May 2017

Patient Acuity as a Predictor of Length of Hospital Stay and Discharge Disposition After Open Colorectal Surgery

Martha Kimpton Badger
University of Wisconsin-Milwaukee

PATIENT ACUITY AS A PREDICTOR OF LENGTH OF HOSPITAL STAY AND DISCHARGE DISPOSITION AFTER OPEN COLORECTAL SURGERY

by

Martha Kimpton Badger

A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree

Doctor of Philosophy

in Nursing

at

The University of Wisconsin-Milwaukee

May 2017

ABSTRACT

PATIENT ACUITY AS A PREDICTOR OF LENGTH OF STAY AND DISCHARGE DISPOSITION AFTER OPEN COLORECTAL SURGERY

by

Martha Kimpton Badger

The University of Wisconsin-Milwaukee, 2017
Under the Supervision of Professor Amy Coenen

Major areas of concern within the US healthcare system today include the quality and cost of healthcare. Open colorectal surgery patients have a higher prevalence of prolonged length of hospital stay (LOS) than most other types of surgery patients and are likely to be discharged to home care or other healthcare settings (DHCS), both of which contribute to increased costs. The ability to predict which patients are at risk for these outcomes early after open colorectal surgery could prompt nursing interventions aimed at improving quality of care and reducing healthcare costs. Radwin and Fawcett's Refined Quality Health Outcomes Model served as the conceptual framework for this study.

In this retrospective cross sectional study of adult open colorectal surgery patients (N=789), nursing documentation in the electronic health record (EHR) was reused to examine the relationships among patient acuity, LOS, and discharge disposition (DD). At the large Midwest healthcare system where this study took place, a patient acuity software system generated real time patient acuity scores from discrete nursing assessment data fields in the EHR. This information was being used by unit nurse managers to guide nurse staffing decisions.

Patient data were stratified by three discharge diagnostic-related groups (DRG) for colorectal surgeries, DRG 329, 330, and 331, to provide some control for comorbidities and post-operative complications. Multiple regression analysis for each DRG examined how patient acuity and select patient characteristics predicted prolonged LOS. Findings included that having a high patient acuity score on Day 2 or 3 after open colorectal surgery was a significant predictor of prolonged LOS for subjects in each DRG (DRG 329: B=1.985, p<0.05; DRG 330: B=1.956, p<0.01; DRG 331: B=0.967, p<0.01). Logistic regression analysis results also indicated that high patient acuity scores on Day 2 or 3 after surgery significantly predicted DHCS for each DRG (DRG 329: OR=3.65, 95% CI [1.39, 9.59], p<0.05; DRG 330: OR=2.86, 95% CI [1.58, 5.16], p<0.01; DRG 331: OR=8.62, 95% CI [2.04, 39.48], p<0.05).

Implications for nursing include the need for further research to examine the use of patient acuity information to support evidence-based clinical decision-making to improve healthcare quality and contain costs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACA	Patient Protection and Affordable Care Act
ACS	American College of Surgeons
AHRQ	Agency for Healthcare Research and Quality
ANA	American Nurses Association
AONE	American Organization of Nurse Executives
ARRA	American Recovery and Reinvestment Act
ASA	American Society of Anesthesiologists
BMI	Body mass index
BPCI	Bundled Payments for Care Improvement
CDC	Centers for Disease Control and Prevention
Clairvia®	Clairvia® CVM™ Outcomes-driven Patient Acuity System
CMS	Centers for Medicare and Medicaid Services
DD	Discharge disposition
DHCS	Discharge to home care or other healthcare setting
DRG	Diagnostic-related group
EHR	Electronic health record
ERAS	Enhanced Recovery After Surgery Protocol
FY	Fiscal year
HITECH	Health Information Technology for Economic and Clinical Health
HRRP	Hospital Readmissions Reduction Program
ICU	Intensive care unit
ID	Identifier

IPPS	Inpatient Prospective Payment System
LOS	Length of stay
NSQIP	National Surgery Quality Improvement Program
ONC	Office of the National Coordinator for Health Information Technology
R-HQOM	Refined Health Quality Outcomes Model
SQL	Structured Query Language
TJA	Total joint arthroplasty

CHAPTER 1 - INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), in 2014 the United States (US) spent 17.5% of its gross domestic product, or $3.0 trillion, on healthcare (CDC, 2016c). This represented more spending per capita than any other industrialized nation (The World Bank, 2016). According to the Agency for Healthcare Research and Quality (AHRQ), hospital inpatient care comprised almost one-third of these health care expenditures. The total cost of inpatient care in 2013 was approximately $381.4 billion. That year, there were 35.6 million hospital stays; the average length of stay (LOS) was 4.5 days; and the average cost was $18,000 per stay. Almost seven million (21.8%) of these hospital stays were for postoperative recovery (AHRQ, 2016).

The CDC estimated that 0.5 million open colorectal surgeries are performed in the US each year (CDC, 2015). Under the current payment system, the Acute Inpatient Prospective Payment System (IPPS) (Centers for Medicare and Medicaid Services [CMS], 2016a), hospitals receive the same pre-negotiated payment for patients in each diagnostic-related group (DRG), regardless of how long the patient stays in the hospital. Open colorectal surgery patients have a higher prevalence of prolonged LOS than most other types of surgery patients (Keller & Stein, 2013). They are also likely to be discharged to home care or other healthcare settings (DHCS) such as long-term care or skilled nursing facilities, which has been shown to increase LOS in this population (Kelly, Sharp, Dwane, Kelleher, & Comber, 2012; Ngui, Hitos, & Ctercteko, 2010; Reddy et al., 2003). Prolonged LOS increases the cost to the healthcare system, diverts resources from other patients, and prevents hospitals from admitting new patients (Thiele et al., 2015). There is value in understanding factors that are associated with prolonged LOS after open colorectal surgery. This study was conducted to increase this understanding.

Significance of Study

Two major concerns for the US healthcare system today include the quality and cost of patient care (Rosenbaum, 2011). Understanding how nurses can improve patient outcomes and reduce hospital costs is important to direct the planning and provision of patient care. Awareness of factors that impact patient outcomes, including prolonged LOS and DHCS, can guide nurses' clinical decision-making. Understanding these factors could assist nurses in predicting which patients are at risk for prolonged LOS and DHCS early in a patient's hospitalization. This knowledge could prompt nursing interventions aimed at improving both the quality of patient care and reducing healthcare costs.

Justification for Study

The justification for this study is that it examines a new approach to assist nurses in identifying open colorectal surgery patients at risk for prolonged LOS and DHCS early in their hospital stay: reusing nursing documentation of patient assessments in the electronic health record (EHR). In the hospitals where this study took place, each patient's overall health status, in the form of patient acuity scores, was available in real time throughout a patient's hospital stay. These patient acuity scores were generated by a software system that was mapped to select clinical data, including discrete nursing assessment documentation fields, in the patient's EHR. Nurse managers used information about patient acuity to guide nurse staffing. This study will reuse patient acuity information to examine the relationships among patient acuity, LOS, and discharge disposition (DD) after open colorectal surgery. Understanding these relationships may provide nurses with another opportunity to improve healthcare quality and reduce healthcare costs associated with prolonged LOS and DHCS for this population.

Purpose of Study

The first purpose of this study was to examine the relationships among patient acuity, LOS, and DD for open colorectal surgery patients. The second purpose was to develop succinct analytical models of patient state and trait characteristics, including patient acuity, that predicted prolonged LOS and DHCS in this study sample.

To assure rigor with the reuse of clinical data, it was essential to assess the quality of the patient acuity information that were reused in this in this study for purposes other than which they were originally intended. Weiskopf and Weng's (2013) data quality assessment framework was applied to address the quality of the patient acuity information and other clinical data that were reused for this study. This framework was developed to address the "inconsistent terminology" (p. 147) used in healthcare studies to report on the quality of data from electronic sources. Weiskopf and Weng proposed that healthcare researchers who reuse electronic healthcare data and information for purposes other than it was originally intended would benefit from adopting a "consistent taxonomy" (p. 147) to assess and report on data quality.

To address the purposes of this study, four research questions were developed. These questions are outlined below, followed by a brief description of DRGs and the reasons why the study sample was stratified by the three DRGs of 329, 330, and 331. Next, conceptual definitions of patient acuity, LOS, and DD are presented. Healthcare policies and clinical protocols that influenced this study are then discussed. Finally, the conceptual framework that guided the selection of patient state and trait characteristics, including patient acuity, to describe the study sample and for inclusion in the prediction models for prolonged LOS and DHCS is presented.

Research Questions

Question 1

What are the patterns of patient acuity, LOS, and DD for open colorectal surgery patients with a DRG of 329, 330, or 331?

Question 2

What are the relationships among patient acuity, LOS, and DD for open colorectal surgery patients with a DRG of 329, 330, or 331?

Question 3

Which combination of patient acuity and select patient trait characteristics predict LOS for open colorectal surgery patients with a DRG of 329, 330, or 331?

Question 4

Which combination of patient acuity and select patient trait characteristics predict DD for open colorectal surgery patients with a DRG of 329, 330, or 331?

Diagnostic Related Groups (DRGs)

Every inpatient is assigned a DRG upon discharge from the healthcare system where the study took place, regardless of their primary payor (D. Kastenholz, personal communication, May 23, 2016). DRGs are a measure of the typical hospital resource use of an inpatient and were originally created in 1982 to guide Medicare reimbursement to hospitals under the IPPS (CMS, 2016a). DRGs eventually became widely used in the US to determine hospital reimbursement by Medicare, Medicaid, as well as private healthcare insurance companies (Hamavid et al., 2016).

The DRG classification system groups patients with similar clinical conditions, or diagnoses, and the procedures they underwent during their inpatient stay. With respect to clinical conditions, the patient's principal diagnosis and up to 24 secondary diagnoses, which include comorbidities or complications, are factored into the DRG assignment. In terms of procedures, the DRG assignment can be affected by up to 25 inpatient procedures. Patient characteristics that also influence a DRG assignment include gender, age, and discharge disposition. DRGs are updated annually by the CMS (CMS, 2016a).

DRGs Used in this Study

Three DRGs, 329, 330, and 331, were used to identify study subjects who had undergone open colorectal surgery. A DRG of 329 is assigned upon discharge to patients who were admitted for major small and large bowel procedures and who had major comorbidities and/or complications. A DRG of 330 is assigned upon discharge to patients who were admitted for major small and large bowel procedures and who had non-major comorbidities and/or complications. And a DRG of 331 is assigned upon discharge to patients who were admitted for major small and large bowel procedures and who did not have major or non-major comorbidities and/or complications (Covidien, 2015). Study subjects were stratified by DRG in an effort to provide some control for comorbidities and postoperative complications. Examining the complex relationships among comorbidities, postoperative complications, and patient acuity was beyond the scope of this study.

A description of each of the three DRGs is presented in Table 1.1. Also included in the table are statistics from fiscal year (FY) 2014 for Medicare beneficiaries regarding the national average LOS for each DRG (Covidien, 2015), the national average payment per DRG (Covidien, 2015), and the prevalence among Medicare patients of each DRG in this US (CMS, 2016b). Generating similar statistics for patients with private healthcare insurance requires detailed proprietary information and they are therefore not included in this study. Moreover, most private healthcare insurance companies use Medicare reimbursement rates as a guide for their own fee structures (Hamavid et al., 2016).

Table 1.1

Diagnostic-related group (DRG) code, DRG description, national average LOS (Covidien, 2015), national average payment (Covidien, 2015), and national prevalence among Medicare patients (CMS, 2016b) by DRG, FY 2014

Discharge DRG Code	DRG Description	National Average LOS (days)	National Average Payment	National Prevalence
329	Major small and large bowel procedures with major comorbidities and/or complications	14.4	$29,819.83	38,833 (33.7%)
330	Major small and large bowel procedures with comorbidities and/or complications	8.4	$14,970.41	52,483 (45.6%)
331	Major small and large bowel procedures without major comorbidities and/or complications <u>or</u> major small and large bowel procedures without comorbidities and/ or complications.	4.8	$9,737.14	23,880 (20.7%)
				115,196 (100%)

Conceptual Definitions

This section contains conceptual definitions for the main variables in the study. These are patient acuity LOS, and DD.

Patient Acuity

Patient acuity has been defined as "the level of severity of a patient's illness or health condition at a point in time" (Miller & Keane, 2005). At the healthcare system where this study took place, a computerized information system calculated patient acuity scores in near-real time. This software system was mapped to discrete nursing assessment documentation fields, medication infusion administration, and select laboratory results in the patient's EHR. The system used these data to automatically calculate patient acuity scores in near-real time.

Patient acuity was the main independent variable in this study. A detailed description of the automated patient acuity scoring system appears in Chapter 3.

Length of Stay (LOS)

Length of stay (LOS) was the total number of days the patient was a hospital inpatient after open colorectal surgery and prior to being discharged. The total length of stay included time spent in the intensive care unit (ICU) and/or on medical surgical units. In this study, "prolonged LOS" was a relative term, which was based on comparing study subjects with each other.

Discharge Disposition (DD)

Discharge disposition (DD) was the final place or setting to which the patient was discharged on the day of discharge from an acute care facility (The Joint Commission, 2012). Discharge dispositions that were used to describe the study sample included discharge to home without healthcare services; discharge to home with healthcare services; and transfer to home hospice, inpatient hospice, inpatient rehabilitation, intermediate care facility, long-term acute care hospital, or skilled nursing facility. For the purpose of the statistical analyses, discharge disposition was a dichotomous variable with a value of either (a) discharge to home without health services, or (b) discharge to home care or other healthcare setting (DHCS).

Background for the Study

This section provides background on healthcare policies and clinical protocols that influenced this study. These included policies regarding nursing documentation, patient acuity, EHR Meaningful Use, LOS, and DD. The enhanced recovery after surgery (ERAS) protocol for open colorectal surgery patients (Wilmore & Kehlet, 2001), which was in place at the hospitals where this study took place, is also described.

Nursing Documentation

Yee et al. (2012) conducted a two-year observational study on 105 inpatient units at 55 hospitals in the US. They found that nurses spent 19% of their time, or approximately one-fifth of their shift, documenting in the EHR. Critics may argue that time spent documenting is time not spent caring for patients (Kossman & Scheidenhelm, 2008). However, nursing documentation has always been an important aspect of patient care because it serves “multiple and diverse purposes” (Cheevakasemsook, Chapman, Francis, & Davies, 2006, p. 366). These include assuring continuity of care, communicating with other healthcare providers, providing legal evidence of the process of nursing care, and supporting evaluation of the quality of patient care (Cheevakasemsook et al.).

State laws delineate nursing documentation guidelines through nurse practice acts and associated rules and regulations (Campos, 2009). The objective of any state’s nursing practice act as it pertains to documentation is the same across the country: “to provide a clear and accurate picture of the patient while under the care of the healthcare team” (Campos, p. 16). To achieve this goal, nurses are required to document their execution of the nursing process, which includes patient assessment, planning, intervention, and evaluation (Wisconsin Nurse Practice Act, 2014).

Reuse of Nursing Documentation

Informatics nurses and nurse researchers are aware of the vast amount of nursing documentation data that are stored in electronic healthcare systems such as the EHR (Johnson, Speedie, Simon, Kumar, & Westra, 2016). A cornerstone of the scope of nursing informatics as a nursing specialty is the reuse of data in electronic healthcare systems and transforming it into information, knowledge, and wisdom (American Nurses Association [ANA], 2015). High quality nursing documentation data can be reused to support clinical decision-making and increase nursing knowledge through research (Johnson et al., 2016).

Patient Acuity

Nurse managers have been using patient acuity systems for more than 50 years to support evidence-based workforce management decisions regarding nurse staffing and scheduling (Fasoli & Haddock, 2011). Whether manual or automated, two types of acuity systems have commonly been used to measure patients' need for nursing care and to determine staffing levels. The first type bases staffing levels on past trends in nurse workload for patients with similar health care issues. Nurse workload is a nurse-centered proxy of patients' need for nursing care and is defined as the amount of time nurses spend performing tasks or interventions related to patient care (Beswick, Hill, & Anderson, 2010). The second type of system bases staffing levels on patients' current level of illness, or patient acuity (Douglas, 2011).

In 2008, the ANA issued the first edition of its *Principles of Safe Staffing*. The ANA argued that evidence-based nurse staffing levels should be determined via "an analysis of healthcare consumer status (e.g., degree of stability, intensity, and acuity)" (ANA, 2008, p. 6). In 2009, the American Organization of Nurse Executives (AONE) published *Guiding Principles for the Nurse Executive to Enhance Clinical Outcomes by Leveraging Technology*. The AONE advocated for the use of existing nursing documentation in the EHR to determine accurate patient acuity and to guide nurse staffing. In contrast to the nurse-centered concept of nurse workload, patient acuity is a patient-centered proxy of a patient's need for nursing care. The

ANA and ANOE principles together suggested the best practice of using a computerized information system to measure patient acuity in real or near-real time.

Increasingly, nurses are using automated systems that measure patients' level of illness in near-real time to guide staffing decisions (Malloch, 2012). Some of these systems use nurses' routine documentation of a patient's condition in the EHR to calculate patient acuity. These systems are valued because they are objective, unbiased, and do not require manual calculation on the part of the nurse managers (Birmingham, 2010). Clairvia® CVM™ Outcomes-Driven Patient Acuity (henceforth referred to as Clairvia®) was used at the healthcare system where this study took place.

Electronic Health Records

On April 27, 2004, President G.W. Bush issued an Executive Order titled "Incentives for the Use of Health Information Technology and Establishing the Position of the National Health Information Technology Coordinator" (Executive Order No. 13,335, 2004). This order created the National Health Information Technology Coordinator within the Department of Health and Human Services to oversee the development of "a nationwide interoperable health information technology infrastructure" (Presidential Documents, 2004, p. 24059). In early 2009, Congress passed the Health Information Technology for Economic and Clinical Health (HITECH) Act as part of the 2009 American Recovery and Reinvestment Act (ARRA) stimulus bill (American Recovery and Reinvestment Act, 2009). According to 42 U.S.C. §17901, the Office of the National Coordinator for Health Information Technology (ONC) was mandated to put the HITECH Act into practice to ensure the establishment of an EHR for each person in the United States by the year 2014 (United States Code, 2010).

The HITECH Act resulted in the allocation of $22 billion to the CMS (ONC, 2015). Beginning in 2011, the CMS began distributing these funds to healthcare providers and hospitals that served Medicare and/or Medicaid beneficiaries as reimbursement incentives for providers of health care to become Meaningful Users of certified EHR technology (CMS, 2014). By December 2014, 93% of healthcare providers and hospitals who received this incentive were using an EHR, and 73% were demonstrating meaningful use (ONC, 2015).

Meaningful Use consists of three stages (HealthIT.gov, 2015). Attaining Stage I indicates the ability to collect and share data using a certified EHR. Achieving Stage II indicates the ability to reuse the data to improve quality, safety, efficiency, and reduce healthcare disparities; engage patients and families; improve care coordination, and population and public health; and maintain privacy and security of patient health information (HealthIT.gov, 2015). The healthcare system where this study takes place achieved Stage II Meaningful Use with ease because they had implemented a certified EHR in 2006 (N. Malesevich, personal communication, March 17, 2016).

The healthcare system has not yet attained Meaningful Use Stage III. Achieving Stage III requires that hospitals demonstrate that the use of a certified EHR is improving clinical and population health outcomes (HealthIT.gov, 2015). The purpose of this study was to examine the relationship among automated patient acuity and the patient outcomes of LOS and DD. This study could contribute to the healthcare system's achievement of Meaningful Use Stage III if the results support improved clinical outcomes for open colorectal surgery patients.

