VARIATIONS IN ADHERENCE TO SURGICAL PROCESS MEASURES AND CLINICAL OUTCOMES

by

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(date) June 16, 2009

*We also certify that written approval has been obtained for any proprietary material contained therein.
the pitcher longs for water to carry

and a person for work that is real

Marge Piercy “To Be of Use”
DEDICATION

To Dana. You are my best friend, my rock, my soul mate.

You make me a better person, and I never would have made

it through without you. I love you.
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Variations in Adherence to Surgical Process Measures and Clinical Outcomes

Abstract

by

JONAH J. STULBERG

To help patients choose high-quality hospitals, the Centers for Medicare & Medicaid Services (CMS), in conjunction with the Hospital Quality Alliance (HQA), publicly report measures of surgical quality via their Hospital Compare website. The current measures report on perioperative guideline-based processes, no measures of patient outcomes are reported, and it is not known whether higher levels of adherence to these measures is associated with better patient outcomes. Furthermore, it is not known whether receipt of these processes is equal among patient subgroups.

In its first section, the study introduces the nine publicly-reported Surgical Care Improvement Project (SCIP) measures and describes development of four new measures of condition-specific and overall adherence. The study then investigates the relationship of both condition-specific and overall adherence rates with surgical complications using 405,720 discharges from 398 hospitals identified in the Premier Perspectives™ Database. The results indicate that publicly reported adherence to SCIP process-of-care measures is associated with a decrease in surgical complications.
The second section presents another look at the association between SCIP performance and outcomes for surgical patients, and we define our outcome as surgical mortality. Using nested logistic regression models, we examined the relationship between surgical mortality and each of measure-specific, condition-specific and overall adherence. The nested models allow us to adjust for both patient- and hospital-level attributes and account for clustering of patients within hospitals. The results indicate that for most currently reported SCIP measures and all four composite measures, adherence is strongly and significantly associated with decreased patient mortality.

The third section examines the patient characteristics associated with poor adherence to identify patient subgroups at greatest risk for receiving poor-quality care. This investigation separates the younger and older populations (<65 and ≥65 years of age respectively) to account for important differences between the two groups. The results demonstrate that patients who are uninsured admitted emergently and those with coexisting comorbid conditions are the most vulnerable patient subgroups and are the least likely to receive appropriate perioperative care.

The findings provide impetus for providers to improve their adherence, as improving the culture of quality can result in improved health for all patients.
CHAPTER 1

INTRODUCTION
Primum non nocere is Latin for “Above all, do no harm,” and for over a century, it has stood as a central tenant in teaching medical students about the practice of medicine (Veatch 1990). For many physicians, it is a hallowed expression of humility and serves as recognition that with the trust bestowed on individuals practicing the art of medicine comes great responsibility to practice at the highest level of one’s knowledge and abilities. Yet currently in the United States, numerous studies have demonstrated large gaps between what is known and what is practiced (Institute of Medicine (U.S.). Committee on Quality of Health Care in America. 2001; McGlynn, Asch et al. 2003; Asch, Kerr et al. 2006). It is estimated that approximately half of all patients in the United States receive the recommended care, and hospital-level performance on quality process measures varies widely among hospitals and among measures (Jha, Li et al. 2005). Given these well-documented deficiencies in quality, creating incentives that promote high-quality care has been a recent focus of policy makers, large employers, healthcare providers and patients.

The Centers for Medicare & Medicaid Services (CMS), as the single largest insurer in the United States, have issued a Quality Improvement Roadmap that provides a broad overview of how they hope to assist and drive improvements in quality (2005; Straube 2005; Services 2008). They start by acknowledging how far America is from providing their vision of: “The right care for every person every time.” Central to their ability to implement many of the changes they propose within the Quality Improvement Roadmap is the passage of the Medicare Prescription Drug, Improvement and
Modernization Act of 2003 (MMA) that enables the CMS to provide financial compensation for quality improvement efforts.

As part of their quality-improvement efforts, the CMS, in conjunction with other stakeholders in the Hospital Quality Alliance (HQA), publicly report quality process measures via their Hospital Compare website (www.hospitalcompare.hhs.gov) to help patients choose high-quality hospitals (HQA 2005; Services 2008). Hospital Compare captures and reports on a select number of process-of-care metrics targeting specific patients and conditions (Services 2008). Process-of-care performance measures are available for patients with acute myocardial infarction (AMI), heart failure (HF), pneumonia, surgical site infection (SSI) prevention, and prevention of venous thromboembolism (VTE). The measures are primarily meant to determine adherence to best-practices guidelines that suggest their association with improved outcomes (Services 2008). However, the current measures focus only on a fraction of the processes actually provided to surgical and medical patients, and very little is known about whether the information provided by these measures can be used as a proxy for improved outcomes (Bratzler 2006). Furthermore, physicians resistant to the idea of “cookie-cutter medicine” are not necessarily convinced that higher adherence rates are indicative of better quality care (Werner and Bradlow 2006; Hawn, Itani et al. 2008; Nguyen, Yegiyants et al. 2008; El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). For the measures of surgical quality, the HQA and CMS publicly report measures developed through the Surgical Care Improvement Project (SCIP).
SCIP is a national quality partnership of organizations interested in improving surgical care by significantly reducing surgical complications. The goal of the project is “to reduce the incidence of surgical complications nationally by 25 percent by the year 2010” (Bratzler 2006). In October of 2005, the CMS released finalized list of 21 SCIP measures (see Table 1 – SCIP Measures). Their list includes seven measures of infection prevention. Six of these are process measures, and one is an outcome measure. In addition, there are three measures specifically for prevention of acute myocardial infarction (AMI) (two process measures and one outcome measure), four for prevention of venous thromboembolism (VTE) (two process measures and two outcome measures), four for prevention of ventilator associated pneumonia (VAP) (three process measures and one outcome measure), one measure specific to vascular-access procedures, and two global outcome measures of quality. These measures undergo an extensive standardization process so that they can be implemented nationwide, and an agreed-upon standard data-collection and reporting process has been published for nine SCIP measures (Centers for Medicare & Medicaid Services 2009). Medicare currently incentivizes hospitals to voluntarily submit their performance on these nine measures through a 2% payment increase to hospitals successfully submitting measure-adherence rates (Bratzler and Hunt 2006).

No study has attempted to determine the effectiveness of the SCIP measures on a national level. There are two studies that attempt to validate the effectiveness of the other (medical) quality indicators in participating hospitals (Werner and Bradlow 2006;
Jha, Orav et al. 2007). These two manuscripts present contrasting views – one saying there is no association, the other concluding that moderate associations exist. Studies evaluating the effectiveness of governmental policies and programs are desperately needed, and this study proposes a novel method for connecting the current process-of-care quality metrics to immediate and measureable outcomes. The methodology is novel in two important ways: first, it is the first nationally representative exploration of this topic at the discharge level, and second, it is the first nationally representative examination of SCIP-measure effectiveness. Previous studies have investigated the medical (non-surgical) quality measures on the Hospital Compare website, and two studies have looked at their single-institution performance on SCIP measures and the associated outcomes (El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). This dissertation also goes a step further by developing and validating all-or-none composite measures which better approximate the culture of quality within a practice.

In the words of Rodney Hayward, MD, Director of the Veteran’s Affairs Center for Practice Management & Outcomes Research, “Misunderstanding and misuse of profiles can waste precious health care resources and potentially do harm (Hayward 1998).” While the performance metrics currently measured by SCIP and publicly reported via the Hospital Compare website are rooted in evidence demonstrating their efficacy, very little evidence exists to explain how the current variations seen in processes of care actually reflect clinically meaningful variations in outcomes of care (Hawn, Itani et al. 2008). Nevertheless, the Hospital Compare website promotes the
reporting of performance on these process measures as a tool to assist patients in choosing high-quality hospitals. This implies that patients can use the reported hospital-performance scores to choose a hospital in which they can expect to achieve a better outcome. While variations in outcomes for patients having surgery are well documented, it is unknown if the reported measures of quality are actually associated with patient outcomes (Chassin and Galvin 1998; Collins, Daley et al. 1999; Dimick, Pronovost et al. 2003; Dimick, Pronovost et al. 2003; Fleischmann, Goldman et al. 2003; Zhan and Miller 2003; Dimick, Chen et al. 2004; Khan, Quan et al. 2006). This project explores the association between adherence to SCIP process measures and the morbidity and mortality rates of patients.

The study has three aims. First, the study develops discharge-level composite measures to approximate the culture of quality within a practice and then uses these to determine whether an association exists between discharge-level adherence to SCIP measures and surgical complication rates. Second, the study looks at whether individual or discharge-level composite measures of SCIP adherence are associated with surgical mortality rates. And finally, the study will investigate whether specific patient subgroups are at an increased risk for receipt of non-adherent care. These studies taken together are meant to improve our understanding of current performance-measurement tools used by the CMS and others for both public reporting and reimbursement of hospitals. Specifically, the purpose is to investigate whether performance on SCIP measures predicts surgical complication rates and surgical
mortality rates and to determine which patient subgroups are at the greatest risk for receiving poor care.
## TABLE 1 – SCIP MEASURES

### INFECTION

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIP INF 1</td>
<td>Prophylactic antibiotic received within one hour prior to surgical incision</td>
</tr>
<tr>
<td>SCIP INF 2</td>
<td>Prophylactic antibiotic selection for surgical patients</td>
</tr>
<tr>
<td>SCIP INF 3</td>
<td>Prophylactic antibiotics discontinued within 24 hours after surgery end time (48 hours for cardiac patients)</td>
</tr>
<tr>
<td>SCIP INF 4</td>
<td>Cardiac surgery patients with controlled 6 a.m. postoperative serum glucose</td>
</tr>
<tr>
<td>SCIP INF 5</td>
<td>Postoperative wound infection diagnosed during index hospitalization (OUTCOME)</td>
</tr>
<tr>
<td>SCIP INF 6</td>
<td>Surgery patients with appropriate hair removal</td>
</tr>
<tr>
<td>SCIP INF 7</td>
<td>Colorectal surgery patients with immediate postoperative normothermia</td>
</tr>
</tbody>
</table>

### CARDIAC

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIP Card 1</td>
<td>Non-cardiac vascular surgery patients with evidence of coronary artery disease who received beta-blockers during the perioperative period</td>
</tr>
<tr>
<td>SCIP Card 2</td>
<td>Surgery patients on a beta-blocker prior to arrival that received a beta-blocker during the perioperative period</td>
</tr>
<tr>
<td>SCIP Card 3</td>
<td>Intra- or postoperative acute myocardial infarction (AMI) diagnosed during index hospitalization and within 30 days of surgery (OUTCOME)</td>
</tr>
</tbody>
</table>

### VENOUS THROMBOEMBOLISM

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIP VTE 1</td>
<td>Surgery patients with recommended venous thromboembolism prophylaxis ordered</td>
</tr>
<tr>
<td>SCIP VTE 2</td>
<td>Surgery patients who received appropriate venous thromboembolism prophylaxis within 24 hours prior to surgery to 24 hours after surgery</td>
</tr>
<tr>
<td>SCIP VTE 3</td>
<td>Intra- or postoperative pulmonary embolism (PE) diagnosed during index hospitalization and within 30 days of surgery (OUTCOME)</td>
</tr>
<tr>
<td>SCIP VTE 4</td>
<td>Intra- or postoperative deep vein thrombosis (DVT) diagnosed during index hospitalization and within 30 days of surgery (OUTCOME)</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SCIP Resp 1</td>
<td>Number of days ventilated surgery patients had documentation of the Head of the Bed (HOB) being elevated from recovery end date (day zero) through postoperative day seven.</td>
</tr>
<tr>
<td>SCIP Resp 2</td>
<td>Patients diagnosed with postoperative ventilator-associated pneumonia (VAP) during index hospitalization (OUTCOME)</td>
</tr>
<tr>
<td>SCIP Resp 3</td>
<td>Number of days ventilated surgery patients had documentation of stress ulcer disease (SUD) prophylaxis from recovery end date (day zero) through postoperative day seven.</td>
</tr>
<tr>
<td>SCIP Resp 4</td>
<td>Surgery patients whose medical record contained an order for a ventilator weaning program (protocol or clinical pathway)</td>
</tr>
</tbody>
</table>

**VASCULAR ACCESS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA 1</td>
<td>Proportion of permanent hospital ESRD vascular access procedures that are autogenous AV fistulas</td>
</tr>
</tbody>
</table>

**GLOBAL**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIP Global 1</td>
<td>Mortality within 30 days of surgery</td>
</tr>
<tr>
<td>SCIP Global 2</td>
<td>Readmission within 30 days of surgery</td>
</tr>
</tbody>
</table>


16. Nguyen N, Yegiyants S, Kaloostian C, Abbas MA, Difronzo LA. The Surgical Care Improvement project (SCIP) initiative to reduce infection in elective colorectal


CHAPTER 2

QUALITY AND SURGERY
Despite numerous medical and technological advances over the past century, health care in the United States falls far short of the results demanded by Ernest Codman and his unyielding persistence to improve outcomes over 100 years ago (Kaska and Weinstein 1998; Institute of Medicine (U.S.). Committee on Quality of Health Care in America. 2001; Neuhauser 2002). The Institute of Medicine’s book *To Err is Human* estimated that between 44,000 and 98,000 deaths are caused by medical errors annually (Kohn, Corrigan et al. 2000). Researchers studying whether patients receive “the right care at the right time,” the proclamation driving the Centers for Medicare & Medicaid Services (CMS) toward value-based purchasing, conclude that Americans receive the correct care only about half of the time (McGlynn, Asch et al. 2003; 2005; Straube 2005; Services 2008). Furthermore, the chasm between what should be done and what is actually done is estimated to cost the health care system an extra $9 billion in lost productivity and an extra $2 billion in hospital costs annually (Varkey, Reller et al. 2007; National Committee for Quality Assurance (U.S.) 2008). The picture painted by these statistics is certainly bleak, but measurement and recognition of our system’s shortcomings has lead to increased focus on improvement. To understand what is being done to improve the current state of affairs and why, we must first understand the structure upon which the debate stands. In the words of Avedis Donabedian, a physician and thought-leader, “to proceed to measurement without a firm foundation of prior agreement of what quality consists in is to court disaster”(Donabedian 1988). This chapter will therefore set the stage for subsequent chapters by briefly discussing the history of the quality movement and the theoretical framework upon which current
efforts to improve the quality of care arise. The chapter concludes by highlighting some of the current efforts to measure and improve the quality of health care in the United States and how this study fits into the quality web.

**Ernest Amory Codman**

Our understanding and definitions of quality in surgical care, our focus on evidence-based medicine, and our pursuit of improved outcomes are largely due to the early work of Ernest Amory Codman (1869 – 1940) and his “end-results” obsession (Kaska and Weinstein 1998; Mallon 2000). Unappreciated during his career and chastised for his comparison of physician-level surgical outcomes regardless of physician seniority, he had a vision to produce a better health care system set him far apart from his peers (Mallon 2000). His relentless pursuit of improved patient outcomes and the outspoken methods he used to motivate others to accept his concepts of improvement landed him a life of financial and personal unrest; yet the premise of his lifelong struggle was simple. He felt that “every hospital should follow every patient it treats, long enough to determine whether or not the treatment has been successful, and then to inquire ‘if not, why not?’ with the view of preventing similar failures in the future” (Codman 1990).

Today, such a simple statement seems logical and not revolutionary, but at the time, no formal system for measurement of patient outcomes existed. In fact, his pursuit of the End Results system cost him his job as a surgeon at Massachusetts General Hospital and resulted in political exile among his peers. He was forced to
pursue his efforts through development of his own hospital, from which he made public the results of his efforts (Codman 1917; Neuhauser 2002). After he devoted the greater majority of his professional life to promoting his idea of The End Result System of Hospital Organization, a handful of hospitals started to follow his teachings (Codman 1917; Kaska and Weinstein 1998). Small note cards were kept by surgeons on every case they performed. The cards stated the disease they encountered and the procedures they performed. One year later, those cards and the patient’s status were reviewed. If the outcome was unfavorable, they investigated what else could have been done. And so the tracking of patient outcomes and the review of those outcomes for the advancement of medical science became ever-so-slowly integrated into the fabric of the surgical community. (Kaska and Weinstein 1998) However, Dr. Codman recorded to the best of his ability every mistake he ever made, and he openly reported to all that would listen how one of every three patients of his hospital experienced an error (Neuhauser 2002). Few, if any, hospitals or surgeons practicing today openly report each and every mistake they make, so perhaps our system still has a lot to learn from Dr. Codman.

