Care and Patient Safety Study Survey, 2005-2006

The Multi-State Nursing Care and Patient Safety Study survey conducted in 2005-2006 is comprised of nurse reports of the nurse's demographics as well as information about the environment in which he or she works. Specifically, the nurse survey data contains information about staffing and the practice environments and culture within the hospital. The survey contains the Practice Environment Scale of the Nursing Work Index Revised (PES-NWI) which is composed of five subscales: 1) nurse participation in hospital affairs; 2) nursing foundations for quality of care; 3) nurse manager ability, leadership, and support of nurses; 4) staffing and resource adequacy; and 5) collegial nurse-physician relations (Lake, 2002).

American Hospital Association Annual Survey of Hospitals, 2006

The American Hospital Association (AHA) is a national organization dedicated to representing hospitals nationally and to engaging in health policy development as well as legislative and regulatory matters pertaining to hospital and healthcare networks. The 2006 AHA Annual Survey of Hospitals used primary survey data to review over 6,500 United States hospitals. The survey provides data on hospital organizational structure, facility and service lines, inpatient and outpatient utilization, expenses, physician arrangements, staffing, corporate and purchasing affiliations, as well as geographic indicators (AHA, 2014). Variables of interest for this study that were sourced from this

data set include: bed size, teaching status, technology status, geographic location, and ownership type.

Medicare Provider Analysis and Review (MedPAR) Research Identifiable File, 2006

The Medicare Provider Analysis and Review (MedPAR) Research Identifiable File (RIF) contains information for all Medicare beneficiaries for every event in which beneficiaries accessed hospital inpatient services (RESDAC, 2013). A given Medicare beneficiary can have multiple MedPAR records, as each record is representative of one inpatient hospital stay (RESDAC, 2013). The MedPAR RIF includes information for each Medicare beneficiary inpatient stay including: ICD-9 diagnoses and procedure codes, diagnosis-related groups (DRGs), dates of service, hospital provider numbers, and demographic information (RESDAC, 2013). This file also appends the date of death, from the National Center for Health Statistics Linked Mortality Files, if death occurred within three years of the date of discharge (CMS, 2013).

Sensitivity analysis datasets

Information about patient socioeconomic status was obtained from United States Census data, which is publically available and collected by the United States Census Bureau. The data has previously been used to create a neighborhood socioeconomic summary index score for each patient's ZIP code (Brooks Carthon et al, 2012; Diez Roux et al, 2001). The socioeconomic index score is a summary of six measures related to an individual's wealth/income (log of the median household income, log of the median value of housing units, the percentage of households receiving interest, dividend or net

rental income), education (percentage of adults 25 years or older who completed high school, percentage of adults 25 years or older who completed college), and occupation/employment (percentage of employed persons 16 years or older in executive, managerial, or professional specialty occupations) (Diez Roux et al, 2001). These six measures were identified through a factor analysis and are reported in the United States Census data in 2000 (Diez Roux et al, 2001). The socioeconomic summary index score was derived from the sum of the z-scores for each of the six measures, with higher scores indicating greater socioeconomic status, within the ZIP code level (Diez Roux et al, 2001). This data was used to explore patient socioeconomic status and hospital socioeconomic status profiles in the sensitivity analysis.

Data about hospital surgical care improvement project performance was collected from Hospital Compare – a website created by CMS to provide publically available data to healthcare consumers about the quality of care in hospitals across the country. In 2006, three measures of hospital surgical care were collected: hospital percentage of surgical patients who/whose (1) received preventative antibiotic(s) one hour before incision, (2) received the appropriate preventative antibiotic(s) for their surgery, and (3) preventative antibiotic(s) were stopped within 24 hours after surgery.

Hospital Magnet® designation statuses are publically reported by the ANCC, the organization responsible for recognizing hospitals that demonstrate nursing excellence and awarding Magnet® designation (ANCC, 2014). The ANCC website provides publically available data indicating the years in which hospitals have been Magnet® designated and re-designated. Hospitals holding Magnet® designation during 2005, 2006 or 2007, were identified as Magnet® hospitals in the analytic sample.

Sample

Hospitals

Eligibility criteria for inclusion of hospitals in the study included 10 or more nurse respondents and 10 or more patients discharged alive following elective THA/TKA. Previous empirical work suggests that 10 or more nurse survey respondents is sufficient for providing reliable estimates of the hospital's organizational features (Aiken et al, 2003). In the sensitivity analysis, the effects of nursing on readmission were assessed at different thresholds for patient volume, including at least 50 and 100 live THA/TKA discharges per hospital.

The percent of all adult non-federal acute care hospitals penalized and the average penalty by state during fiscal year 2015 are listed in Table 3.1. This table represents data from all adult non-federal acute care hospitals in California, Florida, New Jersey and Pennsylvania, as well as all states nationally. Although not representative of surgical readmissions, the data reported here provide evidence for the generalizability of this study's sample to adult non-federal acute care hospitals nationally. During fiscal year 2015, hospital penalties ranged from 0% - 3%. On average, the hospitals in the states under study were penalized more than hospitals in all states nationally. The average penalties for hospitals in California (0.41%) and Florida (0.58%) were less than and equal to the average penalty of hospitals nationally (0.58%). Pennsylvania hospitals' average penalty (0.63%) was slightly higher than all states. New Jersey hospitals' average penalty (0.82%) was far greater than the average national penalty (0.58%). Despite state-to-national variation in the percent of hospitals penalized and the severity of the average penalty, when considered together, the four states in this study are not unlike all states

nationally. Of note is that California is the only state to have mandated staffing legislation, and also has the fewest percent of penalized hospitals and the lowest average penalty compared with other states in the sample.

Table 3.1. Readmission penalties to be applied in fiscal year 2015, by state

State	Percent of hospitals penalized	Average penalty
California	64%	0.41%
Florida	79%	0.58%
New Jersey	98%	0.82%
Pennsylvania	72%	0.63%
All States*	51%	0.58%

Source: (Kaiser Health News, 2014); *excluding Maryland, which has a unique reimbursement agreement with Medicare

Nurses

The nurse sample was limited to registered nurses who worked in an adult non-federal acute care hospital and who reported being a direct care staff nurse. Direct care nurses have the most frequent and direct contact with patients, placing them in a position to have a significant impact on patient care quality and safety.

Patients

The inclusion and exclusion criteria for patients in this study was based on the THA/TKA Readmission Technical Report, which is prepared for CMS by a study team at the Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE). This report is re-evaluated annually and updated as needed to refine the measures. The National Quality Forum has endorsed the THA/TKA readmission measure as an evidence-based and valid measure for performance assessment (QualityNet, 2014a).

Patients were included in the study if they were admitted to one of the study hospitals and met the following inclusion and exclusion criteria set forth in the THA/TKA Readmission Technical Report (Suter et al, 2014). These specified inclusion and exclusion criteria were followed because they are the established criteria used to calculate excess readmissions beyond the expected risk adjusted readmission rates for hospitals under the Hospital Readmission Reduction Program. Following these guidelines makes these study findings more relevant to hospital administrators and policymakers. The inclusion and exclusion criteria as well as the rationale for each criterion are described in Table 3.2 and Table 3.3. The number of THA/TKA patients excluded with each criterion can be found in the Appendix A.

Table 3.2. Inclusion criteria and rationale for the study of elective THA/TKA readmissions

Inclusion Criteria	Rationale
1. Enrolled in Medicare fee-for-service	Hospital claims data are regularly available for only for Medicare fee-for-service beneficiaries.
2. Age 65 or older	Medicare patients younger than age 65 qualify for Medicare due to severe disability, making them distinctly different from the elderly Medicare population.
3. Discharged from a non-federal acute care hospital alive	Only those patients who are alive at time of hospital discharge are eligible for a readmission.
4. Enrolled in Part A and Part B Medicare for the 12 months prior to the date of the index admission	Including Medicare Part A beneficiaries ensures there are no Medicare Part C (Medicare Advantage patients) in the data. Enrollment in Medicare in the 12 preceding months ensures one year of administrative data for risk adjustment purposes.
5. Have a qualifying elective primary THA/TKA procedure, without any of the following:	Elective primary THA/TKA is the procedure of interest in this study.
a. Femur, hip, or pelvic fractures coded in the principal or secondary discharge diagnoses fields of the index admission	Procedures to correct an orthopedic fracture are considered non-elective. Patients with orthopedic fracture tend to have higher mortality, complication, and readmission rates.
b. Partial hip arthroplasty procedures with concurrent THA/TKA	Partial hip arthroplasty are primarily indicated for hip fractures.
c. Revision procedures with a concurrent THA/TKA	Few hospitals perform THA/TKA revision procedures and are associated with higher mortality, complication, and readmission rates.
d. Resurfacing procedures with a concurrent THA/TKA	Resurfacing procedures are distinctly different than THA/TKA and are primarily indicated for younger, healthier patients.
e. Mechanical complication of the pelvis, sacrum, coccyx, lower limbs, or bone/bone marrow or disseminated malignant neoplasm coded in the principal discharge diagnosis field	A mechanical complication was likely present on admission and may require more technically complex procedures to correct. Patients with malignant neoplasms undergoing a THA/TKA are likely not elective and the patients are more likely to have a readmission.
f. Removal of implanted devices/prostheses	Removal of an implanted device/prostheses may be more complicated.
g. Transfer from another acute care facility for THA/TKA	Transfers from another acute care facility for THA/TKA is likely not elective.

Table 3.3. Exclusion criteria and rationale for the study of elective THA/TKA readmissions

Exclusion Criteria	Rationale
1. Without at least 30 days post-discharge enrollment in fee-for-service Medicare	Since readmissions are identified using claims data, 30 days of post-discharge enrollment in Medicare fee-for-service is required.
2. Discharged against medical advice (AMA)	Patients leaving AMA may not allow providers to deliver complete and full care to prepare the patient for discharge.
3. Admitted for the index procedure and subsequently transferred to another acute care facility	Including these cases in the readmission measure makes it difficult to determine to which hospital the readmission outcome should be attributed.
4. With more than two THA/TKA procedure codes during the index hospitalization	More than two THA/TKA procedures likely reflects an error in coding.

For patients who had multiple admissions characterized as a qualifying admission in the study timeframe, one qualifying admission was randomly selected for analysis (Suter et al, 2014). A qualifying admission was characterized as an index admission if an unplanned readmission occurred within 30 days of the index admission discharge (Suter et al, 2014). Randomly selecting one qualifying admission allowed for statistical independence of observations, such that a patient’s prior readmission would not influence a future hospitalization. After this selection process, the sample included a total of 124,300 patients (36,745 THA patients; 87,555 TKA patients).

Measurement and instrument

Outcome

The outcome of interest in this study was unplanned readmission 30 days from discharge. 30 days from discharge is a widely used timeframe in the literature and is designated as the clinically meaningful timeframe in which hospitals should be held accountable for the care outcomes of patients beyond hospitalization, according to the

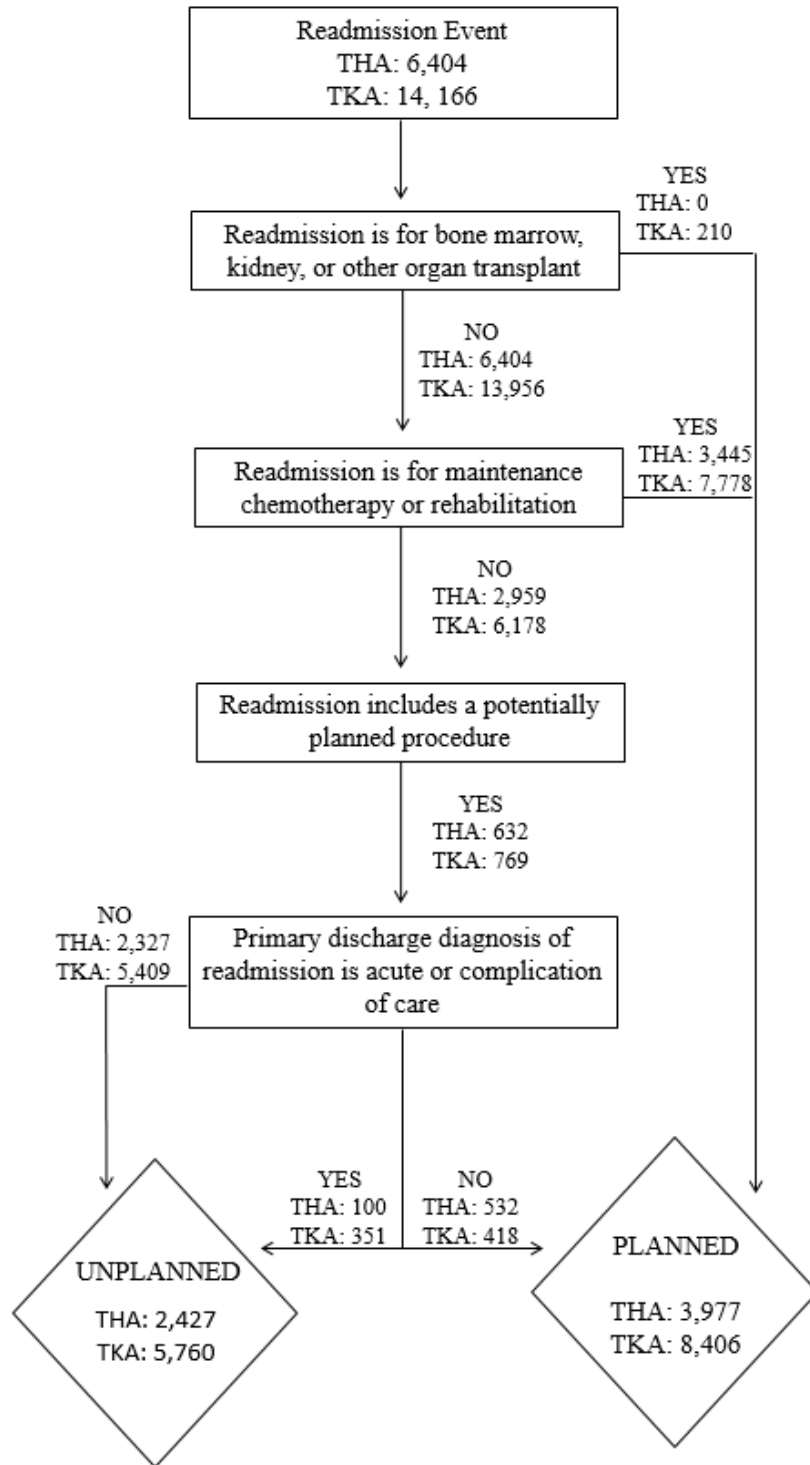
THA/TKA Readmission Technical Report (Suter et al, 2014). In light of criticism that a 30 day timeframe may not be an appropriate assessment of hospital quality (Joynt & Jha, 2012; Vaduganathan, Bonow, & Gheorghiade, 2013), a sensitivity analysis of unplanned readmission 10 days from discharge was also performed.