Length of Stay (LOS)

One of the most wide-reaching and ambitious healthcare policy reforms was the 2010 Patient Protection and Affordable Care Act (ACA) (Rosenbaum, 2011). President Obama was focused on improving the value of healthcare and noted that the ACA would lead to reduced healthcare costs, an improvement in healthcare quality, and increased access to healthcare. This cost-quality-access framework is still being used to evaluate successes and shortcomings of the ACA (US Department of Health and Human Services, 2015). This researcher employed this framework to identify some of the major issues related to LOS.

Cost. Under the current hospital reimbursement system, the IPPS (CMS, 2016a), hospitals receive the same payment for patients in each DRG, regardless of the length of the hospitalization. Open colorectal surgery patients have a higher prevalence of prolonged LOS than most other types of surgery patients (Keller & Stein, 2013). They are also likely to be DHCS, which has been shown to increase LOS in this population (Kelly et al., 2012; Ngui et al., 2010; Reddy et al., 2003). Open colorectal surgery patients with a prolonged LOS increase the cost to the healthcare system (Thiele et al., 2015).

Fee-for-service. Until the early 1980s, hospitals were reimbursed for their Medicare patients' inpatient stays on a fee-for-service basis (McClellan, 1997). Patient hospital stays were prolonged so that providers could perform procedures that could have been done in the outpatient setting. Hospitals also used costly technologies such as MRIs and CAT scans liberally, with the expectation of full payment from Medicare. This system was expensive and inefficient (McClellan, 1997).

Acute Inpatient Prospective Payment System (IPPS). In an effort to reduce LOS and eliminate wasteful spending, the CMS implemented the IPPS in 1982 (CMS, 2016a). Administrators at hospitals that treat Medicare patients agree to accept predetermined rates as payment in full, regardless of the length of the patient's acute care hospital stay.

Predetermined rates are calculated using a complex formula that begins with a patient's discharge DRG. Each DRG is assigned a "Standard Federal Rate" that is composed of labor- and non-labor-related costs. The labor-related cost of this standard amount is then adjusted for geographic differences in wage levels. This new rate is adjusted for the DRG weight, which reflects the level of treatment expected for an average patient with this DRG. Next, payment is adjusted for Medicare-contracted hospitals. These hospitals provide a disproportionate percentage of care to Medicaid or Medicare patients who are not eligible for Medicare Part A, i.e., inpatient care. The payment rate may increase for hospitals that have medical residents on staff. Finally, Medicare might provide an additional payment for beneficiaries whose LOS or costs exceed the threshold rate (CMS, 2016a).

Response to IPPS. A predominant response by hospitals to the IPPS payment system was to decrease Medicare beneficiaries' length of hospital stay (McClellan, 1997). Consequently, readmissions within 30 days of discharge increased because it was still IPPS policy to reimburse the hospital for each inpatient admission (Reinhardt, 1996). In 2011, 1.8 million Medicare recipients were readmitted to acute inpatient hospitals within 30 days of discharge. The total cost to Medicare was $24 billion (Hines, Barrett, Jiang, & Steiner, 2014).

Hospital Readmissions Reduction Program. On October 1, 2012, the ACA instituted the Hospital Readmissions Reduction Program (HRRP) to curb the increase in readmissions and their associated cost to the healthcare system (CMS, 2016c). Under HRRP, CMS can withhold up to 3% of the reimbursement to hospitals if they have a higher-than-expected number of readmissions within 30 days of discharge. Reimbursement for the following six conditions are affected by the HRRP: chronic lung disease, coronary artery bypass surgery, myocardial infarction, heart failure, hip and knee replacements, and pneumonia (CMS, 2016c).

Quality. The length of time a patient stays in an acute care hospital can have positive and negative effects on their health and the quality of healthcare they receive.

Positive effects. If select patients' LOS were prolonged by a day or two, patients could have more time to recover from surgical procedures and/or to ensure that their medical treatments and medication regimen are effective (Bartel, Chan, and Kim, 2014). The extra day or so would give care managers and social workers more time to work with the patient to arrange for necessary and convenient outpatient services. Nurses could also use the extra time with patients to assess their readiness for discharge. A common complaint from patients and nurses is that patients receive hurried, fragmented discharge planning (Phillips et al., 2004).

Negative effects. Every additional day spent in the hospital increases a patient's risk for preventable adverse events such as hospital-acquired infections, falls, pressure ulcers, and medication administration errors (CDC, 2016b). Patients also have the potential to experience psychological and physical setbacks from a prolonged hospital stay. These include functional disability, anxiety, grief, disability, pain and suffering, and change in social functioning and/or daily activities (Zimlichman et al., 2013).

Access. Acute inpatient hospitals have limited operational resources. These consist of hospital beds, the number of operating rooms, the number and availability of healthcare personnel and auxiliary staff, computers and software systems, supplies, and large pieces of medical equipment such as magnetic resonance imaging (MRI) and computerized axial tomography (CAT) scan machines (Harper, 2002).

Patients who are admitted to the hospital have access to these healthcare resources. However, each additional day that a patient stays in the hospital can result in lack of access for other potential acute care inpatients. These patients either remain in emergency departments, in long-term care, or are admitted to inappropriate facilities or hospital units (Brasel, Lim, Nirula, & Weigelt, 2007). Furthermore, acute care hospitals lose the revenue associated with new admissions, thus limiting or reducing their ability to fund operational resources (Thiele et al., 2015).

Discharge Disposition (DD)

With the gradual phase-in of the Bundled Payments for Care Improvement (BPCI) initiative, DD could become as important a financial consideration for acute care hospitals as LOS. The BPCI initiative was implemented in 2013 by the ACA-established Center for Medicare and Medicaid Innovation (CMS, 2015). The purpose of the initiative was to reduce the cost of healthcare by aligning payments across episodes of care.

Under a bundled payment model, participating hospitals receive a single payment for an entire episode of treatment that includes the initial hospital admission, follow-up outpatient care, and any related readmissions. Research to date has shown that bundled payments can align incentives for providers, including hospitals and post-acute care providers, allowing them to work closely together across all specialties and settings (CMS, 2015).

Enhanced Recovery After Surgery (ERAS) Protocol

The ERAS protocol, also referred to as the "fast-track protocol" (Wilmore & Kehlet, 2001, p. 473), was initiated for open colorectal surgery patients in the early 2000s in the United Kingdom. It was implemented at the healthcare system where this study took place in 2013 (R. McIntosh, personal communication, October 22, 2015).

The ERAS protocol was developed by a multidisciplinary team of nutritionists, nurses, surgeons, and anesthesiologists (Gravante & Elmussareh, 2012). Nurses work closely with postoperative patients on five aspects of the protocol: mobilization, oral feeding, analgesia, bowel motility, and catheterization.

Since its introduction in the U.K., the protocol has shortened the average length of postoperative hospital stays for open colorectal surgery patients from 7-12 days to 4-7 days, or by approximately 50% (Gravante & Elmussareh, 2012). Elements of the ERAS protocol that differ from conventional postoperative care include (a) no routine use of nasogastric tubes; (b) no routine use of drains; (c) enforced early mobilization; (d) early oral feeding; (e) intravenous fluid restriction; (f) multimodal analgesia to reduce opiate use; (g) use of laxatives and/or gum chewing to promote early bowel motility; and (h) early removal of bladder catheter (Gouvas, Tan, Windsor, Xynos, & Tekkis, 2009).

Conceptual Framework for the Study

This section contains a description of the conceptual framework that was used to guide this study, the rationale for the selection of this framework, and adaptations that were made to the framework to address the purposes of this study.

Refined Quality Health Outcomes Model

Radwin and Fawcett's (2002) Refined Quality Health Outcomes Model (R-QHOM) was identified as the most appropriate conceptual framework for this study for two main reasons. First, there was no evidence that a theory of any level (i.e., grand, middle-range, or situation-specific) existed to guide the study of the patient outcomes of LOS and DD. Second, the R-QHOM differentiated between patient trait and state characteristics, which supported the study of the relationships among patient acuity and patient outcomes (i.e., LOS and DD after open colorectal surgery).

Radwin and Fawcett's (2002) R-QHOM was based on the Mitchell, Ferketich, and Jennings (1998) Quality Health Outcomes Model (QHOM). The main change to the model arose when Radwin and Fawcett determined that "patient or client characteristics" (Mitchell et al., 1998, p. 43) should be divided into patient state characteristics and patient trait characteristics.

Patient state characteristics. Radwin and Fawcett (2002) noted that patient state characteristics include "temporary health problems and emotions" (p. 356). Patient state characteristics are likely to change during the course of a patient's hospital stay and can be influenced by, among other factors, nursing interventions.

The Shorter Oxford English Dictionary (2002) alluded to the temporary nature of patient state characteristics by defining the person's "state" as "a combination of circumstances or attributes belonging for the time being to a person" (p. 3007). Patient acuity, which has been defined as "the level of severity of a patient's illness or health condition at a point in time" (Miller & Keane, 2005), is a patient state characteristic. Patient acuity was the main independent variable in this study.

Patient comorbidities and postoperative complications are also considered to be patient state characteristics. Healthcare studies have found significant relationships among certain comorbidities and complications and LOS and DD (Campos Lobato et al., 2013; Kelly et al., 2012; Schmelzer et al., 2008). However, studying the relationships among comorbidities and postoperative complications and LOS and DD is complex and beyond the scope of this study. Comorbidities and complications were therefore accounted for in this study by stratifying the sample by the three colorectal surgery DRGs of 329, 330, and 331.

Patient trait characteristics. *The Shorter Oxford English Dictionary* (2002) described the permanent nature of patient trait characteristics by defining a "trait" as "an enduring characteristics or quality of a person, culture, or social group" (p. 3321). Patient trait characteristics neither change significantly during a patient's hospitalization nor are they likely to be influenced by nursing interventions (Radwin & Fawcett, 2002). Examples of patient traits include age, gender, race, and marital status.

Relationships among concepts. In the R-QHOM, reciprocal relationships exist among (a) interventions, system characteristics, and patient state characteristics, and (b) outcomes, system characteristics, and patient state characteristics (Radwin & Fawcett, 2002). With respect to patient trait characteristics, Radwin and Fawcett proposed that because they are less likely to change during a patient's hospitalization, they influence interventions, outcomes, and system characteristics, but the opposite is not true. See Appendix A for Radwin and Fawcett's R-QHOM.

Adaptations to R-QHOM

This section describes how the R-QHOM framework (Radwin & Fawcett, 2002) was adapted for this study.

Intervention-level variables. First, the concept of "Interventions" was omitted from the adapted framework because interventions were not included as variables this study. The patients in the study sample were assumed to be heterogeneous regarding two intervention variables: (a) open colorectal surgery, and (b) the postoperative ERAS protocol.

System-level variables. The concept of "System" was also omitted from the adapted framework because system-level variables were not included as variables this study. As a result, system-level variables that were controlled for included (a) the facility at which the open colorectal surgery took place, (b) the attending surgeon and the surgical team, and (c) the characteristics of the ICU and/or the medical-surgical unit where the patient recovered from surgery.

Patient state characteristic variables. The main independent variable in this study, automated patient acuity derived from select clinical data and discrete nursing assessment documentation fields in the patient's EHR, was named "patient acuity" and superimposed on to the adapted framework under the concept "Patient state characteristics." The state characteristics of patient comorbidities and postoperative complications were not included in the adapted model because they were accounted for in the stratification of the sample by the three colorectal surgery DRGs of 329, 330, 331.

Patient trait characteristic variables. Patient demographics and other independent variables of interest such as LOS in the ICU and body mass index (BMI) appear under the concept "Patient trait characteristics."

Outcome variables. LOS and DD appear under the concept of "Outcomes." DD also appears under "Patient trait characteristics" because it was an independent variable in the study of predictors of prolonged LOS. And LOS appears under "Patient trait characteristics" because it was an independent variable in the study of predictors of DHCS.

Relationships among concepts. The final adaptation to the R-QHOM model was that the relationships among patient state characteristics, patient trait characteristics, and patient outcomes were determined to be unidirectional. See Appendices B and C for the adapted versions of the R-QHOM. The model in Appendix B has LOS as the patient outcome with DD as an independent variable, while the model in Appendix C has DD as the patient outcome with LOS as an independent variable.

Summary

Major areas of concern within the US healthcare system today include the quality and cost of healthcare. Nurses could be in a position to increase quality while containing costs for the open colorectal surgery patient population if they were able to identify factors associated with prolonged LOS and DHCS early in a patient's hospitalization. This study proposed reusing patient acuity information, derived from clinical data and discrete nursing assessment documentation data fields in the patient's EHR, to help nurses identify at risk patients soon after surgery. The main purpose of the study was to examine the relationship among patient acuity, LOS, and DD for patients with a DRG of 329, 330, and 331. An adapted version of Radwin and Fawcett's (2002) R-QHOM served as the conceptual framework for this study.

CHAPTER 2 – LITERATURE REVIEW

In this chapter, the literature guiding this study is reviewed and synthesized. The literature review focused on research related to: (a) patient acuity systems; (b) the enhanced recovery after surgery (ERAS) protocol; (c) factors associated with prolonged length of stay (LOS) after open colorectal surgery; and (d) factors associated with a discharge disposition (DD) of discharge to home care or other healthcare settings (DHCS) after open colorectal surgery. This chapter ends with a discussion of the strengths and limitations of the studies in these research areas and the gaps that existed in the literature.

The review of the literature included published research, symposium proceedings, books, and policy statements from relevant, sanctioned websites. Three electronic literature databases were searched thoroughly. They were PubMed/Medline (National Library of Medicine, Bethesda, MD, USA), Cumulative Index of Nursing and Allied Health Literature (CINAHL) (CINAHL Information Systems, Glendale, CA, USA), and the Cochrane Database of Systematic Reviews (The Cochrane Collaboration). Each database was searched with the limits of English only and date range of 1/1/2000 to 12/31/2016. An ancestry search was conducted as articles were reviewed to determine relevant citations for potential additional papers. An ancestry search method uses citations from relevant studies to track down earlier research that may be pertinent to the literature review (Polit & Beck, 2012). Similarly, Google Scholar was used to retrieve articles that cited the studies that were found using these methods to determine if they were relevant to the review of the literature.

More than 500 items were retrieved based on electronic searches for the terms "patient acuity," "patient acuity measurement," "open colorectal surgery," "colorectal surgery," "length of stay," "prolonged LOS," "discharge disposition," "discharge destination," "factors that influence/affect length of stay," "factors related to length of stay," "predictors of length of stay," "factors that influence/affect discharge disposition," "factors related to discharge disposition," and "predictors of discharge disposition." The final resulting literature search focused on four areas of research: patient acuity systems; the ERAS Protocol in reducing LOS open colorectal surgery; patient state and trait characteristics that were related to prolonged LOS after open colorectal surgery; and patient state and trait characteristics that were related to DHCS after open colorectal surgery.

Patient Acuity Systems

This section presents the relevant nursing literature regarding patient acuity systems that are used to guide nurse staffing. The articles were about patient acuity systems used in nursing practice, and about patient acuity systems that were examined for nursing research. Publications that addressed nurse workload systems, which were contrasted with patient acuity systems in Chapter 1 (Beswick et al., 2010; Douglas, 2011), were not included in this review.

Nursing Practice

Nursing literature about patient acuity focuses on automated patient acuity systems' effectiveness in guiding nurse staffing. Nurse managers and nurse executives have written non-research articles about patient acuity systems for trade journals such as *Nursing Economic$* (Douglas, 2011; Malloch, 2012), *Nurse Leader* (Barton, 2013; Birmingham, 2010; Dent & Bradshaw, 2012), and other trade journals (Kidd, Grove, Kaiser, Swoboda, & Taylor, 2014; Kempson, 2008; Nguyen, 2015).

Six trade journal articles outlined the successes and challenges associated with implementing a computerized patient acuity system to guide nurse staffing at healthcare facilities (Barton, 2013; Birmingham, 2010; Dent & Bradshaw, 2012; Kempson, 2008; Kidd et al., 2014;

Nguyen, 2015). Table 2.1, below, summarizes the authors' description of pre- and post-implementation challenges, success strategies, and benefits incurred as a result of the implementation.

Table 2.1

Successes and challenges of computerized patient acuity systems to guide staffing

Authors, Location, Acuity System	Pre-Implementation Challenges	Post-Implementation Challenges	Success Strategies	Benefits
Barton (2013) 550+ bed Northeast Georgia health system Acuity system not named	Buy-in at all levels that: -Acuity based staffing lends credibility to requests for additional nursing positions -Data can help managers determine overall unit staffing trends and do quality improvement	-Perception that some nurses work harder than others on unit due to difference in number of patients	-Transparency with staff of how system works -Monthly training meetings with nurse managers	-Reduced use of external staffing agencies -Reduced overtime hours -Increased units meeting productivity goals from 40% to 90% -Flexibility enabled by real time information
Birmingham (2010) Facility not named Clairvia® CVM™ Outcomes-Driven Patient Acuity	Buy-in at all levels that: -Use of evidence based staffing brings facility closer to goals of healthcare reform (quality and cost improvement; value to consumer, and access to healthcare)	-Multiple software upgrades require resources	-Work closely with leadership -Conduct focus groups with frontline staff -Establish a Facility Implementation Team	-Provided charge nurses access to real time objective information regarding patient acuity, staff characteristics = equitable distribution of care hours and fairness in workload
Dent (2012)	Buy-in at all levels that:	-Communication gaps	-Nurse leader involvement	-Improved patient outcomes

Two 300+ bed hospitals in West Texas Acuity system not named	-Existing outcomes are not adequate -Acuity-based staffing model is best option -Technology making process simpler	-Nurse leaders questioned data accuracy	-Update acuity every 6 hours -Make assignments based on needs of patient and skill level of nurse	-Increased revenue -Preparing for ACA model -Clinical integration -Transition to community resources -Reduced overtime cost (apx. $4 million annually -PRN staff used more effectively -Increased staff satisfaction
Kempson (2008) 450-bed hospital in Phoenix, AZ RES-Q Labor Resource Management from RES-Q Healthcare Systems	-Arizona law requires hospitals to account for acuity -Manual system in use	-Intensive care units (ICUs) and behavioral health units not using automated system	-Nurse leader involvement	-Efficiency and effectiveness of hospital care -Clinically sound, skill-matched, financially optimized and productive staffing -Accounts for staff preferences -Increased nurse satisfaction
Kidd (2014) 400-bed hospital in Indiana Acuity system not named	-Engage all stakeholders -Enormous training effort	-Some people will never get on board with new process -Ongoing training needed	Focus on pre-implementation issues of: -Inequitable patient assignment -Relying on charge nurses' judgments of patient acuity	-Improved nurse-sensitive patient outcomes (falls, hospital acquired pressure ulcers) -Improved perception by nurses of care delivered
Nguyen (2015)	Buy-in at all levels that:	-Ongoing recalibration of	-Self-service platform allows	-Match patients with nursing

Genesis Healthcare System, Ohio Acuity system not named	-Not all patients are alike -Nurse-to-patient ratio staffing is wasteful and can create skill gaps that can affect patient outcomes	staff is disruptive to staff	nurses to set scheduling preferences and availability -Nurse managers are empowered to make patient-staff assignments to increase workforce satisfaction and minimize safety risk	skills, experience, capacity, and availability -Safer environment for nurses and patients -Can justify staffing decisions if questions arise -Cost of labor savings of > 6%

Summary

Only one article in a nursing trade journal was about the automated patient acuity system, Clairvia®, that is in use where this study took place (Birmingham, 2010). Clairvia® maps the nursing documentation of patient assessments in the electronic health record (EHR) to automatically calculate patient acuity scores in near-real time. The other authors either did not identify the patient acuity measurement tool and/or did not specify that patient acuity measurement was based on nursing documentation of patient assessments. Furthermore, there were no articles about using patient acuity for any other purpose but to guide nurse staffing.