**AVEDIS DONABEDIAN**

Emerging in an era more accepting of the idea of measuring medical quality, Avedis Donabedian (1919 – 2000) became widely known for his conceptualization of the structure-process-outcome framework for measuring quality in medical care (Donabedian 1966; Donabedian 1980). His systems-based model set the stage for the
majority of work on the quality of health care since 1980, and it stands as the
foundation of evaluation in most national initiatives. When Dr. Donabedian gave his
talk at the 1975 Annual Health Conference of the New York Academy of Medicine where
he laid out his vision of how to define quality in health care, he started by stating,
“There is one ... problem that is the very root of all of our other difficulties, and it is this:
We attempt to pass judgment on what we do not understand.” He went on to explain,
“Ask an individual to talk about quality health care, and you are likely to get a catalogue
of platitudes. Ask two people, and you will probably get an argument. Ask three, and
you will probably have chaos. The reason is that each, like the proverbial blind man, has
some different portion of the elephant in his hand” (Donabedian 1976). For his
remaining years, Dr. Donabedian worked to define that elephant and guide realistic
measurement of the quality of health care.

**STRUCTURE, PROCESS, OUTCOME**

The systems-based framework for defining health care quality through structure,
process, and outcome was first proposed by Dr. Donabedian in 1966 (Donabedian
1966). This framework allows one to distinguish the actual care given (process) from
the environment within which the care was provided (structure) and the consequences
of the interaction between the actual care given and the environment (outcome) (see
Figure 1). Process measures are meant to refer to the care that patients actually receive
and are attractive as quality indicators for several reasons. First, because they reflect
the care received, they are often seen by clinicians as fairer measures of performance.
Second, they do not require risk adjustment but rather appropriate inclusion and exclusion criteria. Third, they are often supported by strong clinical effectiveness studies (randomized controlled trials), and finally, they highlight actionable deficiencies that can be linked to quality improvement. The validity of process measures are therefore often assessed through their strength in association to outcomes of care and can have high face validity prior to their implementation.

Structure, in Donabedian’s definition of systems-based health care, refers to the organizational factors that define the system under which health care is provided. Some definitions of health care quality therefore view structure not as a component of care but rather a conduit through which care is delivered or received (Campbell, Roland et al. 2000). Nevertheless, structural measures of the health care system have been used successfully as measures of quality, and examples of structural measures include measures of staff expertise, the availability of hospital resources and measures of procedural volume, whether at the individual physician or hospital level. Measures of surgeon and hospital volume have been repeatedly shown to have strong predictive value in assessment of patient outcomes and are being used currently as drivers towards increasing regionalization. Yet other studies have shown that much of the variation attributed to surgeon and hospital volume may in large part be due to underlying processes (Hannan, Popp et al. 2001).

An outcome, in Donabedian’s definition, refers to the consequences of care and therefore is often thought of not as a component of but as a product of care (Campbell,
Roland et al. 2000; Birkmeyer, Dimick et al. 2004). Since the days of Ernest Codman and his End Results, surgical mortality has been a closely monitored and heavily debated measure of surgical quality, but many other outcome measures exist. For example, the National Surgical Quality Improvement Program (NSQIP) of the Department of Veterans Affairs compiles hospital-specific morbidity rates aggregated across a wide range of surgical specialties (Khuri 2005). Appropriate methods for risk adjustment and difficulties with small sample sizes for physician-specific, procedure-specific measures still present difficulties for researchers, but in many respects the outcomes of care remain the holy grail of quality measurement (Birkmeyer and Dimick 2008).

The relative importance between the care given (process) and the environment within which the care was given (structure) can be said to determine the outcome, and one’s definition and measurement of quality can be engineered to fit their goal of measurement.

**Defining Quality**

Quality is a latent construct that takes on different and sometimes divergent meanings depending on one’s perspective; however, to improve and measure quality in health care, a firm and accountable definition is required. The Agency for Healthcare Research and Quality defines quality health care as “doing the right thing, at the right time, in the right way, for the right person – and having the best possible results.” Avedis Donabedian describes high-quality health care as “that kind of care which is expected to maximize an inclusive measure of patient welfare, after one has taken
account of the balance of expected gains and losses that attend the process of care in all its parts” (Donabedian 1979; Donabedian 1980). Finally, the Institute of Medicine developed a widely cited definition stating that high-quality health care is the “degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.” It is the concept that the provision of care should be “consistent with current professional knowledge” that has allowed for the development of direct measures of quality.

**Measuring Quality**

With the definition of quality health care fluctuating by perspective, interpretation, and timing, the measurement of quality is equally volatile. Fortunately, the National Quality Forum (NQF) has emerged as a “not-for-profit membership organization created to develop and implement a national strategy for health care quality measurement and reporting” (Forum 2009). Over the past decade, they have been instrumental in development of consensus-based standards of care and measurement of that care. Furthermore, after measures go through the NQF’s endorsement process, they gain a necessary amount of face validity to achieve buy-in for improvement efforts. Early measures developed and endorsed by NQF primarily focused on the structural and outcome components of our healthcare system. These components are often easier to define and implement, but they provide little by way of directly actionable results. More recent efforts have focused on development of universally agreed-upon and evidence-based process measures, and the first set of
multi-specialty surgical process measures was developed through the Surgical Infection Prevention (SIP) project (Bratzler and Houck 2005). The development of three original measures of surgical-site infection prophylaxis has group into 21 agreed-upon measures of surgical quality applicable to nearly all surgical specialties and procedures (Bratzler and Hunt 2006).

By expansion into measures of venous thromboembolism prevention, myocardial infarction prevention, respiratory pneumonia prevention, and global measures of post-operative mortality, the SIP project became the Surgical Care Improvement Project (SCIP) (Bratzler 2006). Nine of the 21 SCIP measures are currently included in the voluntary reporting requirements of the Centers for Medicare & Medicaid Services (CMS). Their association with a 2% payment bonus for participation has yielded a 99% participation rate in this voluntary effort (Clancy 2008). However, while we’ve begun, as a healthcare system, to publicly report the processes of surgical care in select circumstances, the measurement and reporting enterprise is still met with a considerable amount of resistance by those being measured.

Not unlike the era of Ernest Codman, there is security in the unknown, and complete transparency is not an accepted truism in the practice of medicine. Furthermore, as described years ago by Avedis Donabedian, passing judgment on that which we do not understand lies at the root of all of our problems. So, how do we know that the portion of the elephant we now hold in our hands represents the elephant as a whole?
This study attempts to answer that very question through investigation of the relative importance between the care given (process) and the environment within which the care was given (structure) can be said to determine the outcome. Current measurement efforts in surgical care have merely a window into select elements of the care provided. It is unknown whether our glimpse into the surgical world through the eyes of the SCIP measures is representative of the true quality of care that a patient receives unless we know the relative importance of variations in that care in determination of patient outcomes.

**Dissertation Aims**

The first aim explores the relative strength of SCIP performance (process) on the prediction of condition-specific and overall complication rates (outcome) (see Figure 2 for a roadmap of the dissertation chapters). The analysis controls for measures at the hospital level (structure) given their known association to complication rates and process variation. Furthermore, the analysis is conducted using aggregated all-or-none composite measures to draw out effects at the system level that may have otherwise been drowned out at the item level (Nolan and Berwick 2006). Given the multilevel nature of the data, nested logistic regression models were used.

The second aim explores the strength of association between SCIP adherence (process) and surgical mortality (outcome), at both the item-specific and composite-measure level. This analysis reports adjusted adherence rates using well-established methods of risk adjustment and nested models to account for both hospital- and
patient-level variation (structure). Both of the first two aims directly address questions of measure validity crucial for continuation of these national initiatives. Face validity arguments work temporarily, but high levels of adherence require assurances for providers that clinical judgment is approximated well enough to consider increases in adherence improvements in quality of care (Donabedian 1976).

The third and final aim explores the relative importance of measures such as patient and hospital characteristics (structure) on variations in adherence to SCIP measures (process). Despite adjustments for insurance status, financial status, geographic location and provider, disparities in the provision of health care along racial, gender, and age categories are described in the primary care setting (Asch, Kerr et al. 2006). Investigations of disparities in the surgical setting have primarily focused on disparate outcomes due to the relative void of data on procedural variation. The incorporation of SCIP measures into physician practices across the nation affords the opportunity to investigate variations in process.
FIGURE 1 - SYSTEMS-BASED FRAMEWORK FOR DEFINING QUALITY IN HEALTH CARE
Figure 2 – Roadmap for Dissertation

1. Individual SCIP measures
2. SCIP Composite Measures
   1. INF-Core
   2. INF
   3. VTE
   4. Global

Chapter 3

1. Complication Rate (8)
2. Mortality Rate

Chapter 4

Patient Characteristics

Chapter 5
LITERATURE CITED


14. Codman EA. A study in hospital efficiency: as demonstrated by the case report of the first five years of a private hospital. Oakbrook Terrace, IL: Joint Commission on Accreditation of Healthcare Organizations; 1917.


CHAPTER 3

ADHERENCE TO SURGICAL CARE IMPROVEMENT PROJECT MEASURES AND THE ASSOCIATION WITH POSTOPERATIVE COMPLICATIONS
ABSTRACT

INTRODUCTION

The Surgical Care Improvement Project (SCIP) is dedicated to reducing surgical complication rates through measurement and reporting of nine process-of-care measures, yet the association between adherence to these measures and reduction in complication rates has not been demonstrated. The objective of this study was to analyze complication rates in relation to currently reported SCIP process measures.

METHODS

Using the Premier Perspectives™ Database, we identified 405,720 patients from 398 hospitals. We aggregated the three original infection prevention measures, all six infection prevention measures, the two venous thromboembolism measures and all nine measures into four separate individual composite scores (INF-Core, INF, VTE, and GLOBAL, respectively). Given the nested nature of the data, we developed hierarchical logistic models for prediction of postoperative complications.

RESULTS

Overall, 57,173 (14.1%) discharges reported an iatrogenic complication, 17,013 (4.2%) discharges had a respiratory complication following surgery, and 4,432 (1.1%) discharges reported a postoperative infection. Seventy seven percent of patients received all INF-Core processes; 72.0% received all INF processes; 82.7% received all VTE processes; and 67.7% received all GLOBAL processes. Failure to receive all INF-Core
processes was significantly associated with an increased postoperative infection rate (Adjusted Odds Ratio [AOR] 1.16, 95%-Confidence Interval [CI] 1.03 – 1.32) after controlling for patient characteristics, admission type, comorbidities, type of surgical procedure, hospital characteristics and location. Further, non-adherence to our GLOBAL composite was associated with an increased likelihood of any complication (AOR 1.08, 95%- CI 1.05 – 1.11).

**Conclusions**

Publicly reported adherence to SCIP process-of-care measures is associated with improved outcomes for surgical patients, as evidenced through lower rates of complication. This finding supports the patients’ reliance on these measures in choosing high-quality providers.
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INTRODUCTION

Two Institute of Medicine reports, *Crossing the Quality Chasm* and *To Err is Human*, documented high postoperative complication rates and called for concerted efforts to decrease these rates (Kohn, Corrigan et al. 2000; Wong, Herndon et al. 2009). The Surgical Care Improvement Project (SCIP) is a national quality partnership dedicated to reducing the rate of surgical complications that has developed 20 measures covering various discrete elements of patient care (Bratzler and Hunt 2006; Clancy 2008). There are nine currently collected and publicly reported SCIP measures (Table 1). These measures are supported by numerous articles attesting to their efficacy, and the development and implementation of these process-of-care measures have been endorsed by the National Quality Forum (NQF) and others (Bratzler and Houck 2005; Bratzler and Hunt 2006; Clancy 2008). The current data-collection process requires hospitals to voluntarily self-report performance data for all nine process-of-care measures. According to the current incentive-based payment structures authorized as part of the Deficit Reduction Act of 2005, the CMS will reimburse hospitals 2% more when the hospital reports on these (McGlynn 2003; Straube 2005; Services 2008). The data then go through a validation and cleaning process before being publicly reported on the Hospital Compare website (www.hospitalcompare.cms.gov).

Despite broad support from national stakeholders, and the significant investment of time and money by the hospitals collecting and reporting these data, no large-scale evaluation of measure effectiveness exists. Further, the limited number of
scientific studies attempting to evaluate the effectiveness of these measures has yielded mixed results with some studies suggesting that adherence to the current SCIP process-of-care measures may not be associated with improved outcomes (Hawn, Itani et al. 2008; Nguyen, Yegiyants et al. 2008; El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). Therefore, the association between self-reported adherence to SCIP measures and complication rates is unknown, leading to debate over the necessity for participation in this large-scale data-collection effort.

It is universally accepted that best practices in prevention of the various complications studied dictates a multimodal approach, and it is therefore acknowledged that adherence to the given guidelines measured is only part of effective patient care (Delaney, Fazio et al. 2001; Bratzler 2006). Other aspects influencing surgical patient outcomes, such as the skill and knowledge of the surgical team and a safe and clean working environment, may be just as important to the assessment of hospital quality, if not more, yet hospital-level performance on SCIP measures is publicly reported “to assist patients in selecting centers of excellence” for receipt of their surgical care (Services 2008). It can therefore be assumed that reported adherence on these measures is not only a proxy for the discrete element but also for a more generalizable concept of quality. By measuring a broad spectrum of complications and by developing composite measures for outcome-specific prevention and global quality, we investigate the strength of association on both of these levels.
Complications are a known cause of increased costs and resource utilization in the health care system, but it is unknown whether the efforts undertaken to adhere to SCIP are truly decreasing postoperative complications (Dimick, Chen et al. 2004). Therefore, we studied the effectiveness of self-reported adherence to the nine currently collected SCIP measures in predicting eight outcomes of surgical care: any medical or surgical complications (COMP), any venous thromboembolism (VTE), any wound infection (WOUND), any postoperative iatrogenic respiratory complication (RESP), postoperative infection (Po-INF), postoperative cerebral vascular attack (PO_CVA), postoperative myocardial infarction (PO_MI), and postoperative pulmonary embolism (Po_PE). The International Classification of Disease, 9th Edition (ICD9) codes used to distinguish these eight outcomes are described in Table 2. We used the nine reported SCIP measures and the eight complications listed to assess the ability of reported adherence on SCIP measures to predict condition-specific complications as well as prediction of overall complication rates.

**METHODS**

**OVERVIEW**

We investigated the effect of discharge-level adherence to SCIP measures on complication rates. To accomplish this, we conducted a cross-sectional study using data from the Premier Inc.’s Perspective™ Database linked with SCIP data from Premier Inc’s quality center. Data was obtained from 398 hospitals within the Premier network and
represents all discharges meeting inclusion criteria for SCIP measures between July 2006 and March 2008. Inclusion criteria were defined by the SCIP guidelines in effect at the time of discharge (Centers for Medicare & Medicaid Services 2009). No exclusions in addition to those used by SCIP were used in the construction of our initial study group.

To quantify discharge-level adherence, we generated composite scores for all infection prophylaxis (INF) SCIP measures, all venous thromboembolism (VTE) SCIP measures, and all collected (GLOBAL) SCIP measures. In addition, a composite score was developed from discharges that had data available for SCIP_INF_1, SCIP_INF_2 and SCIP_INF_3 (INF-Core) (Table 1). We then investigated the association between discharge-level adherence on each of these composite scores with our eight outcomes of interest (Table 2). These complication codes were chosen because they represent surgical complications reported in the literature to have the highest prevalence (Dimick, Pronovost et al. 2003). The study protocol and waiver of informed consent were reviewed and approved by the Institutional Review Board (IRB) of Case Western Reserve University.

**DATA SOURCE**

The Health Insurance Portability and Accountability Act (HIPAA)-compliant (OCR 2007) Premier Perspectives Database (Premier 2009), an inpatient database developed and maintained by Premier Inc. (Charlotte, NC) for quality and utilization benchmarking was used for this study. The administrative extract-based database contains 100% of the discharge data from over 500 acute-care hospitals representing approximately one
of every five discharges in the United States. Patient-level data undergo 95 separate quality assurance and data-validation checks before they are made available for research. The SCIP quality data was also obtained from Premier Inc. and represented data from all 398 hospitals which utilize Premier Inc. as their data vendor for submission of SCIP data. (Premier 2009)

**Patient Population**

Data was obtained from Premier Perspectives™ Database for discharges meeting inclusion criteria for at least one SCIP quality measure between July 1, 2006 and March 31, 2008. Item-level SCIP data was aggregated to the discharge level and merged with administrative discharge-level data. We identified and merged information for 405,720 discharges from all 398 hospitals representing all regions of the country.

**Development of Dependent Variables**

ICD9 codes were used to identify complications. All outcome measures are dichotomous all-or-none complication scores developed for discharge-level analyses. Complication codes indicated as being present on admission, the primary, or the admitting diagnosis were excluded. A list of ICD9 codes used for each outcome is provided in Table 2.

**COMP** – Represents any discharge carrying one of the three-digit category codes indicating either a medical or surgical complication occurred due to the care a patient received. There are certain specific exclusions, as detailed in the ICD9 code manual (Centers for Medicare & Medicaid Services 2009).
**RESP** – Represents any discharge carrying a respiratory complication code with the exception of those specifically due to a tracheostomy procedure or an aspiration pneumonia that occurred during a vaginal delivery.

**WOUND** – Represents any discharge carrying a cellulitis or abscess diagnosis other than when the cellulitis or abscess occurred on the finger or toe. SCIP exclusion criteria have already excluded patients with a primary diagnosis or procedure suggestive of a preoperative infection (Centers for Medicare & Medicaid Services 2009).