The THA/TKA Readmission Technical Report outlines what qualifies as a readmission that can be used to calculate a hospital's readmission rate. A qualifying readmission is defined by a readmission that occurs within 30 days of discharge from an index admission. Any admission that occurs within 30 days of discharge cannot be considered as an index admission. An index admission is defined based on the inclusion and exclusion criteria as previously described (Suter et al, 2014).

Unlike prior readmission policies for medical conditions, which penalized hospitals for all cause readmissions, readmissions for THA/TKA are delineated as either planned or unplanned readmissions. Based on the theory that hospitals should not be penalized for having a patient return to the hospital for a planned readmission, only unplanned readmissions were used to calculate a hospital's readmission rate. The THA/TKA Readmission Technical Report provides a detailed algorithm (Figure 3.1) to distinguish planned and unplanned readmissions. The algorithm is based on condition categories which are clusters of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, as well as individual ICD-9-CM codes (Suter et al, 2014; QualityNet, 2014b). The condition categories are derived from the Hierarchical Condition Categories system, which classifies condition categories into clinically meaningful categories at a more aggregated level (Pope et al, 2000). The Clinical Classifications Software is a tool developed by the Agency for Healthcare

Research and Quality and is used to clinically group diagnoses and procedures to aid in creating manageable condition categories (HCUP, 2012).

Figure 3.1. Planned and unplanned readmission algorithm



Algorithm obtained from: Suter et al, 2014

For the patients in the sample that had multiple unplanned readmissions within 30 days, the first readmission was identified as the unplanned readmission.

After merging the patient sample with the nurse and hospital data, the final analytic sample included 112,018 patients (33,155 THA patients; 78,863 TKA patients). The final count of unplanned readmissions was 7,524 (2,204 THA patients; 5,320 TKA patients). 28 patients who had both a THA and TKA on the same admission were excluded. The final sample also included 23,089 direct care registered nurses who reported working in the 495 study hospitals.

Covariates

Nurse staffing and the practice environment were the main predictors of interest in this study. Other covariates discussed in this section relate to hospital characteristics and patient demographics and were included for risk adjustment in the regression models for the specific aim and/or the sensitivity analysis.

Predictors of interest

Nurse staffing

The Multi-State Nursing Care and Patient Safety Study survey asked nurse respondents to report how many patients were on the nurse's unit and how many registered nurses provided direct patient care on the last shift the nurse worked. Using these data, I created a continuous variable of the average number of patients per registered nurse within each study hospital. For descriptive purposes, this continuous variable was categorized into the following categories representing the number of patients per registered nurse: <4; ≥ 4 & <5; ≥ 5 & <6; ≥ 6 & <7; ≥ 7 . For the regression

analyses, a continuous measure of the hospital aggregated number of patients per nurse was used. This approach has been previously used in the literature on nursing's effect on readmissions following admission for medical conditions and mortality outcomes for postsurgical patients (Brooks Carthon et al, 2012; McHugh & Ma, 2013).

Practice environment

The Multi-State Nursing Care and Patient Safety Study survey included the Practice Environment Scale of the Nurse Work Index (PES-NWI) a survey instrument to measure attributes that comprise the nurse practice environment. The PES-NWI was developed using exploratory factor analysis, which identified five subscales representing the five domains of the practice environment: 1) nurse participation in hospital affairs (9 items); 2) nursing foundations for quality of care (10 items); 3) nurse manager ability, leadership, and support of nurses (5 items); 4) staffing and resource adequacy (4 items); 5) collegial nurse–physician relations (3 items) (Lake, 2002). These five subscales, both independently and as a composite measure, were found to be psychometrically sound and have been tested on data from staff nurses in Pennsylvania hospitals (Lake, 2002).

In this study, the responses from each nurse respondent were aggregated within hospitals to create hospital level composite measures of the practice environment. This composite measure was created as the mean of the five subscale scores (Lake, 2002). A composite quartile approach was used to categorically describe the practice environments across hospitals. Hospitals ranking in the top 25th percentile on the practice environment scale were referred to as a “good” practice environment hospital. Hospitals in the middle 50th percentile on the practice environment scale were referred to as a “mixed” practice

environment hospital. The bottom 25th percentile were referred to as a “poor” practice environment hospital. In the regression analyses, I modeled the effect of a “good” practice environment, leaving “mixed” and “poor” practice environments as the reference category. This approach allows for ease in interpretation such that the good practice environment hospitals are compared to all other hospitals.

Hospital covariates

Bed size

The AHA Annual Survey provides data on hospital bed size. For descriptive and analytic purposes, bed size was categorized as follows: small (≤ 100 beds); medium (101-250 beds); large (> 250 beds) (Brooks Carthon et al, 2012; Friese et al, 2008). For the analysis, each bed size category was dichotomized, with large hospital bed size as the reference category.

Teaching status

Teaching status was defined by the ratio of medical fellows and medical residents to the number of hospital beds. This data was derived from the AHA Annual Survey. Teaching status was categorized as follows: non-teaching hospital (no medical fellows or residents); minor teaching hospital ($\leq 1:4$); major teaching hospital ($> 1:4$) (Ayanian & Weissman, 2002; McHugh & Ma, 2013).

Technology status

For this study, a high technology hospital was defined as a hospital that had the capacity to perform open-heart surgery and/or major organ transplantation (McHugh &

Ma, 2013). If a hospital was not able to perform either of these services, they were categorized as a low technology hospital. This data was available from the AHA Annual Survey. For analytic purposes, technology status was an indicator variable, with low technology status as the reference category.

Patient covariates

Age

Data on patient age was available from the MedPAR RIF. Patient age (years) was descriptively and analytically modeled as a continuous variable.

Sex

Data on patient sex was available from the MedPAR RIF. Patient sex was descriptively and analytically modeled as a categorical variable, with male sex as the reference category in the analyses.

Comorbidities

The MedPAR RIF provided information on patient comorbidities. The THA/TKA Readmission Technical Report delineates which specific comorbidities are meaningful indicators of patient frailty and have strong relationships with readmission (Suter et al, 2014). Each comorbidity was created as a dichotomous variable, with “0” indicating the patient did not have the comorbidity and “1” indicating the presence of the comorbidity.

Type of procedure

The THA/TKA Readmission Technical Report, controls for the type of procedure the patient undergoes (Suter et al, 2014). For the purposes of this study, the procedure types were categorized by the procedure codes on admission: THA or TKA. For descriptive purposes, the patient, hospital and nursing characteristics were described by procedure type. For analytic purposes, the effects of the predictors of interest on readmission included both THA and TKA patients together. In other words, separate regression analyses were not run for each procedure type. This is consistent with the THA/TKA Readmission Technical Report and Hospital Readmission Reduction Program policy (Suter et al, 2014).

Number of procedures

The THA/TKA Readmission Technical Report controls for the number of procedures the patient undergoes on the index admission (Suter et al, 2014). Because patients were excluded from the analysis if they had more than two procedures on the index admission, the number of procedures was dichotomized as either one or two procedures. The number of procedures undergone during the hospitalization was available from the MedPAR RIF.

Statistical analysis

The following describes the data software and statistical analytic plan that were used to meet the specific aim of the study, as well as to conduct the sensitivity analysis.

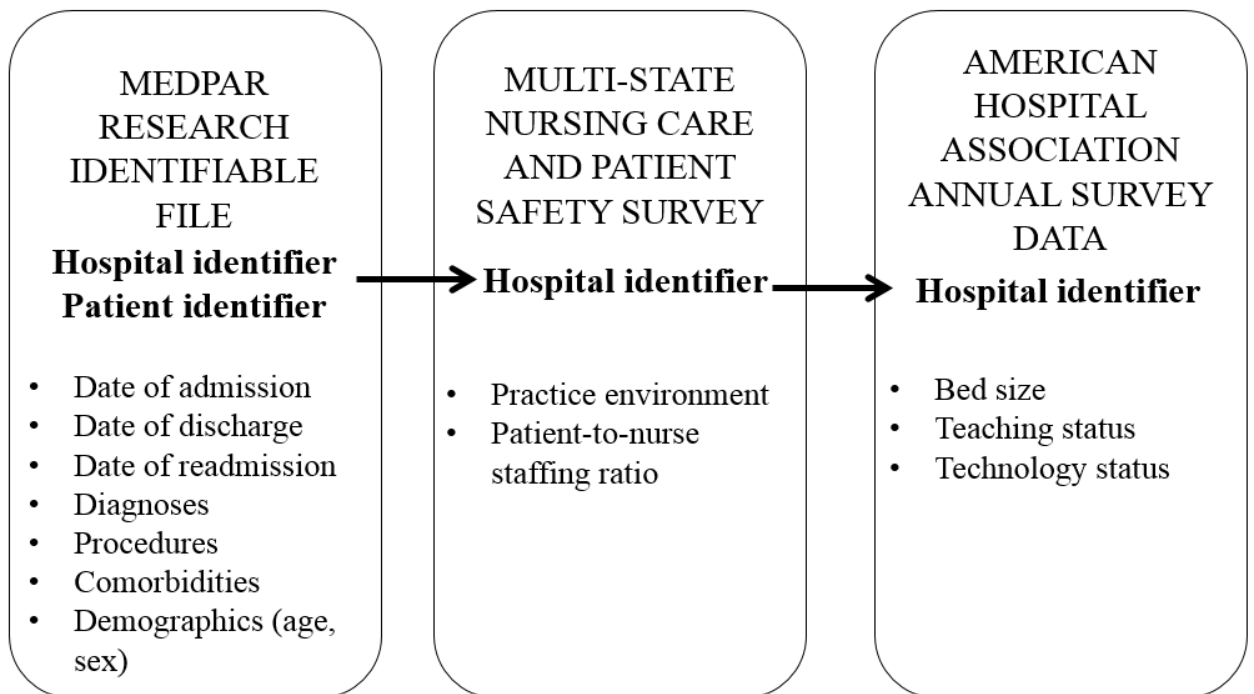
Data analysis software

The data obtained from the Multi-State Nursing Care and Patient Safety Study survey was received by CHOPR in a STATA Version 10.0 file. Within this file, the AHA Annual Survey data had been merged with the nursing data. The file was then converted into a SAS file to systematically check for duplication errors. The MedPAR RIF patient data was received in a SAS file and restricted to include only patients who had a THA and/or TKA procedure. The exploration and analysis of the data was conducted in STATA Version 13.0 (StataCorp, 2013).

Analytic plan

Figure 3.2 diagrams how the three data sources were linked together and from which dataset each of the variables for the specific aim was obtained.

Figure 3.2. Diagram of data sources and linkages



Aim: To examine the extent to which hospital nursing – staffing and the practice environment – are associated with odds of 30 day readmission in a Medicare population undergoing elective total hip and total knee arthroplasty.

First, the study sample was described. In the following descriptive statistics, continuous variables were presented as the mean and standard deviation. Categorical variables were presented as the frequency and percent of the total sample. The characteristics of patients in the sample were described demographically by surgery type (THA, TKA). The most common comorbidities, calculated based on condition categories, were described. Condition categories rather than ICD-9-CM codes were used because they categorize ICD-9-CM codes into more clinically meaningful groups, thus enabling a more comprehensive understanding of the most common comorbidities. The ten most common reasons for readmission, defined by ICD-9 diagnoses and procedures, were described. The sample was compared on patient demographics between patients who were and were not readmitted within surgery types. Comparisons of the variables were made using analysis of variance and t-tests. Among the patients who were readmitted, the characteristics of the readmission event, such as days until readmission and length of stay upon readmission, were described. Additionally, Kaplan-Meier plots and a log-rank test for equality of survivor function were used to identify if there were significant differences in the median time-to-readmission between surgery types.

Additionally, the patient sample, including those patients who died during the initial hospitalization, was examined to assess for competing risk. Dying reduces an individual's probability of readmission to zero; therefore, solely examining readmissions as an indicator of hospital care quality may produce biased findings due to the competing

risk of mortality on readmissions (Gorodeski, Starling, & Blackstone, 2010; Press et al, 2013; Satagopan et al, 2004). Moreover, evidence suggests that hospital readmission rates and mortality rates are negatively correlated such that hospitals with low readmission rates tend to have high mortality rates and vice versa (Gorodeski, Starling, & Blackstone, 2010; Press et al, 2013). These correlations do not necessarily suggest conflicting evidence of hospital quality, but rather elucidate the issue of competing risk. Less than 0.5% of patients died within 30 days of admission, suggesting that mortality did not pose a meaningful competing risk to readmission in this study.

Hospital characteristics by hospital and patient were examined, including histograms of the distribution of patients across hospitals and readmission rates across hospitals. Finally, a comparison of patients who were readmitted versus not readmitted, within surgery type, were compared on the characteristics of the hospitals in which they were initially admitted.

Next, the distribution of registered nurses across the study hospitals were depicted in a histogram. The distribution of both hospitals and patients (by surgery type) were described by nursing characteristics (staffing and the practice environment). Then, a comparison of patients who were readmitted versus not readmitted, within surgery type, were compared on the nursing characteristics in the hospitals to which they were initially admitted.

The final descriptive statistics included a correlation matrix of the hospital and nursing characteristics used in the analysis of the specific aim. A weak correlation was defined by $r = -0.3 - 0.3$; a moderate correlation was defined by $r = -0.6 - -0.3$ or $r = 0.3 - 0.6$; a strong correlation was defined by $r = -1.0 - -0.6$ or $r = 0.06 - 1.0$.

The specific aim – an analysis of the effect of hospital nursing on 30 day readmission – was accomplished by estimating logistic regression models. Robust standard errors (or Huber-White sandwich estimators) were used to account for the clustering of patients within hospitals (Fitzmaurice, Laird, Ware, 2011; Vittinghoff et al, 2012). Clustering of patients within hospitals is important to account for because patients treated in the same hospital are more likely to be demographically alike and more likely to be treated similarly than patients in different hospitals. Failing to account for this correlation between patients in the same hospital could result in: poorly estimated standard errors (too small), confidence intervals (too narrow), p-values (too small) (Fitzmaurice, Laird, Ware, 2011; Vittinghoff et al, 2012). The level of significance at which the null hypothesis was rejected was $\alpha < 0.05$ for a two-tailed test.

The first model consisted of an unadjusted bivariate model or simple logistic regression. No covariates were included in the analysis. This bivariate analysis provides a baseline understanding of the likelihood of the event in relation to the predictor (either staffing or the practice environment), prior to accounting for patient or hospital characteristics that may affect an individual's odds of the event. These unadjusted separate models, estimate the independent effects of each of the primary predictor variables on the readmission outcome, without controlling for the other primary predictor variable.