All authors identified the challenges of implementing a patient acuity system to support staffing decisions, such as obtaining buy-in at all levels of the organization regarding its benefits, training large a large number of staff, and addressing resistance to change. Post-implementation challenges included clear communication of expectations, adaptation to new roles and routines by staff nurses and nurse managers, and an ongoing misperception that nurse-staff ratios were the most equitable way of assigning patients. The authors recommended strategies for success that ranged from keeping nurse leaders involved through every step of the implementation and post-implementation process, being transparent with frontline staff regarding how the computerized acuity system guides staff assignments, and establishing ongoing quality improvement initiatives to ensure reliability and validity of the data in the patient acuity system.

The study authors, without exception, remarked on the benefits of a computerized patient acuity system to guide staffing. They described a positive association between adequate nurse staffing levels and positive patient outcomes, increased nurse satisfaction, productivity, and reduced healthcare costs.

Nursing Research

The two studies described in this section were selected because they (a) defined patient acuity as level of illness rather than nurse workload; and (b) used information from the patients' EHR to determine patient acuity levels (Kontio et al., 2014; Kim, Harris, Savova, Speedie, & Chute, 2007).

Kontio et al. (2014) reviewed 23,528 EHRs of patients with cardiac problems admitted to a university hospital between 2005 and 2009. The goal of the study was to explore the extent to which clinical information can predict patient acuity scores for the following day. Kontio et al. used language technology to analyze nursing narrative notes and the coded system that examined four patient acuity measures that nurses have an ability to impact: (a) breathing, blood circulation and symptoms of disease; (b) nutrition and medication; (c) personal hygiene and excretion; (d) activity, movement, sleep, and rest. The results showed that it is possible to obtain accurate predictions about patient acuity scores for the next day based on the assigned scores and nursing notes from the current day. Kontio et al.'s model achieved a concordance index of 0.821 when predicting the patient acuity scores for the following day.

Kim et al. (2007) reviewed 32 randomly selected EHRs on eight adult intensive care units (ICU) at the Mayo Clinic in Rochester, MN, in December 2004 to explore whether patient data documented in an electronic nursing flow sheet could be used to estimate near-real time patient acuity. The authors used a rule-based system (RBS) to determine values of 13 patient acuity indicators found in EHR nursing flow sheets. They then compared the RBS values with those manually assigned by expert nurses. The results showed an RBS-expert nurse agreement rate of >60% on nine of the 13 patient acuity indicators. Moreover, the lack of agreement was correlated with missing nursing documentation in EHR flow sheets.

Summary

Kontio et al. (2014) and Kim et al. (2007) both determined that software programs can generate patient acuity scores using nursing documentation data in the EHR.

Enhanced Recovery After Surgery (ERAS) Protocol

This section contains a review of the medical and nursing literature regarding the effectiveness of ERAS protocol in reducing LOS. Specifically, it examines research conducted with open colorectal surgery patients.

Medical Studies

Five medical studies that examined the effectiveness of the ERAS protocol in reducing LOS after open colorectal surgery are reviewed in this section. Most of the studies that were conducted by surgeons about the ERAS protocol were randomized-control trials (Thiele et al., 2015; Teeuwen et al., 2010) or meta-analyses of randomized control trials (Rawlinson, Kang, Evans, & Khanna, 2011; Eskicioglu, Forbes, Aarts, Orainec, & McLeod, 2009; Gouvas et al., 2009).

Randomized control trials. During a one-year period, Thiele et al. (2015) compared 109 patients who received the ERAS protocol with 98 patients who received conventional care after open colorectal surgery. They found that postoperative LOS for ERAS patients declined from 7.5

to 5.2 days (*p*=0.007), or by 30%, whereas patients in the conventional care group only had an 8% reduction in LOS (*p*=0.0001). Teeuwen et al. (2010) compared LOS between 61 ERAS patients to 122 conventional care patients. They found that ERAS patients spent significantly fewer days in the hospital postoperatively (*Mdn*=6 days, Range 3-50 days) (*p*=0.032) than conventional care patients (*Mdn*=9 days, Range 3-138 days) (*p*=0.032).

Meta-analyses. Rawlinson et al. (2011) conducted a meta-analysis of 11 randomized control studies and concluded that patients who underwent major open colorectal surgery and were managed with ERAS protocols had a reduction in primary hospital stay of 2.53 days compared to patients managed with traditional care pathways (95% confidence interval [CI] [-35.4,-1.47], *p*<0.00001). This finding was confirmed in a meta-analysis conducted by Gouvas et al. (2009). The authors reviewed four randomized control trials and seven controlled clinical trials and concluded that patients who received the ERAS protocol had an average LOS of 2.62 days fewer than patients who received standard care (95% CI [-3.74,-1.50], *p*<0.00001). Eskicioglu et al. (2009) reviewed five randomized control trials, four of which demonstrated significantly lower postoperative LOS for patients receiving the ERAS protocol compared to patients receiving traditional care.

Nursing Studies

Six studies from the nursing literature the effectiveness of the ERAS protocol for reducing length of hospital stay after open colorectal surgery are reviewed in this section. Three author groups examined the impact of the overall ERAS protocol reducing LOS after open colorectal surgery (Yin, Zhao, & Zhu, 2014; Fitzgerald, 2012; Baird, Maxson, Wrobleski, & Luna, 2010), while the other three examined specific aspects of the ERAS protocol (Higgs, Henry, & Glackin, 2014; Wallstrom & Frisman, 2013; Ng & Neill, 2006).

Overall ERAS protocol. Yin et al. (2014) conducted a meta-analysis of nine randomized control trials that included 947 open colorectal resection patients. All nine trials reported a significantly shorter LOS in patients receiving the ERAS protocol than those conventional care ($p<0.05$). Pooling the data for the 947 patients also revealed a significant decrease for LOS (OR= -0.91, 95% CI [-1.26, -0.57], $p<0.01$). Fitzgerald (2012) conducted a six-month pilot study of the ERAS protocol at three sites with 226 patients. Though she did not provide a level of statistical significance, Fitzgerald found that mean LOS decreased from 14.6 days before the pilot study to 8.8 days during the pilot, a reduction of 40%. Baird et al. (2010) found in a sample of 100 adult patients that mean LOS for patients provided with ERAS protocol was 20% shorter than for patients who received conventional care: 4.66 (SD = 3.11) days and 5.87 days (SD = 3.14), respectively ($p<0.01$).

Single aspects of ERAS protocol. Higgs et al. (2014) surveyed 20 patients who received multi-modal pain management after open colorectal surgery rather than conventional narcotic analgesic control. They found that these patients were more satisfied with their care and stayed in the hospital for a shorter period than patients who were solely administered narcotics ($p<0.01$).

Ng and Neill (2006) conducted a systematic review of 15 randomized control trials involving 1,352 patients. Though they do not report a statistical significance level, they concluded that average LOS was reduced by three days with early feeding, even when older people and those at higher risk for postoperative complications were included in the study.

Wallstrom and Frisman (2013) conducted a systematic review of 34 studies involving 2,243 participants to examine the benefits of early bowel motility. Two-thirds of the studies concluded that LOS was significantly reduced for patients who had early return of bowel function, either from early eating or from chewing gum.

The five medical and six nursing studies regarding the effectiveness of the ERAS on reducing LOS for open colorectal surgery patients are summarized in Table 2.2. The table includes the research design, a description of the study sample, the aspects of the ERAS protocol that were studied, and the results of the data analysis.

Table 2.2

Medical and nursing studies regarding the effectiveness of the Enhanced Recovery After Surgery (ERAS) protocol

Citation, Discipline	Research Design	Study Sample	Aspect of ERAS Protocol	Results of Data Analysis
Baird (2010) Nursing	Retrospective correlational study	Open colorectal surgery patients *N*=100	All	ERAS= 4.66 (*SD*, 3.11) days Conventional care=5.87 (*SD*, 3.14) ($p < 0.01$)
Eskicioglu (2009) Medical	Meta-analysis of 5 randomized control trials	Open colorectal surgery patients	All	4 out of 5 studies showed significant decrease in LOS for ERAS patients compared to conventional care
Fitzgerald (2012) Nursing	Pilot Study	Open colorectal surgery patients 3 sites *N*=226	All	Pre pilot=14.6 days Pilot= 8.8 days
Gouvas (2009) Medical	Meta-analysis of 4 randomized control trials and 7 randomized control trials	Open colorectal surgery patients *N*=1,021	All	2.62 day reduction in primary hospital stay in the ERAS 2.26 days less than standard care (95% CI [-3.74, -1.50], p<0.00001).

Higgs (2014) Nursing	Qualitative	Open colorectal surgery patients *N*=20	Multi-modal pain management	Patients were more satisfied with their care and stayed in the hospital for a shorter period than patients who were only administered narcotics
Ng (2006) Nursing	Systematic Review 15 randomized control trials	Open colorectal surgery patients *N*=1,352	Early feeding	Early feeding reduces LOS by 3 days
Rawlinson (2011) Medical	Meta-analysis of 11 randomized control studies	Open colorectal surgery patients	All	ERAS 2.53 days less than traditional care (95% CI [35.4, -1.47])
Teeuwen (2010) Medical	Randomized control trial	Open colorectal surgery patients *N*=183 ERAS *n* = 61 Conventional care *n* =122	All	ERAS: *Mdn*=6 days, Range 3-50 Conventional care: Mdn=9 days, Range 3-138 days (*p*=0.032)
Thiele (2015) Medical	Randomized Control Trial	Open colorectal surgery patients *N*=207 (ERAS protocol *n* =109 Conventional care *n* =98	All	ERAS: Reduced LOS from 7.5 to 5.2 days (*p*=0.007) for open procedures and from 5.5 days to 3.8 days. Conventional care: Reduced LOS of 0.6 days (*p*= 0.0001)
Wallstrom	Systematic	Open colorectal	Early bowel	Two-thirds of

(2013) Nursing	review 34 studies	surgery patients *N*=2,243	motility	studies concluded that LOS significantly reduced by early bowel motility or chewing gum
Yin (2014) Nursing	Meta-analysis of 8 randomized control trials	Open colorectal surgery patients *N*=756	All	ERAS: 95% CI [-1.26, -0.57] Mean standard deviation − 0.91. Significantly shorter LOS for ERAS than conventional care (p<0.01)

Summary

Regardless of the research design, whether randomized control trial, retrospective correlational, or qualitative, medical and nurse researchers found that the ERAS protocol was successful in reducing LOS after open colorectal surgery. The ERAS protocol became a best clinical practice in the US in 2013 (Mayo Clinic, 2016). It was implemented at that time at the healthcare system where this study took place.

Length of Stay After Open Colorectal Surgery

One of the two patient outcomes of interest in this study is LOS. Ten medical and nursing studies were selected for this review of the literature because they specifically (a) studied relationships among patient state and trait characteristics and LOS; and (b) selected patients who underwent open colorectal surgery procedures, as opposed to laparoscopic.

Patient State Characteristics

Comorbidities. Many of the study authors collected data about patient comorbidities to describe their sample, but did not analyze its relationship with LOS (Ahmed, Lim, Khan, McNaught, and MacFie, 2010; Ngui et al., 2010; Reddy et al., 2003; Wick et al., 2011). Authors who did analyze this relationship included Ahmed Ali, Dunner, Gurland, Vogel, and Kiran (2014); Campos Lobato et al. (2013); Kelly et al. (2012), and Schmelzer et al. (2008).

Ahmed Ali et al. (2014) conducted a cohort study of 1,461 open colorectal surgery patients using a prospectively collected database. They defined prolonged LOS as greater than the national average LOS for the patient's diagnostic-related group (DRG). The authors found that a preexisting cardiac disease was significantly associated with prolonged LOS after open colorectal surgery ($p<0.001$). Campos Lobato et al. (2013) conducted a study of 12,269 open colorectal surgery patients using information from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database (ACS, 2015). Twenty-three percent (2,617) of patients had an LOS that was greater than the third quartile for the patients in their study (*Mdn*=15 days, inter-quartile range 13-22). They found that prolonged LOS was significantly associated with the comorbidities of congestive heart failure and Crohn's disease ($p<0.01$). Kelly et al. (2012) conducted a study of 8197 patients who had undergone open colorectal resections. They defined prolonged LOS as a duration greater than the sample median of 16 days. In a multivariate analysis, they found that having at least one of the following comorbidity prolonged LOS by at least one week: asthma ($p<0.0001$); chronic obstructive pulmonary disease (COPD) (p<0.0001); coronary artery disease (CAD) ($p<0.0001$); or end-stage renal disease (ESRD). Schmelzer et al. (2008) conducted a retrospective analysis of 899 adult patients who underwent open colonic resection over an 8-year period at a tertiary institution.

They defined prolonged LOS as greater than the sample median of 7 days. In a multivariate analysis, Schmelzer et al. determined that having at least one of the following comorbidities was significantly related to prolonged LOS: COPD (odds ratio [OR] = 3.1, 95% CI [1.4, 6.7], p=0.004); CAD (OR=2.8, 95% CI [1.3, 6.5], p=0.006); ESRD (OR= 6.2, 95% CI [1.2, 33.3], p=0.03); alcoholism (OR=2.2, 95% CI [1.2, 4.1], p=0.01); or illicit drug use (OR=10.0, 95% CI [4.1, 24.4], p<0.0001).

Postoperative complications. The following studies revealed significant relationships among postoperative complications and prolonged LOS for open colorectal surgery patients: Campos Lobato et al. (2013), Keenan et al. (2014), Reddy et al. (2003), and Wick et al. (2011). Campos Lobato et al. found a significant relationship (p<0.001) between the postoperative complications of pneumonia, deep vein thrombosis (DVT), catheter-associated urinary tract infection (CAUTI), and surgical site infection (SSI) and prolonged LOS. Keenan et al. conducted a retrospective cohort study of 559 open colorectal surgery patients using clinical and cost data. They found that patients who developed an SSI or postoperative sepsis had a 40% longer LOS (7.9 days versus 4.6 days) than patients who did not (p<0.001). Reddy et al. conducted a prospective observational study of 350 open colorectal surgery patients whose mean LOS was 10 days. The authors found that mean LOS increased by 11.7 days for patients who developed SSIs (p<0.001), by 4.3 days for CAUTIs (p=0.021), and 17.6 days for respiratory infection (p<0.001). Wick et al. conducted a retrospective cohort study of 7020 open colectomy patients over seven years. In multivariate analysis, they found that mean LOS of stay was 15% longer in patients who developed an SSI than those who did not (9.5 days [95% CI 9.0-10.0] versus 8.1 days [95% CI 8.0-8.2] days, respectively; p< 0.001). They also noted that the cost of treating a patient who develops a postoperative SSI is $17,324 greater than for patients who do not ($31,933 compared with $14,608). While Schmelzer et al. (2008) did not find that SSIs were significantly associated with a longer LOS (*p*=0.07), their multivariate analysis revealed a significant relationship between prolonged LOS and developing DVT (OR=2.6, 95% CI [1.6, 4.1], *p*<0.0001) or an intra-abdominal abscess (OR=2.9, 95% CI [1.5, 6.0], *p*=0.002).

Patient acuity. Patient acuity is subject to change during a patient's hospitalization and is therefore considered a patient state characteristic. There were no studies that examined the relationship between patient acuity and LOS after open colorectal surgery.

Patient Trait Characteristics

ASA score. The American Society of Anesthesiologists (ASA) Physical Status Classification System score (ASA, 2014) was the only patient acuity measure that appeared in the literature regarding LOS after open colorectal surgery. However, because the ASA score is measured once preoperatively, it does not subject to change during a patient's hospitalization, and is thus considered a patient trait characteristic.

Ahmed Ali et al. (2014) did not find a significant relationship between a higher ASA score and prolonged LOS (*p*=0.59). However, four author groups did: Ahmed et al. (2010), Campos Lobato et al. (2013), Ngui et al. (2010), and Schmelzer et al. (2008). Ahmed et al. conducted a retrospective case note review of 231 elective open colorectal surgery patients. They determined that the median LOS was 6 days (inter-quartile range 5-9 days). On multivariate analysis, the authors found having a higher ASA score, indicating higher preoperative acuity, was a significant predictor of prolonged LOS (OR=2.85, 95% CI [1.17, 6.89], *p*=0.04). Both Campos Lobato et al. and Schmelzer et al. found that ASA scores of $\geq$ 3 on the six-point scale were significant predictors of prolonged LOS (*p*<0.001). Ngui et al. conducted a retrospective review of prospectively collected data of 161 patients who had elective open colorectal resections. They found that for every one unit of increase in a patient's ASA score, their LOS increased by 1.15 days (p=0.03).

Age. Kelly et al. (2012) and Ngui et al. (2010) found that a significant relationship existed between advanced patient age and prolonged LOS after open colorectal surgery. Kelly et al. found that patients younger than age 60 stayed a mean of 16 days, which was equal to the sample median LOS of 16 days (p<0.001). Patients ages 60-69 stayed a mean of 4 days, or 25%, longer than the sample median (p<0.001); patients ages 70-79 stayed eight days, or 50%, longer (p<0.001), and patients age 80 and above stayed 11 days, or 69%, longer than the sample median (p<0.001). Ngui et al. found that a patient age of greater than 70 years was a significant predictor of prolonged LOS (OR=10.5, 95% CI [3.0, 37.7], p<0.0001). Neither Ahmed Ali et al. (2014) (p=0.74) nor Reddy et al. (2003) (p=0.0617) found that age was a predictor of prolonged LOS for open colorectal surgery patients.

Gender. Most study authors used patient gender to describe their samples. However, Campos Lobato et al. (2013) found on multivariate analysis that male patients were more likely to have prolonged LOS after open colorectal surgery than female patients (p<0.001). Ahmed et al. (2010) and Ahmed Ali et al. (2014) also included gender in their multivariate analyses, but did find a significant relationship between gender and LOS (p=0.54 and p=0.901, respectively).

Discharge disposition. Kelly et al. (2012), Ngui et al. (2010), and Reddy et al. (2003) examined the relationship between discharge disposition and LOS after open colorectal surgery. Discharge disposition is the final place or setting to which the patient was discharged on the day of discharge (The Joint Commission, 2012). Kelly et al. found that open colorectal surgery who were discharged to home without health services had a mean LOS of 20 days compared to 29 days, an increase of 31%, for patients who were DHCS (p<0.001). Ngui et al. found that patients who were discharged to their home without health services had a significantly shorter LOS than patients who were DHCS (OR=15.4, 95% CI [1.6, 150.3], p=0.019). Reddy et al. obtained similar results (p=0.002).

Marital status. Like gender, most study authors used the patients' marital status to describe their samples. However, Kelly et al. (2012) and Ngui et al. (2010) found a significant relationship between marital status and LOS after open colorectal surgery. Kelly et al. noted that being married reduced LOS after open colorectal surgery by 16%, from a mean of 24 days to 20 day (p<0.001). Ngui et al.'s study concluded that being a widower significantly increased LOS after open colorectal surgery (OR=3.5, 95% CI [1.2, 10.2], p=0.02).