**VTE** – Represents any discharge carrying a diagnosis of venous thromboembolism of any location with the exception of those present on admission or when used as the primary diagnosis.

**Po_INF, Po_PE, Po_CVA, Po_MI** – Represent any discharge carrying a diagnosis of postoperative infection, pulmonary embolism, cerebral vascular accident or myocardial infarction designated on discharge as being due to the procedure or operation, respectively.

**Development of SCIP Composites**

Four SCIP composite measures were developed to represent discharge-level adherence to the nine currently collected SCIP measures (Table 1): INF-core, INF, VTE, and GLOBAL. Development of each of these is described below and was described in greater detail in Chapter 4. Briefly, these measures are all-or-none measures of discharge-level adherence able to assume the value of zero or one.
**INF** – represents all patients with at least two recorded infection-prevention measures in a single visit. Discharges where all infection-prevention measures collected were also received achieved a value of one.

**INF-Core** – represents only patients with all three original Surgical Infection Prevention (SIP) project perioperative infection-prevention measures (Bratzler and Houck 2005; Bratzler and Hunt 2006). Discharges where all three SIP measures were collected and all three processes were appropriately received were assigned a value of one.

**VTE** – represents only patients with both venous thromboembolism prevention measures were collected in a single visit. Discharges where both venous thromboembolism-prevention measures were also received achieved a value of one.

**GLOBAL** – represents all patients with at least two SCIP measures collected during a visit. Discharges where all SCIP measures that were collected were also received achieved a score of one.

**Patient Measures**

Data was available for patient age, gender, race, marital status, admission type, and insurance status. We accounted for patients in the following age categories: 18 to 34 years of age, 35 to 54, 55 to 64, 65-74, 75-84, and 85 years and older. Race was grouped as White, Black and Other. Approximately 65% of the population self-reported as White, 10% as Black. We grouped all others in the Other category. Approximately half of the population was married, and all others were classified as non-married.
Admission type was documented by hospitals on the UB92 discharge forms as elective, urgent or emergent. Premier Inc. collects data on 100% of discharges from participating hospitals and therefore has information on all patients and all payers. We aggregated the health insurance information into 5 categories: Medicare, Medicaid, Commercial Insurers, Government Insurers and Uninsured. Diagnosis and procedure information was available through International Classification of Disease 9th edition (ICD9) codes. In addition to the All Payer Refined-Diagnosis Related Group (APR-DRG) Risk of Mortality (ROM) provided by Premier Inc., we calculated a Charlson Comorbidity Index (CCI) for each discharge to assess the effect of comorbidities using two independent methodologies. The CCI was calculated based on the original description by Charlson et al (Charlson, Pompei et al. 1987), with the adaptation to an ICD9 algorithm described by Deyo, et al (Deyo, Cherkin et al. 1992; Quan, Sundararajan et al. 2005). Diagnoses that were listed as primary, admitting or directly related to the primary procedure were not used in development of the CCI in order to identify comorbid conditions, rather than conditions leading to hospital admission.

Both the CCI and APR-DRG ROM are shown in the descriptive analysis (Table 3); however, only the APR-DRG ROM was used in the multivariable analysis because the APR-DRG ROM explained a greater proportion of the variation than the CCI. Further, the APR-DRG ROM is more familiar to hospital administrators, as it is widely used within hospital databases.


**Hospital Measures**

Hospital size (small, medium and large), hospital setting (rural or urban), hospital teaching status and location (North, South, East, West) were provided in the administrative extract. Other variables such as hospital and surgical volume were not provided, as Premier Inc. does not permit identification of participating hospitals.

**Analysis**

Chi-squared tests were used to compare discharges with and without complications to unadjusted discharge-level performance scores, patient characteristics, operative characteristics and hospital characteristics. Patients with one or more complication were compared to patients without any complications for all discharge-level analyses. We used hierarchical (multilevel) multivariable analyses to study the effect of discharge-level adherence to SCIP process measures with adjustments for the surgical procedure performed, patient characteristics and hospital characteristics. These multilevel analyses make use of statistical techniques that adjust for the clustering of patients within hospitals. Thirty-two unique models were developed to test the independent effect of each SCIP composite measure with each postoperative complication.

Data management and univariate analyses were performed using SAS V9.1 (SAS institute Inc., Cary, NC). Hierarchical nonlinear multivariable modeling was performed using HLM6 (Scientific Software International, Lincolnwood, IL). A p-value of less than 0.05 was considered statistically significant for all analyses.
RESULTS

Of the 519,156 unique discharges carrying SCIP data that were collected by Premier Inc. during our study period, 405,720 discharges were successfully matched to the administrative discharge-level data. Of the 517 hospitals which utilize Premier Inc.’s services for SCIP data reporting, 398 had at least 25 discharges with SCIP data and are included in our analysis. The reasons for this 20% decrease are currently unknown, but they are believed to be due to issues related to data processing by the vendor, Premier Inc.. They are currently investigating this drop on our behalf, and an update will be issued once their investigation of this issue is complete. We do not have any reason to believe that this drop in sample size is biased in such a way as to affect the findings of this analysis.

Face Validity of ICD-9 Complication Codes

Face validity of the ICD-9 Complication Codes was investigated through complication-specific and procedure-specific stratifications to determine if the documented complication rates were indeed associated with high-risk operative procedures and increased length of stay, as expected. The average length of stay for all patients was 5.8 days [median 4 days, standard deviation (SD) = 7.7 days]; however, those without a recorded complication had an average length of stay of 4.9 [median 3 days, SD = 5.8 days], and those with a recorded complication averaged 11.6 days [median 8 days, SD = 14.1 days]. Further, patients with a documented postoperative infection had an average length of stay of 20.0 days [median 15, SD = 17.8 days]
compared to 5.7 days [median 4, SD = 7.4 days] for those without a recorded postoperative infection, suggesting that only patients with severe postoperative infections have their infections documented on discharge. The assumption that more severe postoperative infections are more likely to be recorded would also explain the lower-than-expected rate (Dimick, Chen et al. 2004).

Procedure-specific stratification showed similar variations in complication rates to that which is reported in the literature. Patients undergoing colorectal surgery procedures experienced an overall complication rate of 27.2% and a postoperative infection rate of 4.6%, which were both significantly (p<0.001) higher than the average for the population [12.8% overall complication rate and 1.1% postoperative infection rate]. Patients undergoing minor gynecologic procedures, by contrast, had an overall complication rate of 5% and a postoperative infection rate of less than 0.1%.

Finally, it would be expected that medical and surgical complications would be related to patient characteristics such as age, comorbidity index and admission type. All eight complications studied were positively and strongly associated with increasing scores on both the CCI and the APR-DRG ROM. The relationship was typically logarithmic with a 10-fold increase in complication prevalence with each increase in one’s APR-DRG ROM. As an example, the prevalence of postoperative myocardial infarction was 0.5% for those at minor risk, 3.0% for those at moderate risk, 6.5% for those at major risk and 8.6% for those at extreme risk. A patient’s age was positively and strongly associated with their risk of postoperative stroke and postoperative
myocardial infarction, as would be expected, and patients who were admitted emergently had an increased association with all complications studied.

Given that what we observed is what we expected, we felt that the ICD-9 based complications provided reasonable face validity to proceed with our planned analysis. There is an assumed underreporting of minor complications, and we therefore compare complication rates between groups rather than relying on absolute complication rates.

**Patient Characteristics**

Population characteristics are summarized in Table 3. Of the 405,720 discharges meeting our inclusion criteria, 152,460 (37.6%) were men, 140,964 were between 45 and 64 years old (34.7%), 207,348 (51.1%) were married, 185,432 (45.7%) were covered by Medicare and 278,535 (68.7%) were White (Table 3). Further, 273,308 (67.8%) were elective cases, 49,384 (12.3%) were operations performed urgently and 80,444 (20.0%) were performed emergently. Over half (57.1%) of discharges identified were from medium-sized hospitals (100-300 beds) in the South (55.5%).

After stratifying the population by our complication variables, it was noted that patients experiencing complications were significantly different than those not experiencing complications with respect to several variables. As would be expected, patients with documented complications were more likely to be older, to have at least one comorbidity and to have been operated on emergently. All patient characteristics with the exception of marital status (p = 0.003) were statistically significant in their ability to predict complications with p<0.001. Further, all available hospital
characteristics were statistically significantly associated with the likelihood of a complication prior to discharge. Unadjusted complication rates were highest in large, urban, teaching hospitals, and complication rates by geographic region varied based on the complication studied. These findings can be found in Appendix A.

**SCIP Adherence**

Overall adherence at the individual discharge level for each of our composite measures ranged from 67.7% to 82.7% (see Table 3). A significant number of discharges were noted to have only one recorded SCIP measure (120,316), and the majority of these discharges (119,456) recorded only SCIP-INF-6: which measures appropriate hair removal. Univariate analyses demonstrated that in almost every combination of SCIP adherence and complication investigated, adherence was statistically significantly associated with decreased complication rates (Tables 4a and 4b). Most notably, 11% of discharges with documented adherence to the two SCIP VTE process measures had a recorded complication, while 18% of those without documented SCIP VTE adherence had experienced a complication (Table 4a). Further, while 0.5% of patients meeting adherence requirements for our SCIP INF-Core measure had a documented postoperative infection, more than twice as many discharges (1.15%) without documented adherence to SCIP INF-Core had a postoperative infection (Tables 4b).
Relationship Between SCIP Adherence and Risk-Adjusted Complication Rates

In 20 of the 32 associations studied, non-adherence to SCIP measures was associated with an increase in risk-adjusted complication rates (Table 5). Notable exceptions were seen in our investigation of postoperative stroke (Po_CVA) and postoperative myocardial infarctions (Po_MI). In addition, our WOUND and VTE measures showed mixed results depending on the SCIP composite used.

Patients without documented receipt of all recommended SCIP processes as measured through our GLOBAL composite measure had an 8% increased likelihood of having a complication after adjusting for patient severity of illness, patient demographics, the procedure performed, hospital characteristics and insurance status [Adjusted Odds Ratio (AOR) = 1.08, 95% Confidence Interval (CI) = 1.05 – 1.11]. Using the same adjustments, adherence to SCIP VTE measures showed a non-statistically significant association with respiratory complication rates [AOR = 1.05, 95%-CI = 0.96 – 1.14], and failure to demonstrate adherence on our SCIP INF-Core composite measure was associated with a 16% increase in the likelihood of a postoperative infection [AOR = 1.16, 95%-CI = 1.02 – 1.33] after all adjustments. Paradoxically, non-adherence on our GLOBAL composite was associated with a decreased risk of postoperative myocardial infarction [AOR = 0.92, 95% CI = .86 – 0.98], and non-adherence on INF-Core was associated with a decreased risk of postoperative stroke [AOR = 0.73, 95% CI = 0.56 – 0.95]. (Table 5)
**Discussion**

Even though SCIP measures are broadly integrated into hospital quality-measurement efforts across the United States, the association between reported discharge-level adherence and complication rates is unknown. We investigated this relationship through development of four composite measures and eight complication measures and hypothesized that adherence to SCIP measures would be associated with decreased complication rates across all eight measures.

In general, our findings confirm our hypothesis, and reported complication rates were statistically significantly higher in patients who did not receive SCIP processes after controlling for patient characteristics, procedure performed, insurance status, comorbidities and hospital characteristics. Exceptions to this pattern were seen in four complication measures: WOUND, VTE, Po_CVA and Po_MI. The association between both WOUND and VTE complication metrics with our four composite measures was mixed, which likely represents variations and inaccuracies in the ICD-9 complication rates. One study that formally estimated the positive predictive value and sensitivity of ICD-9 coded venous thromboembolism found this to be a poor measure complicated by thromboses present on admission yet unrecognized (Leibson, Needleman et al. 2008). It is quite possible that our WOUND measure suffers similarly from an underlying multi-peak distribution.

SCIP measures were designed to reflect discrete aspects of care delivery rather than assessing global quality; however, our measures of postoperative stroke (Po_CVA)
and postoperative myocardial infarction (Po_MI) were intended to assess the element of SCIP adherence reflective of improved overall quality. Current SCIP measures focus on infection and venous thromboembolism prevention, which would not inherently be predictive of postoperative heart attack or stroke risk. Yet, through public reporting of procedure-specific hospital performance of these metrics, adherence on SCIP processes is a proxy of overall quality. If SCIP adherence were truly aligned with improved overall quality, we would expect the unmeasured acts in higher quality centers to decrease a patient’s risk of preventable outcomes. Our intent when including the Po_CVA and Po_MI metrics was to investigate this hypothesis.

The association between SCIP non-adherence and postoperative stroke appears mixed and neutral, suggesting that the majority of stroke variation is captured in independent variables other than the processes measured. However, the negative association between SCIP adherence and postoperative myocardial infarctions may suggest that patients receiving all SCIP processes have their unmeasured processes neglected. An over-emphasis on demonstrating SCIP adherence could lead to a relative under-emphasis on other best practices, suggesting an unintended consequence of measuring discrete processes. However, due to the low rates of both postoperative myocardial infarctions and strokes, these two measures may contain a higher level of “unavoidable” complications which would be by definition not related to the quality of care one receives. These points can certainly be debated, and further study of this finding is warranted.
No studies currently exist evaluating the effect of SCIP performance on clinical outcomes at the national level. A handful of single-institution evaluations have been presented at national conferences, and each of these has failed to find a positive effect associated with SCIP adherence (El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). This has led the authors of the above-referenced studies to conclude that adherence to SCIP measures is not associated with improved complication rates; however, our study refutes their conclusion. These measures have been strongly linked to patient outcomes in clinical trials and are considered by many to be in line with clinical best-practices, but we must keep in mind that the complication rates studied are likely to be influenced by many factors independent of these measures. The measurement of these discrete processes as proxies for overall quality has yet to be established. Proponents of the SCIP measurement process are claiming to demonstrate a 25% reduction in complication rates over 5 years (Bratzler and Hunt 2006); however, our findings suggest a more modest decrease (less than 10%).

Several limitations to our study should be noted. First, ICD9 complication codes recorded on administrative discharge records have debatable sensitivity and positive predictive value (Lawthers, McCarthy et al. 2000; McCarthy, Iezzoni et al. 2000; Wolff, Starfield et al. 2002; Leibson, Needleman et al. 2008; Olsen, Lefta et al. 2008), and the magnitude of our associations may be minimized by the inaccuracy of our outcome measures. Studying multiple complications was undertaken to limit our focus on specific associations and refocus us on general patterns and trends across multiple
associations. The limitations of specific ICD9-coded complications were demonstrated through our WOUND and VTE measures, but our validation attempts prior to the full analysis strengthen our belief in the measures of overall complication rate (COMP), postoperative infection (Po_INF) and respiratory complications (RESP). Further, the rates of postoperative myocardial infarction and postoperative stroke seen in our administrative data are similar to rates reported in the literature. Finally, while further validation of this methodology is warranted, many authors have used ICD-9-based complication rates in publications in reputable journals, which demonstrates a precedence for their use (Wolff, Starfield et al. 2002; Delaney, Chang et al. 2008).

Secondly, although use of the Premier Perspectives™ Dataset allowed us to do a unique analysis at the patient level, the rates of adherence to quality measures may not be reflective of the rest of the country. Hospitals participating in the Premier Inc. system may, on average, be more dedicated to improving the quality of their hospital. Therefore, the rates of adherence may be higher in our sample population than seen on the Hospital Compare website, which represents all participating hospitals (Services 2008). More research is needed to determine if the SCIP-adherence rates applied to hospitals are associated with decreased complication rates at the hospital level.