Equation 1 depicts the form of a simple logistic regression:

$$(1) \log \left(\frac{p_i}{1-p_i} \right) = \beta_0 + \beta_1 x_{i1}$$

where β_0 represents the intercept of the slope of the odds ratio, and where β_1 represents the odds ratio, or likelihood of experiencing the outcome, given explanatory variable x .

The second and third levels of analyses were multivariate logistic regression models, controlling for patient covariates, and then hospital and patient covariates, respectively. The effects of the main explanatory variables of interest – staffing and the practice environment – were modeled independently of each other, or separately. Sequentially building the models in this way allowed for the ability to identify the extent to which each level of analysis had an impact on the outcome.

Equation 2 depicts the form of multivariable logistic regression:

$$(2) \log \left(\frac{p_i}{1-p_i} \right) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots \beta_p x_{ip}$$

where each β_i represents a covariate in the risk adjustment. In the first three models, the effects of the nursing primary predictor variables were modeled separately.

In the fourth and final model, the effects of staffing and the practice environment were examined jointly. In the joint model, the effect of primary predictors of interest on the readmission outcome control for the patient and hospital covariates in addition to adjusting for the effects of each other.

All of the models were assessed for model goodness-of-fit by computing the area under the receiver operating characteristic (ROC) curve (c-statistic). C-statistics range from 0.5 (probability of predicting the outcome is no better than chance) to 1.0 (predicts the outcome perfectly), with 0.7 indicating a reasonable fit and 0.8 indicating a strong fit (Hosmer & Lemeshow, 2001).

Sensitivity analysis plan

An extensive sensitivity analysis was performed to address conflicting findings in the literature related to which patient and hospital characteristics have an effect on readmission odds. One set of sensitivity analyses explored whether variation in the hospital volume of live THA/TKA discharges affected the findings. This analysis was warranted because the THA/TKA Readmission Technical Report does not specify a minimum number of discharges needed per hospital to be at risk for penalty by CMS. Analyses for the specific aim were conducted for hospitals with at least 10 live THA/TKA annual discharges, to be conservative. The sensitivity analysis explored the extent to which restricting the analytic sample to hospitals with at least 50 annual discharges and at least 100 annual discharges changed the findings.

Additional sensitivity analyses used the outcome of 10 day unplanned readmission, rather than 30 day unplanned readmission, to address the common criticism that 30 days is not an appropriate timeframe for assessing hospital quality (Joynt & Jha, 2012; Vaduganathan, Bonow, & Gheorghiade, 2013). 10 days was chosen as the cut-off point because it was approximately the median time-to-readmission for both THA and TKA patients.

Finally, the sensitivity analyses examined the effect of specific patient and hospital covariates on readmission. The patient covariates included: discharge destination, length of stay on the index admission, race/ethnicity, and patient socioeconomic status. The hospital covariates included: geographic location, caseload volume, ownership type, socioeconomic status profile, Magnet® designation, and surgical care improvement project performance measures. These covariates were chosen

based on the conflicting findings in the literature about the effects of the variable on readmission and/or because of controversial debate about whether the variable should be adjusted for in the readmission rate calculations. The sensitivity analyses show the unadjusted effect of the specific additional covariate on the outcome and the effects of the primary predictors of interest, adjusting for all patient and hospital covariates, including the additional covariate. Descriptions of how each of these additional covariates were analyzed in the sensitivity analysis can be found in the Appendix B.

Data integrity plan

The data analyzed for this study were retained on a secured computer server maintained by the Office of Technology and Information Systems (OTIS) at the University of Pennsylvania in the School of Nursing. OTIS was responsible for the nightly and weekly backing up of all computer-generated information, which is stored in a secure off-site location. Firewalls, antiviral software, patches, and other software updates were routinely updated on the School of Nursing's computer system. Specifically, the data used in this study were analyzed on my password protected computer in a locked office located in CHOPR.

Human subjects

This study was a secondary analysis of existing data that had previously received Institutional Review Board (IRB) approval. Although the nurse survey contains sensitive information regarding the nurse's perception of their hospital quality and safety, the nurse's identifying information had been detached from the survey before returning to the sender. Thus, the nurse survey data are de-identified. The nurse respondents were able to consent to the study by completing and returning the survey. A detailed consent form, a

Participants Bill of Rights, and the contact information of the study team were printed on the front of the survey explaining the consent process. The Multi-State Nursing Care and Patient Safety Study (IRB Protocol #176400) received exempt status upon evaluation by the University of Pennsylvania IRB. The study continues to undergo continuing review and was most recently approved on March 20, 2014. Additional IRB approval for this particular study was obtained and considered exempt (IRB Protocol #821910).

CHAPTER 4: RESULTS

Introduction

The purpose of this study was to examine the extent to which hospital nursing – staffing and the practice environment – was associated with 30 day readmission in a Medicare population undergoing elective THA/TKA. This chapter describes the characteristics of the sample, including the patients, hospitals, and nurses. The incidence of readmission 30 days from discharge is described. Then, the findings from multiple logistic regression analyses which address the specific aim of this study are described. The main findings from the sensitivity analysis will be briefly described. A detailed explication of the sensitivity analysis is available in the Appendix C.

Characteristics of the sample

Patients

The final sample included 112,018 Medicare patients (33,155 patients underwent THA; 78,863 patients underwent TKA). Characteristics of the patient sample, by surgery type, are shown in Table 4.1. Both the THA and TKA patients had a similar incidence of readmission within 30 days of discharge (5.61% and 5.66%, respectively). THA patients were slightly older on average (75.9 years) than TKA patients (75.3 years). There were more females in the TKA patient sample (64.30%) than the THA patient sample (61.69%); and overall, the patient sample was substantially more female than the general population. TKA patients underwent two procedures on the same admission (6.59%) markedly more often than did the THA patients (0.61%). TKA patients had slightly more comorbid conditions on average (1.78), than THA patients (1.75). THA patients had

marginally longer lengths of stay (3.84 days) compared with TKA patients (3.75 days) and were less often discharged home (40.21%) compared to TKA patients (44.67%).

Table 4.1. Patient characteristics, by surgery type

Patient characteristics	THA n = 33,155		TKA n = 78,863	
	N/Mean	%/SD	N/Mean	%/SD
No. of readmission 30 days after discharge	1,859	5.61	4,463	5.66
Age (years), (mean, SD)	75.9	6.05	75.3	5.82
Sex				
Male	12,702	38.31	28,153	35.70
Female	20,453	61.69	50,710	64.30
No. of procedures				
1	32,953	99.39	73,662	93.41
2	201	0.61	5,201	6.59
No. of comorbidities, (mean, SD)	1.75	1.29	1.78	1.27
Length of stay (days), (mean, SD)	3.84	2.07	3.75	1.95
Discharge destination				
Home or home with home healthcare	13,331	40.21	35,225	44.67
Other facility	19,824	59.79	43,638	55.33

Note. Percentages may not sum to 100% due to rounding. Discharge to “other facility” includes e.g. inpatient rehabilitation and skilled nursing facility.

The common comorbidities of the study patients are shown in Table 4.2.

Hypertension was the most prevalent comorbid condition for both THA (63.33%) and TKA patients (67.51%), followed by chronic arthrosclerosis / angina (THA 22.43%; TKA 21.72%). The prevalence of the comorbid conditions varied only marginally between the surgery types. The largest variation is noted for diabetes or diabetes mellitus complications (THA 14.44%; TKA 20.27%).

Table 4.2. Common comorbidities of study patients, by surgery type

Comorbidity	THA n = 33,155		TKA n = 78,863	
	N	%	N	%
Hypertension	20,998	63.33	53,242	67.51
Chronic atherosclerosis or angina	7,437	22.43	17,129	21.72
Diabetes or diabetes mellitus complications	4,790	14.44	15,986	20.27
Specified arrhythmias	4,896	14.77	11,405	14.46
Disorders of fluid/electrolyte/acid-base	3,305	9.97	7,080	8.98
Chronic obstructive pulmonary disease	3,253	9.81	6,372	8.08
Vascular or circulatory disease	3,160	9.53	6,353	8.06
Major symptoms, abnormalities	1,671	5.04	3,629	4.60
Congestive heart failure	1,416	4.27	3,423	4.34
Renal failure	1,411	4.26	3,183	4.04
Rheumatoid arthritis and inflammatory connective tissue disease	1,242	3.75	2,808	3.56
Polyneuropathy	599	1.81	1,571	1.99
Cancer	551	1.66	1,037	1.31
History of infection	518	1.56	932	1.18
Morbid obesity	483	1.46	1,633	2.07
Other injuries	492	1.48	1,086	1.38
Dementia or other specified brain disorders	481	1.45	947	1.20
Major psychiatric disorders	223	0.67	701	0.89
Pneumonia	235	0.71	565	0.72
Hemiplegia, paraplegia, paralysis, functional disability	200	0.60	458	0.58
Decubitus ulcer or chronic skin ulcer	160	0.48	181	0.23
Skeletal deformities	129	0.39	≤10*	--
Cellulitis, local skin infection	85	0.26	259	0.33
Post traumatic osteoarthritis	76	0.23	127	0.16
Severe hematological disorders	66	0.20	94	0.12
Protein-calorie malnutrition	62	0.19	112	0.14
Metastatic cancer or acute leukemia	56	0.17	70	0.09
Stroke	46	0.14	74	0.09
End-stage renal disease or dialysis	25	0.08	39	0.05

Note. Patient comorbidities are defined by condition categories (Pope et al, 2000). *Due to CMS' cell size suppression policy, numbers of 10 or less are not displayed.

The ten most common reasons for readmission, by surgery type, are shown in Table 4.3. Patients were readmitted for both medical and surgical reasons. The most common reason patients were readmitted following THA was for a packed cell transfusion (5.81%), followed by dislocation of the prosthetic joint (5.76%), and closed reduction of the dislocated hip (5.43%). Following TKA, patients were most commonly readmitted for a postoperative infection (6.39%), followed by localized osteoarthritis (5.60%) and packed cell transfusion (5.33%). Both THA and TKA patients were more often readmitted with a primary medical diagnosis than a procedural diagnosis. In sum, the ten most common reasons for readmission accounted for 39.76% of readmissions for THA and 38.94% for TKA patients.

Table 4.3. Ten most common reasons for 30 day readmission, by surgery type

Most common reason for readmission	THA n= 1,859		TKA n = 4,463	
	N	(%)	N	(%)
1	Packed cell transfusion (p) 108 (5.81)		Postoperative infection (m) 285 (6.39)	
2	Dislocation of prosthetic joint (m) 107 (5.76)		Osteoarthritis (m) 250 (5.60)	
3	Closed reduction of dislocated hip (p) 101 (5.43)		Packed cell transfusion (p) 238 (5.33)	
4	Osteoarthritis (m) 81 (4.36)		Atrial fibrillation (m) 175 (3.92)	
5	Postoperative infection (m) 73 (3.93)		Venous catheterization (p) 151 (3.38)	
6	Atrial fibrillation (m) 63 (3.39)		Infection due to internal joint prosthesis (m) 147 (3.29)	
7	Intestinal infection due to C. diff (m) 57 (3.07)		EGD with closed biopsy (p) 139 (3.11)	
8	Hematoma complicating procedure (m) 56 (3.01)		Arthrocentesis (p) 132 (2.96)	
9	Venous catheterization (p) 47 (2.53)		Intestinal infection due to C. diff (m) 112 (2.51)	
10	EGD with closed biopsy (p) 46 (2.47)		Congestive heart failure (m) 109 (2.44)	
Total	683	(36.76)	1,738	(38.94)

Note. Reasons for readmission are defined by ICD-9 diagnoses and procedures. (m) and (p) designate medical ICD-9 codes and ICD-9 procedure codes, respectively. C. diff, *Clostridium difficile*; EGD, esophagogastroduodenoscopy

Approximately 6% of the study sample experienced an unplanned readmission within 30 days following discharge. The patients who experienced a readmission were significantly different than the patients who did not experience a readmission, as shown in Table 4.4. For both THA and TKA patient populations, patients who were older in age, male, had more comorbidities, longer lengths of stay on the index admission, and were discharged to a facility, were all significantly more likely to experience a readmission. TKA patients who underwent bilateral knee replacements on the same admission were significantly more likely to be readmitted than TKA patients who had only one knee replacement procedure. The number of procedures were not significantly different between THA patient who were and were not readmitted; however, this may be an effect of how few THA patients had bilateral hip replacements.

Table 4.4. Thirty day readmission by patient characteristics and by surgery type

Patient characteristics	THA				p-value	TKA				
	Readmitted N = 1,859		Not Readmitted N = 31,296			Readmitted N = 4,463		Not Readmitted N = 74,400		
	N/ Mean	%/ SD	N/ Mean	%/ SD		N/ Mean	%/ SD	N/ Mean	%/ SD	p-value
Age (years)	77.55	6.35	75.81	6.02	<0.001	76.58	6.06	75.23	7.80	<0.001
Sex										
Male	758	40.77	11,943	38.16	0.0122	1,770	39.66	26,383	35.46	<0.001
Female	1,101	59.23	19,352	61.84		2,693	60.34	48,017	64.54	
No. of										
1	1,844	99.19	31,109	99.41	0.2514	4,005	89.74	69,657	93.63	<0.001
2	15	0.81	186	0.59		458	10.26	4,743	6.38	
No. of comorbidities	2.23	1.38	1.73	1.28	<0.001	2.21	1.37	1.76	1.26	<0.001
Length of stay (days)	4.50	3.45	3.81	1.95	<0.001	4.33	3.36	3.71	1.83	<0.001
Discharge destination										
Home or home with home healthcare	448	24.10	12,883	41.17	<0.001	1,249	27.99	33,976	45.67	<0.001
Other facility	1,411	75.90	18,412	58.83		3,214	72.01	40,424	54.33	

Note. Percentages may not sum to 100% due to rounding. Analysis of variance and t-tests were used to compare differences across patients who were and were not readmitted.

The characteristics of the readmission event for those patients who were readmitted are described in Table 4.5. On average, THA patients remained out of the hospital roughly one day longer (11.30 days) than TKA patients (10.50 days). The length of stay on readmission was approximately 2 days longer than the average length of the stay on the index admission for both THA and TKA patients. The majority of THA (52.23%) and TKA (60.70%) patients were discharged home with or without home healthcare following the readmission. Notably, some of the patients who were readmitted died in the hospital upon readmission.