Body mass index. Three author groups determined that having a body mass index (BMI) of "obese," or $\geq$ 30 kilograms per meters squared (kg/m^2) (Centers for Disease Control and Prevention [CDC], 2016a) was a predictor for prolonged LOS after open colorectal surgery. Using bivariate analysis, Schmelzer et al. (2008) found that having a high BMI was a significantly related to prolonged LOS (p=0.02). Wick et al. (2011) also found a significant relationship between elevated BMI and prolonged LOS using both bivariate (OR=1.61, 95% CI [1.34, 1.93], p<0.05) and multivariate analysis (OR=1.59, 95% CI [1.32-1.91], p<0.05). Tapper, Dixon, Frampton, and Frizelle (2013) conducted an 18-month prospective study of 345 patients that focused on the cost of postoperative care for open colorectal surgery patients. They found that LOS for patients with a BMI of $\geq$ 30 kg/m^2 was 25% longer than patients with lower BMIs (p=0.014). Neither Ahmed Ali et al. (2014) nor Ahmed et al. (2010) found statistically significant relationships between a high BMI and prolonged LOS (p=0.61 and p=0.576, respectively).

A summary of these 10 studies regarding the relationship between LOS and patient state and trait characteristics appears in Table 2.3. A “+” sign indicates that the study found significant relationships among the patient states or traits and the patient outcome of prolonged LOS. A “Ø” symbol indicates that the authors noted that the relationships were not significant. A blank cell means that the relationships were not studied.

Table 2.3

Patient state and trait characteristics that influence length of hospital stay (LOS) after open colorectal surgery

Citation	Comor-bidities	Postoperative Complications	ASA Score	Age	Gender	Discharge Disposition	Marital Status	BMI
Ahmed (2010)			+		Ø			Ø
Ahmed Ali (2014)	+		Ø	Ø	Ø			Ø
Campos Lobato (2013)	+	+	+		+			
Keenan (2014)		+						
Kelly (2012)	+			+		+	+	
Ngui (2010)			+	+		+	+	
Reddy (2003)		+		Ø		+		
Schmelzer (2008)	+	+	+					+
Tapper (2013)								+

Wick (2011)		+						+
Totals (+)	4	5	4	2	1	3	2	3
Totals (Ø)	0	0	1	2	2	0	0	2

Summary

The results of the 10 studies indicated that there was both agreement and disagreement regarding patient state and trait characteristics that are related to prolonged LOS for open colorectal surgery patients. This lack of consistency could be the result of studying samples from different populations, using different sample sizes, defining the term prolonged LOS differently, or employing different methods of data analysis. Nonetheless, the most commonly reported patient trait characteristics will be studied to determine which, if any, are significant among open colorectal surgery patients at the healthcare system where the study takes place. Patient state characteristics of comorbidities and complications will be taken into account by stratifying the sample by DRG.

The most common patient trait characteristics that were associated with prolonged LOS for open colorectal surgery patients were high ASA score, advanced patient age, male gender, discharge disposition other than to home without health services, being married, and a high BMI. Patient acuity as automatically calculated by a software system that maps to nursing documentation on patient assessment in the EHR will be included in the study because it is the main independent variable of interest in this study. Though there was a lack of studies about the relationship between LOS in the ICU and total LOS after open colorectal surgery, this will be examined in this study because it was reported as significant at the 2015 Midwest Nursing Research Conference (MNRS) by one of the dissertation committee members (A. Talsma, personal communication, March 28, 2015).

Discharge Disposition After Open Colorectal Surgery

The second patient outcome of interest in this study is DD after open colorectal surgery. There were no studies that examined the relationships among patient state or trait characteristics and DD after open colorectal surgery. Thus, the six medical and nursing studies that were selected for this review of the literature concern patients who underwent knee or hip arthroplasty patients, hereafter referred to as total joint arthroplasty (TJA). This was the primary population that has been used to study the relationships among patient state and trait characteristics and DD. Though open colorectal surgery patients were not studied, these articles provide information regarding the relationships among patient state and trait characteristics and DD.

Patient State Characteristics

Comorbidities. Three author groups found that there was a significant relationship between patient comorbidities and being DHCS: Barsoum et al. (2010), Halawi et al. (2015), Titler et al. (2006), and Vochteloo et al. (2012). Barsoum et al. conducted a retrospective review of 517 medical charts of TJA patients and used logistic regression to develop a model for determining the probability that a patient will be DHCS. They found that a patient history of pulmonary disease was significantly related to DHCS (p=0.0044). They did not find that CAD (p=0.273) or diabetes (p=0.371) were significantly related to DD. Halawi et al. conducted a retrospective study of 372 TJA patients. They found on bivariate analysis that patients with at least one comorbidity were more likely to be DHCS (p<0.001) than patients without comorbidities. Vochteloo et al. analyzed 310 consecutive TJA patients ages 50 and older and found on multiple regression analysis that the comorbidity of dementia was predictive of DHCS (OR=9.98, 95% CI [1.23, 80-85], p=0.031).

Postoperative complications. Titler et al. (2006) conducted a retrospective descriptive study of 569 patients aged 60 or greater over a period of four years using data from multiple hospital electronic data repositories. They found that patients who required nursing interventions for postoperative complications were more likely to be DHCS than patients who did not experience complications (p<0.0001).

Patient acuity. There was a lack of studies that examined the relationship between patient acuity and DD for any patient population.

Patient Trait Characteristics

ASA score. Bozic, Wagie, Naessens, Berry, and Rubash (2006); Sharareh, Le, Hoang, and Schwarzkopf (2014); and Vochteloo et al. (2012) all found that higher ASA scores were related to DHCS. Bozic et al. conducted an analysis of 7,818 TJA patients at three large hospital facilities over a period of four years. They found on multivariate analysis that an ASA score of $\geq$ 4 was an independent predictor of DHCS for total hip arthroplasty (THA) patients (OR=10.79, [CI 8.47, 12.43], p<0.0001), and that an ASA score of $\geq$ 3 was an independent predictor for total knee arthroplasty (TKA) patients (OR=1.56, CI [1.23-3.21], p<0.0001). Sharareh et al. conducted a retrospective cohort study of 50 patients who were discharged to home without healthcare services and 50 patients who were DHCS. They found on multivariate analysis that patients who were DHCS had higher ASA scores (2.94 +/- 0.48, range 2-4) compared to patients who were discharged to home without healthcare services (2.73 +/- 0.49, range of 2-4) (p=0.03). Vochteloo et al. found on bivariate analysis that having and ASA of III or IV had a 75% greater chance of being DHCS than patients with an ASA of I or II (p=0.007). However, on multivariate analysis, ASA was not found to be a predictor of DHCS.

Age. Barsoum et al. (2010) found that advanced age was significantly related to DHCS for TJA patients when they conducted a bivariate analysis ($p<0.0001$), but that it was not a significant predictor on multivariate analysis ($p=0.119$). Bozic et al. (2006) found that being 40 years old or greater was a significant predictor for THA patients ($p<0.0001$), but it took being 80 years old or greater to be a significant predictor for TKA patients ($p<0.0001$). Halawi et al. (2015) conducted a multivariate analysis and found that the age of 60 was a "significant cut point with regards to likelihood" (p. 541) of DHCS ($p<0.001$). Vochteloo et al. (2012) found in multivariate analysis that an age of 65 or greater was a predictor of DHCS (OR=3.76, 95% CI [1.48, 9.55], $p=0.005$). However, Sharareh et al. (2014) did not find that age was significantly related to DHCS for TJA patients (p=0.12).

Gender. Campos Lobato et al. (2013) had found that the male gender was significantly related to prolonged LOS. Conversely, Barsoum et al. (2010), Bozic et al. (2006), Halawi et al. (2015), and Vochteloo et al. (2012) all found that being female was significantly related to DHCS ($p<0.0001$, $p<0.0001$, $p<0.001$, and $p<0.0001$, respectively). Neither Titler et al. (2006) nor Sharareh et al. (2014) found that gender was significantly related to DHCS ($p>0.05$ and $p=0.20$, respectively) .

Length of stay. While Kelly et al. (2012), Ngui et al. (2010), and Reddy et al. (2003) found that DD after open colorectal surgery was significantly related to LOS, Sharareh et al. (2014) found that the inverse was also true. In their retrospective cohort study of TJA patients, they determined that having a longer LOS was related to DHCS ($p=0.02$)

Marital status. Of the six studies in this section, Titler et al. (2006) and Vochteloo et al. (2012) were the only two author groups that examined the relationship between marital status and DHCS after TJA. Using multivariate analysis, Titler et al. found that patients who were widowed, separated, divorced, or single were more likely to DHCS than married patients ($p<0.001$). On bivariate analysis, Vochteloo et al. found a significant association between not "having a partner" and DHCS ($p<0.001$), but this relationship was not sustained under multivariate analysis.

BMI. In multivariate analysis, Halawi et al. (2015) and Titler et al. (2006) found a statistically significant relationship between a BMI of > 30 kg/m^2 and DHCS ($p=0.044$ and $p=0.03$, respectively). However, Barsoum et al.'s (2010) multivariate analysis did not yield statistically significant results regarding the relationship between BMI and DD ($p=0.9117$).

A summary of these six studies regarding the relationship between DD and patient state and trait characteristics appears in Table 2.4. A "+" sign indicates that the study found significant relationships among the patient states or traits and the outcome of DHCS. A "Ø" symbol indicates that the authors noted that the relationships were not significant. A blank cell means that the relationships were not studied.

Table 2.4

Patient state and trait characteristics that influence discharge disposition (DD) after total joint arthroplasty (TJA) surgery

Citation	Comor-bidities	Postoperative Complications	ASA Score	Age	Gender	Length of Stay	Marital Status	BMI
Barsoum (2010)	+			Ø	+			Ø
Bozic (2006)			+	+	+			
Halawi (2015)	+			+	+			+
Sharareh (2014)			+	Ø	Ø	+		

Titler (2006)	+	+			Ø		+	+
Vochteloo (2012)	+		Ø	+	+		+	
Totals (+)	4	1	2	3	4	1	2	2
Totals (Ø)	0	0	1	2	2	0	0	1

Summary

The results of the six studies indicated that there was both agreement and disagreement regarding patient state and trait characteristics that are related to DD after TJA surgery. Similar to studies regarding LOS for open colorectal surgery patients, this lack of consistency could be the result of studying samples from different populations, using different sample sizes, defining the term DHCS differently, or employing different methods of data analysis. Nonetheless, the most commonly reported patient trait characteristics will be studied to determine which, if any, are significant among open colorectal surgery patients at the healthcare system where the study takes place. Patient state characteristics of comorbidities and complications will be taken into account by stratifying the sample by DRG.

The most common patient trait characteristics that were associated with DD for TJA patients were high ASA score, advanced patient age, female gender, being married, and a high BMI. Patient acuity will be included in the study because it is the main independent variable of interest in this study. Only one study examined the relationship between prolonged LOS and DD for TJA patients. Because the authors found that the relationship was significant, it will be examined in this study.

Strengths and Limitations of Body of Literature

This section describes the strengths and limitations of the body of literature relating to patient acuity systems, the ERAS protocol for open colorectal surgery patients, and LOS and DD after open colorectal surgery. This section ends with a discussion of the gaps in the literature that this study attempts to fill.

Patient Acuity Systems

One the strengths of the body of literature regarding patient acuity systems was that there were a number of articles that were written by nurses for nursing. Articles appeared in nursing trade journals (Barton, 2013; Birmingham, 2010; Dent & Bradshaw, 2012, Kempson, 2008; Kidd et al., 2014; Nguyen, 2015) and peer-reviewed nursing journals (Kim et al., 2007; Kontio et al., 2014).

There were also limitations to this body of literature. First, four of the six authors did not name the patient acuity system that was discussed in their trade journal articles (Barton, 2013; Dent & Bradshaw, 2012; Kidd et al., 2014; Nguyen, 2015). Doing so would have helped compare patient acuity systems with the one that is in use at the healthcare system where this study took place, as described by Birmingham (2010). Second, there were few research articles about patient acuity systems (Kim et al., 2007; Kontio et al., 2014). Those that existed described how to nursing documentation in the EHR was used to determine patient acuity, but did not discuss how this knowledge was used in nursing practice.

Enhanced Recovery After Surgery (ERAS) Protocol

The body of literature regarding the effectiveness of the ERAS protocol for reducing LOS after open colorectal surgery also had strengths and limitations. The first strength was that the medical and nursing studies were mostly Level I and Level II studies. Evidence hierarchies rank the relative authority of various types of research designs. The Rating System for the Hierarchy of Evidence (Melnyk & Fineout-Overholt, 2011) uses a seven-level scale. Level I studies, the highest rank, are systematic reviews or meta-analyses of all relevant experimental research on a topic, i.e., randomized control trials. Level II studies are experimental in design. Level VII studies, the lowest rank, consist of evidence from the opinion of authorities and/or reports from expert committees. Eskicioglu et al. (2009), Gouvas et al. (2009), Ng & Neill (2006), Rawlinson et al. (2011), Wallstrom & Frisman (2013), and Yin et al. (2014) published systematic reviews or meta-analyses of randomized control trials. Thiele et al. (2015) and Teeuwen et al. (2010) conducted Level II studies, i.e., randomized control trials.

The second strength was that more than half of the studies regarding ERAS in this review were published in nursing journals (Baird et al., 2010; Fitzgerald, 2012; Higgs et al., 2014; Ng & Neill, 2006; Wallstrom & Frisman, 2013; Yin et al., 2014). Moreover, three of these six articles were Level I systematic reviews or meta-analyses of randomized control trials (Ng & Neill; Wallstrom & Frisman; Yin et al.). However, a limitation of these Level I nursing studies was that they were systematic reviews of experimental trials that were conducted by surgeons and published in surgical journals, not by nurses.

A second limitation of this body of literature was that there were no experimental, or Level II, studies conducted by nurse researchers regarding the effectiveness of the ERAS protocol for reducing LOS after open colorectal surgery. Four nursing research studies exist in the literature. Fitzgerald (2012) conducted a small cohort study (Level IV on the Rating System for the Hierarchy of Evidence), Baird et al. (2010) conducted a retrospective correlational study (Level VI), and Higgs et al. (2014) conducted a qualitative study (Level VI).

Length of Stay (LOS)

A strength of the body of literature regarding LOS was that 10 studies had been published that specifically examined (a) open colorectal surgery patients and (b) the relationships among patient state and trait characteristics and LOS (Ahmed et al., 2010; Ahmed Ali et al., 2014;

Campos Lobato et al., 2013; Kelly et al., 2012; Keenan et al., 2014; Ngui et al., 2010; Reddy et al., 2003; Schmelzer et al., 2008; Tapper et al., 2013; Wick et al., 2011). Among the 10 studies, the patient state characteristics of comorbidities and postoperative complications were studied, and the patient characteristics of ASA score, age, gender, discharge disposition, marital status, and BMI were examined.

A limitation of the body of literature regarding LOS after open colorectal surgery was that none of the 10 studies used an experimental design. They all used non-experimental, retrospective, descriptive designs, which are classified as a Level VI on the Rating System for the Hierarchy of Evidence (Melnyk & Fineout-Overholt, 2011). Polit and Beck (2012) noted that, compared with experimental or quasi-experimental studies, "non-experimental studies are weak in their ability to support causal inferences" (p. 228). Non-experimental studies do support correlational relationships, though they may not receive as much recognition as they deserve because of their low ranking on the Rating System for the Hierarchy of Evidence. Consequently, healthcare policy makers may be reluctant to create or update policy based on based on non-experimental studies. Similarly, healthcare system executives and nurse managers may be reluctant to support changes in clinical practice based on nonexperimental studies. A final limitation of non-experimental studies is that the findings are not considered to be as generalizable as those generated from experimental studies (Polit & Beck).

Discharge Disposition (DD)

The body of literature regarding the relationships among patient state and trait characteristics and DD for open colorectal surgery patients was not strong. In fact, there were no studies that specifically examined the open colorectal surgery patient population. While literature exists regarding the relationships among patient state and trait characteristics and DD, most of it is published in orthopedic surgery journals and relates to total hip or total knee arthroplasty patients (Barsoum et al., 2010; Bozic et al., 2006; Halawi et al., 2015; Sharareh et al., 2014; Titler et al., 2006; Vochteloo et al., 2012). The results of these studies were similar to the studies about LOS in terms of factors that predict DD. Also like the literature regarding LOS, none of the studies about the relationships among patient state and trait characteristics and DD used experimental designs.

Gaps in the Literature

Several gaps in the literature became apparent when conducting this comprehensive literature review. First, there were no studies that examined the reuse of real time patient acuity derived from nursing assessment documentation in the EHR for purposes other than guiding nursing staffing. Second, there were no studies that examined relationships among patient acuity the patient outcomes of LOS or DD for any patient population. While there were studies that examined the relationship between patient characteristics and LOS after open colorectal surgery, there were no studies that examined the relationships between patient characteristics and DD for this patient population. This study aims to fill these gaps.

Summary

This chapter provided an overview of the state of the science and a comprehensive literature review regarding patient acuity systems, the ERAS protocol for open colorectal surgery patients, and LOS and DD after open colorectal surgery. Only one nursing non-research article addressed Clairvia®, the automated patient acuity system that was in use where this study took place. Two nurse research articles reported that patient acuity scores could be calculated electronically using nursing documentation in the EHR. Medical and nurse researchers found that the ERAS protocol was successful in reducing LOS after open colorectal surgery. There was both agreement and disagreement among research studies regarding patient state and trait characteristics that are related to prolonged LOS for open colorectal surgery patients. The only studies that examined predictors of DD were about the TJA patient population. The strengths and limitations of the body of literature with respect to patient acuity, the ERAS, LOS, and DD were presented. This chapter concluded with the gaps in the literature regarding the relationships among patient acuity, LOS, and DD and predictors of prolonged LOS and DHCS that this study begins to fill.

CHAPTER 3 - RESEARCH METHODS

The study methods are presented in this chapter. The study design; sample and setting; human subject protection plan; the stratification variable and independent and dependent variables; data collection tools; procedures for data collection and data analysis; and limitations and assumptions of the study are described.

Research Design

The research design for this study was retrospective and cross-sectional because data about the study variables were collected from patients who had open colorectal surgery during a two-year period in the recent past. Polit and Beck (2012) noted that this type of study design is an efficient way to collect a large amount of data about study variables. Hulley, Cummings, Browner, Grady, and Newman (2013) also noted that cross-sectional designs are well suited to the goal of describing study variables and their distribution patterns.

Sample and Setting

The population of interest for this study was adult patients who were hospitalized and discharged after open colorectal surgery between the dates of July 1, 2014, and June 30, 2016. The setting included 10 medical-surgical hospitals affiliated with a large Midwest US health system. Subjects were identified through the healthcare system data warehouse (Oracle®, 2016).

Inclusion Criteria

The inclusion criteria for this study were:

a) adults (age 18 and greater); and

b) primary surgical procedure was open; and

c) surgery involved the colon or the rectum; and

d) surgery and was performed between July 1, 2014, through June 30, 2016; and

e) hospital discharge date after surgery was between July 1, 2014 and June 30, 2016; and

f) subjects' discharge diagnosis-related group (DRG) was 329, 330, or 331.

Exclusion Criteria

The exclusion criteria for this study were:

a) children (age 18 and younger); or

b) laparoscopic colorectal surgery procedures; or

c) primary surgical procedures that involved the small bowel; or

d) subjects who expired during hospitalization after open colorectal surgery; or

e) subjects with an American Society of Anesthesiologists (ASA) Physical Status Classification System score of VI (i.e., declared brain-dead patient whose organs are being removed for donor purposes) (ASA, 2014); or

f) subjects who were readmitted for another open colorectal surgery procedure during the study time period.