Despite these limitations, our study demonstrates that the publicly reported adherence to SCIP process measures is associated with improved patient outcomes. A strong and statistically significant association between increased adherence to SCIP with
a decrease in the likelihood of a postoperative complication suggests that patients can use reported rates of adherence to choose high-quality providers.
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<tbody>
<tr>
<td>SCIP Card 2</td>
<td>Surgery Patients on Beta-Blocker Therapy Prior to Admission Who Received a Beta-Blocker During the Perioperative Period.</td>
<td>Surgery patients on beta-blocker therapy prior to admission who receive a beta-blocker during the perioperative period.</td>
</tr>
<tr>
<td>SCIP INF 1</td>
<td>Prophylactic Antibiotic Received Within One Hour Prior to Surgical Incision</td>
<td>Number of surgical patients who received prophylactic antibiotics within one hour prior to surgical incision (two hours if receiving vancomycin)</td>
</tr>
<tr>
<td>SCIP INF 2</td>
<td>Prophylactic Antibiotic Selection for Surgical Patients.</td>
<td>Number of surgical patients who received prophylactic antibiotics recommended for their specific surgical procedure.</td>
</tr>
<tr>
<td>SCIP INF 3</td>
<td>Prophylactic Antibiotics Discontinued Within 24 Hours After Surgery End Time.</td>
<td>Number of surgical patients whose prophylactic antibiotics were discontinued within 24 hours after surgery end time (48 hours for CABG or Other Cardiac Surgery).</td>
</tr>
<tr>
<td>SCIP INF 4</td>
<td>Cardiac Surgery Patients With Controlled 6 A.M. Postoperative Blood Glucose.</td>
<td>Surgery patients with controlled 6 A.M. blood glucose (≤ 200 mg/dL) on POD 1 and POD 2.</td>
</tr>
<tr>
<td>SCIP INF 6</td>
<td>Surgery Patients with Appropriate Hair Removal.</td>
<td>Surgery patients with surgical site hair removal with clippers or depilatory or with no surgical site hair removal.</td>
</tr>
<tr>
<td>SCIP INF 7</td>
<td>Colorectal Surgery Patients with Immediate Postoperative Normothermia.</td>
<td>Surgery patients whose first recorded temperature was greater than or equal to 96.8°F within the first fifteen minutes after leaving the operating room.</td>
</tr>
<tr>
<td>SCIP VTE 1</td>
<td>Surgery Patients with Recommended Venous Thromboembolism Prophylaxis Ordered.</td>
<td>Surgery patients with recommended venous thromboembolism (VTE) prophylaxis ordered anytime from hospital arrival to 48 hours after Surgery End Time.</td>
</tr>
<tr>
<td>SCIP VTE 2</td>
<td>Surgery Patients Who Received Appropriate Venous Thromboembolism Prophylaxis Within 24 Hours Prior to Surgery to 24 Hours After Surgery</td>
<td>Surgery patients who received appropriate venous thromboembolism (VTE) prophylaxis within 24 hours prior to Surgical Incision Time to 24 hours after Surgery End Time.</td>
</tr>
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# Table 2

Outcome Measures: ICD9 Code-Based Complication Composites

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
<th>ICD9 Codes Used</th>
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<tbody>
<tr>
<td>COMP</td>
<td>Any iatrogenic complication</td>
<td>996.x, 997.x, 998.x, 999.x</td>
</tr>
<tr>
<td>RESP</td>
<td>Any iatrogenic respiratory complication</td>
<td>997.3, 512.1, 415.11, 668.0, 518.5, 518.4, 518.5</td>
</tr>
<tr>
<td>WOUND</td>
<td>Any cellulitis or abscess (other than the finger or toe)</td>
<td>682.x</td>
</tr>
<tr>
<td>VTE</td>
<td>Any venous thromboembolism</td>
<td>451.11, 451.19, 451.2, 453.8</td>
</tr>
<tr>
<td>Po-INF</td>
<td>Postoperative infection</td>
<td>998.59</td>
</tr>
<tr>
<td>Po_PE</td>
<td>Postoperative pulmonary embolism</td>
<td>415.11</td>
</tr>
<tr>
<td>Po_MI</td>
<td>Postoperative myocardial infarction</td>
<td>997.1</td>
</tr>
<tr>
<td>Po_CVA</td>
<td>Postoperative cerebral vascular attack</td>
<td>997.02</td>
</tr>
</tbody>
</table>

Footnote:
- An x in the ICD9 code indicates that any number can occur at that location.
- When an ICD9 code appeared as the primary diagnosis or admitting diagnosis, it was not considered a complication but an indication for care.
# Table 3 - Unadjusted and Unweighted Population Distributions: Adherence to SCIP Measures, Patient Characteristics and Hospital Characteristics by Outcome

<table>
<thead>
<tr>
<th>Discharge-level SCIP Adherence</th>
<th>405,720 Total Discharges</th>
<th>Population</th>
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<tr>
<td></td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td><strong>INF-Core</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>44,417</td>
<td>22.9%</td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>154,963</td>
<td>77.1%</td>
</tr>
<tr>
<td><strong>INF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>59,356</td>
<td>28.0%</td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>158,304</td>
<td>72.0%</td>
</tr>
<tr>
<td><strong>VTE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>29,433</td>
<td>17.3%</td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>143,495</td>
<td>82.7%</td>
</tr>
<tr>
<td><strong>GLOBAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>90,412</td>
<td>32.3%</td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>194,992</td>
<td>67.7%</td>
</tr>
</tbody>
</table>

### Patient Characteristics

#### Admission Type

- Emergent: 80,444 (20.0%)
- Urgent: 49,384 (12.3%)
- Elective: 273,308 (67.8%)

#### Age

- 18 - 24 years old: 14,147 (3.5%)
- 25 - 44 years old: 73,328 (18.1%)
- 45 - 64 years old: 140,964 (34.7%)
- 65 - 74 years old: 86,273 (21.3%)
- 75 - 84 years old: 69,316 (17.1%)
- 85+ years old: 21,692 (5.4%)

#### Charlson Comorbidity Index

- Charlson Score = 0: 277,330 (68.4%)
- Charlson Score = 1: 69,209 (17.1%)
- Charlson Score = 2+: 59,181 (14.6%)

#### APR Mortality Risk

- 1 – Minor: 262,769 (64.8%)
- 2 – Moderate: 86,933 (21.4%)
- 3 – Major: 36,833 (9.1%)
- 4 – Extreme: 19,107 (4.7%)

#### Gender

- Female: 253,257 (62.4%)
- Male: 152,460 (37.6%)

#### Marital Status

- Not-Married: 198,317 (48.9%)
- Married: 207,348 (51.1%)

#### Insurance Status

- Medicare: 185,432 (45.7%)
- Medicaid: 31,301 (7.7%)
- Commercial: 158,404 (39.1%)
- Uninsured: 13,661 (3.3%)
- Governmental/Other: 16,874 (4.2%)

#### Race

- White: 278,535 (68.7%)
- Black: 43,954 (10.8%)
- Other: 83,154 (20.5%)

### Hospital Characteristics (398 Hospitals)

#### Hospital Size

- Small (<100 beds): 20,218 (5.0%)
- Medium (100 - 300 beds): 231,530 (57.1%)
- Large (>300 beds): 153,972 (38.0%)

#### Geographic Region

- Midwest: 62,512 (15.4%)
- Northeast: 41,882 (10.3%)
- South: 225,174 (55.5%)
- West: 76,152 (18.8%)

#### Teaching Status

- No: 277,067 (68.3%)
- Yes: 128,653 (31.7%)

#### Location

- Rural: 77,301 (19.1%)
- Urban: 328,419 (81.0%)
Table 4a. Unadjusted Distributions: Association between Adherence to SCIP Measures and Complication Rates

Complication Rates by Adherence to SCIP Measures

- GLOBAL
- GLOBAL (Non-Adherence)
- INF-Core
- INF-Core (Non-Adherence)
- INF
- INF (Non-Adherence)
- VTE
- VTE (Non-Adherence)
Table 4b. Unadjusted Distributions: Association between Adherence to SCIP Measures and Complication Rates

![Complication Rates by Adherence to SCIP Measures](image)

<table>
<thead>
<tr>
<th></th>
<th>WOUND</th>
<th>VTE</th>
<th>RESP</th>
<th>Po_Inf</th>
<th>Po_CVA</th>
<th>Po_MI</th>
<th>Po_PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL</td>
<td>1.0%</td>
<td>1.1%</td>
<td>4.5%</td>
<td>0.93%</td>
<td>0.23%</td>
<td>2.51%</td>
<td>0.18%</td>
</tr>
<tr>
<td>GLOBAL (Non-Adherence)</td>
<td>1.1%</td>
<td>1.3%</td>
<td>5.7%</td>
<td>1.59%</td>
<td>0.25%</td>
<td>2.48%</td>
<td>0.23%</td>
</tr>
<tr>
<td>INF-Core</td>
<td>0.4%</td>
<td>0.6%</td>
<td>3.3%</td>
<td>0.53%</td>
<td>0.21%</td>
<td>2.55%</td>
<td>0.17%</td>
</tr>
<tr>
<td>INF-Core (Non-Adherence)</td>
<td>0.7%</td>
<td>1.0%</td>
<td>4.6%</td>
<td>1.15%</td>
<td>0.18%</td>
<td>2.29%</td>
<td>0.22%</td>
</tr>
<tr>
<td>INF</td>
<td>0.5%</td>
<td>0.8%</td>
<td>4.1%</td>
<td>0.68%</td>
<td>0.24%</td>
<td>2.72%</td>
<td>0.19%</td>
</tr>
<tr>
<td>INF (Non-Adherence)</td>
<td>0.8%</td>
<td>1.1%</td>
<td>5.7%</td>
<td>1.42%</td>
<td>0.28%</td>
<td>2.93%</td>
<td>0.22%</td>
</tr>
<tr>
<td>VTE</td>
<td>0.6%</td>
<td>0.8%</td>
<td>2.8%</td>
<td>0.99%</td>
<td>0.09%</td>
<td>1.01%</td>
<td>0.20%</td>
</tr>
<tr>
<td>VTE (Non-Adherence)</td>
<td>1.3%</td>
<td>1.3%</td>
<td>5.5%</td>
<td>2.26%</td>
<td>0.13%</td>
<td>1.31%</td>
<td>0.27%</td>
</tr>
</tbody>
</table>
Table 5. Adjusted Odds Ratios: Non-Adherence to SCIP Measures by Outcome

Ability of Non-Adherence on SCIP Measures to Predict Complications
Adjusted Odds Ratios
### Appendix A. Unadjusted Proportional Distributions: Adherence to SCIP Measures, Operative Characteristics, Patient Characteristics and Hospital Characteristics by Outcome

<table>
<thead>
<tr>
<th>Discharge-level SCIP Adherence</th>
<th>Overall Rate</th>
<th>COMP</th>
<th>Resp</th>
<th>Po_INF</th>
<th>Po_MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>INF-Core</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>14.9%</td>
<td>4.6%</td>
<td>1.15%</td>
<td>2.29%</td>
<td></td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>10.3%</td>
<td>3.3%</td>
<td>0.53%</td>
<td>2.55%</td>
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</tr>
<tr>
<td>INF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>16.5%</td>
<td>5.7%</td>
<td>1.42%</td>
<td>2.93%</td>
<td></td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>11.9%</td>
<td>4.1%</td>
<td>0.68%</td>
<td>2.72%</td>
<td></td>
</tr>
<tr>
<td>VTE</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>18.1%</td>
<td>5.5%</td>
<td>2.26%</td>
<td>1.31%</td>
<td></td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>11.0%</td>
<td>2.8%</td>
<td>0.99%</td>
<td>1.01%</td>
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</tr>
<tr>
<td>GLOBAL</td>
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<td></td>
</tr>
<tr>
<td>Did not receive all recommended care</td>
<td>16.8%</td>
<td>5.7%</td>
<td>1.59%</td>
<td>2.48%</td>
<td></td>
</tr>
<tr>
<td>Received All Recommended Care</td>
<td>13.2%</td>
<td>4.5%</td>
<td>0.93%</td>
<td>2.51%</td>
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#### Patient Characteristics

<table>
<thead>
<tr>
<th>Admission Type</th>
<th>Overall Rate</th>
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<th>Resp</th>
<th>Po_INF</th>
<th>Po_MI</th>
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<td>Emergent</td>
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<tr>
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<tr>
<td>Elective</td>
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</tr>
<tr>
<td>Age</td>
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</tr>
<tr>
<td>18 - 24 years old</td>
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<td>25 - 44 years old</td>
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<tr>
<td>45 - 64 years old</td>
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<td>65 - 74 years old</td>
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<td>75 - 84 years old</td>
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<td>Charlson Comorbidity Index</td>
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<td>1 - Minor</td>
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<td>3 - Major</td>
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<td>4 - Extreme</td>
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<tr>
<td>Other</td>
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#### Hospital Characteristics (398 Hospitals)

<table>
<thead>
<tr>
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<th>COMP</th>
<th>Resp</th>
<th>Po_INF</th>
<th>Po_MI</th>
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<tbody>
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<td>Small (&lt;100 beds)</td>
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<tr>
<td>Medium (100 - 300 beds)</td>
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<tr>
<td>Large (&gt;300 beds)</td>
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<td>Geographic Region</td>
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<td>West</td>
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<td>Teaching Status</td>
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<td>Urban</td>
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</tbody>
</table>

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


**Literature Cited**


13. Nguyen N, Yegiyants S, Kaloostian C, Abbas MA, Difronzo LA. The Surgical Care Improvement project (SCIP) initiative to reduce infection in elective colorectal


CHAPTER 4

RISK-ADJUSTED SURGICAL MORTALITY RATES AND ADHERENCE TO SURGICAL CARE IMPROVEMENT PROJECT MEASURES
ABSTRACT

INTRODUCTION

Although the Surgical Care Improvement Project (SCIP) measures are based on best-practices recommendations, the relationship between publicly reported adherence to these measures and outcomes such as surgical mortality is unknown.

METHODS

Using data from Premier Inc. for January 2006 through March 2008, we examined mortality among 450,720 patients from 398 hospitals who underwent a surgical procedure meeting inclusion criteria for at least one of the nine currently reported SCIP measures. Using nested regression models, we examined the relationship between surgical mortality and each of measure-specific adherence, condition-specific adherence, and overall adherence to SCIP measures, after adjusting for patient- and hospital-level attributes.

RESULTS

Adherence to SCIP measures was inversely related to surgical mortality for six of the nine individual measures [P<0.01 for all six] and not related to the other three. The Adjusted Odds Ratios (AOR) when modeling the increased risk associated with non-adherence for the six measures varied from 1.81 [95%-Confidence Interval (CI) 1.44-2.29] for cardiac surgery patients without a controlled 6 A.M. postoperative blood glucose, to an AOR=1.17 [95%-CI, 1.04-1.37] for surgery patients who did not receive
appropriate venous thromboembolism prophylaxis within the 24-hour window either before or after surgery. We developed four composite measures to assess systematic adherence to quality practices, and all were statistically significant in their inverse associations with mortality rate: Non-adherence predicted increased mortality rates with an AOR=1.19 [95%-CI=1.04-1.37] for the core infection-prevention measures, AOR=1.15 [95%-CI=1.04-1.27] for all infection-prevention measures, AOR=1.18 [95%-CI=1.05-1.32] for all venous thromboembolism-prevention measures and an AOR=1.20 [95%-CI=1.11-1.29] for our GLOBAL composite measure.

**Conclusions**

For most currently reported SCIP measures, adherence is strongly and significantly associated with decreased patient mortality. Patients can improve their chances of survival by selecting providers who consistently adhere to the publicly reported perioperative practices measured by SCIP.
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INTRODUCTION

Quality of Health Care in the United States has been shown by numerous studies to be imbalanced and often inadequate (Ayanian, Weissman et al. 1998; Chassin and Galvin 1998; Institute of Medicine (U.S.). Committee on Quality of Health Care in America. 2001; McGlynn, Asch et al. 2003; Jha, Li et al. 2005; Asch, Kerr et al. 2006). In an effort to decrease variation and improve overall quality, the Centers for Medicare & Medicaid Services (CMS), in conjunction with other for-profit and not-for-profit stakeholders, started participating in the Hospital Quality Alliance (HQA) (HQA 2005). One of the central tenants of HQA is making performance information available to the public via Medicare’s Hospital Compare website (Services 2008). The website encourages patients to use the publicly reported performance scores to choose high-quality hospitals and is based on the assumption that performance on the reported measures is indeed a sign of higher quality care. However, it is unknown if adherence to these measures is related to overall quality (2005; Bratzler and Hunt 2006). Despite this, CMS provides the financial incentives for reporting, and the Joint Commission requires reporting for most U.S. hospitals to achieve accreditation (Williams, Schmaltz et al. 2005; Services 2008).

Early studies of data reported on the Hospital Compare website suggest that the quality measures offer very little information from which to inform patient decisions (Werner and Bradlow 2006; Fonarow 2007; Birkmeyer and Dimick 2008); however, none of these early studies investigated the effect of the surgical quality
measures. After some early setbacks, there are currently nine measures of surgical quality reported on the Hospital Compare website. These measures were developed through efforts of the Surgical Care Improvement Project (SCIP) (Bratzler 2006; Bratzler and Hunt 2006; Services 2008).

To date, there are no large, nationally representative evaluations of the reported SCIP measures. To fill this gap in the literature, we undertook a comprehensive evaluation of the risk of surgical mortality associated with non-adherence to best-practices procedures as measured through SCIP in a large, nationally representative population of patients. We had two primary aims: to assess the association between adherence on individual SCIP measures and surgical mortality and to assess the association between measures of systematic adherence to quality practices and surgical mortality. We hypothesized that reported adherence to SCIP measures would be associated with improved outcomes, as evidenced by an associated decrease in risk-adjusted mortality rates.

**Methods**

**Overview**

Patients meeting inclusion criteria for SCIP at the time of their discharge were identified by Premier Inc. Quality Center and sent to the various hospitals for collection of the numerator and denominator of each individual measure. Sampling of patients in hospitals large enough to submit a sample rather than complete extracts was performed
by Premier Inc. to avoid bias. Exclusion criteria for SCIP measures evolved over the study period, and our sample will be reflective of the appropriate population based on the recommendations in place at the time of discharge. We added no additional exclusion criteria to those found in the SCIP specifications manual. The study protocol and waiver of informed consent were reviewed and approved by the institutional review board of Case Western Reserve University.