Table 4.5. Characteristics of the readmission event, by surgery type

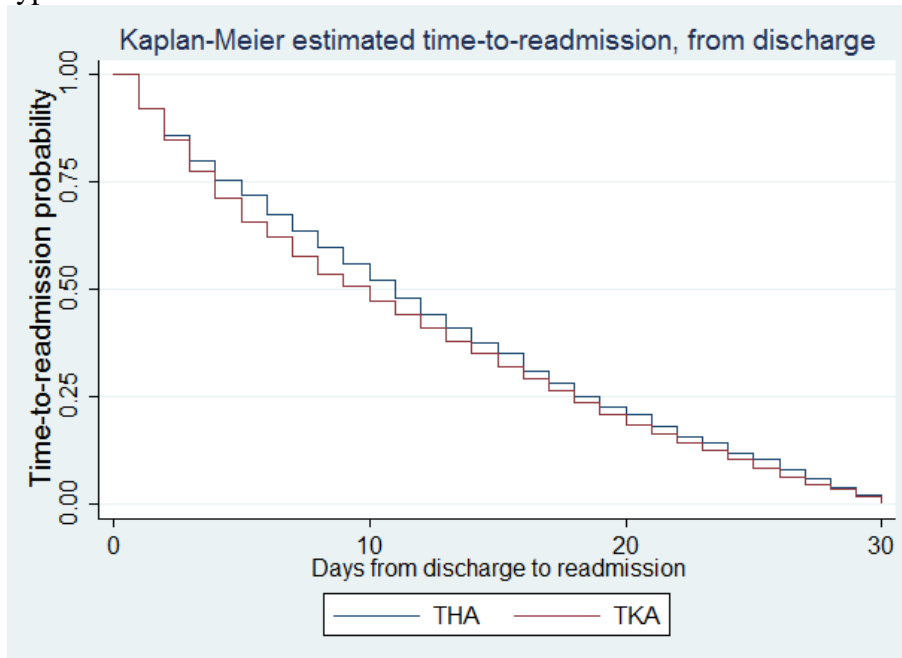
Patient characteristics	THA n = 1,859		TKA n = 4,463	
	N/Mean	%/SD	N/Mean	%/SD
Days from discharge to readmission, (mean, SD)	11.30	8.83	10.50	8.71
Length of stay (days), (mean, SD)	5.44	4.89	5.10	3.95
Discharge destination				
Home or home with home healthcare	971	52.23	2,709	60.70
Skilled nursing facility	586	31.52	1,125	25.21
Inpatient rehabilitation	202	10.87	470	10.53
Other facility	89	4.79	140	3.14
Against medical advice	≤10*	--	≤10*	--
Expired in hospital	≤10*	--	13	0.29

Note. Percentages may not sum to 100% due to rounding. *Due to CMS' cell size suppression policy, numbers of 10 or less are not displayed.

Figure 4.1 shows Kaplan-Meier time-to-readmission curves for THA/TKA patients who were readmitted within 30 days of discharge. The median time-to-readmission was 11 days for THA patients who were readmitted and 10 days for TKA patients. A log-rank test for equality of survivor function revealed a statistically

significant difference in median time-to-readmission between THA and TKA patients ($p = 0.0030$).

Figure 4.1. Time-to-readmission for THA/TKA patients who were readmitted, by surgery type



Note. Median time-to-readmission for patients experiencing a readmission event was 11 days from discharge following THA ($n = 1,859$) and 10 days following TKA ($n = 4,463$).

Hospitals

As described in Table 4.6, the final study sample included 495 acute care nonfederal hospitals in four states (California, New Jersey, Pennsylvania, and Florida). The study hospitals were distributed among the four states with approximately 37% of hospitals in California, 12% in New Jersey, 25% in Pennsylvania, and 26% in Florida. The majority of hospitals were large, urban, not-for-profit, non-teaching hospitals. Less than half (47.68%) of the study hospitals had a high-technology status, meaning they had the capacity to perform open-heart surgery and/or major organ transplantation. The patients were similarly distributed within the hospitals by hospital characteristics, except

that both THA and TKA patients more often went to a high technology status hospital on the index admission (THA 66.55%; TKA 64.40%).

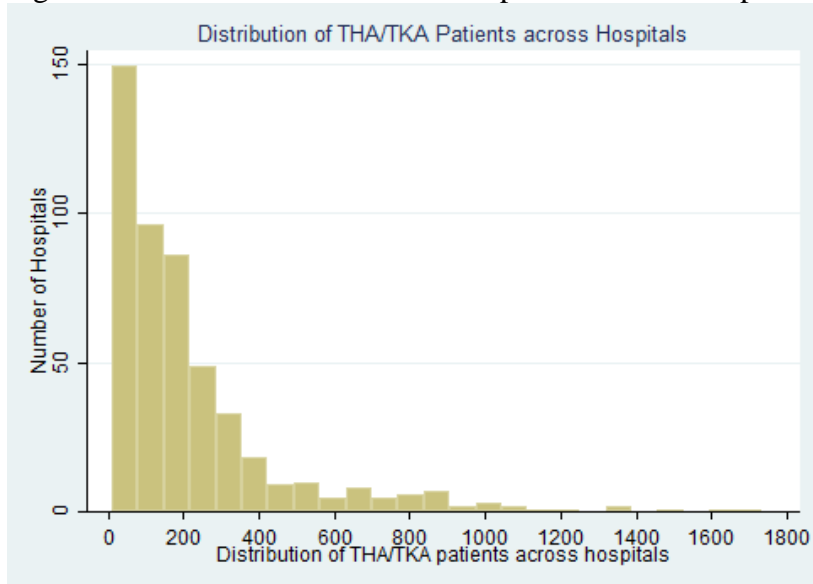
Table 4.6. Distribution of the hospital and patient study sample by hospital characteristics

Hospital characteristics	Hospital n = 495		THA n = 33,155		TKA n = 78,863	
	N	%	N	%	N	%
State						
California	182	36.77	10,446	31.51	23,948	30.37
New Jersey	57	11.52	3,569	10.76	7,677	9.73
Pennsylvania	126	25.45	7,115	21.46	18,284	23.18
Florida	130	26.26	12,025	36.27	28,954	36.71
Geographic location						
Urban	444	89.70	31,162	93.99	73,080	92.67
Rural	51	10.30	1,993	6.01	5,783	7.33
Ownership type						
For profit	93	18.79	5,270	15.90	13,440	17.04
Not-for-profit	361	72.93	25,663	77.40	60,099	76.21
Government, nonfederal	41	8.28	2,222	6.70	5,324	6.75
High technology	236	47.68	22,063	66.55	50,785	64.40
Hospital size						
Small	48	9.70	1,197	3.61	4,116	5.22
Medium	222	44.85	9,978	30.10	25,517	32.36
Large	225	45.45	21,980	66.29	49,230	62.42
Teaching status						
Non-teaching	261	52.73	16,930	51.06	40,930	51.90
Minor	203	41.01	13,195	39.80	32,207	40.84
Major	351	6.26	3,030	9.14	5,726	7.26

Note. Percentages may not sum to 100% due to rounding.

Figure 4.2 shows the distribution of the combined THA/TKA patients across the 495 study hospitals. The mean number of THA/TKA patients admitted to a hospital on an index admission was 226 patients (SD 253) and ranged from 11-1,733 patients.

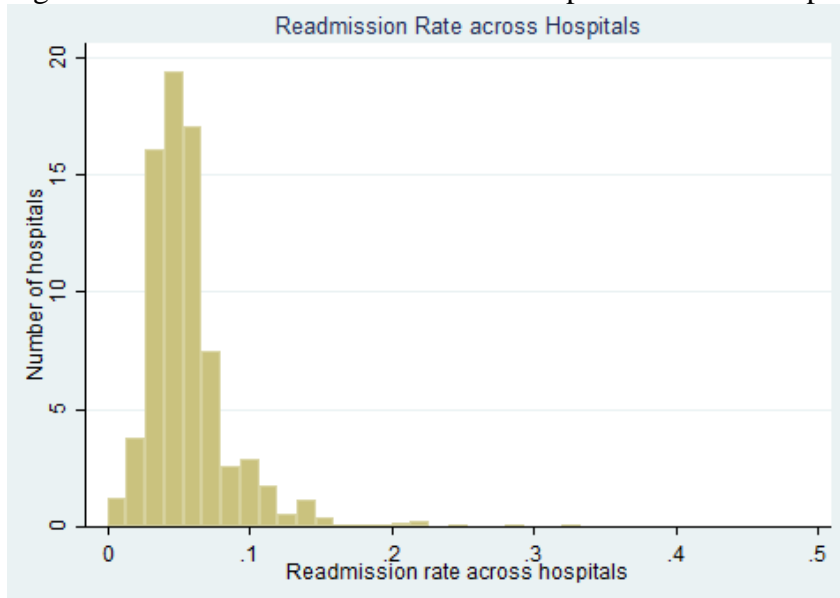
Figure 4.2. Distribution of THA/TKA patients across hospitals



Note. The sample includes 112,018 patients in 495 hospitals

The combined readmission rate for THA and TKA patients, varied across hospitals. The mean hospital readmission rate was 6.4% (SD 4.1%) and ranged from 0%-33.33%, as shown in Figure 4.3.

Figure 4.3. Readmission rate of THA/TKA patients across hospitals



Note. The sample includes 112,018 patients in 495 hospitals

As shown in Table 4.7, patients who experienced a readmission event were significantly different than the patients who did not experience a readmission, on a number of different hospital characteristics. For both THA and TKA patient populations, patients who were readmitted tended to be in urban hospitals. Patients in California and Florida hospitals were significantly less likely to be readmitted; while the opposite was observed for patients in New Jersey hospitals. Patients were also slightly more likely to be readmitted in Pennsylvania hospitals; however the difference was only marginally significant.

Hospital ownership type had only marginal differences between readmitted and not-readmitted THA patients. The differences were greater for TKA patients, who were more likely to be readmitted in a not-for-profit hospital and less likely to be readmitted in a for-profit hospital. TKA patients cared for in a high technology hospital were slightly more likely to avoid being readmitted. Finally, no differences between THA patients who were and were not readmitted were observed based on hospital bed size. Only marginal differences were observed in the TKA sample, with patients in smaller hospitals less likely to be readmitted. Finally, there was a significant trend in the association between hospital teaching status and readmission, such that patients in non-teaching hospitals were less likely to be readmitted, compared with patients in major teaching hospitals.

Table 4.7. Thirty day readmission by hospital characteristics and surgery type

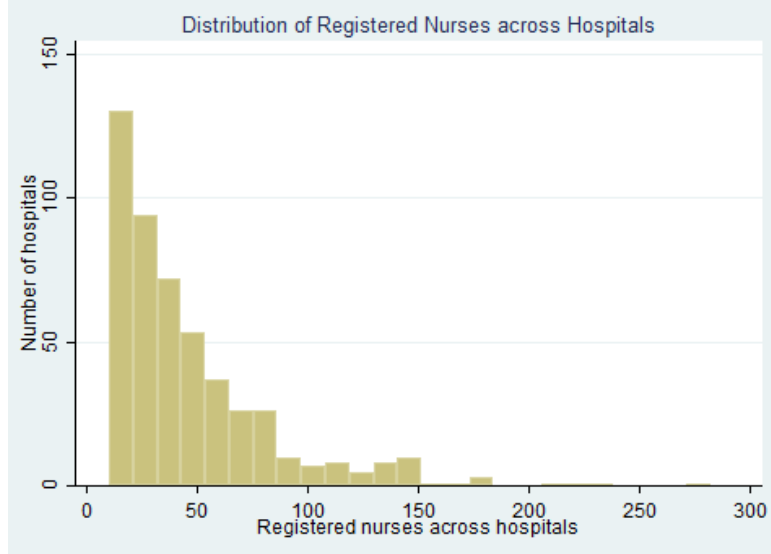
Hospital characteristics	THA					TKA				
	Readmitted N = 1,859		Not Readmitted N = 31,296		P- value	Readmitted N = 4,463		Not Readmitted N = 74,400		P- value
	N	%	N	%		N	%	N	%	
State										
California	497	26.73	9,948	31.79	<0.001	1,115	24.98	22,833	30.69	<0.001
New Jersey	327	17.59	3,242	10.36	<0.001	721	16.16	6,956	9.35	<0.001
Pennsylvania	430	23.13	6,685	21.36	0.0710	1,095	24.54	17,189	23.10	0.0277
Florida	605	32.54	11,420	36.49	0.006	1,532	34.33	27,422	36.86	0.007
Geographic location										
Urban	1,768	95.10	29,393	93.92	0.0372	4,190	93.88	68,890	92.59	0.0013
Rural	91	4.90	1,902	6.08		273	6.12	5,510	7.41	
Ownership type										
For profit	266	14.31	5,004	15.99	0.0541	660	14.79	12,780	17.18	<0.001
Not-for-profit	1,484	79.83	24,178	77.26	0.0101	3,526	79.01	56,573	76.04	<0.001
Government, nonfederal	109	5.86	2,113	6.75	0.1366	277	6.21	5,047	6.78	0.0678
High technology	1,212	65.20	20,851	66.63	0.2040	2,796	62.65	47,989	64.50	0.0120
Hospital size										
Small	63	3.39	1,134	3.62	0.5982	179	4.01	3,937	5.29	0.0002
Medium	560	30.12	9,418	30.09	0.9785	1,442	32.31	24,075	32.36	0.9461
Large	1,236	66.49	20,743	66.28	0.8557	2,842	63.68	46,388	62.35	0.0748
Teaching status										
Non-teaching	904	48.63	16,027	51.21	0.0304	2,178	48.80	38,752	52.09	<0.001
Minor	780	41.96	12,414	39.67	0.0499	1,946	43.60	30,261	40.67	<0.001
Major	175	9.41	2,855	9.12	0.6722	339	7.60	5,387	7.24	0.3744

Note. Percentages may not sum to 100% due to rounding. Analysis of variance and t-tests were used to compare differences across patients who were and were not readmitted.

Nurses

As shown in Figure 4.4, the final study sample included 23,089 registered nurses who reported working in one of the 495 nonfederal acute care hospitals included in this study. The mean number of registered nurses per hospital was 47 (SD 38), and ranged from 10-282 nurses.

Figure 4.4. Distribution of registered nurses across study hospitals



Note. The sample includes 23,089 registered nurses in 495 hospitals

Each registered nurse survey respondent reported on the working conditions in the hospital where the nurse worked. Responses from nurses working in the same hospital were aggregated to create hospital level measures of hospital nursing characteristics. The results of this analysis are reported in Table 4.8 at the hospital and patient level. On average, nurses in this study cared for 5 patients on their last shift (SD 1). Of the 495 study hospitals, 183 hospitals (36.97%) had a staffing ratio of 4-5 patients per registered nurse. Nearly half of THA patients (44.57%) and TKA (42.07%) patients were cared for in hospitals with a staffing ratio of 4-5 patients per registered nurse. Although far fewer,

some hospitals (4.85%) had staffing ratios of 7 or more patients per registered nurse, accounting for approximately 3% of the THA and TKA patients in the sample.