Power and Sample Size

A power analysis was conducted to determine the sample size needed to protect against Type II error, or the failure to reject the null hypothesis when it is false (Hulley et al., 2013). For a regression analysis with a two-sided alpha of 0.50, a power of 0.80 (beta = 0.20), a small-to-medium effect size (0.15), and up to 15 variables, 139 subjects were needed to establish a correlation coefficient different from 0.5. Because open colorectal surgery patients were stratified by three DRGs, the sample size was three times as large, i.e., 417 subjects. It was realistic to collect data on this number of subjects because, during the fiscal year of July 1, 2014

– June 30, 2015, approximately 750 open colorectal surgeries for patients with the three DRGs were performed at the healthcare system where this study took place.

Protection of Human Subjects

Steps were taken prior to obtaining data for this study in an effort to ensure the protection of human subjects. First, approval for the study was obtained in writing from the Chief Nursing Officer (CNO) and the Director of the research institute at the healthcare system where this study took place. Then, the research institute assigned an honest broker to the study. An honest broker is an individual who acts on behalf of the researcher to obtain study data that may contain patient identifiers. The honest broker provides the study data to the researcher that does not contain patient identifiers, i.e., de-identified data (University of Pittsburgh, 2016). The honest broker for this study removed each subject's first and last name, date of birth, medical record number (MRN), and patient encounter numbers (PEN) from the study data. Each subject was then assigned a false identification number.

This study did not pose any risk to human subjects. Neither did the subjects benefit directly from this study. However, future patients and the healthcare system could benefit because this study will increase knowledge of the relationships among patient acuity, length of stay (LOS), and discharge disposition (DD) for open colorectal surgery patients.

The Institutional Review Boards (IRB) at the healthcare system and the University of Wisconsin-Milwaukee approved this study (L. Beaumont, personal communication, May 19, 2016; M. Harries, personal communication, May 11, 2019).

Variable Measurement

This section describes the study variables and their measurement. They are listed in the following order: (a) the sample stratification variable of DRG; (b) the dependent, or patient outcome, variables of LOS and DD; and (c) the independent variables. The independent variables included:

(i) patient acuity, a patient state characteristic variable;

(ii) patient trait characteristic variables that have been shown in the literature to predict LOS and/or DD; and

(iii) additional patient trait characteristic variables that were used to describe the study sample, with the exception of Readmission within 30 Days of Discharge.

Sample Stratification Variable

The subjects in this study were stratified into the three colorectal surgery DRGs of 329, 330, and 331.

Diagnostic-related group (DRG).

Conceptual Definition. DRGs are a classification system that groups similar clinical conditions (i.e., diagnoses) and/or the procedures furnished by the hospital during an inpatient stay (Centers for Medicare and Medicaid Services [CMS], 2016a). Each patient is assigned to one DRG upon hospital discharge.

Operational Definition. The DRGs that were studied included 329, 330, and 331.

Data Collection Tool. DRGs are identified for each patient and stored with their health record in a data warehouse. A report from the healthcare system data identified patients who were discharged with one of the three DRGs during the study period.

Level of measurement. Nominal.

Timing. Collected one time for each open colorectal surgery patient discharge over the two-year study.

Rationale. Stratification of patients by DRG provided some control for comorbidities and postoperative complications in the study sample.

Dependent Variables

LOS and DD were the two dependent, or outcome, variables of interest in this study. LOS and DD were also examined as independent variables in two regression models. This was because a DD of discharge to home care or other healthcare setting (DHCS) has been shown to predict LOS for open colorectal surgery patients (Kelly et al., 2012; Ngui et al., 2010; Reddy et al., 2003). Similarly, Sharareh et al. (2014) found that LOS predicted DD among total joint arthroplasty (TJA) patients.

Length of stay (LOS).

Conceptual definition. The length of time a patient is in an acute inpatient hospital for one admission.

Operational definition. The LOS was studied in two ways. Length of stay as a ratio-level variable was defined as the number of inpatient hospital days open colorectal surgery patients stayed in the hospital after being transferred out of the operating and recovery rooms to the intensive care unit (ICU) or the medical-surgical unit. LOS was also examined as a nominal-level variable with two categories. The first category included subjects whose LOS was at or below the national average LOS per DRG (Covidien, 2015). The second included subjects whose LOS was above the national average LOS per DRG.

Data collection tool. The length of hospital stay, in days, was obtained from a report from the healthcare system data warehouse.

Level of measurement. Ratio and nominal.

Timing. Collected one time for each open colorectal surgery admission during the study time period.

Rationale. LOS as a ratio-level variable (a) was used to describe the sample; (b) was the dependent variable in the multiple regression analysis to determine predictors of LOS; and (c)was an independent variable in the logistic regression to determine predictors of DD. LOS as a nominal-level variable was used to describe the sample.

Discharge disposition (DD).

Conceptual definition. The final place or setting to which the patient was discharged from the hospital and, if discharged to home, whether the patient required home health services (The Joint Commission, 2012).

Operational definition. DD categories that were used to describe the study sample were (a) home without home healthcare services; (b) home with healthcare services; (c) acute care hospital; (d) assisted living; (e) home hospice; (f) inpatient hospice; (g) inpatient rehabilitation; (h) intermediate care facility; (i) long-term acute care hospital; and (j) skilled nursing facility.

DD was transformed into a variable with two categories for statistical analyses. The first category included subjects who were discharged to home without home healthcare services. The second included subjects who were discharged to home care or other healthcare settings (DHCS).

Data collection tool. The DD was obtained from a report from the healthcare system data warehouse.

Level of measurement. Nominal.

Timing. Collected one time upon discharge for each open colorectal surgery admission during the study time period.

Rationale. The DD variable with multiple categories was used to describe the sample. DD as a binary variable (a) was the dependent variable in the logistic regression analysis to determine predictors of DHCS; and (b) was an independent variable in the multiple regression analysis to determine predictors of LOS.

Independent Variables

Patient state characteristic: patient acuity.

C*onceptual Definition*. Patient acuity is the level of severity of a patient's illness or health condition at a point in time (Miller & Keane, 2005). Patient acuity is a patient state characteristic because it is likely to change during the course of a patient's hospital stay and can be influenced by, among other factors, nursing interventions (Radwin & Fawcett, 2002).

Operational Definition. Patient acuity was operationalized in this study by using patient acuity scores from the Clairvia® (Clairvia®, n.d.) software program that was used at the healthcare system to guide nurse staffing. See the "Data Collection Tools" section of this chapter for a detailed description of how patient acuity scores were generated in Clairvia® and collected for data analysis for this study.

Data Collection Tool. Clairvia® Structured Query Language (SQL) Report.

Level of measurement. Ratio.

Timing. Patient acuity is a repeated measure. All patient acuity scores that were generated during the patient's hospitalization for open colorectal surgery were collected in chronological order.

Rationale. Patient acuity was the independent variable of interest in this study.

Patient trait characteristics. The following patient trait characteristics have been found in the healthcare literature to be associated with LOS and DHCS. Patient trait characteristics neither change significantly during a patient's hospitalization, nor are they likely to be influenced by nursing interventions (Radwin & Fawcett, 2002).

Age. Age in years on the patient's date of admission to the hospital was collected from the healthcare system data warehouse. Age is a ratio-level variable whose value was recorded one time.

Gender. The patient's gender on the date of admission to the hospital was collected from the healthcare system data warehouse. Gender is a nominal-level variable whose value was recorded one time. Patients were categorized as either male or female.

Body mass index (BMI). The patient's BMI prior to surgery was derived from a computation of the patient's weight and height, which were collected from the healthcare system data warehouse. BMI is a patient's weight in kilograms divided by the square of their height in meters (Centers for Disease Control and Prevention [CDC], 2016a). Depending upon the BMI value, a patient can be classified as underweight (BMI <18.5 kg/m^2), normal or healthy weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), or obese (>30.0 kg/m^2). For this study, BMI was reported as a ratio-level variable and its value was recorded one time.

A description of BMI classifications, according to the CDC (2016a), is presented in Table 3.1.

Table 3.1

Body mass index (BMI) classifications (CDC, 2016a)

BMI Value	Weight Status
<18.5 kg/m^2	Underweight
18.5-24.9 kg/m^2	Normal or Healthy Weight
25.0-29.9 kg/m^2	Overweight
>30.0 kg/m^2	Obese

ASA score. The patient's ASA Physical Status Classification System score (ASA, 2014) was collected from the healthcare system data warehouse. ASA is an interval-level variable whose value was documented one time preoperatively by an anesthesiologist or a surgeon. ASA will be analyzed as a ratio-level variable in this study because the intervals between the values I through VI are considered to be approximately equal (Polit & Beck, 2012). Table 3.2 presents the six ASA scores and their descriptions.

Table 3.2

American Society of Anesthesiologists (ASA) physical status classification system (ASA, 2014)

Score	Description
I	Normal healthy patient
II	Patient with mild systemic disease
III	Patient with severe systemic disease
IV	Patient with severe systemic disease that is a constant threat to life
V	Moribund patient who is not expected to survive without the operation
VI	Declared brain-dead patient whose organs are being removed for donor purposes

Marital status. The patient's marital status on the date of admission to the hospital was collected from the healthcare system data warehouse. Several marital status values were used to describe the sample (i.e., married, single, divorced, widowed). For the statistical analyses, patients were categorized as either married or not married. Marital status is a nominal-level variable whose value was recorded one time.

ICU stay. Information regarding whether or not a patient spent time in the ICU after open colorectal surgery was obtained from the healthcare system data warehouse. ICU stay is a nominal-level variable whose value was recorded one time upon discharge. Patients were categorized as either having stayed in the ICU or not.

Length of ICU stay after surgery. The number of days a patient stayed in the ICU after open colorectal surgery, if appropriate, was obtained from the healthcare system data warehouse. LOS in ICU is a ratio-level variable whose value was recorded one time upon discharge.

Additional patient trait characteristics. Several patient trait characteristics have not yet been shown in the literature to have a significant relationship with LOS or DHCS. They were collected to describe the sample. With the exception of readmission within 30 days of discharge, these patient trait characteristics were also included in the regression analyses to determine statistically significant predictors of LOS and DHCS.

Race. The patient's primary race and ethnicity on the date of admission to the hospital were collected from the healthcare system data warehouse. Race categories included (a) American Indian or Alaskan Native; (b) Asian; (c) Black; (d) Other; and (e) White. If a patient's ethnicity was "Hispanic or Latino," it replaced the patient's the primary race in the data collection tool. Thus, six race categories were used to describe the sample. For the statistical analyses, patients were classified as either White or non-White. Race is a nominal-level variable whose value was recorded one time.

Primary diagnosis. The patient's primary diagnosis on the date of discharge from the hospital was collected from the healthcare system data warehouse. Thirteen different primary diagnosis values were used to describe the sample. For the statistical analyses, subjects were classified into three primary diagnosis categories, including (a) neoplasm; (b) diverticulitis; and (c) other disorders of the colon or rectum. Primary diagnosis is a nominal-level variable whose value was recorded one time.

Admission type**.** The patient's admission type was collected from the healthcare system data warehouse. The three admission types in the data warehouse were used to describe the sample: (a) Non-Urgent; (b) Urgent; and (c) Emergency. For the statistical analyses, subjects were categorized as either Non-Urgent or Urgent (which included emergency admissions). Admission type is a nominal-level variable whose value was recorded one time.

Admission source**.** The subject's admission source, or the location from which the subjects was admitted to the hospital for open colorectal surgery, was collected from the healthcare system data warehouse. Eight admission source values were used to describe the sample. For the statistical analyses, two categories were used for admission source: (a) admitted from a non-healthcare point of origin, or (b) admitted from a healthcare point of origin. Admission source is a nominal-level variable whose value was recorded one time.

Primary payor**.** The patient's primary payor for on the date of discharge from the hospital was collected from healthcare system data warehouse. Six primary payor values were used to describe the sample: (a) commercial insurance; (b) Medicaid Managed Care; (c) Medicaid Traditional; (d) Medicare Managed Care; (e) Medicare Traditional; (f) government payor; and (g) self-pay. For the statistical analyses, patients were categorized as either having commercial health insurance or a government payor, which included Medicare and Medicaid. Primary payor is a nominal-level variable whose value was recorded one time.

Readmission within 30 days of discharge**.** For the purpose of this study, readmission within 30 days of discharge was defined as a readmission unrelated to the initial admission for an open colorectal surgery procedure (American Hospital Association, 2015). This variable was only used to describe the sample because patients who were readmitted for open colorectal surgery during the study time period were excluded from the study. It is a nominal-level variable whose value was collected once for each patient that was admitted for open colorectal surgery during the study period.

The study variables that were collected for this study are listed in Table 3.3. The data source, measurement level and potential values, timing of data collection, and two rationales for inclusion in the study are identified for each variable.

Table 3.3

Variables collected for this study

Variable	Data Source	Measurement Level and Potential Values	Timing	Rationale for Inclusion 1	Rationale for Inclusion 2
Diagnostic-related group (DRG)	Healthcare system data warehouse	Nominal: • 329 • 330 • 331	Once, on discharge	Account for comorbidities and postoperative complications	Stratification of sample
Length of stay (LOS)	Healthcare system data warehouse	Interval: Number of days in hospital after surgery Nominal: • Below national average LOS • Above national average LOS	Once, on discharge	Dependent variable in LOS regression analysis	Independent variable in DD regression analysis
Discharge disposition (DD)	Healthcare system data warehouse	Nominal: • Home without health services • Home with healthcare services • Acute care hospital • Assisted living • Home hospice • Inpatient	Once, on discharge	Dependent variable in DD regression analysis	Independent variable in LOS regression analysis

		hospice • Inpatient rehabilitation • Intermediate care facility • Long-term acute care hospital • Skilled nursing facility			
Patient acuity	Clairvia® SQL database	Ratio: Score from 1.00 to 5.00	4 times per day during hospital stay	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Age at time of surgery	Healthcare system data warehouse	Ratio: • Ages 18 and greater	Once, on admission	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Gender	Healthcare system data warehouse	Nominal: • Male • Female	Once, on admission	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
BMI	Healthcare system data warehouse	Ratio • BMI Scores	Once, prior to surgery	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
ASA Score	Healthcare system data warehouse	Interval: I through VI	Once, prior to surgery	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Marital Status	Healthcare system data warehouse	Nominal: • Married • Single • Divorced • Widowed	Once, on admission	Independent variable in LOS regression analysis	Independent variable in DD regression analysis

		• Other			
ICU stay	Healthcare system data warehouse	Nominal: • Yes • No	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Length of stay in ICU after surgery	Healthcare system data warehouse	Interval: Number of days in ICU after surgery	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Race	Healthcare system data warehouse	Nominal: • American Indian or Alaskan Native • Asian • Black • Hispanic/Latino • White • Other	Once, on admission	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Primary Diagnosis	Healthcare system data warehouse	Nominal • Neoplasm of colon or rectum • Diverticulitis of colon • 11 other disorders of colon or rectum	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Admission Type	Healthcare system data warehouse	Nominal: • Non-Urgent • Urgent • Emergency	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Admission Source	Healthcare system data warehouse	Nominal: • Non-healthcare point of origin • Seven healthcare point of origin	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis

		admission sources			
Primary Payor	Healthcare system data warehouse	Nominal: • Commercial • Medicaid Managed Care • Medicaid Traditional • Medicare Managed Care • Medicare Traditional • Government • Self-Pay	Once, at discharge	Independent variable in LOS regression analysis	Independent variable in DD regression analysis
Readmission within 30 Days of Discharge	Healthcare system data warehouse	Nominal: • Yes • No	Once, after each discharge after open colorectal surgery	Describe sample	

Data Collection Tools

Data were gathered from two sources: the healthcare system data warehouse and the Clairvia® SQL database. This section describes how the data came to be stored in the two data collection tools in this study. The two tools were (a) a report from the healthcare system data warehouse; and (b) a report from the Clairvia® SQL database.

Healthcare System Data Warehouse

The healthcare system data warehouse contains vast quantities of data representing a wide variety of healthcare elements, including inpatient clinical information from the electronic health record (EHR) and billing information (D. Kastenholz, personal communication, February 2, 2016). The healthcare system data warehouse contained all of the data necessary to conduct this study, with the exception of patient acuity scores. Clinical and billing data are uploaded once a month into the data warehouse by a private consulting firm.

Clairvia® SQL Database

Clairvia® is a commercial software product. The healthcare system where the study took place used 15 acuity items in Clairvia® to automatically calculate a patient acuity score. These scores could be accessed for any inpatient via Clairvia® SQL database.

A team of informatics nurses at the healthcare system where this study took place selected the 15 acuity items from a nursing outcomes classification system called Nursing Outcomes Classification (NOC) (Moorhead, Johnson, Mass, & Swanson, 2013). The team also mapped the appropriate nursing assessment documentation data fields, medication infusion administration, and laboratory values from the EHR to the 15 acuity items in Clairvia®. The NOC measures served as a proxy for determining patient acuity for each acuity item and to automatically calculate a patient acuity score (S. Timmons, personal communication, May 14, 2014).

The 15 acuity items included in Clairvia® were:

1. Cardiac Pump Effectiveness
2. Coping
3. Discomfort Level
4. Electrolyte and Acid Base Balance
5. Fall Prevention Behavior
6. Gastrointestinal Function
7. Infection Severity
8. Kidney Function

9. Knowledge: Treatment Regimen

10. Neurological Status

11. Nutritional Status: Food and Fluid Intake

12. Respiratory Status

13. Self-Care: Activities of Daily Living (ADL)

14. Tissue Integrity: Skin and Mucous Membrane

15. Tissue Perfusion: Peripheral

Each acuity item was calculated using data retrieved, in real time, from nursing documentation in the EHR. The algorithm in the Clairvia® software program that was used to calculate 15 acuity item scores and a patient acuity score was developed by nurse researchers, nurse leaders, and staff nurses at the healthcare system. The algorithm is described, below.

Acuity item scores. Each of the 15 acuity items was scored on a 1-5 Likert scale. All Clairvia® patient acuity scores in the Clairvia® SQL database reflected the fact that a score of 1 indicated the highest acuity and 5 the lowest acuity. However, to facilitate analysis and reporting of the results of this study, the Likert scale values were transposed as the first step in data management. Thus, a score of 1 indicated the lowest acuity and a score of 5 indicated the highest acuity. All further discussion, analysis, or reporting of patient acuity scores in this study are based on this transposed Likert scale.

Each patient acuity item score was an amalgam of two dimensions assigned to the data in the associated nursing documentation fields in the EHR. The first dimension was referred to as the patient's deviation from "normal." This dimension was measured on a on a 1-5 Likert scale, with a score of 5 indicating severe deviation from the norm (i.e., high acuity) and a score of 1 indicating no deviation (i.e., low acuity).

The second dimension was referred to as the relevancy rank. This dimension was also measured on a on a 1-5 Likert scale. A score of 5 was the most indicative of a poor outcome and a score of 1 is the most indicative of a positive outcome (S. Timmons, personal communication, May 14, 2014).

For example, a nurse could select the option of “Pain level unacceptable - collaborate with provider” when documenting an assessment in the “Pain Level at Rest” field in the EHR. In this situation, the acuity item “Discomfort Level” would receive the highest deviation score (5 on a 1-5 Likert scale), and the highest relevancy ranking (5 on a 1-5 Likert scale), resulting in a “Discomfort Level” acuity item score of 5.

Appendix D contains select clinical data in the EHR, including nursing assessment documentation fields, medication infusion administration, laboratory values, that were mapped to the 15 acuity items in Clairvia® by the nursing informatics team (S. Timmons, personal communication, May 14, 2014). The values in Appendix D were selected because they had been assigned a score of 5 on both the deviation score and relevancy ranking Likert scales, but are not inclusive of all values that received these scores. The NOC definitions of the 15 acuity items (Moorhead et al., 2013*)* are also presented in Appendix D.