**Patient Population and Data Sources**

We obtained 100 percent of the Premier Inc. Quality Center data for discharges meeting inclusion criteria for at least one SCIP measure between July 1, 2006 and March 31, 2008. The Premier Perspectives™ Database, which contains hospital-discharge abstracts for all patients from all Premier Network participating hospitals, was combined with the quality data to create our main data sets for analysis. Item-level SCIP data were aggregated to the discharge level and merged with administrative discharge-level data so that quality scores could be applied to an individual discharge. We identified and merged data for 405,720 discharges from 398 hospitals from all regions of the country.

**Defining Surgical Mortality**

For the purposes of this study, mortality was defined as any inpatient mortality or discharge to hospice, which we termed surgical mortality. Because Premier releases only de-identified patient-level data, it was not possible for us to identify patient mortality occurring within 30 days after hospital discharge. Therefore, we included
discharges to hospice in our definition of mortality in order to include those at highest risk for death within 30 days of discharge. Further, whether or not the patient expired within the walls of the hospital was deemed less relevant than the recognition that the surgical procedure resulted in imminent death. A sensitivity analysis was performed by running both univariate and multivariable statistics with and without the hospice-discharge patients within the mortality definition. There were no differences in the magnitude or direction of any relationships studied. Nearly identical results were achieved with both methods; however, the sample size for surgical mortality with the inclusion of hospice patients was slightly greater, yielding tighter confidence intervals.

In our data, there were 1,433 patients (17%) discharged to hospice and 6,954 (83%) patients who expired while in the hospital. Therefore, we had 8,387 patients who met our criteria for surgical mortality.

**Development of SCIP Composites**

Each of the nine SCIP measures can take on the value of either zero or one. A value of one indicates that a patient received the care, and a value of zero indicates that they did not receive the care although they were eligible. Not all patients are eligible for all measures, and when a patient is ineligible for a given measure, it is recorded as missing. Four SCIP composite measures were developed to represent discharge-level adherence: **INF-core**, **INF**, **VTE** and **GLOBAL**. These measures were also developed as all-or-none measures of discharge-level adherence able to assume the value of zero or one. In developing these composite measures, our intention was to assess systematic
adherence to quality practices which may be distinct from high adherence to a single measure. Multiple measures have been developed to assess infection prophylaxis, for example, because it is recognized that multiple actions influence infection prevention and that each measure assesses only a discrete unit of care. Although the available measures certainly do not cover all discrete elements of infection prophylaxis, requiring that a composite measure for an individual reflects best practices on more than one discrete measure can help us better approximate the systems of care. To determine how many discrete elements to require in a composite measure, we calculated changes in the discharge-level adherence rate and sample size as the required number of SCIP measures per patient increased (Figure 1). As can be seen in the figure, the adherence rate is stable from a requirement of two measures through a requirement of six measures. The only difference came in the decreasing sample size from which we would be identifying systematic adherence. From this analysis, it was determined that each composite measure would require a minimum of two individual SCIP measures.

Three composite measures were developed using this method: **INF** represents all patients with at least two recorded infection-prevention measures in a single visit, **VTE** represents patients with both venous thromboembolism-prevention measures, and **GLOBAL** represents all patients with any two SCIP measures collected during a visit. We also developed one additional measure of adherence, **INF-Core**, which requires that all three Surgical Infection Prevention (SIP) project measures were collected during a single visit (Bratzler and Houck 2005; Bratzler and Hunt 2006). As these three measures are
applicable to all surgical patients and are the only measures supported by published scientific literature attesting to their effectiveness, the performance of this composite measure can be used to gauge the relative magnitude of effect from the other composite measures.

**Measures of Patient and Hospital Characteristics**

We adjusted the analysis to account for characteristics of both patients and hospitals. The characteristics of the patient for which we adjusted included age (using the following categories: 18-24, 25-44, 45-64, 65-74, 75-84, 85+), gender, race (White, Black, Other), marital status (married and not), procedure performed (using the procedural grouping information used with these measures for reporting and tracking purposes by The Joint Commission and CMS (Centers for Medicare & Medicaid Services 2009)), whether the procedure was performed electively (Elective, Urgent, Emergent) and insurance status (Medicare, Commercial, Medicaid, Uninsured, Government/Other). Diagnosis and procedure information was identified using the appropriate International Classification of Disease 9th Edition (ICD9) codes. We explored two alternative approaches to the incorporation of data on coexisting conditions for the purposes of risk adjustment. In addition to the All Payer Refined-Diagnosis Related Group (APR-DRG) Risk of Mortality (ROM) provided at the discharge level by Premier Inc., we calculated a weighted Charlson Comorbidity Index (CCI) for each discharge. The CCI was calculated based on the original description by Charlson et al. (Charlson, Pompei et al. 1987) with the adaptation to an ICD9 algorithm described by Deyo, et al. (Deyo, Cherkin et al. 1992)
and the updates suggested by Quan (Quan, Sundararajan et al. 2005) that account for coding updates in ICD9 since the index was originally described. Any diagnosis that was listed as the primary or admitting diagnosis, or if it was directly related to the primary procedure, was not included in the calculation of CCI to isolate truly comorbid conditions.

Both the CCI and APR-DRG ROM are shown in the descriptive analysis; however, only the APR-DRG ROM was used in the multivariable analysis to avoid colinearity. The APR-DRG ROM and CCI behaved virtually identically in both univariate and multivariable models; however, the variation explained by the APR-DRG ROM was greater than that of the CCI. Thus, our adjusted odds ratios are shown using the APR-DRG ROM for risk adjustment.

Consistent with previous research to study surgical mortality (Birkmeyer and Dimick 2008), the characteristics of the hospital for which we adjusted included hospital size (small, medium and large), hospital setting (rural or urban), hospital teaching status and location (North, South, East, West). Other variables such as hospital and surgeon volume were not available, and Premier Inc. does not permit identification of participating hospitals.

Analysis

We computed unadjusted discharge-level proportions of patient characteristics and hospital characteristics and compared proportional differences by discharge status using chi-squared tests. Separate hierarchical (multilevel) multivariable models were
used to determine each adjusted odds ratio (AOR) with accompanying 95% Confidence Intervals (95%-CI) of discharge-level adherence to SCIP process measures with adjustments for the surgical procedure performed, patient characteristics and hospital characteristics as described above. Each relationship between an individual SCIP measure or composite SCIP measure with surgical mortality was derived after development of a unique nested model for the study of that specific association.

Data management and univariate analyses were performed using SAS V9.1 (SAS institute Inc., Cary, NC). Hierarchical nonlinear multivariable modeling was performed using HLM6 (Scientific Software International, Lincolnwood, IL), and weighted estimates were applied at the discharge level to approximate the population of the United States. A p-value of less than 0.05 was considered statistically significant for all analyses, and all tests were two-sided.

**RESULTS**

**PATIENT CHARACTERISTICS**

The characteristics of the study population are presented in Table 1. A total of 405,720 patients from 398 Premier network hospitals met inclusion criteria for at least one SCIP measure between July 2006 and March 2008. Overall, the surgical mortality rate was 2.1% (8,387 patients), with over half of these deaths occurring in patients operated on emergently (4,687 patients, mortality rate = 5.8%). The surgical mortality rate for elective cases was 0.8% (2,143 patients). Surgical mortality increased
significantly with age (0.4% in patients 25 to 44 years of age, compared with 6.8% in patients 85 years of age or older). Mortality also varied by sex and race, with higher rates for men than for women (2.4% vs. 1.6%, respectively) and for Blacks than for Whites (2.4% vs. 2.0%). Both measures of comorbidity risk assessment showed to be significantly associated with increased mortality in a dose-response fashion. When using the CCI, the rate of mortality increased from 0.8% in patients with a score of zero to 7.6% in patients with a score greater than or equal to two. Similarly, the rate of mortality increased from 0.1% to 27.8% in patients with an APR-DRG ROM of one and four, respectively.

**SCIP Adherence**

Item-level adherence rates varied from 79.9% for SCIP INF 7 to 94.4% for SCIP INF 6 and are shown in Table 2. Respectively, these measures represent whether there is documented evidence that colorectal surgery patients achieved postoperative normothermia within 15 minutes of leaving the operating room and whether surgery patients received appropriate hair removal prior to surgery. In all cases except for our composite measure of venous thromboembolism (VTE) prophylaxis, our composite measures of systematic SCIP adherence were significantly lower than that of the individual item-adherence scores. The lack of a decrease in adherence on the VTE composite when compared to SCIP VTE 2 suggests that both measures are evaluating the same underlying behavior.
When investigating performance by surgical mortality, the non-adherence rate was shown to be consistently higher and often more than twice as high in the surgical mortality group across all individual and composite SCIP measures (p<0.001 for all measures except SCIP INF 6 where p=0.006) (Table 2). Patients did not receive prophylactic antibiotics within one hour of incision in 8.6% of discharges from the hospital, yet 19.5% of patients experiencing surgical mortality were not given appropriately timed antibiotics. Similarly, while 11.5% of cardiac surgery patients who were discharged from the hospital did not have controlled 6 A.M. blood glucose, 19.6% of cardiac surgery patients who died had non-adherent care. The only measure not following this pattern was SCIP INF 6, which showed improved adherence to appropriate hair-removal practices in the patients that died. However, as a population of patients, those experiencing operative mortality were clearly exposed to an inferior level of perioperative care.

**Relationship Between SCIP Adherence and Risk-Adjusted Surgical Mortality Rates**

After adjusting for comorbidities, patient and hospital characteristics and the procedure performed, non-adherence to three SCIP measures no longer predicted increased operative mortality: SCIP INF 3 (discontinuation of prophylactic antibiotics within 24 hours after surgery end time), SCIP INF 6 (appropriate hair removal), and SCIP INF 7 (colorectal patients achieving immediate normothermia). Non-adherence on all other individual and composite SCIP measures remained statistically significantly
associated with an increased likelihood of operative mortality (Table 3). The strength of this association varied from an adjusted odds ratio of 1.17 (95%-CI=1.05-1.31) for SCIP VTE 2 (reception of VTE prophylaxis within the 48 hours surrounding the operative procedure) to 1.81 (95%-CI=1.44-2.29) for SCIP INF 4 (cardiac surgery patients achieving controlled postoperative blood glucose levels).

Adherence on all four composite measures was inversely related to risk-adjusted surgical mortality. Our measure of overall adherence (GLOBAL) was associated with a 20% increase in a patient’s likelihood of surgical mortality when there was a lack of documented adherence to recommended SCIP procedures. The strength of association between non-adherence and surgical mortality was consistent across all four measures varying from 1.15 (INF) to 1.20 (GLOBAL) and was always statistically significant (P<0.05). (Table 3)

**Discussion**

Given our large sample size and the generalizability of estimates using projected weights with the Premier Perspectives™ data, we were able to investigate the relationship between SCIP-measure adherence and surgical mortality with a high level of precision. All four composite measures suggested that adherence to SCIP process measures was associated with a decrease in surgical mortality. Six of the nine individual SCIP measures demonstrated the same statistically significant association, and the other three measures showed no statistically significant association between adherence and mortality.
Our findings are particularly relevant for policymakers deciding which measures to endorse and for hospital quality officers working to increase adherence to SCIP measures among their physicians and staff. Internal debates at our own hospital as well as discussions on the SCIP-user support listserv suggest that significant resistance still exists in attempts to achieve high levels of measure adherence. In particular, physicians often request proof that adherence on average is truly associated with improved patient outcomes – which this study now demonstrates. Additionally, recent findings presented at national conferences and in the published literature from single-institution studies are suggesting that improved adherence on the SCIP measures is not associated with improved outcomes, which has led some to believe that the same is true at the national level (El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). However, our findings refute the findings of these smaller studies on six of the nine individual measures and on all of our composite measures.

It is not surprising that some individual SCIP measures are more strongly associated with mortality than others. SCIP measures were developed to reflect evidence-based health care practices known to prevent surgical complications; however, the strength of the association between the underlying process and surgical mortality is variable and documented for each measure (Optimal Solutions Group 2009). Further, the ability of SCIP measures to assess the true underlying adherence to these guidelines is unknown, and SCIP adherence is not necessarily equivalent to best practices. To design a performance measure for which 100% adherence is the goal
would require that the measure itself be 100% accurate – free from inappropriate or unnecessary inclusion or exclusion criteria and universally applicable. In medicine, this is an impossible standard. The final decision of patient care rests in the hands of the physician, and therefore, some of the non-adherence may be in line with best practices.

This is the first study to suggest that a statistically significant relationship between reported adherence to SCIP measures and surgical mortality exists on a national level. Previous studies have measured the various actions underlying the SCIP measures that can be used to validate the efficacy of the underlying processes but not necessarily the effectiveness of the measure (Optimal Solutions Group 2009). Studies that have attempted to study SCIP-measure effectiveness by investigating the association between adherence and complication rates have concluded that adherence to these SCIP measures is not associated with improved outcomes (Hawn, Itani et al. 2008; Nguyen, Yegiyants et al. 2008; El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). Our findings are in contrast with that of previous studies, but our study differs in two important ways. First, our sample size is large enough to study rare outcomes, and previous studies were likely under-powered. Second, all prior studies were single-institution studies, which may have important differences in the underlying reasons for non-adherence compared to our multi-institution approach. For example, if the hospital internally evaluating SCIP measures is a center of excellence, their non-adherent practices may be primarily composed of decisions made in the best interests of the patient that for one reason or another are not captured appropriately by the SCIP
inclusion and exclusion criteria – a factor of an imperfect measurement tool rather than an inappropriate medical decision.

Our study has several important limitations. First, because we used Premier Perspectives™ data, our patients were restricted to hospitals within the Premier network. These hospitals may represent a cohort of hospitals which more highly value quality measurement and quality adherence, and therefore, our estimates of national adherence rates may be higher than true national estimates. However, although patient-level adherence rates cannot be determined using data from the Hospital Compare website, SCIP-performance data is publicly reported, our hospital-level performance-rate estimates were similar to those on the website. Secondly, although our study was large, some of the subgroups within the item-level analyses were based on small numbers of patients when considering our outcome of mortality. In particular, the number of surgical mortalities that exists in young patients undergoing elective procedures will be very small. Thus, our findings may be less relevant to this patient population. Third, our analysis is reliant on accurate coding of procedure, diagnosis and adherence, and errors in coding would add to the imprecision of our estimates. However, there is no reason to think that the errors in coding would be biased. Coding errors should simply add noise to our estimates. In addition, our ability to assess mortality is likely to be highly accurate, and the results show good face validity, attesting to a reasonably high level of accurate documentation. Fourth, use of Premier Perspectives™ data did not allow for estimates of hospital and surgeon volume. These
rates were therefore unable to be used in our adjusted models of surgical mortality despite their known association.

Finally, our ability to perform adequate risk adjustment using administrative data may be questioned by readers, and this argument would suggest that only clinical studies are appropriate in estimating the strength of the SCIP adherence-outcome relationship. Unfortunately, development of a large enough clinical study would be exceedingly expensive and furthermore could artificially inflate adherence rates due to the special nature of clinical studies. Clinical studies have already demonstrated the efficacy of the underlying procedures, and therefore, this study is designed to assess the effectiveness of the measurement enterprise as much as the measurement efficacy.

Our findings have direct implications for ongoing quality measurement initiatives, because publicly reporting quality data using current methods consumes an enormous amount of hospital resources. Although CMS has already incorporated a 2% Medicare payment bonus to participating hospitals, the ability of the surgical-quality measures to perform their stated purpose of assisting patients in selection of high-quality hospitals was yet unknown. Our analysis confirms that patients with demonstrated receipt of the perioperative processes dictated by most of the SCIP measures have a lower mortality rate, on average, than those who do not. Our findings further suggest that patients in an environment that systematically adheres to the procedures set forth by SCIP measures have consistently lower mortality rates. These findings provide impetus for hospitals and providers to improve their adherence to SCIP.
processes for the betterment of their patients, and the findings provide patients with evidence suggesting they are better off choosing providers that consistently adhere to the SCIP measures.

Policymakers should note the differences in predictive power of the various individual SCIP measures. Variation in adherence evaluated by the two measures of venous thromboembolism prophylaxis was exceedingly small, indicating these two measures do not reflect separate processes. Our composite measure, which required adherence to both measures, only differed from SCIP VTE 2 by two patients. This suggests that the resources allocated to collecting data for both VTE measures might be better utilized elsewhere, as little additional information is obtained by collecting both measures separately. Further, measures that were shown to be unrelated to surgical mortality may not be worth funding for future data collection without refinement. Finally, reporting of SCIP adherence may be better suited to composite measures rather than individual measures, as the composite measures demonstrated increased stability. A global measure of overall quality practices that spans across the numerous discrete elements of care may be particularly helpful for patients deciding on a location for their surgical procedure.