The largest proportion of hospitals was characterized as having a mixed (47.07%) or poor (33.54%) practice environment. The majority of THA (51.94%) and TKA (49.58%) patients were cared for in hospitals with a mixed practice environment. Approximately 20% of the hospitals in the sample were characterized as having a good practice environment. Approximately one quarter of the study patients were cared for in a hospital regarded as having a good practice environment.

Table 4.8. Distribution of the hospital and patient study sample by nursing characteristics

Nursing characteristics	Hospital n = 495		THA n = 33,155		TKA n = 78,863	
	N	%	N	%	N	%
Staffing						
<4	74	14.95	4,583	13.82	10,071	12.77
4-<5	183	36.97	14,777	44.57	33,175	42.07
5-<6	162	32.73	10,707	32.29	27,349	34.68
6-<7	52	10.51	2,328	7.02	6,258	7.94
7 +	24	4.85	760	2.29	2,010	2.55
Practice environment						
Good	96	19.39	8,450	25.49	19,673	24.95
Mixed	233	47.07	17,222	51.94	39,098	49.58
Poor	166	33.54	7,483	22.57	20,092	25.48

Note. Percentages may not sum to 100% due to rounding. Staffing indicates a ratio of the number of patients to the number of registered nurses.

As shown in Table 4.9, patients who experienced a readmission were significantly different than the patients who did not experience a readmission, in terms of hospital nursing characteristics. In both THA and TKA patient samples, patients cared for by nurses with lower workloads were less often readmitted. Patients cared for in good practice environments were also less often readmitted; however the difference was not statistically significant for THA patients.

Table 4.9. Thirty day readmission by nursing characteristics and surgery type

Nursing characteristics	THA				p-value	TKA				p-value
	Readmitted N = 1,859		Not Readmitted N = 31,296			Readmitted N = 4,463		Not Readmitted N = 74,400		
	N	%	N	%		N	%	N	%	
Staffing										
<4	235	12.64	4,348	13.89		530	11.88	9,541	12.82	
4-<5	766	41.20	14,010	44.77		1,779	39.86	31,396	42.20	
5-<6	620	33.35	10,087	32.23	<0.001	1,684	37.73	25,665	34.50	0.0029
6-<7	177	9.52	2,151	6.87		362	8.11	5,896	7.92	
7 +	61	3.28	699	2.23		108	2.42	1,902	2.56	
Practice environment										
Good	535	28.78	9,255	29.57	0.4657	1,144	25.63	21,501	28.90	<0.001
Mixed	1,019	54.81	17,002	54.33	0.6826	2,570	57.58	40,603	54.57	<0.001
Poor	305	16.41	5,038	16.10	0.7255	749	16.78	12,296	16.53	0.6554

Note. Percentages may not sum to 100% due to rounding. Analysis of variance and t-tests were used to compare differences across patients who were and were not readmitted.

The correlation matrix of nursing and hospital characteristics is shown in Table 4.10. Each of the five subscales of the PES-NWI were strongly to moderately correlated with each other, with correlations ranging from $r = 0.54$ (nurse participation in hospital affairs and collegial nurse-physician relations), to $r = 0.88$ (nurse participation in hospital affairs and foundations for quality of care). The staffing and resource adequacy subscale of the PES-NWI was moderately correlated with the direct measure of nurse staffing ($r = -0.40$). The moderate correlation and the conceptual overlap between the staffing subscale and the direct measure of staffing, suggest a reasonable argument for excluding the staffing subscale from the practice environment measure. Therefore, the analysis of the specific aim included all five subscales of the PES-NWI, and, in a sensitivity analysis, the staffing and resource adequacy subscale was excluded. The correlations among the other nursing and hospital characteristics were weak, with the exception of a moderate correlation between technology status and hospital bed size ($r = 0.47$).

Table 4.10. Correlation matrix of hospital and nursing characteristics, hospital level (N=495)

	1	2	3	4	5	6	7	8	9
1. Practice environment									
2. Staffing & resource adequacy	0.71								
3. Foundations for quality of care	0.84	0.72							
4. Collegial nurse-physician relations	0.70	0.61	0.61						
5. Nurse participation in hospital affairs	0.83	0.66	0.88	0.54					
6. Nurse manager ability, leadership, & support of nurses	0.80	0.71	0.76	0.55	0.75				
7. Staffing	-0.26	-0.40	-0.29	-0.27	-0.26	-0.29			
8. Bed size	0.09	-0.03	0.19	-0.03	0.14	0.03	-0.16		
9. Teaching status	-0.03	-0.10	-0.04	-0.04	-0.05	-0.09	-0.08	0.27	
10. Technology status	0.09	0.06	0.17	0.05	0.14	0.06	-0.27	0.47	0.18

Note. Weak correlation: -0.3 – 0.3; moderate correlation: -0.6 – -0.3 or 0.3 – 0.6; strong correlation: -1.0 – -0.6 or 0.6 – 1.0

Analysis of specific aim

The associations between hospital nursing and readmission were explored using logistic regression analysis, accounting for clustering of patients within hospitals. First, analyses were conducted in hospitals with at least 10 live THA/TKA patient discharges (Table 4.11). The analytic sample was then restricted to hospitals with (1) at least 50 (Table 4.12) and (2) at least 100 live THA/TKA patient discharges (Table 4.13), to test if the results were sensitive to patient volume effects.

Four levels of analysis were conducted. First, the bivariate, or unadjusted, association between 30 day readmission and each of the hospital nursing features (staffing and practice environment) were explored. Second, the associations were examined adjusting for patient characteristics, including: age, sex, comorbidities, type of surgery (THA vs. TKA), and number of procedures (1 vs. 2). In the third level of analysis, each association additionally adjusted for hospital characteristics, including: bed size, teaching status, technology status. Finally, the fourth model examined the effects of nurse staffing and the practice environment jointly.

The effects of nurse staffing and the practice environment on 30 day readmission in the 495 hospitals, before and after controlling for patient and hospital characteristics are described in Table 4.11. The unadjusted, separate model for staffing describes the effect of one additional patient per nurse on the odds of 30 day unplanned readmission. The unadjusted, separate model for practice environment describes the effect of being cared for in a good practice environment (as compared to a mixed or poor environment) on the odds of readmission.

The bivariate association of staffing was significantly associated with readmission in the hypothesized direction (OR 1.10, 95% CI 1.04-1.17). The relationship remained

significant after controlling for patient and hospital covariates (OR 1.08, 95% CI 1.02-1.15) and after controlling for the practice environment in the joint model (OR 1.07, 95% CI 1.00-1.14).

The bivariate association of the practice environment was significantly associated with readmission in the hypothesized direction (OR 0.83, 95% CI 0.73-0.94) and the relationship remained significant after controlling for patient and hospital covariates (OR 0.87, 95% CI 0.76-0.99). In the joint model, after adjusting for nurse staffing, the effect of the five subscale practice environment is rendered insignificant (OR 0.90, 95% CI 0.78-1.04). The c-statistic for the specific aim was 0.64, which is similar to the c-statistic of 0.65 reported in the THA/TKA Readmission Technical Report (Suter et al, 2014).

Table 4.11. Effects of hospital nursing on 30 day readmission, in hospitals with at least 10 live THA/TKA discharges (N = 112,018)

Odds of 30 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.10** (1.04-1.17)	1.08** (1.02-1.15)	1.08* (1.02-1.15)	1.07* (1.00-1.14)
Practice environment	0.83** (0.73-0.94)	0.86* (0.76-0.97)	0.87* (0.76-0.99)	0.90 (0.78-1.04)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

The analysis was restricted to hospitals with at least 50 live THA/TKA discharges, as shown in Table 4.12. This analytic sample consists of 108,906 patients in 396 hospitals. The association between staffing and readmission remain significant in the separate model adjusting for patient and hospital covariates, but are rendered insignificant, in the joint model adjusting for practice environment (OR 1.06, 0.99-1.14). Although statistically insignificant, the joint effect of staffing approaches significance and is in the hypothesized direction.

The bivariate effect of practice environment is statistically significant (OR 0.85, 95% CI 0.75-0.96), even after controlling for patient covariates (OR 0.87, 95% CI 0.77-0.99). The association is insignificant after controlling for hospital characteristics, and in the joint model; however, the odds ratio remains in the hypothesized direction.

The analysis was further restricted to hospitals with at least 100 live THA/TKA discharges, as shown in Table 4.13. This analytic sample consists of 103,080 patients in 318 hospitals. The findings for the practice environment reveal a similar pattern, such that after adjusting for hospital and patient characteristics, the effect becomes insignificant (OR 0.88, 95% CI 0.77-1.01). The magnitude of the staffing effect in the bivariate analysis is large and significant (OR 1.11, 95% CI 1.03-1.19) and remains significant after controlling for patient and hospital covariates (OR 1.09, 95% CI 1.02-1.17) and the practice environment (OR 1.08, 95% CI 1.00-1.16).

Table 4.12. Effects of hospital nursing on 30 day readmission, in hospitals with at least 50 live THA/TKA discharges (N = 108,906)

Odds of 30 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.09** (1.02-1.16)	1.07* (1.02-1.14)	1.07* (1.01- 1.14)	1.06 (0.99-1.14)
Practice environment	0.85* (0.75-0.96)	0.87* (0.77-0.99)	0.88 (0.77- 1.01)	0.99 (0.79-1.05)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 108,906 patients in 396 hospitals.

Table 4.13. Effects of hospital nursing on 30 day readmission, in hospitals with at least 100 live THA/TKA discharges (N = 103,080)

Odds of 30 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.11** (1.03-1.19)	1.09* (1.01-1.16)	1.09* (1.02-1.17)	1.08* (1.00-1.16)
Practice environment	0.84* (0.74-0.96)	0.87* (0.76-0.99)	0.88 (0.77-1.01)	0.91 (0.78-1.06)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 103,080 patients in 318 hospitals.

Additional analyses were conducted to examine the effect of the practice environment with the staffing and resource adequacy subscale excluded from the measure. The results in Table 4.14 reflect the analyses of 495 hospitals with at least 10 live THA/TKA discharges. As anticipated, the effect of staffing remains significant in the joint model (OR 1.07, 95% CI 1.01-1.14). The four subscale practice environment is significantly associated with readmission in the bivariate association (OR 0.85, 95% CI 0.75-0.96) and after adjusting for patient covariates (OR 0.88, 95% CI 0.78-0.99). The effect of the practice environment becomes insignificant once adjusting for hospital characteristics; however, the association approaches significance in the hypothesized direction (OR 0.89, 95% CI 0.78-1.01).

Table 4.14. Effects of hospital nursing on 30 day readmission, 4 subscale practice environment (N = 112,018)

Odds of 30 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.10** (1.04-1.17)	1.08** (1.02-1.15)	1.08* (1.02-1.15)	1.07* (1.01-1.14)
Practice environment	0.85* (0.75-0.96)	0.88* (0.78-0.99)	0.89 (0.78-1.01)	0.92 (0.79-1.06)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

Additional analyses were conducted to examine the association of staffing and the practice environment on readmissions occurring within 10 days of discharge. Although the Hospital Readmission Reduction Program penalties define 30 days from discharge as the meaningful timeframe for measuring hospital care quality, many readmission studies examine shorter timeframes from discharge to isolate whether the influence of readmission predictors is more pronounced in earlier versus later readmission. The following analyses explore the effects of hospital nursing on 10 day readmission because the median time-to-readmission for the readmitted patients in this sample was approximately 10 days. 967 THA patients (2.92%) and 2,538 TKA patients (3.22%) were readmitted within 10 days of discharge.

As shown in Table 4.15, there is a pronounced association of nurse staffing and 10 day readmission, even after adjusting for hospital and patient covariates (OR 1.12, 95% CI 1.02-1.23). This relationship remains significant after restricting to the 396 hospitals with at least 50 live discharges (Table 4.16; OR 1.11, 95% CI 1.01-1.23) and after restricting to the 318 hospitals with at least 100 live discharges (Table 4.17; OR 1.14, 95% CI 1.02-1.27). After controlling for the practice environment (five subscales), the staffing effect becomes insignificant in each of the models (Table 4.15, Table 4.16, Table 4.17). The effect of the practice environment is significant in the bivariate associations; however, adjusting for patient and hospital covariates renders the effects insignificant.

Table 4.15. Effects of hospital nursing on 10 day readmission, in hospitals with at least 10 live THA/TKA discharges (N = 112,018)

Odds of 10 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.12* (1.03-1.22)	1.10* (1.01-1.20)	1.12* (1.02-1.23)	1.10 (1.00-1.22)
Practice environment	0.81* (0.68-0.98)	0.84 (0.70-1.10)	0.85 (0.70-1.03)	0.89 (0.72-1.09)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.63

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

Table 4.16. Effects of hospital nursing on 10 day readmission, in hospitals with at least 50 live THA/TKA discharges (N = 108,906)

Odds of 10 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.11* (1.01-1.23)	1.09 (0.99-1.20)	1.11* (1.01-1.23)	1.10 (0.99-1.22)
Practice environment	0.82* (0.68-0.99)	0.85 (0.71-1.03)	0.86 (0.70-1.04)	0.89 (0.72-1.10)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 108,906 patients in 396 hospitals.

Table 4.17. Effects of hospital nursing on 10 day readmission, in hospitals with at least 100 live THA/TKA discharges (N = 103,080)

Odds of 10 day Readmission	Unadjusted, Separate	Adjusted for patient characteristics, Separate †	Adjusted for hospital & patient characteristics, Separate	Adjusted for hospital & patient characteristics, Joint
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Staffing	1.14* (1.03-1.27)	1.12* (1.01-1.24)	1.14* (1.02-1.27)	1.12 (1.00-1.26)
Practice environment	0.82 (0.67-1.00)	0.85 (0.70-1.03)	0.85 (0.69-1.05)	0.90 (0.72-1.12)

p <0.05*; p<0.01**; p<0.001***

† C-statistic 0.64

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 103,080 patients in 318 hospitals.