Patient acuity score. The patient acuity score was a non-weighted average of the scores of the 15 acuity items at a point in time. Patient acuity scores ranged from 1.00 to 5.00, with 1.00 indicating the lowest patient acuity and 5.00 indicating the highest. A patient acuity score was generated only when at least 13 of the 15 acuity items contained documentation relating to nursing assessment, a laboratory value, or medication infusion administration. A patient acuity score was also generated every time there was new data regarding nursing assessment documentation, laboratory values, or medication infusion administration. Each patient's patient acuity score was thus calculated in near-real time, multiple times a day (Clairvia®, n.d.).

Data Collection Procedures

This section describes how data were collected from reports in the healthcare system data warehouse and the Clairvia® SQL database. Also explained are how the two de-identified files were provided to this researcher, and the manner in which data in the files were manipulated to prepare for describing the sample and conducting data analysis.

Healthcare System Data Warehouse Report

A data analyst at the healthcare system where this study took place generated a report from the healthcare system data warehouse. The report included adult patients who were admitted and discharged from a facility at the healthcare system between July 1, 2014, and June 30, 2016, and who were assigned to a DRG of 329, 330, or 331. This report was sent directly to the honest broker. The honest broker collected the relevant data for the list of eligible subjects from the healthcare system data warehouse report.

The report contained values for the variables listed in Table 3, above, as well as:

a) Patient encounter number (PEN);

b) Medical record number (MRN);

c) Patient first and last name;

d) Patient date of birth (DOB);

e) Primary procedure code;

f) Primary procedure description;

g) Primary diagnosis code;

h) Primary diagnosis description;

i) Secondary diagnosis codes;

j) Secondary diagnosis descriptions;

k) Secondary procedure codes; and

l) Secondary procedure descriptions

m) Date of colorectal surgery.

Clairvia® SQL Database Report

The same report that was generated by the data analyst at the healthcare system to identify adult patients who were admitted and discharged from a facility at the healthcare system between July 1, 2014, and June 30, 2016, and who were assigned to a DRG of 329, 330, or 331 was sent directly to a senior data analyst at Clairvia®. The senior data analyst then collected the relevant patient acuity information for the eligible study subjects from the Clairvia® SQL Database. This report was sent directly to the honest broker at the healthcare system.

The report from the Clairvia® SQL database contained:

a) Patient encounter number (PEN);

b) Medical record number (MRN);

c) Patient first and last name;

d) Patient date of birth (DOB);

e) Scores for 15 acuity items;

f) Patient acuity scores; and

g) Date and time patient acuity scores were generated in Clairvia®.

De-identification of Data

The honest broker de-identified the data in the reports from the healthcare system data warehouse and the Clairvia® SQL database. He assigned false identifier (ID) numbers to the subjects, ensuring that each subject's false ID on the report from the healthcare system data warehouse matched the false ID on the report from the Clairvia® SQL database. The honest broker then provided this researcher with two Excel files (Microsoft® Office, 2016) of de-identified data, one with data from the healthcare system data warehouse and the other from the Clairvia® SQL database.

A visual image of the data collection process for this study appears in Figure 1, below.

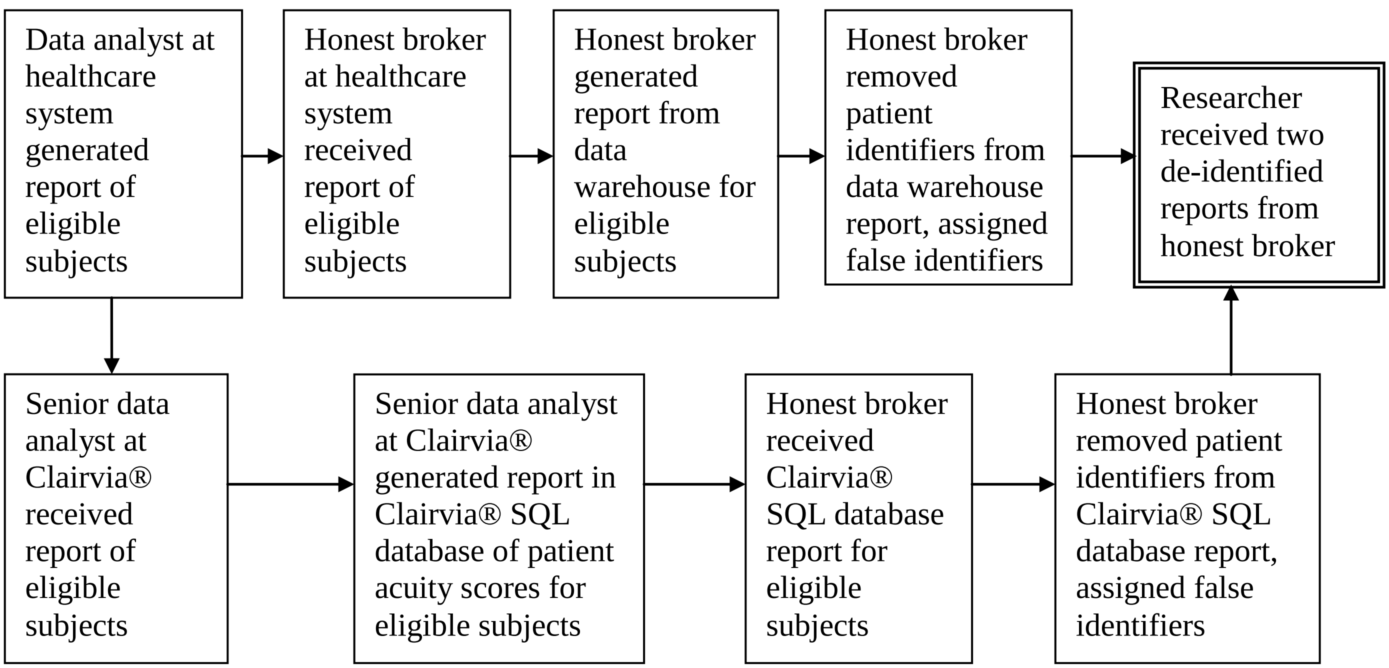


Figure 1

Data collection process

Manipulation of Data Prior to Analysis

This section describes how the data were manipulated once this researcher received the de-identified reports from the healthcare system data warehouse and the Clairvia® SQL database from the honest broker. The data from the two reports were merged, three study variables were altered so they could be examined more meaningfully for this study, and select nominal-level variables were transformed into dummy variables to facilitate statistical analysis.

Merging two reports. The original version of each Excel file received from the honest broker was saved in a password-protected file on a secure computer hard drive. The files were then saved again and dated each time the data were manipulated. A written log of changes was kept to assist this researcher with remembering and reporting the data manipulation.

Prior to merging the two files, the subjects in the report from the healthcare system data warehouse were reviewed for inclusion and exclusion criteria and removed from the sample, if appropriate. The remaining subjects were matched using their false identifiers with subjects in the Clairvia® SQL database report. The two reports were then merged into one Excel file and uploaded into SPSS (IBM®, n.d.) for data analysis.

Altering three study variables. The three study variables that were altered so they could be interpreted and examined appropriately were patient acuity, BMI, and race.

Patient acuity. Four patient acuity scores were collected each day of hospitalization after open colorectal surgery, i.e., at 0000, 0600, 1200, and 1800. However, as described in the "Data Collection Tools" section of this chapter, patient acuity scores were calculated in Clairvia® in near real time, multiple times a day. For example, patient acuity scores could be generated for one patient on one day at 0052 (score = 2.34); then at 0130 (score = 3.00); then at 0323 (score = 2.87; then at 0845 (score = 2.87); then at 1102 (score = 3.20), then at 1315 (score = 3.42), … through midnight.

To standardize data analysis, the patient acuity scores that were closest to and prior to 0000, 0600, 1200, and 1800 each day after open colorectal study were selected for data analysis in this study. In the example above, the score at 0323 would be used to represent the patient's patient acuity score at 0600 (score = 2.87); the score at 1102 (score = 3.20) would be used to represent the score at 1200, and so forth.

To further standardize the analysis of patient acuity scores, a sequential coding system was created to identify each score by day of hospitalization and time. Actual calendar dates were not used. Day 0 represented the day of the open colorectal surgery. Day 1 was the day after the surgery, Day 2 the day after that, and so on, reflecting the number of days the patient stayed in the hospital after open colorectal surgery. For example, patient acuity scores recorded on the day of surgery were coded as 0-0000, 0-0600, 0-1200, and 0-1800. Patient acuity scores recorded on the day after surgery were coded as 1-0000, 1-0600, 1-1200, and 1-1800, etc. These times were selected because was they were times at which nurses on day, evening, and night shifts were likely to have completed their patient assessment documentation.

A fictitious example of patient acuity scores generated in Clairvia® for a patient who had open colorectal surgery on January 12, 2015, is presented in Table 3.4. Column 1 contains the patient's false identifier; Column 2 the date after open colorectal surgery; Column 3 the time; and Column 4 the patient acuity score in Clairvia® at that date and time. The last two columns represent the coded day and time of the score, and the score that was included in a data analysis for this study.

Table 3.4

Patient acuity scores after open colorectal surgery for a fictitious subject

False Patient ID	Date	Time	Patient Acuity Score in Clairvia®	Data Collection Day and Time for Study	Patient Acuity Score Recorded for Study
#35748	1/12/2015	2245	3.48	1-0000	3.48
#35748	1/13/2015	0052	2.34	None	None
#35748	1/13/2015	0130	3.00	None	None
#35748	1/13/2015	0323	2.87	1-0600	2.87
#35748	1/13/2015	0845	2.87	None	None
#35748	1/13/2015	1102	3.20	1-1200	3.20
#35748	1/13/2015	1315	3.42	None	None
#35748	1/13/2015	1656	3.35	1-1800	3.35
#35748	1/13/2015	1922	3.35	None	None

#35748	1/13/2015	2112	3.38	2-0000	3.38
#35748	1/14/2015	0314	2.99	None	None
#35748	1/14/2015	0530	4.01	2-0060	4.01

BMI. It was possible to collect subjects' height and weight from the healthcare system data warehouse, but not their BMIs. BMI was calculated by dividing the patient's weight in kilograms by the square of their height in meters (CDC, 2016a). Because height was collected in inches and weight in pounds in the healthcare system data warehouse, formulas were incorporated into columns in the Excel file to convert inches to meters and pounds to kilograms. The data in these two columns were then used in the formula that was introduced into a third column to calculate the subjects' BMIs.

Race. The report from the healthcare system data warehouse contained one set of codes for race and one for ethnicity. Only race was a variable in this study. Hispanic/Latino is an ethnicity and not a race, but was coded as a race to describe the sample. A new race code was created for subjects with an ethnicity of Hispanic or Latino. This code then replaced the subject's original race code from the healthcare system data warehouse report. Subjects with an ethnicity of "Non-Hispanic or Latino" kept their original race codes.

Dummy variables. After the sample was described and prior to conducting statistical analyses, dummy variables were created for select nominal-level variables. The variables that were transformed into dummy variables were those that had a largely unequal distribution of values across categories. For example, one category contained greater than 50% of the subjects, or several categories contained less than 5% of the subjects. Upon creation of a dummy variable, each value category contained at least 5% of the original variable values (Meyers, Gamst, & Guarino, 2013).

When several values of a nominal-level variable were combined to create two categories, one was coded 0 and other coded 1, thus these variables were sufficiently dummied. When values for a nominal-level variable were combined to create more than two categories, all but one category of the variable were treated as separate variables and assigned a value of 0 or 1, depending on the value's presence or absence in each dummy variable (Meyers et al., 2013). The variables that were transformed into nominal variables with two categories were discharge disposition, race, marital status, admission source, admission type, and primary payor. Primary diagnosis was the only variable to be transformed into a dummy variable with three categories.

The original nominal-level variable values that were used to describe the sample and the dummy values used in statistical analyses appear in Table 3.5.

Table 3.5

Transformation of nominal-level variables into dummy variables used in statistical analyses

Variable	Values for Describing Sample	Values Used in Analyses
Discharge Disposition	Home without health services Home with healthcare services Home hospice Inpatient hospice Inpatient rehabilitation Acute care hospital Long-term acute care hospital Intermediate care facility Skilled nursing facility Assisted living	0 = Discharge to home without healthcare services 1 = Discharge to home or other healthcare setting (DHCS)
Race	American Indian or Alaskan Native Asian Black Hispanic White Other	0 = Non-White 1 = White
Marital Status	Single Married or significant other Widowed Divorced or legally separated	0 = Not Married 1 = Married

	Other	
Admission Type	Non-Urgent Urgent Emergency	0 = Non-Urgent 1 = Urgent (includes Emergency)
Admission Source	Non-healthcare point of origin Clinic or provider's office Transfer from ambulatory surgery center Transfer from another hospital Transfer from another healthcare facility Transfer from distinct unit within hospital Transfer from skilled nursing facility, intermediate care, or assisted living facility	0 = Non-healthcare point of origin 1 = Healthcare point of origin
Primary Diagnosis	Acute Appendicitis *C. difficile* infection Colonic volvulus Crohn's disease of colon Diverticulitis of colon Fistula involving colon or rectum Intussusception of colon Neoplasm of colon or rectum Obstruction of colon or rectum Perforation of colon or rectum Rectal prolapsed Ulcerative colitis Other disorders of colon or Rectum	0 = Other disorders of colon or rectum 1 = Neoplasm of colon or rectum 1 = Diverticulitis of colon (Two dummy variables created for three categories)
Primary Payor	Commercial Medicaid Managed Care Medicaid Traditional Medicare Managed Care Medicare Traditional Self-Pay Government	0 = Commercial (includes Self-Pay) 1 = Government (includes Medicaid and Medicare)

Statistical Analysis Procedures

In this section of the study methods, the study statistical analysis procedures are described. The statistical analysis tool, the quality of the data, the methods used to describe the sample, the statistical analysis procedures used to answer the four research questions, assumptions for each of the statistical analyses, and management of study data to meet these assumptions are discussed.

Statistical Analysis Tool

The statistical analyses were conducted using IBM®'s SPSS version 22 (IBM®, n.d.). The study data and statistical analysis result files were stored in password protected files on this researcher's secure computer hard drive.

Quality of the Data

The quality of data that were collected for this study were analyzed using Weiskopf and Weng's (2013) data quality assessment framework. Weiskopf and Weng proposed five dimensions of EHR data quality assessment which, if achieved, would support the data's reuse for research purposes. The five dimensions of the framework were:

a) Completeness: Is a truth about a patient present in the EHR?
b) Correctness: Is an element that is present in the EHR true?
c) Concordance: Is there agreement between elements in the EHR, or between the EHR and another data source?
d) Plausibility: Does and element in the EHR makes sense in light of other knowledge about what that element is measuring?
e) Currency: Is an element in the EHR a relevant representation of the patient state at a given point in time?

The results of the quality assessment of the data, which include an analysis of the reliability and validity of the data, are presented in Chapter 4. Reliability reflects the consistency of a measure, i.e. similar results are produced under consistent conditions (Waltz, Strickland, &

Lenz, 2010). Validity reflects the accuracy of a measure, i.e., measurements were well-founded and corresponded accurately to the real world (Waltz et al.).

Describing the Sample

First, the total study sample was described according to subjects' nominal-level (e.g., age, race, gender, marital status, DD) and ratio-level (e.g., patient acuity score, LOS, BMI) variables. Then three subgroups of the sample were described using the same variables after the sample was stratified by DRG, i.e., 329, 330, and 331.

Measures of central tendency and distribution. Descriptive statistics were derived for all variables listed in Table 4. For each variable, measures of central tendency and distribution were described, as appropriate. For ratio- and interval-level variables, means, standard deviations and ranges were calculated. For nominal- and interval level variables, frequencies, percentages were obtained.

Differences among DRGs. A generalized linear model (GLM) repeated measures test was conducted to determine if statistically significant differences existed among the three DRGs with respect to the independent variable of patient acuity. Patient acuity was measured every six hours during each subject's hospital stay after colorectal surgery.

Analysis of variance (ANOVA) tests were conducted to determine if significant differences existed among the three DRGs with respect to the remaining ratio-level dependent and independent variables in the study. Chi-Square (χ^2) tests were conducted to determine if statistically significant differences existed among the DRGs with respect to nominal-level variables.

An alpha value of 0.05 was used to denote statistically significant differences among DRGs (Hulley et al., 2013).

Statistical Analysis Procedures for Research Questions

Question 1. "What are the patterns of patient acuity, LOS, and DD for open colorectal surgery patients with a DRG of 329, 330, or 331?"

Pattern of patient acuity. The data were stratified by DRG. Patient acuity scores were recorded for each subject four times each day from midnight on the first day after surgery until discharge (1-0000, 1-0060, 1-1200, 1-1800, 2-0000, 2-06000, etc.). The average patient acuity score at each data collection time was calculated for each and plotted on the primary *y*-axis. The data collection day and time was plotted on the *x*-axis, and the number of subjects who remained in the hospital after colorectal surgery was plotted on the secondary *y*-axis. These graphs allowed for a visual image of the pattern of acuity scores over the course of the patients' hospitalization after open colorectal surgery.

Pattern of LOS. The data were stratified by DRG. The pattern of LOS was examined in two ways. First, the distribution of LOS as a ratio-level variable by DRG was examined. Second, the distribution of LOS as a nominal-level variable, i.e., subjects whose LOS was below the national average LOS per DRG and those whose LOS was above the national average LOS, was described.

Pattern of DD. The data were stratified by DRG. A DD frequency table with bar chart was produced for each DRG. DD had two possible values. The first was discharge to home without home healthcare. The second was discharge to home care or other healthcare setting (DHCS).

Question 2. "What are the relationships among patient acuity, select patient trait characteristics, LOS, and DD for open colorectal surgery patients with a DRG of 329, 330, or 331?"

Correlation matrices. The data were stratified by DRG. Correlation matrices were created for each DRG to analyze the relationships between each variable pair in the study. Readmission within 30 days was not included in the correlation matrices because this variable was only used to describe the sample. The Pearson product-moment correlation coefficient (also referred to as Pearson's r coefficient) parametric measure was used to determine the strength and direction of relationships that existed between two ratio-level variables. The Spearman's rank-order correlation coefficient (also referred to as Spearman's rho coefficient) nonparametric measure was used to determine the strength and direction of relationship that existed between (a) one ratio-level and one nominal-level variable, or (b) two nominal-level variables (Meyers et al., 2013)

Multicolinearity. The relationships among the independent variables in the correlation matrices were examined for multicolinearity. Multicolinearity existed when two or more independent variables were highly correlated with each other, meaning that one variable could be linearly predicted from the other(s) with a high degree of accuracy (Meyers et al., 2013). In this study, a statistically significant correlation coefficient of $r \geq 0.7$ denoted multicolinearity. If it existed, a decision would need to be made regarding which of the redundant variables would be included in the regression analyses.

Question 3. "Which combination of patient acuity and select patient trait characteristics predict LOS for open colorectal surgery patients with a DRG of 329, 330, or 331?"

Multiple regression. Multiple regression is used to predict the value of a ratio-level dependent variable based on the value of two or more independent variables (Polit & Beck, 2012). Multiple regression analyses were conducted for each DRG to determine which patient trait characteristics, along with patient acuity, predicted prolonged LOS.