Future studies should investigate whether the publicly reported rates, which are only available at the hospital level, are associated with improved surgical mortality. The variations apparent on the Hospital Compare website may be too narrow, and the level of the hospital may be too broad, to be associated with clinically meaningful differences
in mortality rate. Nevertheless, the measures themselves are predictive, which should help administrators and quality directors change the behavior of providers reluctant to adhere to the SCIP processes.
Figure 1. The Effect on SCIP Adherence Rate Measured by GLOBAL and Denominator Size as the Number of Measures per Discharge is Increased.
Table 1. Unadjusted and Unweighted Characteristics of Patients Meeting Inclusion Criteria for Surgical Care Improvement Project (SCIP) Measurement by Discharge Status.

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Discharged to Home or Step Down</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n     (%)</td>
<td>n     (%)</td>
</tr>
<tr>
<td>Overall</td>
<td>397,252 (97.9%)</td>
<td>8,387 (2.1%)</td>
</tr>
</tbody>
</table>

### Admission Type
- Emergent: 75,753 (94.2%)
- Urgent: 47,881 (97.0%)
- Elective: 271,160 (99.2%)

### Age
- 18 - 24 years old: 14,115 (99.8%)
- 25 - 44 years old: 139,081 (98.7%)
- 45 - 64 years old: 64,653 (96.2%)
- 65 - 74 years old: 84,235 (97.6%)
- 75 - 84 years old: 66,653 (96.2%)
- 85+ years old: 20,224 (93.2%)

### Charlson Comorbidity Index
- Charlson Score = 0: 275,234 (99.2%)
- Charlson Score = 1: 67,417 (97.4%)
- Charlson Score = 2+: 54,666 (92.4%)

### APR Mortality Risk
- 1 - Minor: 262,565 (99.9%)
- 2 - Moderate: 86,023 (99.1%)
- 3 - Major: 34,770 (94.4%)
- 4 - Extreme: 13,794 (72.2%)

### Gender
- Female: 249,128 (98.4%)
- Male: 148,186 (97.2%)

### Marital Status
- Not-Married: 193,273 (97.5%)
- Married: 203,992 (98.4%)

### Insurance Status
- Medicare: 179,169 (96.6%)
- Medicaid: 30,843 (98.5%)
- Commercial: 157,192 (99.2%)
- Uninsured: 13,408 (98.2%)
- Governmental/Other: 16,657 (98.7%)

### Race
- White: 272,828 (98.0%)
- Black: 42,916 (97.6%)
- Other: 81,500 (98.0%)

### Hospital Characteristics (398 Hospitals)

<table>
<thead>
<tr>
<th>Hospital Size</th>
<th>Discharged to Home or Step Down</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (&lt;100 beds)</td>
<td>20,018 (99.0%)</td>
<td>200 (1.0%)</td>
</tr>
<tr>
<td>Medium (100 - 300 beds)</td>
<td>226,985 (98.0%)</td>
<td>4,535 (2.0%)</td>
</tr>
<tr>
<td>Large (&gt;300 beds)</td>
<td>150,314 (97.6%)</td>
<td>3,655 (2.4%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geographic Region</th>
<th>Discharged to Home or Step Down</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>61,423 (98.3%)</td>
<td>1,089 (1.7%)</td>
</tr>
<tr>
<td>Northeast</td>
<td>40,832 (97.5%)</td>
<td>1,050 (2.5%)</td>
</tr>
<tr>
<td>South</td>
<td>220,251 (97.8%)</td>
<td>4,914 (2.2%)</td>
</tr>
<tr>
<td>West</td>
<td>74,811 (98.2%)</td>
<td>1,337 (1.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Status</th>
<th>Discharged to Home or Step Down</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>271,625 (98.0%)</td>
<td>5,430 (2.0%)</td>
</tr>
<tr>
<td>Yes</td>
<td>125,692 (97.7%)</td>
<td>2,960 (2.3%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharged to Home or Step Down</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>75,859 (98.1%)</td>
<td>1,442 (1.9%)</td>
</tr>
<tr>
<td>Urban</td>
<td>321,458 (97.9%)</td>
<td>6,948 (2.1%)</td>
</tr>
</tbody>
</table>

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

**Differences between population distributions by outcomes were all statistically significant to p<0.0001**
<table>
<thead>
<tr>
<th>SCIP Process of Care Measures</th>
<th>Overall (Non-adherence)</th>
<th>Discharge to Home or Step Down (Non-adherence)</th>
<th>Mortality (Non-adherence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIP Card 2</td>
<td>11.0%</td>
<td>10.9%</td>
<td>17.4%</td>
</tr>
<tr>
<td>SCIP INF 1</td>
<td>8.7%</td>
<td>8.6%</td>
<td>19.5%</td>
</tr>
<tr>
<td>SCIP INF 2</td>
<td>6.0%</td>
<td>5.9%</td>
<td>12.2%</td>
</tr>
<tr>
<td>SCIP INF 3</td>
<td>13.3%</td>
<td>13.2%</td>
<td>22.9%</td>
</tr>
<tr>
<td>INF-Core</td>
<td>22.3%</td>
<td>22.1%</td>
<td>38.2%</td>
</tr>
<tr>
<td>SCIP INF 4</td>
<td>11.7%</td>
<td>11.5%</td>
<td>19.6%</td>
</tr>
<tr>
<td>SCIP INF 6</td>
<td>5.6%</td>
<td>5.6%</td>
<td>4.9%</td>
</tr>
<tr>
<td>SCIP INF 7</td>
<td>20.1%</td>
<td>19.9%</td>
<td>27.0%</td>
</tr>
<tr>
<td>INF</td>
<td>27.3%</td>
<td>27.1%</td>
<td>41.4%</td>
</tr>
<tr>
<td>SCIP VTE 1</td>
<td>13.5%</td>
<td>13.3%</td>
<td>26.6%</td>
</tr>
<tr>
<td>SCIP VTE 2</td>
<td>17.0%</td>
<td>16.7%</td>
<td>35.1%</td>
</tr>
<tr>
<td>VTE</td>
<td>17.0%</td>
<td>16.7%</td>
<td>35.1%</td>
</tr>
<tr>
<td>GLOBAL</td>
<td>31.7%</td>
<td>31.5%</td>
<td>42.3%</td>
</tr>
</tbody>
</table>

*The performance (or SCIP adherence) rate is the inverse of the percentage noted.

**All comparisons were statistically significant at p<0.0001 with the exception of SCIP INF 6 where p=0.006
<table>
<thead>
<tr>
<th><strong>SCIP Process of Care Measures</strong></th>
<th><strong>Mortality</strong>&lt;sup&gt;^&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCIP Card 2</strong></td>
<td>Surgery Patients on Beta-Blocker Therapy Prior to Admission Who Received a Beta-Blocker During the Perioperative Period.</td>
</tr>
<tr>
<td><strong>SCIP INF 1</strong></td>
<td>Prophylactic Antibiotic Received Within One Hour Prior to Surgical Incision</td>
</tr>
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</tr>
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<td><strong>SCIP INF 3</strong></td>
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</tr>
<tr>
<td><strong>INF-Core</strong></td>
<td>Patients meeting inclusion for SCIP INF 1, 2 and 3</td>
</tr>
<tr>
<td><strong>SCIP INF 4</strong></td>
<td>Cardiac Surgery Patients With Controlled 6 A.M. Postoperative Blood Glucose.</td>
</tr>
<tr>
<td><strong>SCIP INF 6</strong></td>
<td>Surgery Patients with Appropriate Hair Removal.</td>
</tr>
<tr>
<td><strong>SCIP INF 7</strong></td>
<td>Colorectal Surgery Patients with Immediate Postoperative Normothermia.</td>
</tr>
<tr>
<td><strong>INF</strong></td>
<td>Patients meeting inclusion for at least 2 INF measures</td>
</tr>
<tr>
<td><strong>SCIP VTE 1</strong></td>
<td>Surgery Patients with Recommended Venous Thromboembolism Prophylaxis Ordered.</td>
</tr>
<tr>
<td><strong>SCIP VTE 2</strong></td>
<td>Surgery Patients Who Received Appropriate Venous Thromboembolism Prophylaxis Within 24 Hours Prior to Surgery to 24 Hours After Surgery</td>
</tr>
<tr>
<td><strong>VTE</strong></td>
<td>Patients meeting inclusion for both VTE measures</td>
</tr>
<tr>
<td><strong>GLOBAL</strong></td>
<td>Patients meeting inclusion for at least 2 SCIP measures</td>
</tr>
</tbody>
</table>

<sup>^</sup>Modeling likelihood of mortality given non-adherence to SCIP measure, using projected United States population weighting and APR-DRG Risk of Mortality to account for Co-morbidities

**A nested model was used to control for patient age, gender, race, co-morbidities, procedure performed, admission type, marital status, insurance type, as well as hospital characteristics of teaching status, setting, size and geographic area.**


CHAPTER 5

MOST VULNERABLE PATIENTS ARE LEAST LIKELY TO
RECEIVE APPROPRIATE PERIOPERATIVE SERVICES
ABSTRACT

INTRODUCTION

Although health care disparities in general are well documented, the extent to which quality of perioperative surgical care varies among patient subgroups is unknown. Our objective was to determine which patient subgroups were most likely to receive poor-quality perioperative care.

METHODS

Using data from Premier Inc. for all discharges between January 2006 and March 2008, we identified 285,404 patients and conducted a hierarchical analysis of the patient characteristics associated with variations in adherence to Surgical Care Improvement Project (SCIP) best practice recommendations. All-or-none composite scores were generated to represent adherence to the three original infection-prevention measures (INF-Core), all current infection prevention measures (INF), venous thromboembolism prophylaxis measures (VTE), and all SCIP measures (GLOBAL). Using projection-weighted hierarchical logistic modeling, we controlled for hospital characteristics while examining the relationship between patient characteristics and guideline-adherent perioperative care.

RESULTS

The most significant associations to overall adherence were found with the type of admission [GLOBAL AOR=0.65, 95% Confidence Interval (95%-CI) 0.61-0.69 for
emergent and AOR=0.82, 95%-CI 0.75-0.90 for urgent admissions, when compared to elective admissions in patients under 65) and the presence of two or more Charlson comorbid conditions [GLOBAL AOR=0.76, 95%-CI=0.72-0.80, when compared to none in patients 65 and older]. Adherence to VTE was more sensitive to patient characteristics than INF and INF-Core measures, and the adjusted-odds ratio (AOR) for receipt of venous thromboembolism prophylaxis varied widely by age, type of admission, gender, insurance status and presence of coexisting conditions. Race was not associated with variations in the care they received. Male patients and those who were uninsured were significantly less likely than their female counterparts and those with health insurance to receive VTE prophylaxis [AOR=0.79, 95%-CI=0.74-0.85, and AOR=0.71, 95%-CI=0.63-0.80, respectively]. Patients 85 and older were less likely to receive guideline-adherence infection prevention, yet they were more likely to receive venous thromboembolism prevention [INF-Core AOR=0.83, 95%-CI=0.78-0.89, VTE AOR=1.05, 95%-CI=0.97-1.15].

Conclusions

Patients that are uninsured, admitted emergently, and have coexisting conditions represent the most vulnerable patient subgroups and are the least likely to receive appropriate perioperative care. Adherence to best practices needs to become more systematic in order to provide high-quality care to all patient subgroups.
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INTRODUCTION

Disparities in adherence to best practices are documented for patients of different ages, genders and races, but the majority of these studies focus on the primary care setting (Kohn, Corrigan et al. 2000; Evans 2001; Institute of Medicine (U.S.) Committee on Quality of Health Care in America. 2001; McGlynn, Asch et al. 2003; Adams, Greiner et al. 2004; Williams, Schmaltz et al. 2005; Asch, Kerr et al. 2006; Polk, Birkmeyer et al. 2006). Evidence exists to suggest that the disparities seen in outpatient medical care also exist with inpatient surgical care, but this has primarily been demonstrated through higher surgical mortality rates (Bach, Cramer et al. 1999; Lucas, Stukel et al. 2006; Birkmeyer and Dimick 2008; Halm, Tuhrim et al. 2009). In the book Challenging Inequities in Health, the authors discuss how to judge the equity of apparent variations in health outcomes (Evans 2001). They remind us that there are not only avoidable and unavoidable causes of health-outcome variation, but that there are also acceptable and unacceptable causes. For this, it is important to understand the causes of the documented variations in surgical mortality (Birkmeyer and Dimick 2008). Dr. McGlynn and colleagues document significant deficiencies in adherence to basic processes of care in the United States (U.S.), which they assert pose significant risk to the health of Americans (McGlynn, Asch et al. 2003; Asch, Kerr et al. 2006). However, the extent of adherence to basic processes of perioperative care and the understanding of which patients are at greatest risk for receipt of poor-quality care are currently unknown.
In an effort to improve the overall quality of care for patients undergoing surgical procedures in the United States (U.S.), the Hospital Quality Alliance (HQA), a collaborative effort of several national stakeholders, adopted the Surgical Care Improvement Project (SCIP) measures of perioperative care. Hospital-level performance on nine processes, intended to be reflective of evidence-based best practices, is publicly reported via the Center for Medicare & Medicaid’s (CMS) Hospital Compare website (Services 2008). In previous studies, we have demonstrated that documented adherence to SCIP is associated with decreased postoperative complication rates and decreased surgical mortality (Chapters 2 and 3, respectively). However, it is unknown whether adherence to these guideline-based best practices is equivalent across patient subgroups. Therefore, we designed a cross-sectional study, using patient-level SCIP data on 285,404 patients from 398 hospitals to determine which patients were at greatest risk for receiving poor care.

**Methods**

We obtained item-level SCIP data for all discharges between July 1, 2006 and March 31, 2008 from Premier Inc. (Charlotte NC), and we merged this with the Premier Perspectives™ administrative dataset. From this merged file, we identified 285,404 discharges meeting specifications for our four composite measures that measure system-level adherence to best practices. The construction and validation of these measures was presented previously, and a brief description is provided below. Using
this merged dataset, we investigated patient characteristics predictive of variations in adherence to best practices.

**DATA SOURCES**

Although made available to researchers, the Premier Perspectives™ database is an administrative database collected and maintained by Premier Inc. for quality and utilization benchmarking purposes (Premier 2009). Patient-level data go through 95 quality-assurance and data-validation checks before being released to researchers, and the SCIP item data is submitted to CMS and the Joint Commission for publication as hospital performance scores on their websites. The data submitted to Joint Commission is further used for accreditation purposes for most hospitals in the U.S. (Commission 2008). We obtained data from 100% of discharges between January 2006 and March 2008 meeting the inclusion criteria for at least one SCIP measure.

**PATIENT POPULATION**

Patient- and discharge-level criteria for inclusion in an individual SCIP measure was determined by Premier prior to data collection, and we applied no exclusion criteria in addition to those recommended by the specification documentation for SCIP measures (Centers for Medicare & Medicaid Services 2009). We identified 285,404 discharges meeting inclusion criteria for at least one of our composite measures. A discharge must have data from a minimum of two separate SCIP items in order to meet inclusion criteria for our composite measures, which are described further below. No
exclusions were applied during the development of our sample population that exceeded those applied by the SCIP specification manual and applied at the time of data collection (Centers for Medicare & Medicaid Services 2009).

We investigated the effects of patient age, gender, race, marital status, admission type and insurance status on provider adherence to best practices while accounting for hospital characteristics. We studied age effects using the following age categories: 18 to 34 years of age, 35 to 54, 55 to 64, 65-74, 75-84 and 85 years and older. We grouped Race into three categories: White, Black and Other. Just over half of the population was married, and all others, including those who were divorced, widowed and separated, were classified as non-married. We used admission type as documented by hospitals on the UB92 discharge forms: Elective, Urgent or Emergent. Because Premier Inc. collects data on 100% of discharges from participating hospitals and therefore has information on all patients and all payers, we were able to aggregate the health-insurance information into 5 categories: Medicare, Medicaid, Commercial Insurers, Government Insurers and Uninsured. Diagnosis and procedure data were available through International Classification of Disease 9th edition (ICD9) codes and all primary and secondary diagnoses were included within our data extract. We used the definitions of comorbid disease defined in the Charlson Comorbidity Index (CCI) to create a count of comorbid diseases. This count was calculated based on the original description by Charlson et al. (Charlson, Pompei et al. 1987), with the adaptation to an ICD9 algorithm described by Deyo, et al. (Deyo, Cherkin et al. 1992; Quan, Sundararajan
et al. 2005). In order to identify comorbid conditions, rather than conditions leading to hospital admission, diagnoses that were listed as primary, admitting or directly related to the primary procedure were not used in development of our CCI count. Interactions between the CCI and SCIP adherence were first analyzed through assumption that the Charlson score was a continuous variable, and then we used it as a categorical variable with three categories: 0, 1 and 2+.