Sensitivity analysis

A sensitivity analysis was conducted, controlling for patient and hospital level covariates. All of the sensitivity analyses were conducted using the analytic sample of 112,108 patients in 495 hospitals with at least 10 live THA/TKA discharges. Patient level covariates used in the sensitivity included: discharge destination (home with/without homecare vs. other), length of stay on the index admission, race/ethnicity (white non-Hispanic vs. other), and socioeconomic status (high socioeconomic status vs. other). Hospital level covariates, including: geographic location (urban vs. rural), patient caseload volume, ownership type (profit, not-for-profit, vs. government nonfederal), socioeconomic status profile (hospitals in the highest decile of the proportion of patients with low socioeconomic status), Magnet® designation, and surgical care improvement project performance measures. Controlling for patient and hospital level covariates did not have a clinically meaningful impact on the associations between staffing and the practice environment on 30 day unplanned readmission. The tables and a more detailed explication of the findings are located in the Appendix C.

Summary

Nearly 6% older adults experience an unplanned rehospitalization following elective total hip and total knee arthroplasty. For every additional patient a nurse cared for, each patient had an 8% increase in the likelihood of readmission, even after adjusting for patient and hospital characteristics. Patients cared for in a better practice environment, as compared to a mixed or poor environment, had 13% lower odds of readmission. The effect of staffing was more pronounced for readmissions occurring within 10 days compared with 30 days, suggesting that hospital nursing has an important role to play in

reducing avoidable readmissions. The main findings from this study point to hospital nursing as a potential strategy for reducing readmissions among older adult orthopedic surgical patients.

CHAPTER 5: DISCUSSION

Introduction

This study found that hospital nurses who provide care at the bedside serve an important role in lowering the risk for readmission following discharge. This study examined the association between characteristics of hospital nurses – staffing and the practice environment – and older patients’ odds of unplanned readmission following elective THA/TKA. This chapter discusses the main findings of the study and the limitations of the research. Finally, the implications of these findings and recommendations for future research are considered.

Main findings

Nurse staffing and the practice environment were significantly associated with 30 day unplanned readmissions for older adults following elective THA/TKA. Each additional patient per nurse was associated with an 8% higher odds of readmission (OR 1.08, 95% CI 1.02-1.15). This staffing effect was substantially larger than previous findings for surgical patients (Ma, McHugh, & Aiken, 2015), and similar to the staffing effects found among medical patients (McHugh & Ma, 2013). The effect of nurse staffing was more pronounced in regards to 10 day readmission as compared with 30 day readmission, suggesting that many readmissions following THA/TKA are strongly related to hospital care quality – specifically nursing care. Patients cared for in the best practice environments were 13% (OR 0.87, 95% CI 0.76-0.99) less likely to experience a readmission compared to patients in either a mixed or poor practice environment. Previous studies report an effect of the practice environment ranging between 3% for surgical patients and 10% for pneumonia patients (Ma, McHugh, & Aiken, 2015). The

main findings of this study suggest that better staffing and better practice environments are associated with lower odds of readmission – findings that are consistent with prior work (Joynt & Jha, 2011; Ma, McHugh, & Aiken, 2015; McHugh & Ma, 2013).

Although the effect of the practice environment was large (OR 0.87, 95% CI 0.76-0.99), once adjusting for nurse staffing and the practice environment simultaneously in the joint model, the effect of the practice environment became insignificant. Due to the moderate correlation between the staffing and resource adequacy subscale and the direct measure of staffing ($r = -0.40$), the subscale was excluded from the practice environment measure to test whether that particular subscale was driving the effect. The four subscale practice environment (without staffing and resource adequacy) was not significantly associated with readmission and did not detract from the pronounced effect of staffing in the joint model. This provided some evidence that the significance of the practice environment may be driven, in part, by the staffing and resource adequacy subscale.

An extensive sensitivity analyses revealed that even after controlling for additional patient and hospital characteristics the associations between hospital nursing and readmissions remained. Controlling for patient discharge destination had the most pronounced effect on the association of both staffing and the practice environment. The effect of staffing was reduced by two percentage points (OR 1.06, 95% CI 1.00-1.12) and the practice environment was rendered insignificant (OR 0.89, 95% CI 0.80-1.01). These findings are not entirely unexpected in consideration of prior evidence (Bini et al, 2009; Schairer et al, 2014; Tsai et al, 2013; Zmistowski et al 2013). These findings are interesting given that the majority of these postoperative patients go to either skilled nursing facility or inpatient rehabilitation upon discharge. Future research should

highlight the role that these facilities have on readmission among this population. In sum, the relationship between hospital nursing and readmission was found to be robust, even after adjusting for potentially confounding patient and hospital characteristics. A more detailed discussion of the findings from the sensitivity analysis can be found in the Appendix D.

Discussion of corollary findings

While readmissions in this population were prevalent, mortality following this elective surgery was found to be extremely rare. In this study, less than 0.5% of THA/TKA patients in the sample died within 30 days of admission. These findings are similar to those reported in the literature, suggesting that even in an older adult population, mortality following elective surgery is rare (Singh et al, 2011; Katz et al, 2004). These findings are not entirely surprising given that patients who undergo elective surgery are deemed sufficiently healthy to tolerate an invasive operation followed by arduous rehabilitation. Given the low incidence in this study, mortality was not considered to be a meaningful competing risk with readmission; however, it remains an important consideration for future research.

Among readmitted patients, comorbid conditions were more prevalent, compared to the patients who were not readmitted. This finding is consistent across the literature for older patients following THA/TKA (Khan et al, 2012; Mahomed et al 2003; Riggs et al, 2010; Saucedo et al, 2014; Schairer et al, 2014; Schairer, Vail, & Bozic, 2014). This finding yields important implications for clinical practice, including provider awareness of the risk factors for readmission. Knowing what characteristics predispose patients to

readmission helps providers identify the patients at greatest risk and allocate resources accordingly.

Patients were more frequently rehospitalized for a primary medical diagnosis than a procedural diagnosis. Although there is no consensus in the literature regarding the common reasons for readmission, many studies found that THA patients were more often readmitted for medical conditions (Cullen, Johnson, & Cook, 2006; Khan et al, 2012; Pugely et al 2013; Saucedo, 2014; Schairer et al, 2014; Vorhies et al, 2011; Vorhies et al, 2012). Interestingly, the most common reason THA patients in this study were readmitted was for a packed cell transfusion (5.81%) – a procedural diagnosis, which is likely indicative of postsurgical anemia due to hemorrhage. A recent study cited surgical site infection to be the most common reason for unplanned readmission following THA/TKA (Merkow et al, 2015). While postoperative infection was the most common reason for TKA patients (6.39%) it was the fifth most common reason for THA patients (3.93%). In sum, the literature lacks a consensus on the reasons THA/TKA patients are readmitted.

In this study, the top ten reasons for readmission accounted for less than 40% of the observed readmissions, suggesting a diverse array of post-discharge issues. While many of the top reasons for readmission appear to be related to the surgery, readmissions for atrial fibrillation and congestive heart failure may be indicative of uncontrolled comorbid conditions. Given that readmitted patients have more comorbidities on average compared with non-readmitted patients, and patients are readmitted for conditions unrelated to the prior hospitalization, it is plausible that comorbid conditions may not be adequately addressed and monitored during the hospitalization. This begs the question

whether the care delivered in hospitals is too narrowly focused on the acute reason for admission, and whether this narrow focus contributes to readmissions.

Additionally, future research should examine how the care delivered in post-acute care facilities, such as inpatient rehabilitation and skilled nursing facilities, may contribute to the incidence of readmission. Considering the major reasons for readmission, it is reasonable to suspect that some of the postoperative complications, such as dislocation of the prosthetic joint, postoperative infection, or intestinal infection due to *Clostridium difficile*, could be attributed to the care quality in post-acute care facilities.

On average, patients who were readmitted had approximately two days longer lengths of stay on the readmission as compared to the average length of stay on the index admission. It is unclear to what extent reimbursement associated with diagnosis-related groups (DRGs) is related to patient length of stay, in this study. Hospitals are reimbursed on a DRG system, whereby hospitals are given a pre-specified reimbursement per diagnosis/procedure. Hospitals that discharge patients sooner, generally make a profit on the admission, compared to when patients are hospitalized for longer. Despite pay-for-performance policies that are meant to incentivize hospitals to prevent readmissions, hospitals may struggle with the perverse incentive of not preventing a readmission in order to earn an additional DRG payment for the return hospitalization. Many have argued that the current penalties are too small to meaningfully incentivize behavior, which implies that policymakers should consider increasing the penalty (Jha, 2013; Werner & Dudley, 2012; Werner et al, 2011). Alternatively, the reason for readmission

may warrant a larger DRG payment than the THA/TKA admission DRG, which may explain the longer lengths of stay on readmission.

Patients who were readmitted were also more likely to be discharged home than to a facility, as compared with their index admission. This suggests that hospitals may keep readmitted patients in the hospital longer to ensure they are medically stable enough to return home, thereby reducing the odds of a second readmission. Patients who are able to go home (with or without home care) at discharge, tend to be more medically stable and have adequate support systems to help the patient safely transition to independent living and self-care. In sum, it remains unclear how hospitals are responding to pay-for-performance penalties to reduce readmissions.

Various characteristics of the hospitals where patients received care were found to be associated with higher odds of readmission; however, these hospital characteristics are largely unmodifiable and therefore lack feasible strategies for improving health outcomes. Despite this study's findings and the literature, it remains unclear if and to what extent certain hospital characteristics are associated with readmissions. At this time, sufficient evidence is lacking to support any recommendations for risk adjusting on hospital structural characteristics for the purposes of reimbursement penalties.

Limitations

This study was not without limitations. The cross-sectional design limits the understanding of causal relationships. A longitudinal approach would be needed to support causal relationships. Although cross-sectional, the carefully selected covariates and extensive sensitivity analyses aided in risk adjusting for differences across patients and hospitals, allowing for more valid comparisons across groups. Moreover, the

hospitals in the four states included in this study are generalizable to nonfederal acute care hospitals, nurses, and patients nationally.

Another limitation is that the data used for this study were collected in 2005-2006, which is not contiguous with the introduction of readmission penalties under the Affordable Care Act, which began in fiscal year 2013. This limitation, while worth mentioning, is negligible because the predictor variables of interest – nurse staffing and the practice environment – have likely not changed significantly since the data collection. The penalties levied against hospitals only represent a small fraction of CMS reimbursements and, for many hospitals, are too small to incentivize immediate and meaningful changes in practice (Jha, 2013; Werner & Dudley, 2012; Werner et al, 2011).

One concern regarding the nurse survey is that nurses may not give reliable reports of their working conditions. It is reasonable to assume that the nurse respondents had no incentive to be dishonest on the survey because it was confidential and mailed to the nurse's home address rather than place of work. Furthermore, evidence suggests that nurse reported quality of care is a valid predictor of hospital performance (McHugh & Witkoski Stimpfel, 2012). The nurse survey used in this study constitutes a unique data set incomparable to other existing data about registered nurses working in hospitals.

Both the incidence of readmissions and their association with hospital nursing may be underestimated in this study. In the 12 month study period, only one index admission per individual and only the first readmission to occur within 30 days of the index admission were selected for analysis. This was done to ensure statistical independence of observations, because a patient who was readmitted previously would be more likely to be readmitted in the future.

A final point to consider when interpreting the study findings is that logistic regression assumes a linear relationship between the predictor variable and the log odds, such that the log-odds represents a one-unit increase in the predictor variable. In other words, the odds ratio increases exponentially with a one-unit increase in the predictor variable. This is a strong assumption because, for example, adding another patient to a nurse's workload of six patients may have less of an effect than adding another patient to a nurse's workload of four patients, or vice versa. Prior work related to nurse staffing's effect on mortality found no evidence that the relationship is nonlinear (Aiken et al, 2002). In this study, staffing ratios ranged from 2.93 to 9.79 patients per nurse (mean 5.1; SD 1.04). Two additional patients per nurse was associated with a 17% increase in the patients' likelihood for readmission ($1.08 \times 1.08 = 1.17$). Extrapolation of the odds ratios, in this way, should not extend beyond the staffing ranges observed in this study and should be interpreted with caution.

Implications

These findings have important implications for patients, providers, and policymakers, alike. For many older adults, recurrent hospitalization reduces functional independence and quality of life (Boltz, Capezuti, & Shabbat, 2011; Boltz et al, 2012; Kortebein et al, 2008; Ponzetto et al, 2003). Although the recent attention to readmissions has been brought about as a matter of the financial implications of the Hospital Readmission Reduction Policy, the human consequences of hospitalization should also be stressed.

The study findings that many hospital nursing characteristics are associated with readmission suggest that readmissions following THA/TKA can be reduced. Nurse

staffing had a more pronounced effect on readmission within 10 days as compared to 30 days, suggesting that greater attention to the patient care delivered *in the hospital* may significantly reduce an older adult's likelihood of readmission.

These findings are supported by decades of research that better hospital working conditions, including staffing and the practice environment, are associated with better patient outcomes (Kane et al, 2007; Kazanjian et al, 2005; Shekelle, 2013). More recently, studies have begun to show that better hospital nursing conditions are associated with fewer readmissions (Joynt & Jha, 2011; Ma, McHugh, & Aiken, 2015; Ma, Shang, & Stone, 2014; McHugh, Berez, & Small, 2014; McHugh & Ma, 2013; Weiss, Yakusheva, & Bobay, 2011). These study findings add to the existing evidence and have important implications for hospitals which are now at risk for CMS reimbursement penalties. Despite robust evidence, many hospitals have not moved the needle on increasing investments in hospital nursing.

To date, hospitals have invested in numerous disease-specific interventions aimed at reducing readmissions, yet these interventions yield mixed results in practice (Hansen et al, 2011). While few of these interventions have proven successful in particular patient populations, most are short-sighted and may be unsustainable over the long term. Strategies that are dependent upon existing staff to carryout additional care tasks (eg. telephone follow-up calls), or specialized personnel (eg. patient care coordinators), add additional complexity to an already complex system. Staff nurses report missing aspects of nursing care due to a lack of time (Kalisch, 2006; Kalisch, Gay & Williams, 2009) which is associated with readmissions (Brooks Carthon et al, 2015). While specialized personnel may theoretically reduce the number of tasks a staff nurse is responsible for,

adding specialized caregivers further fragments an already fragmented system. Without robust evidence that such strategies are effective across various patient populations, it is plausible that these strategies may actually impede care delivery efficiency and negatively impact patient outcomes.

Hospital administrators, in particular, should be cautious of the effects of reducing investments in hospital nursing in an effort to cut expenses. Although there has been no public discussion about whether the CMS readmission penalties will continue to increase over time, it seems as though reimbursement from both public and private payers has made an irreversible shift towards reimbursing for value, rather than volume. Whether the financial incentives are strong enough to encourage hospitals to reconsider their structural organization of care delivery has yet to be seen; however, these findings add to the growing evidence that improving investments in hospital nursing characteristics may be a reasonable strategy to reduce readmissions.