Variables. LOS as a ratio-level dependent variable was used to answer research question 3. The patient acuity information collection days and times that were included in the multiple regression analysis for each DRG were selected based on three main factors. First, the data collection time was within the first three days of open colorectal surgery. It was logical to select a day shortly after the surgery because one purpose of this study was to determine if patient acuity was a significant predictor of prolonged LOS. Second, the time of 1200 was selected because nurses working the day shift would likely have completed documentation of the patient assessment by then. Third, the results of this researcher's pilot study revealed that patient acuity was higher, on average, during the day than at night (Badger, 2016). Thus, the patient acuity information collection day and time for DRG 329 was Day 3 at 1200, and Day 2 at 1200 for DRGs 330 and 331.

A multiple regression model for predicting LOS for each DRG that includes the independent variable of interest, patient acuity, is presented in Chapter 4.

Question 4. "Which combination of patient acuity and select patient trait characteristics predict DD for open colorectal surgery patients with a DRG of 329, 330, or 331?"

Logistic regression. Logistic regression is used to predict the value of a nominal-level dependent variable based on the value of two or more independent variables (Polit & Beck, 2012). Logistic regression analyses were conducted for each DRG to determine which patient trait characteristics, along with patient acuity, predicted DHCS.

Variables. The nominal-level dependent variable of DD was used to answer research question 4. In this study, DD had two values: (a) discharge to home without home health care;

and (b) discharge to home care or other healthcare setting (DHCS). Because another purpose of this study was to determine if patient acuity was a significant predictor of DHCS, and for ease of comparison with prolonged LOS, the patient acuity information collection days and times that were used in the logistic regression analysis for each DRG were the same as those used in the multiple regression analysis to answer Question 3.

A logistic regression model for predicting DD for each DRG that includes the independent variable of interest, patient acuity, is presented in Chapter 4.

Assumptions of Statistical Analyses used in this Study

Most statistical analyses are based on a set of assumptions. When the assumptions are violated, the results of the analyses can be misleading or incorrect (Meyers et al., 2013). The four main assumptions upon which descriptive and inferential statistical analyses are based are (a) the data have a normal distribution; (b) there is homogeneity of variances, i.e., data from multiple groups have the same variance; (c) the data have a linear relationship; and (d) the data are independent (Meyers et al.). Assumptions of the statistical analyses used in this study are described in more detail, below.

Descriptive statistics. The main assumption when describing ratio-level variables is that the data have a normal distribution. The measures of central tendency and dispersion that were conducted to test for normal distribution in this study included the variable mean, standard deviation, median, range, mode, skewness and kurtosis. Skewness is a measure of the lack of symmetry of a distribution curve, compared to a normal curve. Kurtosis is a measure of whether the distribution curve is heavy-tailed, i.e., there are outliers in the data, or light-tailed. Levels of skewness and kurtosis that meet the assumption of a normal distribution fall between –2 and +2 (Meyers et al., 2013).

Generalized linear model (GLM) repeated measures. The assumptions for GLM are that (a) the cases are independent from each other; (b) the distribution of residuals is normal; and (c) homoscedasticity exists, i.e., homogeneity of variance (Meyers et al., 2013).

Analysis of variance (ANOVA). The assumptions for analysis of variance (ANOVA) analyses are the same as the assumptions for the GLM.

Chi-Square Test. The assumptions for Chi-Square (χ^2) tests are (a) that fewer than 20% of the cells have expected counts of less than five; (b) the cases are independent of each other; and (c) each case should have a pair of values to compare, i.e., cases with missing values are not included in the χ^2 test (Meyers et al., 2013).

Correlation. The assumptions for Pearson's r coefficient are (a) that each variable is ratio-level; (b) each case should have a pair of values; (c) there are no outliers; (d) variable variables are normally distributed; (e) there is a linear relationship between the variables; and (f) homoscedasticity exists, i.e., homogeneity of variance (Meyers et al., 2013). The assumptions for Spearman's rho coefficient are almost identical to those for the Pearson's r, with the exception that the variables do not have to be ratio-level (Meyers et al., 2013).

Multiple regression. The assumptions for multiple regression analysis, used in this study to determine which independent variables predict the dependent ratio-level variable of LOS, are (a) the dependent variable is ratio- or interval-level; (b) the independent variables are ratio-, interval-, ordinal-, or nominal-level; (c) nominal-level independent variables are transformed into dummy variables; (d) the relationships between the independent variables and dependent variable are linear; (e) all independent variables measure different concepts, i.e., they are not redundant; and (f) the error terms for each independent variable are independent and normally distributed (Meyers et al., 2013).

Logistic regression. The assumptions of logistic regression analysis, used in this study to determine which independent variables predict the dependent nominal-level variable of DD, are (a) the dependent variable is binary; (b) the independent variables are ratio, interval, ordinal, or nominal level; (c) the ratio-level independent variables are normally distributed; (d) each category of the dependent variable has at least 10 cases; (e) the cases are independent of each other; (f) there are no outliers; (g) all independent variables measure different concepts, i.e., they are not redundant; and (h) the error terms for each independent variable are independent and normally distributed; and (i) the independent variables are linearly related to the log odds (Meyers et al., 2013).

Meeting Assumptions of Statistical Analyses

Outliers. One of the main assumptions of all inferential statistical analyses is a normal distribution in values around a variable mean. Outliers can cause distribution curves to become positively or negatively skewed compared to a normal distribution (Polit & Beck, 2012). Outliers were identified by determining if they are 3.29 times greater than the standard deviation above or below the mean (Meyers et al., 2013). Subjects with outlier values were removed from the sample.

Missing values. Another assumption that exists for nearly all standard statistical methods is that complete information for all the variables are included in the analysis. Missing values can weaken statistical power and bias results (Soley-Bori, 2013). One method to handle missing values is to replace them with the variable's mean. This technique can be used (a) if fewer than 5% of a variable's values are missing, and (b) if the "pattern of missingness" (Soley-Bori, p. 4) is random; both conditions were met. This technique of replacement with the mean was used for the missing variables in this study.

Variability. Variation in the study variables must be established in order to justify proceeding to inferential statistical tests such as correlation and regression analyses (Polit & Beck, 2012). Descriptive and inferential statistical analyses were used to determine if variation existed within the study variable values, and among and between the variables with respect to DRG groups.

Study Assumptions and Limitations

This section outlines the assumptions and the limitations of this study. The main assumption was related to the quality of the electronic data and information that were reused in this study for reasons other than the purpose for which they were originally collected (Weiskopf & Weng, 2013). The main limitation was generalizability due to convenience sampling.

Assumption of Data Quality

Nursing documentation. The first assumption regarding the quality of the data was that the information that was entered into the EHR by the nurses was timely, complete, accurate, and a true representation of their assessment of a patient's health condition (Weiskopf & Weng, 2013). The study variable that was most at risk due to this assumption was patient acuity. Patient acuity scores were calculated in Clairvia® based on data retrieved, in real time, from nursing assessment documentation in the EHR.

Inpatient billing. The inpatient billing content of the healthcare system data warehouse provided data for several independent variables in this study. Inpatient billing is complex (Mitchell, Anderson, & Braun, 2003). The second assumption regarding the quality of the data was that inpatient diagnoses and procedures were coded appropriately in the billing system, and that admission, discharge, and transfer data were accurate. The study variables that were at risk due to this assumption were DRG, LOS, LOS in ICU, primary diagnosis, primary payor, admission type, admission source, and DD.

Data collection method. To protect human subjects, this researcher did not extract data from either of the data collection tools used in the study, i.e., the healthcare system data warehouse and the Clairvia® SQL database reports. Instead, a data analyst at the healthcare system where the study took place created a list of eligible subjects by DRG and time period of the study. This list was sent to the honest broker at the healthcare organization research institute, who collected relevant study data about the subjects from the data warehouse. The list was also sent to a senior business analyst at Clairvia®, who collected patient acuity information for the study subjects from the SQL database reports and then provided it to the honest broker. Thus, the third assumption regarding the quality of the data was that the data analysts identified appropriate study subjects, that the honest broker and Clairvia® senior business analyst collected accurate data regarding the study subjects, and that the honest broker assigned matching false identifiers to subjects on the two reports.

Limitation of Design

External validity. External validity is the extent to which the results of a study can be generalized to other settings and samples (Polit & Beck, 2012). This study was conducted with a sample of open colorectal surgery patients at one Midwest healthcare system during a two-year period. A limitation of the design was that the results are not likely to be generalizable to other settings or patient populations.

Non-experimental design. The design of this study was retrospective and cross-sectional. Retrospective studies collect information about events that occurred in the past and are descriptive, i.e., non-experimental, in nature. In experimental studies, also referred to as randomized control trials, subjects are randomly assigned to treatment and control groups. Quasi-experimental studies also have treatment and control groups, though assignment of subjects to these groups is not random (Polit & Beck, 2012). This study used a convenience sample of patients who were discharged from hospitals at one Midwest healthcare system after colorectal surgery within a two-year time period. A limitation of the non-experimental design of this study was that it would not support causal inferences regarding patient acuity and LOS and DD. However, the study could reveal correlational relationships among these variable.

Studies that use non-experimental designs are classified as Level VI on the Rating System for the Hierarchy of Evidence (Melnyk & Fineout-Overholt, 2011). Level I studies, the highest rank, are systematic reviews of all relevant randomized control trials. Level VII studies, the lowest rank, consist of evidence from the opinion of authorities and/or reports from expert committees. Non-experimental studies may not receive as much recognition as they deserve because of their low ranking on the Rating System for the Hierarchy of Evidence. Consequently, healthcare policy makers may be reluctant to create or update policy based on based on non-experimental studies. Similarly, healthcare system executives and nurse managers may be reluctant to support changes in clinical practice based on Level VI studies.

Diagnostic-related groups (DRGs.) Stratification of patients by DRG was both a strength and limitation of the study. It was a strength because this method allowed for the examination of an array of patient trait and state characteristics as predictors of prolonged LOS and DHCS, while providing some control for the complex covariates of comorbidities and postoperative complications.

The stratification of patients by DRG was also a limitation of this study. Much has been written about the impact of comorbidities and complications on LOS (Ahmed Ali et al., 2014;

Campos Lobato et al., 2013; Kelly et al., 2012; Schmelzer et al., 2008) and DD (Barsoum et al., 2010; Halawi et al., 2015; Titler et al., 2006; Vochteloo et al., 2012) after open colorectal surgery. However, including additional variables regarding comorbidities and complications was beyond the scope of this study.

Summary

This chapter described the research methods of this study. This retrospective, cross sectional study of adults who had open colorectal surgery took place at a large healthcare system in the Midwest US. Human subject protection was assured by the use of an honest broker. Subjects' deidentified data from Clairvia® and the healthcare system data warehouse were combined, manipulated, and analyzed by this researcher using descriptive and inferential statistics methods. The assumptions regarding the quality of the data and the limitations of the study design were also outlined in this chapter.

CHAPTER 4 - RESULTS OF DATA ANALYSIS

This chapter presents the results of the data analysis. A multiple and logistical analysis were used to examine which patient trait characteristics, along with patient acuity, predicted prolonged length of stay (LOS) and discharge to home care or other healthcare settings (DHCS) after colorectal surgery. The purpose of this chapter is to (a) explain the data management that occurred prior to analysis; (b) provide an evaluation of the quality of the data collected for this study; (c) describe the study sample; (d) answer the four research questions; (e) present succinct analytical models of predictors of prolonged LOS and DHCS; (f) summarize the major findings of this study.

Data Management

The purpose of this section is to describe the eligible subjects that were identified for the study at the healthcare organization. The final sample (N = 789) was created based on exclusion criteria, removal of outliers, and adjustments for missing data.

Preliminary Dataset

The data analyst at the healthcare system produced a list of 2006 subjects from the healthcare system data warehouse who were eligible for this study based on inclusion criteria. These subjects were eligible because they were (a) admitted to the hospital for open colorectal surgery during the study time period of July 1, 2014, through June 30, 2016; and (b) had a discharge diagnosis-related group (DRG) of 329, 330, or 331. There were 504 (25.1%) subjects with a DRG of 329, 1,013 (50.5%) subjects with a DRG of 330, and 489 (24.3%) subjects with a DRG of 331.

Applying Exclusion Criteria

The first exclusion criterion that was applied to the preliminary dataset was a discharge disposition (DD) of “Expired.” The 40 subjects, representing 19.4% of the preliminary dataset, who expired in the hospital after open colorectal surgery during the study time period were removed. The second exclusion criterion that was applied was that patients had a laparoscopic approach to colorectal surgery, as opposed to an open approach. This resulted in the removal of an additional 734 subjects (36.6% of the preliminary dataset) from the dataset. Third, the 367 (18.3% of the preliminary dataset) patients whose primary procedure codes or procedure descriptions indicated that their surgery involved the small bowel only, and not the colon or rectum, were removed. None of the remaining subjects had an American Society of Anesthesiologists (ASA) Physical Status Classification System score of VI (ASA, 2104), nor had they been readmitted for a second open colorectal surgery during the study time period, so these exclusion criteria did not need to be applied.

After applying the exclusion criteria, 865 subjects, representing 43.1% of the preliminary dataset, remained in the sample: 238 (27.5%) had a DRG of 329, 460 (53.2%) a DRG of 330, and 167 (19.3%) had a DRG of 331.

Removing Outliers

Outliers were defined as values for the ratio-level variables of LOS, LOS in the intensive care unit (ICU), and body mass index (BMI) that were 3.29 standard deviations above or below the mean (Meyers et al., 2013). Because the number of outliers was less than 5% (*n*=35, 4.2%) of the sample, they could be removed without significantly altering the study results (Lien & Balakrishnan, 2005). First, 19 (2.2%) patients with outlier values for LOS were removed from the sample. Second, eight (0.9%) patients with outlier values for ICU LOS were removed. Finally, nine (1.0%) patients with outlier values for BMI were removed from the sample.

After removing outliers, 829 subjects, representing 41.3% of the preliminary dataset, remained: 214 (25.8%) had a DRG of 329; 448 (54.1%) a DRG of 330; and 167 (20.1%) had a DRG of 331. This group of subjects was further examined to look for missing data.

Managing Missing Data

Clairvia® SQL database. There were 40 (4.8%) subjects in the sample of 829 patients whose patient acuity information in Clairvia® did not match their LOS in the healthcare system data warehouse. For example, patient acuity information were collected in the Clairvia® SQL report for four days after open colorectal surgery, but their LOS was seven days according to the healthcare system data warehouse report. After these 40 subjects were removed from the sample, 789 subjects, representing 39.3% of the preliminary dataset remained: 202 (25.6%) subjects with a DRG of 329, 422 (53.5%) with a DRG of 330, and 165 (20.9%) with a DRG of 331.

Healthcare system data warehouse. There were very few missing data (0.9%) in the report from the healthcare system data warehouse. Of the 789 subjects that remained, less than five subjects were missing an ASA score, and two were missing a BMI. Because fewer than 5% of the variables values were missing and the "pattern of missingness" (Soley-Bori, 2013, p. 4) was random, missing data were replaced with the mean for each variable. No further subjects were removed from the sample.

Sample Size Changes Resulting from Exclusion Criteria, Outliers, and Missing Data

After applying the exclusion criteria, removing outliers, and managing missing data, 789 subjects remained in the final study sample: 202 (25.6%) subjects with a DRG of 329, 422 (53.5%) with a DRG of 330, and 165 (20.9%) with a DRG of 331.

The results of data management and its effect on the sample size, by DRG, are outlined in Table 4.1. The number of subjects removed from the dataset at each data management step appears in parentheses above the number of subjects that remained after that data management step. The total number of subjects, and the percent of the original sample it represented, appears in the final column of the table.

Table 4.1

Sample size changes as a result of exclusion criteria, removing outliers, and managing missing data, by DRG

DRG	329	330	331	Sample Size
	n	*n*	*n*	*n % of Preliminary Data Set*
Preliminary Dataset	504	1013	489	2006 (100%)
Patient Expired	(-40) 464	(-0) 1013	(-0) 489	1966 (98.0%)
Laparoscopic Procedure	(-86) 378	(-387) 626	(-261) 228	1232 (61.4%)
Small Bowel Procedure	(-140) 238	(-166) 460	(-61) 167	865 (43.1%)
Outliers for LOS	(-12) 226	(-7) 453	(-0) 167	846 (42.2%)
Outliers for LOS in ICU	(-7) 219	(-1) 452	(-0) 167	838 (41.8%)
Outliers for BMI	(-5) 214	(-4) 448	(-0) 167	829 (41.3%)
Missing Data in Clairvia®	(-12) 202	(-26) 422	(- 2) 165	789 (39.3%)

In summary, 1217 patients (60.7%) were removed from preliminary dataset of 2006 patients due to exclusion criteria, outliers, and missing data. The largest percentage (36.6%, *n*=734) of patients were removed because they had laparoscopic, and not open, colorectal surgery. Nonetheless, the sample size remained large enough to meet the power and sample size requirements of this study, i.e., at least 139 subjects in each DRG.

The DRG code, DRG description (Covidien, 2015), and distribution of subjects in the original study sample and the final sample are presented for comparison in Table 4.2. The distribution of subjects by DRG in the final sample was similar to the distribution in the preliminary dataset.

Table 4.2

Diagnostic-related group (DRG) code, description (Covidien, 2015), and comparison of distribution of study subjects by DRG in preliminary dataset and final study sample

Discharge DRG Code	DRG Description	Distribution of Subjects in Preliminary Dataset (Q3 2014-Q2 2016)	Distribution of Subjects in Final Sample (Q3 2014-Q2 2016)
329	Major small and large bowel procedures with major comorbidities and/or complications	504 (25.1%)	202 (25.6%)
330	Major small and large bowel procedures with comorbidities and/or complications	1,013 (50.5%)	422 (53.5%)
331	Major small and large bowel procedures without major comorbidities and/or complications or major small and large bowel procedures without comorbidities and/ or complications.	489 (24.3%)	165 (20.9%)
Total Sample		2006 (100%)	789 (100%)

Data Quality Assessment

Weiskopf and Weng (2013) developed a data quality assessment framework to evaluate data retrieved for clinical research from electronic health records (EHRs). The five dimensions of the framework and examples of the terms Weiskopf and Weng used to describe them appear in Table 4.3, below. The dimensions are completeness, correctness, concordance, plausibility, and currency.

Table 4.3

Five dimensions of data quality assessment framework (Weiskopf & Weng, 2013)

Completeness	Correctness	Concordance	Plausibility	Currency
Accessibility	Accuracy	Agreement	Believability	Recency
Availability	Errors	Consistency	Trustworthiness	Timeliness
Missingness	Misleading	Reliability		
	Validity	Variation		

A quality assessment of data that were collected for this study from the healthcare system data warehouse and from Clairvia® SQL database was conducted using these five dimensions. Overall, the data were of high quality according to Weiskopf and Weng's (2013) data quality assessment framework.

Completeness

The data obtained from the healthcare organization data warehouse report and from the Clairvia® SQL database report were complete after managing the missing data. The data were easily accessed by the healthcare organization data analyst, the honest broker, and the senior data analyst at Clairvia®. De-identified data were made available to this researcher by the study's honest broker. There were few missing data (n = 7) in the healthcare organization data warehouse report, namely two BMI and five ASA Score values. Only 40 subjects (4.8%) were excluded from the study sample due to missing data in the Clairvia® SQL database report.

Correctness

Examination of the de-identified data via description of the sample and data analyses revealed that the data were accurate, had few errors, and were not misleading. The data reflected clinical knowledge of the open colorectal surgery population. For example, subjects with the most serious comorbidities and complications, i.e., subjects with a DRG of 329, stayed in the hospital longer (M = 9.94 days, SD = 4.87 days) than patients with no comorbidities or complications, i.e., subjects with a DRG of 331 (M = 4.46 days, SD = 1.42 days). Furthermore, subjects with a DRG of 329 had a higher average patient acuity during their hospital stay (M = 3.13, SD = 0.52) than subjects with a DRG of 331 (M = 2.62, SD = 0.52).