Premier provides four hospital-level variables: Hospital Size (grouped as small, medium and large referring to hospitals with less than 100 beds, between 100 and 300 beds or more than 300 beds, respectively), Geographic Region (categorized as Midwest, Northeast, South and West), Teaching Status (given as a yes or no variable) and Location (grouped into Urban or Rural). The majority of patients reporting SCIP data in the Premier dataset were from non-teaching, medium-sized hospitals in the South, and they were located in an urban setting. However, Premier worked with the CMS in development of a projection-weighting variable to be used to adjust their sample of patients to be representative of the U.S. population. Both our univariate and multivariable analyses used the projection weighting provided by Premier to make our results more generalizable.

**SCIP Composite Measures**

Individual SCIP items are designed to measure discrete elements of perioperative practices that have been demonstrated in the published literature to be associated with improved outcomes (Bratzler and Hunt 2006; Centers for Medicare & Medicaid Services
Our composite measures (INF-Core, INF, VTE & GLOBAL) are aggregates of multiple SCIP measures designed to approximate systematic adherence to quality practices (Nolan and Berwick 2006). Each composite measure is an all-or-none variable able to assume the value of zero or one. A value of one is achieved when all elements of perioperative best practices are adhered to, and a value of zero is therefore assigned if any process is neglected for which that patient was eligible. INF-Core requires that a patient be eligible for all three original Surgical Infection Prevention (SIP) measures (prophylactic antibiotic given within one-hour of incision, prophylactic antibiotic stopped within 24 hours after the operation and the appropriate prophylactic antibiotic given for the procedure) (Bratzler 2006). INF, VTE and GLOBAL measures require that a patient be eligible for two each of the infection prevention, venous thromboembolism prevention or any SCIP measures, respectively. Development of composites measures in this fashion has been shown to assess quality practices with the same validity obtained when requiring up to six measures without decreasing reliability (see Chapter 3).

Our primary outcome of interest was overall adherence to perioperative best practices as measured by GLOBAL. We further investigated the condition-specific practices through development of INF-Core, INF and VTE. These four measures were developed and validated in previously in chapters 2 and 3, but we describe their development briefly here.

**Analysis**
All data management and univariate analyses were performed using SAS V9.1 (SAS institute Inc., Cary, NC). Hierarchical nonlinear multivariable modeling was performed using HLM6 (Scientific Software International, Lincolnwood, IL). A p-value of less than 0.05 was considered statistically significant for all analyses. Chi-squared tests were used to compare patient characteristics to unadjusted discharge-level adherence. Because it was felt that patients under the age of 65 may be treated differently in the United States (U.S.) health care system than patients 65 years and older, due to older patients’ ability to qualify for Medicare, we created two cohorts. Very few (353) patients were uninsured in the 65 and older cohort, and given the special nature of circumstances for which a patient would be over the age of 65 and uninsured, we eliminated them prior to multivariable analysis to avoid confounding our main effects. To isolate the effects of individual patient characteristics on SCIP adherence, a unique nested logistic model was developed for each composite measure. These multilevel analyses make use of statistical techniques that adjust for the clustering of patients within hospitals. Therefore, each adjusted-odds ratio has been adjusted by all other patient-level characteristics in addition to hospital size, hospital location, hospital teaching status and geographic region. The multilevel analysis was weighted using patient-level projections to approximate the population of the U.S.

RESULTS

CHARACTERISTICS OF STUDY POPULATION
Table 1 presents the characteristics of the study population. There were 285,404 patients in our sample, 50.7% (147,282 patients) of the population was below the age of 65, with the majority (107,448 patients, 72.95% of the cohort) of those under 65 between the ages of 45 and 64. Seventy percent (201,224 patients) of the entire sample was White, 28,548 (10.0 %) patients were Black and the rest we classified as Other (55,574 patients, 19.5% of the population). Patients under the age of 65 were more likely than those over 65 to be Black (13.1% vs. 6.7%) and female (64.6% vs. 57.3%). Although 15.3% (43,736 patients) of the entire population had two or more coexisting conditions, this reflected 9.6% (14,188 patients) of the younger cohort and 21.4% (29,548 patients) of the older cohort. The 65+ cohort was nearly twice as likely (20.8% vs. 12.8%) to have been admitted emergently. Nine percent of our under-65 cohort were on Medicaid, and 4.6% were uninsured.

Overall, 77.7% of eligible patients received all three original SIP measures when eligible for all three (INF-Core), 72.7% of patients received all recommended infection prophylaxis measures (INF), 83.0% of patients received all recommended venous thromboembolism prophylaxis (VTE) and 68.3% received all recommended perioperative care for which they were eligible (GLOBAL). Data on adherence rates by patient characteristics within each of our cohorts is presented in Table 2. Receipt of appropriate care varied greatly by age across all four composite measures. The youngest patients (18-24 year olds) and the oldest patients (85 + years old) were consistently the least likely to receive recommended preventive care. Patients admitted
emergently were consistently about 10% less likely to receive appropriate care compared to their elective counterparts. This disparity was greatest for our VTE measure in the under 65 cohort which was 22% less likely to receive guideline-based care (62.9% of emergent admissions vs. 85.3% of elective admissions). Wide variations in adherence were also seen in patient cohorts based on presence of comorbidities. Patients with two or more coexisting Charlson conditions were between 7% and 13% less likely to receive appropriate care (61.4% vs. 68.2% for under-65-year-old patients on GLOBAL, and 70.3% vs. 83.0% for under-65-year-old-patients on the VTE measure). Very little variation was observed by gender or marital status. Men tended to be 2% to 5% less likely to receive appropriate care compared to women, and those who were married tended to be 1% to 3% more likely to receive appropriate care compared to their unmarried counterparts.

Insurance status did play a bigger role in patients under the age of 65 and was a primary consideration for division of our patient population into two cohorts. Ninety percent of the 65 and older cohort was enrolled in Medicare, with 7.5% of the remaining patients enrolled in a commercial plan. The variation in care among these older patients was at times quite large (51% of the uninsured vs. 71% of Medicare patients receive appropriate infection prevention in the over-65 age group), but we are hesitant to suggest meaning behind these variations given the likelihood of confounding in this select population. Variation in insurance status for the under-65 cohort, on the other hand, showed variation to a much lesser degree. In general, patients with insurance
were more similar to each other than to uninsured patients, with the greatest variation occurring in rates of venous thromboembolism prophylaxis.

**Adjusted Relationships to Perioperative Best Practices**

Figure 1 demonstrates the ability of each patient characteristic to predict adherence on each of the four composite measures through adjusted-odds ratios (AOR) for those under the age of 65, and Figure 2 demonstrates relationships in the 65 and older cohort. All AORs are adjusted for the other patient characteristics shown in addition to hospital size, location, teaching status and geographic region.

In the younger cohort, the variations seen in adherence rates with respect to Marital Status and Race were eliminated after adjusting for other patient and hospital factors. Consistent with the univariate analysis, males were shown to be less likely to receive all infection and all venous thromboembolism prophylaxis (AOR=0.92, 95%-CI=0.87-0.98 for INF and an AOR=0.76, 95%-CI=0.69-0.84 for INF), although both effect sizes were relatively small, and there was no gender difference noted for our INF-Core and GLOBAL measures. Lack of insurance was significantly associated with poor care with regards to VTE prophylaxis, but there was no statistically significant difference based on insurance status for infection prophylaxis (VTE AOR = 0.78, 95%-CI = 0.69-0.87, vs. INF AOR=0.97, 95%-CI=0.83-1.07). The variations seen in univariate analysis were explained by other patient characteristics. The largest predictors of poor care were seen in patient age, admission type and presence of coexisting conditions.
Increasing age was associated with a stepwise increase in the likelihood that the patient would receive appropriate venous thromboembolism prophylaxis, with 18- to 24-year-olds one-third as likely, and 25-44 year olds two-thirds as likely compared to 45 to 65 year olds (AOR=0.42, 95%-Confidence Interval (CI)=0.36-0.48, and AOR=0.72, 95%-CI=0.67-0.78, respectively). Inferior performance for the 18- to 24-year-old patients was also observed in infection-prevention measures and our GLOBAL measure (INF-Core AOR=0.48, 95%-CI=0.39-0.60, INF AOR=0.53, 95%-CI=0.44-0.64, GLOBAL AOR=0.55, 95%-CI=0.49-0.61) but did not continue into the older age groups. Infection-prevention practices were equivalently adhered to for all patients 25 years of age and older.

The largest effects of poor adherence can be seen in patients who were admitted emergently. Patients admitted emergently or urgently are approximately one third as likely to receive VTE processes when compared to their elective surgical patient counterparts (AOR=0.28, 95%-CI=0.26-0.31 and AOR=0.47, 95%-CI=0.39-0.56 for Emergent and Urgent, respectively). A similar trend of deficient adherence was seen for infection-prevention measures, with emergent admissions less likely than urgent and much less likely than elective admissions to receive appropriate care (Figure 1).

Finally, the presence of two or more comorbid Charlson conditions was significantly associated with decreased adherence to fundamental processes of care as measured by all four composite measures. The presence of one coexisting condition did not appear to effect receipt of appropriate care for the younger cohort. The presence of two or more conditions predicted that a patient was nearly half as likely to receive
appropriate VTE and INF measures. A similar association to comorbid conditions was present in the older cohort as well.

The older cohort demonstrated a similar risk profile to that seen in the younger cohort but with a few important differences. The overwhelming majority of patients were enrolled in Medicare, and therefore, our estimates of the effects of insurance status had wide confidence intervals and were never statistically significantly associated with poor adherence. Race, on the other hand, appeared to play a role in appropriate care for this cohort. Black patients were less likely to receive appropriate preventative care (INF-Core AOR=0.88, 95%-CI=0.79-0.97, INF AOR=0.88, 95%-CI=0.81-0.96, VTE AOR=0.81, 95%-CI=0.72-0.91, GLOBAL AOR=0.89, 95%-CI=0.83-0.96). The effect of age on adherence was divided for this older population, with increasing age associated with decreased adherence on INF-Core, INF and GLOBAL but increased adherence on VTE. The increased adherence on VTE with age over 85 was not statistically significant (VTE AOR = 1.05, 95%-CI = 0.97-1.15, vs. INF-Core AOR = 0.83, 95%-CI = 0.78-0.89, INF AOR = 0.88, 95%-CI = 0.83-0.93, and GLOBAL AOR = 0.90, 95%-CI = 0.85-0.95).

The likelihood of receiving deficient care increased as the number of comorbidities increases in a dose-response association (AOR=0.97, 95%-CI=0.945-1.002 for predicting adherence to GLOBAL in patients with one comorbidity and AOR=0.78, 95%-CI=0.743-0.810 with two or more comorbidities). The effect of comorbidities on infection-specific and venous thromboembolism-specific care measures was more profound than that seen with the GLOBAL measure and still suggested the same dose-
response trend (from an AOR=0.91, 95%-CI=0.882-0.948 with one comorbidity to an AOR=0.63, 95%-CI=0.598-0.665 with two or more comorbidities when predicting INF, and from an AOR=0.91, 95%-CI=0.863-0.950 to an AOR=0.60, 95%-CI=0.562-0.642 when predicting VTE).

**DISCUSSION**

Many studies have shown that health disparities exist with regard to surgical outcomes, but few have investigated the variations in perioperative processes associated with patient characteristics. We have previously reported that adherence to SCIP measures is associated with decreased postoperative complication rates and decreased mortality rates (Chapters 2 and 3, respectively). And, because lack of adherence to SCIP is associated with poor outcomes, and therefore deficient care, we sought to determine the patient subgroups most likely to receive inappropriate care as measured by poor adherence to SCIP measures.

Our findings suggest that patients who are admitted emergently and who have two or more comorbidities are the most likely to receive inappropriate care. Circumstances of increased time pressure and multiple competing considerations are logically associated with an increased likelihood for errors, and it is precisely for that reason that situations of higher risk require increased vigilance. Our findings suggest that these higher-pressure, increased-responsibility situations are the ones receiving the most deficient care. Systems of care designed to deliver fundamental best practices
during emergent admissions and for patients with multiple comorbidities are needed to ensure that consistent and equitable care is received by all patient subgroups.

Our findings further suggest that racial disparities do not appear to exist within these perioperative practices, and therefore, the differences seen in outcomes between racial groups is most likely due to factors outside of adherence to perioperative guidelines. These might include access to care, disease severity at the time of presentation and the differences in the locations where one receives care. Furthermore, gender was not strongly associated with disparities in quality practices even though men were less likely to receive appropriate venous thromboembolism prophylaxis. Since women tend to have a higher risk of venous thromboembolism, the gender differences seen in care practices may be highlighting an area of clinical decision making, where providers disagree with published guidelines or are more likely to remember the guidelines in higher risk (female) patients. This is likely to be the case in the dramatic association between adherence to venous thromboembolism prophylaxis and age, as patients between 18 and 24 years of age are less likely to develop thromboses. Providers perceive older patients to be at an increased risk for the development of a clot and are more likely to treat them prophylactically to prevent postoperative emboli. This is demonstrated through the step-wise progression of increased adherence with increasing age.

The effects of insurance status were mixed in our study. It appears that our VTE measure was more sensitive to insurance type than our other measures, and this is
puzzling. This could either reflect our VTE measure’s increased sensitivity to underlying quality issues, or it could reflect confounding from a yet unknown source. Further investigation into the effects of insurance status on the quality of perioperative care is certainly warranted, and new measures and methods are needed to determine the true effect.

Our study has several limitations. Measurement and public reporting of processes associated with quality in and of itself is associated with improvements in the measured process (Institute of Medicine (U.S.). Committee on Quality of Health Care in America. 2001; Hibbard, Stockard et al. 2003; Jha, Li et al. 2005; Lindenauer, Remus et al. 2007). This effect has been well documented and is a driving force behind the Hospital Quality Alliance’s (HQA) goal of transparency of practice. However, because the SCIP measures are known to the hospitals to be collected and publicly reported measures of hospital quality, the adherence of providers to SCIP quality measures is not necessarily reflective of the overall quality of care. By aggregating the individual measures in a form that requires more than one measure be collected for an individual discharge, and by using an all-or-none metric, we attempt to better estimate the environment of quality rather than adherence to specific processes (Nolan and Berwick 2006). However, this composite does not necessarily approximate a provider’s adherence to quality practices that are not publicly reported. This caveat should bias our estimate towards no association. Secondly, our quality data was obtained from hospitals participating in the Premier network of hospitals and may reflect higher-than-
average quality. Therefore, our adherence rates may be higher than those of the hospitals throughout the U.S. Although item-level SCIP data is not available publicly, the estimates from publicly available sources at the hospital-level, which represent all hospitals in the U.S., suggest similar adherence rates (Services 2008).

Our findings have direct implications for ongoing quality-improvement initiatives. We have highlighted that patients most vulnerable to adverse events are the ones who are least likely to receive all appropriate care. The impact of encouraging providers to improve their processes of care could be significantly impaired when the patients who have the most to gain from such an initiative are falling through the cracks. These findings highlight the need to develop systematic processes of adherence that work in situations presenting a high risk for non-adherence: emergency admissions and patients with multiple comorbid conditions. Future studies should investigate the magnitude of effect these variations in care have on patient outcomes.
Table 1. Characteristics of the Sample Patient Population, the Under 65 Cohort, and the 65 and Older Cohort

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Overall</th>
<th>Entire Sample</th>
<th>Under 65 Cohort</th>
<th>65 and Older Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n (%)</td>
<td>n</td>
<td>n %</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 - 24 years old</td>
<td>1,887</td>
<td>(0.7%)</td>
<td>1,887</td>
<td>(1.3%)</td>
</tr>
<tr>
<td>25 - 44 years old</td>
<td>37,947</td>
<td>(13.3%)</td>
<td>37,947</td>
<td>(25.8%)</td>
</tr>
<tr>
<td>45 - 64 years old</td>
<td>107,448</td>
<td>(37.7%)</td>
<td>107,448</td>
<td>(73.0%)</td>
</tr>
<tr>
<td>65 - 74 years old</td>
<td>68,341</td>
<td>(24.0%)</td>
<td>--</td>
<td>68,341</td>
</tr>
<tr>
<td>75 - 84 years old</td>
<td>54,053</td>
<td>(18.9%)</td>
<td>--</td>
<td>54,053</td>
</tr>
<tr>
<td>85+ years old</td>
<td>15,728</td>
<td>(5.5%)</td>
<td>--</td>
<td>15,728</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>201,224</td>
<td>(70.5%)</td>
<td>98,567</td>
<td>(66.9%)</td>
</tr>
<tr>
<td>Black</td>
<td>28,548</td>
<td>(10.0%)</td>
<td>19,271</td>
<td>(13.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>55,574</td>
<td>(19.5%)</td>
<td>29,408</td>
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<td>(16.6%)</td>
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<tr>
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<td>(10.3%)</td>
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<tr>
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<td>(73.0%)</td>
<td>114,230</td>
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<tr>
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<td>(75.4%)</td>
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<tr>
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<td>(15.3%)</td>
<td>14,188</td>
<td>(9.6%)</td>
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*Percentages may not sum to 100% due to rounding.
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<tr>
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<td>% Adherence</td>
<td>% Adherence</td>
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<tr>
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</tr>
<tr>
<td>Emergent</td>
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<td>67.7</td>
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<tr>
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<td>73.7</td>
<td>70.3</td>
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<td>72.8</td>
<td>71.0</td>
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<tr>
<td>Black</td>
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<td>64.8</td>
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<tr>
<td>Other</td>
<td>79.5</td>
<td>76.9</td>
<td>74.9</td>
<td>72.2</td>
</tr>
</tbody>
</table>

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

**All frequencies are presented as weighted projections of the U.S. population.

• All tabulations of SCIP Adherence by patient characteristic were statistically significant to p<0.0001, with the exception of INF-Core by gender (p = 0.02) in the <65 Cohort, and INF by marital status (p=0.88) in the 65+ Cohort.
Figure 1. Adjusted Odds Ratios for Patient Characteristics Predicting Adherence to SCIP Measures, Under 65 Cohort
Figure 2. Adjusted Odds Ratios for Patient Characteristics Predicting Adherence to SCIP Measures, 65 and Over Cohort
Literature Cited


CHAPTER 6

DISCUSSION
This study was a detailed examination of whether adherence rates on the currently reported Surgical Care Improvement Project (SCIP) measures are associated with improved patient outcomes. Once an association between increased adherence rates was linked to decreased surgical complications and lower surgical mortality, the study focused on whether specific patient subtypes were at greater risk for receiving non-adherent care. The study found that the youngest age group (18-24-year-olds) and the oldest age group (85+-year-olds) were at the greatest risk for receipt of inadequate infection prevention. Furthermore, patients who are admitted emergently or who have multiple comorbidities are the least likely to receive all basic perioperative SCIP measures.