As pay-for-performance becomes more pervasive in healthcare, providers will be increasingly incentivized to deliver value across the entire spectrum of health conditions and care settings. For example, the Bundled Payments for Care Improvement initiative, which began in January 2013, incentivizes better care quality at a lower cost to Medicare by allowing hospitals to voluntarily bear the financial risk for a specified episode of care. Among these episodes of care is joint replacement. This initiative represents an early sign that provider reimbursement will increasingly move beyond penalties and incentives for preventing negative outcomes, such as unplanned readmissions, and target high value comprehensive care across the entire spectrum of healthcare delivery.

In light of the changing reimbursement climate, it is important to recognize that hospital care is often myopically focused on the acute issue requiring hospitalization. Yet for many older adults, comorbid conditions and complicated social needs demand a holistic approach to care. Strategies that consider patient conditions in isolation fail to appreciate the complex context of the individual patient. Registered nurses are uniquely trained in the “protection, promotion, and optimization of health and abilities” and “prevention of illness and injury” (ANA, 2015). The essence of nursing requires a holistic approach that seeks to identify and address the needs and goals specific to each individual. In doing so, nurses are able to help individuals optimize quality of life and wellness.

However, hospital investments to improve patient outcomes often fail to optimally utilize their most numerous healthcare providers – nurses. For example, investments in system level hospital nursing features would likely yield better outcomes across healthcare settings and clinical conditions, as compared to the commonly implemented disease-specific approaches. With hospitals already investing a significant proportion of their budget in nursing staff (Kane & Siegrist, 2002), there should be heightened attention to ensure that staff nurses have the time and resources to optimize their effectiveness. Moreover, every hospitalized patient has a nurse; whereas only certain patients receive the additional care interventions characteristics of many of the current readmission reduction efforts. Hospital nursing care should be considered as a building block upon which additional interventions could be added. The impact of any additional interventions beyond hospital nursing care is contingent on having a solid foundation of care delivery. Early evidence suggests that hospital nursing may be a high-

value investment (Martsolf et al, 2014; Weiss, Yakusheva, & Bobay, 2011; Yakusheva, Lindrooth, & Weiss, 2014a; Yakusheva, Lindrooth, & Weiss, 2014b). As pay-for-performance initiatives encompass more aspects of care across the healthcare setting, staff nurses may further prove to be a valuable asset.

Hospitals can capitalize on the opportunity to improve nursing care in multiple ways. This study provides evidence that increasing nurse staffing may reduce readmissions. This can be achieved in numerous ways, such as an individual hospital's commitment to better staffing, or through national or state legislation, such as mandated staffing ratios. Hospitals can improve the nurse practice environment by earning Magnet® recognition through the ANCC or the ANCC Pathway to Excellence® (ANCC, 2014). The Pathway to Excellence®, like Magnet®, has a focus on nurse autonomy, safety, quality, professional development, and leadership; which are closely aligned with the domains of the PES-NWI. The Pathway to Excellence® has less of a focus on nurse-driven research, which makes it a more approachable and affordable choice for many hospitals looking to benefit from a better practice environment (ANCC, 2014).

Despite an increased focus on improving post-acute care in the community where overhead is considerably lower, the hospital will continue to be a safety-net of care for many invasive surgeries, acute health needs, and the nation's most vulnerable people. While the causes of readmission are multifactorial, these study findings demonstrate that hospital nursing care has important implications for patient outcomes. Administrators should consider investing in evidence-based value strategies that simplify care delivery and enhance the effectiveness of existing providers.

In light of these study findings, policymakers should continue to reward providers for high value care. Early evidence suggests that hospital pay-for-performance is not associated with improvements in care (Ryan et al, 2015), yet some contend that this may be due too small financial incentives and the overly intricate design of the incentive system (Jha, 2013; Werner & Dudley, 2012; Werner et al, 2011). Whether or not the pay-for-performance incentives have been successful in improving care delivery and patient outcomes, they represent initial steps toward promoting high value care. As hospitals re-imagine how to deliver high value care effectively, they should consider how to strategically use their most numerous providers – nurses.

Patients are also becoming increasingly aware of hospital quality as a result of public reporting of hospital performance measures on the Hospital Compare website and public knowledge about hospital Magnet® accreditation. Access to information about hospital quality on various performance measures, including readmission rates, gives patients tools to make more informed choices about where to seek healthcare. The public also has a responsibility to engage in political decisions including nurse staffing laws, which could make hospitals safer environments for patients and providers alike.

Future research

Future research in the areas of hospital nursing and readmissions is warranted. To date, research in this area has been cross-sectional. The study of causal relationships could be supported through longitudinal studies that account for patterns and changes over time. Such an analysis would provide stronger evidence of the relationship between hospital nursing and readmissions.

Future research should explore the processes through which better staffing and practice environments are linked to fewer readmissions. A recent study showed that missed nursing care – that is, care left undone due to a lack of time – may be one mechanism by which hospital nursing is linked to readmissions (Brooks Carton et al, 2015). This study conceptualized nurse staffing as a measure of patient surveillance. Additional research is needed to understand if and to what extent nursing surveillance, or other important tasks central to nursing – such as patient education and care coordination – , explain nursing’s relationship to readmissions.

Comparative effectiveness studies contrasting various current practice models – such as telephone follow-up calls, care coordinators, or transitional care programs –, with improvements in nurse staffing and/or the practice environment, may yield additional insights into the efficacy and generalizability of various readmission reduction strategies. A comparative effectiveness approach may provide a reasonable method to compare costs associated with each intervention. Evidence about the comparative costs and benefits of investments in hospital nursing compared with current disease-specific approaches may add to the growing value-case for investments in hospital nursing.

Additional lines of research on readmissions should explore strategies for reducing readmissions among the most vulnerable patients at greatest risk of readmission. For example, this study and others have found that racial minorities are at higher risk for readmission compared with their white counterparts (Hu, Gonsahn, & Nerenz, 2014; Jencks, Williams, & Coleman, 2009; Joynt, Orav, & Jha, 2011; Zmistowski et al, 2013). Interestingly, in this study and others, racial minorities tend to be in better staffed hospitals compared with white patients (Brooks Carthon et al, 2012). Future research

should explore whether there is a moderating effect of race and staffing on readmission outcomes. One hypothesis is that better nurse staffing may have a more pronounced effect on readmission outcomes for minority patients. Such an analysis would provide evidence for more targeted readmission reduction strategies. Given the financial pressures faced by many hospitals, system level investments targeted at the most vulnerable populations may be one initial strategy to reduce health disparities and improve healthcare quality overall.

Conclusion

The findings of this study demonstrate an association between hospital nursing and readmissions in an older adult population undergoing elective THA/TKA. These findings have important implications that extend from patients, to providers, payers, and policymakers. Due to pay-for-performance initiatives in the Affordable Care Act, hospitals are pressured from payers and policymakers to improve health outcomes and processes of care. As hospital care quality becomes more transparent to the public, patients may also become more conscientious of where they seek healthcare, which will have important implications for hospitals. Indeed, the priority of healthcare should be providing safe care to patients. Despite increased attention to care quality, hospitals remain a dangerous environment for many older adults. Hospital readmissions are largely avoidable. Investments in hospital nursing may be one strategy to reduce readmissions. Failure to reduce readmissions remains a signal for low quality, high cost healthcare and jeopardizes the health, safety, and quality of life of patients.

APPENDIX A

Figure A.1. Inclusion criteria for the study of elective THA/TKA readmissions

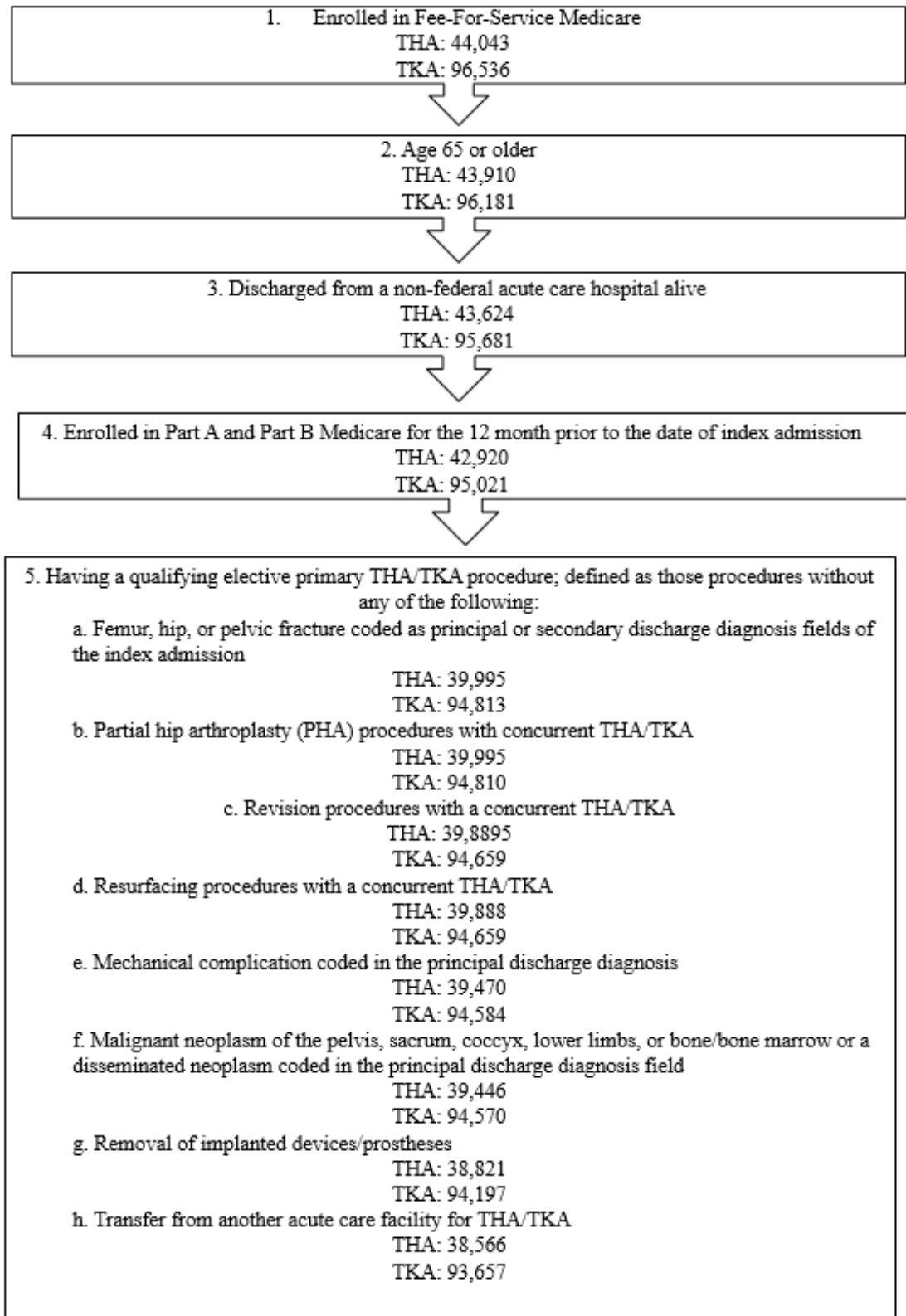
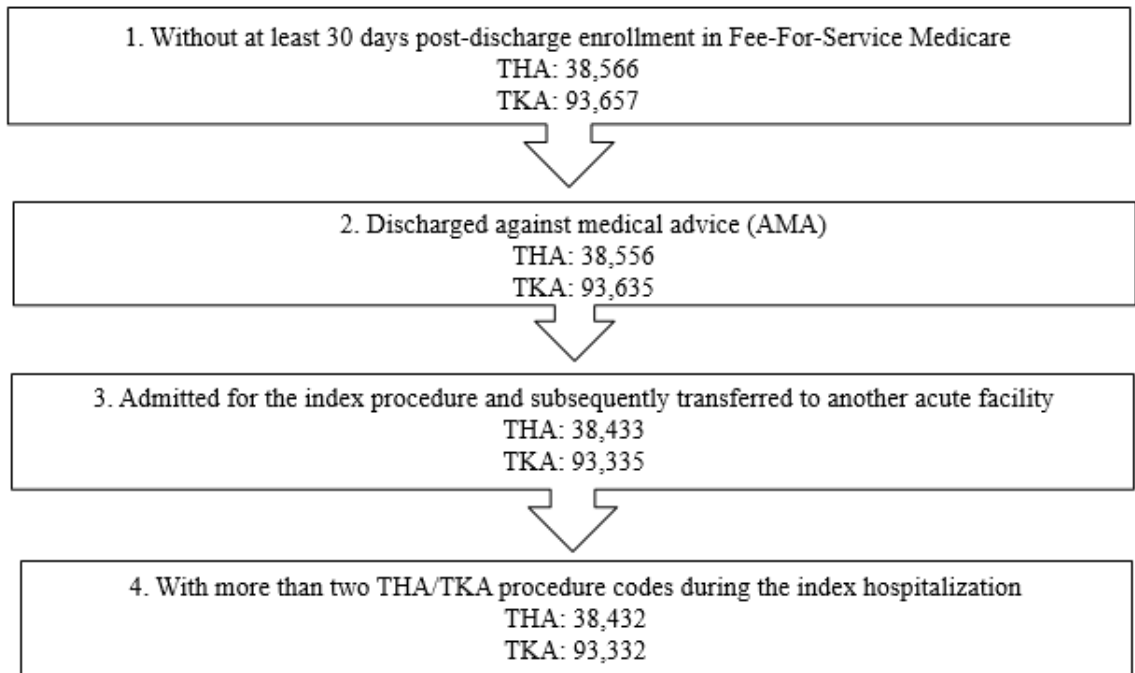


Figure A.2. Exclusion criteria for the study of elective THA/TKA readmissions



APPENDIX B

Methods: Sensitivity analysis

Patient characteristics

Discharge destination

Data on where the patient was discharged following admission was available from the MedPAR RIF. Discharge destination was descriptively and analytically modeled as a dichotomous variable. Discharge destination was specified as “discharged to home” or “not discharged to home”. “Discharged to home” included being discharged to a private residence either with or without home healthcare services. “Not discharged to home” included, for example, a skilled nursing facility or inpatient rehabilitation facility.

Length of stay

Length of stay was calculated from the date of admission and date of discharge, which was provided in the MedPAR RIF. Length of stay was descriptively and analytically modeled as a continuous variable. Length of stay describes the number of days the patient was hospitalized on the initial admission.

Race/ethnicity

Data on patient race/ethnicity was available from the MedPAR RIF. The vast majority of patients in the sample were identified as white non-Hispanic. For analytic purposes, race/ethnicity was dichotomously coded as “white non-Hispanic” versus “other”, with “other” as the reference category.