These findings have implications for many different stakeholders, and this chapter presents the impact of these findings from multiple perspectives. This section will further discuss the strengths and weaknesses of the study as well as issues requiring further exploration in future studies.

**Implications**

**Patient Perspective**

This study determined the necessary link between the processes of care received and the outcomes that can be expected from receipt of that care. Based on our results, patients can use the information from this study to give them the confidence necessary to use reported SCIP-adherence rates in choosing a provider for their surgical care. For
patients to reliably use adherence rates in their decision-making process, they should have confidence that increased adherence to the processes measured is associated with improved outcomes. Otherwise, they might want to receive care from the provider with a lower adherence rate – which would imply they receive fewer procedures and lower costs in our procedure-based financial system.

While the association between increased adherence to processes and improved outcomes was assumed during the development of SCIP measures, no studies have yet confirmed this assumed relationship, and there were a multitude of reasons to believe that adherence rates were not necessarily reflective of improved care. For example, the level of adherence by a hospital to these measures is self-reported by the hospital. The details of inclusion and exclusion criteria were developed after and often divergent from the inclusion and exclusion criteria used in the studies referenced during measure development. And finally, the measurement and reporting enterprise for SCIP measures has never been evaluated by a third party. Therefore, the results of this study provide a critical component – the assurance that reported measure adherence rates do lead to a decreased risk of a surgical complication.

**Provider Perspective**

Despite the SCIP measures’ evidence-based roots, there has been a surprising amount of reluctance on the part of hospital administrators and physicians. Many believe that the enormous efforts required to participate in SCIP are not worthwhile. The advent of a nationwide quality-reporting effort is seen as a top-down invasion into
clinical practice and an attempt by payers to dictate clinical decision making. Furthermore, providers have argued that the ability of the SCIP-measurement enterprise to accurately reflect the true underlying adherence rate to best practices is unknown (El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). To design a performance measure for which 100% adherence is the goal would require that the measure itself be 100% accurate – free from inappropriate or unnecessary inclusion or exclusion criteria and universally applicable. In medicine, this is an impossible standard. The final decision of patient care rests in the hands of the physician, and therefore, some of the non-adherence may be in line with best practices. However, the extent to which this is the case is unknown. Therefore, by studying the association between the reported adherence rates and subsequent complication and surgical mortality rates, we subsume the limitations from the arguments raised by providers. The degree to which these arguments are true is simply the strength of association between recommended processes and clinical outcomes in the ideal setting of clinical trials minus the strength of association between the measured processes and clinical outcomes in our study. However, more relevant than determining the extent to which the measurement enterprise and clinical decision making obscure the reality of underlying best practices is the proof that patients with reported adherent care are more likely to receive a good outcome than patients without.

Our findings suggest to providers that the current levels of adherence are insufficient and that many of the patients without documented adherence are at an
increased risk for postoperative complications and mortality. Providers of care should work to increase their adherence to the majority of SCIP measures for the betterment of their patients.

**Policy Perspective**

This study provides justification for the efforts to date from the CMS and HQA, and it suggests that their efforts are improving the quality of health care in the United States. Published studies and publicly reported quarterly updates have documented an increase in adherence to the SCIP measures since implementation (Bratzler 2006; Services 2008). However, without evidence that documented improvements in adherence are associated with improvements in patient outcomes, arguments that increasing adherence rates were irrelevant could be legitimized. In addition, the lack of a proven association to outcomes limited their ability to further current efforts (Straube 2005; Nguyen, Yegiyants et al. 2008; El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). The evidence provided in this study can be used by policymakers to further their agenda of collecting and reporting SCIP process measures.

As adherence rates rise closer to 100%, the proportion of non-adherent care that results in an increased risk for patients gets smaller. Non-adherence in reported performance can be due to administrative errors, correct clinical judgment or inappropriate care. The findings of this study are therefore relevant to the current state of affairs and not necessarily to future reported rates, as the types of care which make up the non-adherent group can change over time and for different measures. This
effect may already be occurring, for example, in SCIP INF 6. Patients are receiving appropriate hair removal greater than 95% of the time, and non-adherence is not associated with increased infection rates or mortality rates, as would be suggested by the studies referenced during measure development. This may suggest that the less than 5% of patients receiving non-adherent care are truly receiving adherent care, yet the administrative reporting of their care is deficient. Therefore, reporting of this measure may be costing providers time and money without providing a benefit to patients. The CMS and HQA need to continually appraise the value of each SCIP measure and consider removing measures that do not provide benefit.

This study also presented and validated a method for aggregating and reporting condition-specific and global quality rates using current SCIP measures. These rates isolated efforts on the part of providers to adhere to either infection prevention or venous thromboembolism prevention, and adherence on these composite measures statistically significantly predicted decreases in complication and mortality rates. While individual measures may be difficult for patients to associate with overall quality, our composite measures and global measure present a reasonable alternative. Further, issues of individual items reaching the limits of their ability to predict improved outcomes, as was seen in SCIP INF 6, are mitigated through aggregation. This provides time for recognition and cleaning of such issues. The creation and report of composites also raise the bar for providers and yield more accurate overviews of general quality, giving one an insight into the culture of quality (Nolan and Berwick 2006). Policy makers
should consider the results presented on individual measures in eliminating unnecessary measure collection, and they should consider publicly reporting more stable measures that are more reflective of a culture of quality, such as our condition-specific and global measures.

Finally, consistent adherence across multiple patient subgroups is imperative for eliminating disparities and improving health care for all patients. Furthermore, the patients in the highest risk subgroups may be the most important patients for decreasing overall complication rates. As those admitted emergently, those with multiple comorbidities and those over the age of 85 have higher-than-average complication rates, the lower adherence rates specific to these patient subgroups may be inhibiting the potential of the SCIP initiative to decrease complication rates by 25% – their stated goal (Bratzler 2006; Bratzler and Hunt 2006; Clancy 2008).

**Strengths**

This is the first study to suggest a statistically significant relationship between reported adherence to SCIP measures and surgical outcomes exists on a national level. It is also the first study to suggest that perioperative practices are underprovided to the most vulnerable subgroups. Previous studies have measured the various actions underlying the SCIP measures that can be used to validate the efficacy of the underlying processes but not necessarily the effectiveness of the measure (Optimal Solutions Group 2009). Researchers that have attempted to study SCIP-measure effectiveness by
investigating the association between adherence and complication rates have concluded that adherence to these SCIP measures is not associated with improved outcomes (Hawn, Itani et al. 2008; Nguyen, Yegiyants et al. 2008; El-Badawi, Mahmood et al. 2009; Pastor, Artinyan et al. 2009). Our findings are in contrast with that of previous studies, but our study improves upon prior efforts in several important ways. First, our sample size is large enough to study rare outcomes, and previous studies were likely under-powered. Second, all prior studies were single-institution studies, which may have important differences in the underlying reasons for non-adherence compared to our multi-institution approach. For example, if the hospital internally evaluating SCIP measures is a center of excellence, their non-adherent practices may be primarily composed of decisions made in the best interests of the patient that for one reason or another are not captured appropriately by the SCIP inclusion and exclusion criteria – a factor of an imperfect measurement tool rather than an inappropriate medical decision.

Previous analyses of hospital-level performance on the medical (non-surgical) quality measures have disagreed as to the effectiveness of performance reported on the Hospital Compare website (Werner and Bradlow 2006; Jha, Orav et al. 2007). Our study methodology differs from these previous studies in two important ways. First, we are studying surgical patients which have higher mortality rates and therefore the potential for a stronger association. Second, our analysis was conducted at the discharge level, whereas previous studies used hospital-level data only. Use of discharge-level data improves upon previous studies through more accurate risk adjustment and estimation.
of effect sizes. Hospital Compare performance scores are reported at the hospital level and are based on a sample of patients seen by that hospital (Services 2008; Centers for Medicare & Medicaid Services 2009). Furthermore, hospital-level mortality rates are based on all-cause mortality estimates for all patients within that hospital. A statistically significant result given a hospital-level analysis requires greater variation in discrete elements of hospital quality than does a discharge-level analysis. This also means that the results of our study, while relevant at the individual discharge level, may not be relevant at the hospital level. This is an important point, given that performance scores on SCIP are currently reported at the hospital level and not the discharge level.

Furthermore, use of a projected weighting variable improves the generalizability of our findings. The Premier Network is not a random sample of hospitals or patients, and it is therefore not necessarily representative of the U.S. population. Through working with the CMS, Premier Inc. has developed a patient-level weighting variable in order to adjust the sample of patients to reflect the U.S. population. By using this variable in our analysis, we improved the reliability and generalizability of our findings.

Finally, the use of nested models over simple multiple logistic regression models greatly enhances the validity of our estimates. Running our data using a simple multiple regression model would have resulted in vast over-estimation of the variation in outcomes attributable to our SCIP-adherence variables. A sensitivity analysis was run as part of the data model development, and while all effect sizes remained in the same direction, the effects of adherence were three-fold smaller when using a nested model.
This demonstrates that clustering of estimates was apparent in our results, meaning that hospital-level variables do influence patient outcomes, a fact supported by the published literature (Wennberg, Lucas et al. 1998; Birkmeyer, Siewers et al. 2002; Birkmeyer, Dimick et al. 2004; Dimick, Welch et al. 2004; Polk, Birkmeyer et al. 2006; Birkmeyer and Dimick 2008).

**LIMITATIONS**

Our study has several important limitations. The use of Premier Perspectives™ Data was convenient for elucidation of discharge-level associations between SCIP processes and surgical outcomes; however, Premier Network hospitals may not be representative of all U.S. hospitals. Hospitals reporting data for this study may, on average, be higher quality hospitals, and therefore, the absolute estimates of SCIP-adherence rates may not be representative of the actual national rates. In addition, the patients receiving non-adherent care may be more likely to be receiving appropriate care. However, these biases should shift our estimates towards the null and cause an underestimation of the true effect of SCIP adherence.

Secondly, although our study was large, some of the subgroups within the item-level analyses were based on small numbers of patients when considering our outcome of mortality. In particular, the number of surgical mortalities that exist in young patients undergoing elective procedures will be very small. Thus, our findings may be less relevant to this patient population. Third, our analysis is reliant on accurate coding of
procedure, diagnosis and adherence, and errors in coding would add to the imprecision of our estimates. However, there is no reason to think that the errors in coding would be biased. Coding errors should simply add noise to our estimates. In addition, our ability to assess mortality is likely to be highly accurate, and the results show good face validity attesting to a reasonably high level of accurate documentation. Fourth, use of Premier Perspectives™ data did not allow for estimates of hospital and surgeon volume. These rates were therefore unable to be used in our adjusted models of surgical mortality despite their known association (Birkmeyer 2000; Birkmeyer, Siewers et al. 2002).

Additionally, our ability to perform adequate risk adjustment using administrative data may be questioned by readers, and this argument would suggest that only clinical studies are appropriate in estimating the strength of the SCIP adherence-outcome relationship. Unfortunately, development of a large enough clinical study would be exceedingly expensive and furthermore could artificially inflate adherence rates due to the special nature of clinical studies. Clinical studies have already demonstrated the efficacy of the underlying procedures, and therefore, this study was designed to assess the effectiveness of the measurement enterprise as much as the measurement efficacy.

Finally, the findings presented herein should not be construed as providing evidence that SCIP is working. The goal of the SCIP program is to decrease surgical complications by 25% by the year 2010. This study makes no attempt to measure the
complication rates before and after implementation of SCIP on a national level and can therefore not speak to whether this dramatic decrease in surgical complications has already occurred. Rather, our studies should be taken to show that there is still room for improvement. As long as the patients receiving non-adherent care are on average experiencing increased complication and mortality rates, increasing the level of adherence to SCIP can result in improvements in surgical care. Furthermore, as long as the patient subgroups most vulnerable to surgical complications are the same subgroups most likely to receive non-adherent care, the SCIP program will continue to fall short of its true potential.

**DATA MERGING PROBLEMS**

Data from Premier Inc. came in 27 separate data files formatted as permanent SAS (Statistical Analysis Software) datasets. Twenty-five of these files make up what they consider their Premier Perspectives™ Dataset, which is a relational dataset of administrative data, and the other two files were specific and unique to the data request for this project. One of the files was item-level SCIP information, and the other was a linking file. The SCIP data and administrative data use different unique IDs to identify an individual discharge and an individual patient, and therefore, we must link these data files using the linking file. Unfortunately, our discharge-level population decreased by 20% (from 519,156 unique discharges to 404,720) when we link item-level SCIP data to discharge-level administrative. Despite root-cause analysis, we were unable to determine the underlying cause of this decline. We have contacted Premier
consistently for the past four months, as the problem is assumed to be due to data-file development on their end. However, they have been unresponsive and have yet to find a solution. We are hopeful that the data-merging issues are random and do not present a bias in our analysis; however, we have no way of confirming this without the help of Premier Inc.

**Future Direction**

The CMS encourages patients to choose high-quality hospitals for receipt of their medical and surgical care needs through use of the Hospital Compare website. CMS has further laid the groundwork to incentivize hospitals and physicians to improve the quality of care they provide by tying financial incentives to the reporting and performance on various measures of quality. To create an effective system that minimizes unintended consequences and engages providers in the quality-improvement process, the measure set used needs to be consistently evaluated and updated. Many questions remain to assist in the future development of the public reporting of quality data.

First, our analysis focused on discharge-level associations between adherence and outcomes, yet the publicly reported performance scores are at the hospital level. Our analysis was successful in demonstrating that adherence is associated with outcomes, but we do not demonstrate that the variations, which are often minimal, between hospitals are helpful to patients when choosing hospitals. A hospital-level
analysis, preferably using the entire Hospital Compare measure set, would be required to answer such a question.

Secondly, the stated goal of SCIP of decreasing surgical complication rates implies that surgical complication rates before and after implementation are compared. Our analysis compares adherent and non-adherent care during implementation and may underestimate the level of benefit achieved from SCIP implementation. Future studies should find ways of measuring surgical complication rates before and after implementation in order to assess the level of success.

Finally, future studies of who receives high-quality perioperative care should involve measures of socioeconomic status and access to care. The deficient care received by both uninsured patients and patients admitted emergently highlighted by our study may suggest a group of patients doubly disadvantaged in the current system. Patients who are uninsured are less likely to receive preventative care and are more likely to be admitted emergently. These patients may also be receiving on average different types of operations compared to their insured counterparts. More investigation is necessary to disentangle the many competing factors that influence receipt of poor perioperative care.

**CONCLUDING REMARKS**

This study examines in detail the currently reported SCIP measures, their association with surgical outcomes and the extent of patient-level disparities. The
results indicate that higher adherence rates are associated with decreases in surgical complication rates and lower surgical mortality. They further demonstrate that patients admitted emergently, patients with multiple comorbidities and patients who are uninsured are the least likely to receive adherent care. These findings suggest that patients can improve their chances of a good surgical outcome by choosing providers that adhere to SCIP processes. Further, our findings provide evidence for quality managers and policymakers to use with providers resistant to follow SCIP guidelines. Increasing adherence to SCIP measures will improve patient morbidity and mortality, and creating systems that support adherence regardless of admission status, insurance status or age will improve results for the most vulnerable patients.
LITERATURE CITED


10. Optimal Solutions Group L. The Surgical Care Improvement Project Literature Review, April 2009 Update; 2009 April 2009.


COMPLETE REFERENCES

Specifications Manual for National Hospital Quality Measures. Version 2.4, Joint Commision, CMS.


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