Socioeconomic status

Patient socioeconomic status was defined using the neighborhood socioeconomic summary index score for each ZIP code, available from the United States Census data. Socioeconomic status was categorized into tertiles: low (bottom 25%), average (26%-74%), and high (top 25%). For analytic purposes, each of the three categories was created as indicator variables, with average and high socioeconomic status as the reference category, to ease interpretation.

Hospital characteristics

Geographic location

The AHA Annual Survey includes a measure of population density in the surrounding area where each hospital is located. This Census-derived measure is known as the core-based statistical area and was categorized as follows: division (>2.5 million); metropolitan (50,000 - 2.5 million); micropolitan (10,000 - <50,000); rural (<10,000) (Brooks Carthon et al, 2012). To ensure consistency with other studies and to simplify the analysis, population density of the hospital's location was restricted to urban ($\geq 50,000$) and rural (<50,000). Rural was the reference category in the regression analysis.

Caseload volume

The caseload volume was derived from the MedPAR RIF as the number of live discharges per hospital of patients who met the inclusion and exclusion criteria for this study. Each study hospital's caseload volume was used to create tertiles such that the lowest volume tertile represented hospitals in the lowest third for caseload volume. A high volume hospital was represented as a hospital in the highest third of the study

hospitals for caseload volume. The volume tertiles were created as dummy variables and the high volume variable was the reference category in the regression analyses.

Ownership type

Hospital ownership type was available from the AHA Annual Survey. Hospitals were categorized as being for-profit, not-for-profit, or government-non-federal. Government-non-federal was the reference category in the analysis, so that the effect of each ownership type on readmission could be assessed.

Socioeconomic status profile

The hospital socioeconomic status profile was defined by the proportion of low socioeconomic status patients within the hospital. Hospitals serving higher proportions of low socioeconomic status patients may deliver a larger share of uncompensated care, or be less well reimbursed by Medicaid, than commercial third party payers. This lack of reimbursement through uncompensated care, and minimal reimbursement through Medicaid, reflects the hospital's ability to invest in structural and organizational features that may influence patient outcomes.

After identifying the individual socioeconomic score of patients by linking their home addresses with the United States Census data, a rough measure of patient socioeconomic status was identified. The top 10% of hospitals in the study sample with the highest proportion of low socioeconomic status patients were classified as a hospital serving a disproportionate share of low socioeconomic status patients (Joynt, Orav, & Jha, 2011). Hospitals defined as serving a disproportionate share of low socioeconomic

status patients was an indicator variable in the regression analysis, with non-disproportionate share hospitals as the reference category.

Magnet® designation

Hospital Magnet® designation status data was available from the ANCC website. An indicator variable was created to identify whether a hospital was designated as a Magnet® hospital in the years 2005, 2006, or 2007.

Surgical care improvement project process measures

Hospital performance on 2006 surgical care improvement project process measures, were analytically modeled as a continuous variable of the percentage of patients within the hospital for whom the hospital met each of the three quality measures. Additionally, an average of the hospital's performance on all three measures was used to create a total score. The total score on surgical care improvement project quality performance was also modeled in the sensitivity analysis.

APPENDIX C

Results: Sensitivity analysis

Patient characteristics

The findings reflect: (1) the unadjusted effect of the additional patient level covariate on readmission, and (2) separate models adjusting for patient and hospital covariates, including the additional patient level covariate being tested in the sensitivity analysis. The patient level covariates, as shown in Table A.1, included: discharge destination (home with/without homecare vs. other), length of stay on the index admission, race/ethnicity (white non-Hispanic vs. other), and socioeconomic status (high socioeconomic status vs. other).

The unadjusted effects are consistent with prior findings that white non-Hispanic race/ethnicity and discharge to home are associated with lower odds of readmission and longer lengths of stay are associated with greater odds of readmission. Patient socioeconomic status was not significantly associated with readmission in the unadjusted analysis (OR 1.08, 95% CI 0.95-1.23).

The association of staffing and 30 day readmission proved to be robust, after controlling for patient level covariates in the sensitivity analysis. Indeed, even after separately controlling for discharge destination, length of stay, race/ethnicity, and socioeconomic status, the effects of staffing remain significant. Where patients rehabilitate following discharge appears to be somewhat predictive of the patients' odds of readmission. Except when controlling for discharge destination, the effects of practice environment remain significant.

Table A.1. Patient level sensitivity analysis of the effects of hospital nursing on 30 day readmission (N = 112,018)

Odds of 30 day Readmission	Discharge destination	Length of stay on index admission	Race/Ethnicity	Socioeconomic status
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	0.46*** (0.42-0.50)	1.10*** (1.09-1.11)	0.86* (0.77-0.97)	1.08 (0.95-1.23)
Staffing	1.06* (1.00-1.12)	1.09** (1.03-1.16)	1.09** (1.02-1.16)	1.09** (1.03-1.16)
Practice environment	0.89 (0.80-1.01)	0.87* (0.76-0.99)	0.87* (0.76-0.99)	0.84* (0.74-0.96)

p <0.05*; p<0.01**; p<0.001***

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

Hospital characteristics

Sensitivity analyses were also conducted for hospital level covariates, including: geographic location (urban vs. rural), patient caseload volume, ownership type (profit, not-for-profit, vs. government nonfederal), socioeconomic status profile (hospitals in the highest decile of the proportion of patients with low socioeconomic status), Magnet® designation, and surgical care improvement project performance measures. Controlling for each of these hospital level covariates does not have a clinically meaningful impact on the associations between staffing and the practice environment on 30 day readmission (Table A.2). In fact, the association between practice environment and readmission actually became more pronounced after controlling for specific hospital covariates, such as ownership type (OR 0.84; 95% CI 0.73-0.95).

In the unadjusted models, hospital caseload volume, socioeconomic status profile, and Magnet® designation were not significantly associated with readmission. Urban location was associated with greater odds of readmission (OR 1.25; 95% CI 1.06-1.49). For-profit hospitals had lower odds of readmission (OR 0.86; 95% CI 0.76-0.98) and not-for-profit had greater odds of readmission (OR 1.17; 95% CI 1.04-1.32).

Table A.3 shows the hospital nursing effects adjusted for hospital level surgical care improvement project performance measures, in addition to other patient and hospital covariates. The following surgical care improvement project measures from 2006 were examined separately and then combined into an overall average score: percentage of surgery patients who/whose (1) received preventative antibiotic(s) one hour before incision, (2) received the appropriate preventative antibiotic(s) for their surgery, and (3) preventative antibiotic(s) are stopped within 24 hours after surgery. The surgical care

improvement project measures were not associated with readmission in the unadjusted models. The staffing and practice environment effects remained significant even after adjusting for each of the surgical care improvement project measures.

Table A.2. Hospital level sensitivity analysis of the effects of hospital nursing on 30 day readmission (N = 112,018)

Odds of 30 day Readmission	Geographic location	Patient caseload volume	Ownership type	Socio-economic status profile	Magnet® designation
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	1.25** (1.06-1.49)	1.16 (0.63-2.13)	Profit: 0.86* (0.76-0.98) Not-For-Profit: 1.17* (1.04-1.32)	1.10 (0.86-1.42)	0.98 (0.13-7.33)
Staffing	1.09** (1.03-1.17)	1.08** (1.02-1.15)	1.08** (1.02-1.15)	1.08* (1.02-1.15)	1.08* (1.02-1.15)
Practice environment	0.87* (0.76-0.99)	0.86* (0.75-0.98)	0.84** (0.73-0.95)	0.86* (0.76-0.98)	0.87* (0.76-0.99)

p <0.05*; p<0.01**; p<0.001***

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

Table A.3. Hospital surgical care improvement project measure sensitivity analysis of the effects of hospital nursing on 30 day readmission (N = 112,018)

Odds of 30 day Readmission	Antibiotic(s) 1 hour before incision	Appropriate antibiotic(s) for surgery	Antibiotic(s) stopped within 24 hours after surgery	Average score
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted	1.00 (1.00-1.01)	1.01 (1.00-1.01)	1.00 (1.00-1.01)	1.01 (1.00-1.01)
Staffing	1.08** (1.02-1.15)	1.08* (1.02-1.15)	1.07* (1.01-1.14)	1.08* (1.01-1.14)
Practice environment	0.87* (0.76-0.99)	0.85* (0.75-0.98)	0.86* (0.76-0.99)	0.86* (0.76-0.99)

p <0.05*; p<0.01**; p<0.001***

Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: bed size, teaching status, technology status. All of the models account for clustering of patients within hospitals. This analysis contains 112,018 patients in 495 hospitals.

APPENDIX D

Discussion: Sensitivity analysis

The sensitivity analyses revealed that including additional patient and hospital characteristics into the regression models did not substantively detract from the association between hospital nursing and readmissions. Controlling for discharge destination had the most pronounced effect on the association of both staffing and the practice environment. The effect of staffing was reduced by two percentage points (OR 1.06, 95% CI 1.00-1.12) and the practice environment was rendered insignificant (OR 0.89, 95% CI 0.80-1.101). These findings are not entirely unexpected in consideration of prior evidence (Bini et al, 2009; Schairer et al, 2014; Tsai et al, 2013; Zmistowski et al 2013). Given such robust evidence that discharge to a facility significantly increases the odds of readmission above and beyond patient acuity, it begs the question whether discharge destination should be risk adjusted for in readmission penalties. Currently, CMS does not risk adjust for discharge destination because it is believed to be associated with patient comorbidities, which is currently adjusted for in the readmission measure (Suter et al, 2014). Discharge destination is also related to the structure of the healthcare system, such as the availability of providers, which is generally beyond the scope of hospital control (Suter et al, 2014). These considerations suggest a valid argument for not risk adjusting for discharge destination in the readmission penalties.

Controlling for patient length of stay on the index admission, race/ethnicity, and socioeconomic status resulted in a greater effect of staffing on readmission. For example, once race/ethnicity was controlled for, the effect of staffing increased one percentage point. A likely explanation for this could be that non-white patients are in better staffed

hospitals yet have worse readmission outcomes. Additional analyses (Table A.4) revealed that non-white patients were, in fact, cared for in hospitals with better staffing than white patients (mean staffing: 4.94 vs. 4.69, $p < 0.001$). Similar results were found for length of stay and socioeconomic status (Table A.5).

Although patient socioeconomic status was not significant in the unadjusted model, the effect of being in a good practice environment became even more pronounced as compared to when socioeconomic status was not included in the model (OR 0.84, 95% CI 0.74 - 0.96). Patients with low socioeconomic status were more likely to be in hospitals rated as having poor practice environments (Table A.6).

Table A.4. Nursing characteristics by patient race

Nursing Characteristics	White non-Hispanic patients N = 102,887		Non-White patients N = 9,130	
	N	%	N	%
Staffing				
<4	13,036	12.67	1,618	17.72
4-<5	43,500	42.28	4,451	48.75
5-<6	35,534	34.54	2,522	27.62
6-<7	8,185	7.96	401	4.39
7 +	2,632	2.56	138	1.51

Table A.5. Patient characteristics by patient race

Patient Characteristics	White non-Hispanic patients N = 102,887		Non-White patients N = 9,130	
	N	%	N	%
Length of stay (days) (mean, SD)	3.74	1.94	4.15	2.39
Socioeconomic status				
Low	23,136	23.43	4,061	46.50
Medium	50,542	51.19	3,184	36.46
High	25,061	25.38	1,489	17.05

Table A.6. Nursing characteristics by patient socioeconomic status

Nursing Characteristics	Low socioeconomic status		Medium socioeconomic status		High socioeconomic status	
	N = 27,197		N = 53,726		N = 26,550	
	N	%	N	%	N	%
Practice environment						
Poor	9,166	34.07	13,678	25.46	3,391	12.77
Mixed	13,352	49.09	27,467	51.12	13,529	50.96
Good	4,579	16.84	12,581	23.42	9,630	36.27

Recently, there has been increased debate about whether socioeconomic status should be risk adjusted for in the readmission penalties. The complexity of this debate centers around the desire for performance measures to be based on fair comparisons across providers while not masking or perpetuating disparities that exist (NQF, 2014). Risk adjusting for socioeconomic status can mask disparities in health outcomes of vulnerable populations by effectually “adjusting away” the observed disparities (NQF, 2014; Suter et al, 2014). Doing so holds hospitals to different standards based on the socioeconomic status of their patient populations (Suter et al, 2014). This might lower the incentives for hospitals with a lower socioeconomic status population to improve readmission rates – effectively allowing those hospitals to perform worse on quality because that is the expectation (NQF, 2014).

Alternatively, there are valid concerns about the impact of not risk adjusting for socioeconomic status. Hospitals serving the neediest populations are penalized disproportionately, which makes improving care even more difficult in already under-resourced hospitals (NQF, 2014; Rau, 2013). This results in adverse feedback loops that could worsen, rather than improve, health disparities. Early evidence shows that safety-net hospitals tend to have smaller improvements in performance measures over time,

compared with non-safety-net hospitals (Werner, Goldman, & Dudley, 2008). Additionally, with reimbursement at risk, providers have an incentive to “cherry pick” patients who are more likely to perform better on outcome measures (NQF, 2014; Werner, Asch, & Polsky, 2005). This phenomenon was observed when public reporting (unadjusted for race/ethnicity) for mortality rates following coronary artery bypass grafts (CABG) was introduced – fewer CABGs were performed on racial and ethnic minorities (Werner, Asch, & Polsky, 2005).

Evidence to date demonstrates that hospitals serving a larger portion of economically disadvantaged patients are more severely affected by readmission penalties. In the first year of implementing CMS penalties for hospitals with worse than expected readmission rates, 77% of safety-net hospitals were penalized, whereas only 36% of hospitals, which cared for the fewest low-income individuals, were penalized (Rau, 2013). Adjusting for socioeconomic status would likely equalize the expected readmission rates among hospitals that are safety-net and non-safety-net, alleviating the readmission penalty disparities between otherwise similar hospitals. Yet the debate still lingers as to whether the CMS penalties should account for hospitals’ case-mix of patient socioeconomic status (Hu, Gonsahn, & Nerenz, 2014; Nagasako et al, 2014).

Hospital characteristics were also included in the sensitivity analysis as covariates that might confound the hospital nursing and readmission relationship. Controlling for geographic location of the hospital, patient caseload volume, ownership type, socioeconomic status profile, and whether or not the hospital was Magnet® designated, had no meaningful impact on the effect of staffing or the practice environment on readmission. Also, adjusting for hospital performance on surgical care improvement

project performance measures did not explain the relationship between hospital nursing and readmission. In sum, the relationship between hospital nursing and readmission was found to be robust, even after adjusting for potentially confounding patient and hospital characteristics.

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