The data were also examined for validity, i.e., the value measurements were well-founded and corresponded accurately to the real world (Waltz et al., 2010). A brief description of methods used by the healthcare system to ensure the validity of the data in the reports from the healthcare system data warehouse and Clairvia® SQL database is provided, below.

Healthcare system data warehouse validation process. The healthcare system provided data from the EHR and the financial software systems to an outside contractor, who downloaded it monthly into a data warehouse (Oracle®, 2016). Prior to the monthly downloads, a data analyst in the informatics department at the healthcare system and the counterpart at the contractor's site conducted an analysis of the validity of the data. They retrieved a sample of 50 patients for whom data has been collected from the EHR and financial systems. They independently verified the data that was queued to be downloaded into the warehouse against the original sources of the data, i.e., the EHR and financial systems. They then communicated with each other to discuss data inaccuracies they might have encountered. If there was an obvious issue with the validity of the data, such as all 100 patients' birthdates are identical, they investigated and resolved the problem prior to releasing the data into the warehouse.

Clairvia® SQL database report validation process. Nurse managers at the healthcare system conducted monthly validity testing of the data in Clairvia® by running Clairvia® *Acuity Validation Reports* (Clairvia®, n.d.). Each month, the nurse managers either selected five patients at random to audit, or reviewed patients that were identified by staff nurses as having acuity scores that were questionable. The nurse manager compared the 15 acuity item scores on the *Acuity Validation Reports* with nursing assessment documentation sources in the EHR for each patient. The nurse manager also manually calculated patient acuity scores. The results of the monthly audits were submitted to a Clairvia® specialist in the IT department at the healthcare system. If the nurse manager noticed a discrepancy between the patient acuity scores and the nursing assessment documentation, he or she reviewed the audits with the Clairvia® specialist. If the Clairvia® specialist concurred that there was a discrepancy, she contacted a counterpart at Clairvia® to discuss how to resolve the issue. The Clairvia® specialist explained to this researcher that nurse managers regularly reported discrepancies in the first three months after the Clairvia® system was implemented in early 2014. However, more recently the monthly audit reports only needed follow-up approximately twice each year (S. Timmons, personal communication, February 24, 2016).

Concordance

The concordance of the study data was evaluated while compiling the description of the sample and conducting statistical analyses to answer the four research questions. There was agreement in the data between the two sources, data analysis results were consistent, and there was variation within variable values and among variables with respect to DRGs.

The data from the two sources were also evaluated for reliability, i.e., the measurement tools yielded the same results on repeated trials (Waltz et al., 2010). A brief description of methods used by the healthcare system to ensure reliability of the data in the reports from the healthcare system data warehouse and Clairvia® SQL database is provided, below.

Healthcare system data warehouse report. It was not possible for this researcher to directly verify the reliability of the data in the healthcare system data warehouse report because only de-identified data were available for this study. However, reliability was verified indirectly by this researcher during data analysis. Because the description of the sample and results of the statistical analyses used to answer the research questions appeared logical and clinically probable, the data were considered reliable.

Clairvia® SQL database report. The reliability of the data in Clairvia® was examined during a pilot study (Badger, 2016). Clairvia® was developed to guide nurse staffing on inpatient hospital units by calculating patient acuity scores in near-real time. The healthcare system's Clairvia® specialist identified two nurse managers, one on an ICU and one on a medical-surgical unit, at a healthcare system hospital who were conscientiously using the nurse staffing and patient acuity system as designed. A strong significant relationship between unit patient acuity and unit nurse staffing on these two units would support that the data in Clairvia® were reliable.

In the pilot study, nurse staffing and patient acuity information were collected during two one-month periods in 2014 on the two hospital units, one ICU and one medical-surgical, at the healthcare system hospital. A correlation analysis, using the Pearson's product moment (Pearson's r), revealed that there was significant positive relationship between unit acuity and nurse staffing on both the ICU ($r = 0.71$, $p<0.01$), and the medical-surgical unit ($r = 0.63$, $p<0.01$) (Badger, 2016). In this pilot study, the data in Clairvia® were determined to be reliable.

Plausibility

Because the data from the two sources demonstrated completeness, correctness, and concordance, they had the quality of plausibility. In other words, the data were believable and trustworthy. There were no outliers with impossible values (e.g., a BMI of 150 kg/m^2), nor were there variable values that were not clinically plausible. For example, for subjects who were admitted to the ICU after surgery, the data indicated that their LOS in the ICU was always shorter than or equal to their total LOS in the hospital after open colorectal surgery. Also, the dates for open colorectal surgery always preceded the discharge date, which made logical sense.

Currency

The data were current because they were collected retrospectively for a recent two-year period. Moreover, data analysis began as soon as data collection was complete, and results were made available within one year of collection.

Description of the Sample

The purpose of this section is to describe the study sample. The total sample is described, as well as the sample after stratification by the three DRGs. The nominal-level variables are first described, then ratio-level variables. Chi-Square (χ^2) tests were conducted to determine if there were statistically significant differences among the DRGs for nominal-level variables. Generalized Linear Modeling (GLM) repeated measures and analyses of variance (ANOVA) were conducted to determine if there were statistically significant differences among the DRGs with respect to ratio-level variables.

Nominal-Level Variables

Nominal-level variables were described using frequencies and percentages. These variables included gender, race, marital status, admission type, admission source, primary diagnosis, DD, primary payor, ICU stay after surgery, LOS above or below the national average LOS per DRG, and readmission within 30 days.

Appendix E contains a table with frequencies and percentages of the nominal-level variables in this study for the total sample. Appendix F contains a similar table for the sample stratified by DRG. In the table in Appendix F, asterisks appear next to the variable name when statistically significant differences among the DRGs existed. One asterisk (*) denotes a significance level of $p<0.05$. Two asterisks (**) denote a significance level of $p<0.01$.

Total sample. For the total sample, 55.6% (n=439) of subjects were female; 90.7% (n=716) were white; 52.2% (n=415) were married; 61.5% (n=485) of admissions were non-urgent; 88.8% (n=701) of admissions were from a non-healthcare point of origin; 37.3% (n=294) had a primary diagnosis of neoplasm of the colon or rectum; 26.4% (n=208) a diagnosis of diverticulitis; 55% (n=458) had a DD to home without healthcare services; 40.9% (n=323) had commercial health insurance; 73.9% (n=585) were not admitted to the ICU during their stay; 23.7% (n=179) stayed longer than the national average LOS for their DRG (Covidien, 2015); and 26.2% (n=207) were readmitted to hospital within 30 days of discharge from the admission for open colorectal surgery.

Sample stratified by DRG. There was no difference among the DRGs with respect to gender and race. Differences at the $p<0.5$ level of statistical significance existed among the DRGs for marital status: 47.0% (n=95) of patients with a DRG of 329 were married, 51.9% (n=219) with DRG 330, and 61.2% (n=101) of patients with a DRG of 331. Differences at the $p<0.01$ level of statistical significance existed for admission type, admission source, primary diagnosis, DD, ICU stay, primary payor, and readmission within 30 days of discharge, and LOS above or below national average per DRG. For admission type, 27.7% (n=56) of patients with a

DRG of 329 had a non-urgent admission type, 67.8% (*n*=286) with DRG 330, and 86.7% (*n*=143) of patients with a DRG of 331. For admission source, 82.7% (*n*=167) of patients with a DRG of 329 were admitted from a non-healthcare point of origin, 89.3% (*n*=377) with DRG 330, and 95.2% (*n*=157) of patients with a DRG of 331. For primary diagnosis, 30.7% (*n*=62) or patients with a DRG of 329 had a primary diagnosis of neoplasm of the colon or rectum, 38.2% (*n*=161) with DRG 330, and 43.1% (*n*=71) of patients with a DRG of 331. For DD, 30.2% (*n*=61) of patients with a DRG of 329 were discharged to home without healthcare services, 60.9% (*n*=257) with DRG 330, and 84.7% (*n*=140) of patients with a DRG of 331. For ICU stay, 55.4% (*n*=112) of patients with a DRG of 329 were admitted to the ICU after open colorectal surgery, 19.0% (*n*=80) with DRG 330, and 8.5% (*n*=14) of patients with a DRG of 331. For primary payor, 28.2% (*n*=57) of patients with a DRG of 329 had commercial insurance, 39.6% (*n*=167) with DRG 330, and 60.0% (*n*=99) of patients with a DRG of 331. For readmission within 30 days of discharge, 38.6% (*n*=78) of patients with a DRG of 329 were readmitted, 21.3% (*n*=90) with DRG 330, and 23.6% (*n*=39) of patients with a DRG of 331

A notable difference among the DRGs arose with respect to the percentage of subjects who stayed in the hospital longer than the national average LOS per DRG (Covidien, 2015). For DRGs 329 and 330, only 17.8% (*n*=36) and 17.5% (*n*=74) of subjects, respectively, stayed in the hospital longer than the national average LOS. However, 41.8% (*n*=69) of subjects with a DRG of 331 stayed in the hospital longer than the national average LOS. DRG 331 has the shortest national average LOS of the three DRGs because these patients do not have comorbidities or postoperative complications (Centers for Medicare and Medicaid Services [CMS], 2016a).

Several nominal-level variables were transformed into dummy variables after describing the sample and prior to conducting statistical analyses to answer the four research questions. The values, dummy codes, frequencies and percentages of the nominal-level variables that were transformed appear in Table 4.4. Asterisks appear next to the variable name when statistically significant differences among the DRGs existed. One asterisk (*) denotes a significance level of $p<0.05$. Two asterisks (**) denote a significance level of $p<0.01$.

Table 4.4

Values, dummy codes, frequencies, and percentages for nominal-level variables used in the analyses, by DRG

DRG	329 (*n*=202)		330 (*n*=422)		331 (*n*=165)	
Nominal-Level Variable	*n*	(%)	*n*	(%)	*n*	(%)
Discharge Disposition**						
0 = Discharge to home without home healthcare services	61	(30.2%)	257	(60.9%)	140	(84.7%)
1 = Discharge to home or other healthcare setting (DHCS)	141	(69.8%)	165	(39.1%)	25	(15.3%)
Race						
0 = Non-White	19	(9.4%)	39	(9.7%)	13	(7.9%)
1 = White	183	(90.6%)	381	(90.3%)	152	(92.1%)
Marital Status*						
0 = Not Married	107	(53.0%)	203	(48.1%)	64	(38.8%)
1 = Married	95	(47.0%)	219	(51.9%)	101	(61.2%)
Admission Type**						
0 = Non-Urgent	56	(27.7%)	286	(67.8%)	143	(86.7%)
1 = Urgent	146	(72.3%)	136	(32.2%)	22	(13.3%)
Admission Source**						
0 = Non-healthcare point of origin	167	(82.7%)	377	(89.3%)	157	(95.2%)
1 = Healthcare point of origin	35	(17.3%)	45	(10.7%)	8	(4.8%)
Primary Diagnosis**						
0 = Other disorders of colon or rectum	79	(39.1%)	154	(36.5%)	54	(32.6%)
1 = Neoplasm of colon or rectum	62	(30.7%)	161	(38.2%)	71	(43.1%)
1 = Diverticulitis of colon	61	(30.2%)	107	(25.3%)	40	(24.3%)
Primary Payor**						
0 = Commercial	59	(28.2%)	171	(39.6%)	102	(17.0%)
1 = Medicaid/Medicare	143	(38.6%)	251	(30.6%)	63	(17.0%)

*The difference is significant at the 0.05 level.
** The difference is significant at the 0.01 level.

Ratio-level Variables

Ratio-level variables in the study were described using measures of central tendency and dispersion. The ratio-level variables were patient acuity, LOS, LOS in ICU, age, BMI, and ASA score. The measures of central tendency and dispersion included the variable mean, standard deviation, median, range, mode, skewness and kurtosis. The description of these variables for the total sample and for the sample stratified by DGR appears in Table 4.5.

Asterisks appear next to the variable name in Tables 4.5 and 4.6 when statistically significant differences among the DRGs existed. One asterisk (*) denotes a significance level of $p<0.05$. Two asterisks (**) denote a significance level of $p<0.01$.

Table 4.5

Descriptive statistics for LOS in days, LOS in ICU in days, age in years, BMI in kg/m^2, and ASA score for total sample (*N*=789) and by DRGs 329 (*n*=202), 330 (*n*=422), and 331 (*n*=165)

Variable	Mean	*SD*	Median	Range	Mode	Skewness	Kurtosis
Patient Acuity Score**							
Total Sample	2.89	0.52	2.86	1.00-5.00	3.00	0.16	2.87
DRG 329	3.13	0.52	3.13	1.00-5.00	3.00	0.24	2.76
DRG 330	2.78	0.53	2.77	1.00-5.00	3.00	0.21	2.52
DRG 331	2.62	0.52	2.62	1.00-4.13	3.00	0.17	2.12
LOS**							
Total Sample	6.84	3.70	5.97	0.7-26.95	4.97	1.85	4.83
DRG 329	9.94	4.87	8.76	2.10-26.95	6.84	1.14	1.11
DRG 330	6.29	2.53	5.97	0.70-15.09	6.83	0.93	1.09
DRG 331	4.46	1.42	4.21	1.33-9.14	4.97	0.47	0.61
LOS in ICU**							
Total Sample	0.78	1.78	0.0	0.0-13.88	0.00	2.93	9.63
DRG 329	1.99	2.54	0.79	0.00-8.80	0.00	1.18	0.27
DRG 330	0.45	1.31	0.00	0.00-13.88	0.00	4.98	34.53
DRG 331	0.17	0.67	0.00	0.00-4.84	0.00	4.74	24.26
Age**							
Total Sample	63.55	14.74	64.00	19-90	50	-0.33	-0.16
DRG 329	68.12	13.54	69.50	29-90	66	-0.50	-0.18
DRG 330	63.32	15.41	64.00	19-90	50	-0.41	-0.10
DRG 331	58.56	12.60	58.00	24-89	50	-0.02	0.21

BMI*							
Total Sample	29.04	6.27	28.28	13.57-51.99	31.19	0.61	0.50
DRG 329	28.08	6.30	27.17	13.57-46.13	13.57	0.44	-0.13
DRG 330	29.50	6.59	28.86	14.76-51.99	35.43	0.73	0.67
DRG 331	29.02	5.21	28.31	17.78-40.80	17.78	0.27	-0.42
ASA Score**							
Total Sample	2.72	0.63	3.00	1-5	3	-0.04	0.01
DRG 329	3.01	0.59	3.00	2-5	3	0.15	0.46
DRG 330	2.70	0.60	3.00	1-4	3	-0.04	-0.24
DRG 331	2.40	0.59	2.00	1-4	2	-0.23	-0.55

*The mean difference among DRGs is significant at the 0.05 level.
** The mean difference among DRGs is significant at the 0.01 level.

Subjects with a DRG of 329, i.e., subjects with major comorbidities and/or major postoperative complications, had the highest mean age (*M*=68.12 years, *SD*=13.54), mean patient acuity scores (*M*=3.13, *SD*=0.52), LOS (*M*=9.94 days, *SD*=4.87), mean LOS in the ICU (*M*=1.99 days, *SD*=2.54), and mean ASA Scores (*M*=3.01, *SD*=0.59) among the three DRGs. They also had the highest median age (*Mdn*=69.50 years, range 29-90), median patient acuity scores (*Mdn*=3.13, range 1.00-5.00), median LOS (*Mdn*=8.76 days, range 2.10-26.95), and median LOS in ICU (*Mdn*=0.79 days, range 0.00-8.80). Subjects with a DRG of 331, i.e. subjects with no comorbidities or postoperative complications , had the lowest mean age (*M*=58.56 years, *SD*=12.60), mean patient acuity scores (*M*=2.62, *SD*=0.52) , mean LOS (*M*=4.46 days, *SD*=1.42), mean LOS in the ICU (*M*=0.17 days, *SD*=0.67), and mean ASA Scores (*M*=2.40, *SD*=0.59). They also had the lowest median age (*Mdn*=58.00 years, range 24-89), median patient acuity scores (*Mdn*=2.62, range 1.00-4.13), median LOS (*Mdn*=4.21 days, range 1.33-9.14), and median ASA Scores (*Mdn*=2.00, range 1-4).

Statistically significant differences existed among the three DRGs for all of the ratio-level variables. There were also statistically significant differences among the three DRGs for most of the nominal-level variables. These findings justified conducting further statistical analyses with the sample stratified by DRG to provide some control for comorbidities and complications. The sample of subjects in each DRG could be said to belong to different populations (Polit & Beck, 2012).

All ratio-level variables had a normal distribution for each DRG. The exception was that subjects with a DRG of 330 or 331 had a skewed distribution of LOS in the ICU (Skewness DRG 330 = 4.98; Skewness DRG 331 = 4.74). More than 50% (*n*=112, 55.4%) of subjects with a DRG of 329 were admitted to the ICU after open colorectal surgery, and this group of subjects displayed a normal distribution of LOS in the ICU. However, only 19.0% ($n=80$) of subjects with a DRG of 330 and 8.5% ($n=14$) of subjects with a DRG of 331 were admitted to the ICU after surgery. Their distribution curves were skewed to the right, and their skewness values (4.98 and 4.74, respectively) were double the accepted level of 2.0 for normality (Meyers et al., 2013). Consequently, for statistical analyses that assumed a normal distribution, the ratio-level variable of "LOS in the ICU" was used for DRG 329, and the nominal-level variable of "ICU Stay" was used for DRGs 330 and 331.

The average length of hospital stay (LOS) after open colorectal surgery for subjects in each DRG were statistically significantly lower ($p<0.05$) than the national average LOS for each DRG. The national average LOS for DRG 329 was 14.4 days (Covidien, 2015), while the mean for the study subjects with DRG 329 was 9.94 days ($SD=4.87$). For DRG 330, the national average LOS was 8.4 days (Covidien, 2015), and it was 6.29 ($SD=2.53$) days for the study subjects with DRG 330. Finally, for DRG 331, the national average LOS was 4.8 days (Covidien, 2015), and it was 4.46 ($SD=1.42$) for the study subjects with DRG 331. The national average LOS and the study subjects' average lengths of stay after open colorectal surgery, by DRG, appear in Table 4.6. The table also contains the ranges of the study subjects' LOS and percent of the national average LOS that each study LOS represents.

Table 4.6

Comparison of national average length of hospital stay (LOS) (Covidien, 2015) with mean LOS for study sample, by DRG

Discharge DRG Code	DRG Description	National Average LOS by DRG	Study Sample Mean LOS by DRG
329 *n*=202	Major small and large bowel procedures with major comorbidities and/or complications	14.4 days	9.94 days** Range = 2.1 - 26.9 days 69.0% of national average
330 *n*=422	Major small and large bowel procedures with comorbidities and/or complications	8.4 days	6.29 days** Range = 0.7 - 15.0 days 74.9% of national average
331 *n*=165	Major small and large bowel procedures without major comorbidities and/or complications or major small and large bowel procedures without comorbidities and/ or complications.	4.8 days	4.46 days* Range = 1.33 - 9.44 days 92.9% of national average

*The difference in means is significant at the 0.05 level.
** The difference in means is significant at the 0.01 level.

Summary. The mean LOS for study subjects in each DRG was lower than the national average LOS per DRG. Subjects with a DRG of 329 spent 31.0% fewer days, on average, in the hospital after open colorectal surgery than the national average of patients with a DRG of 329. Subjects with a DRG of 330 spent 25.1% fewer days, on average, and subjects with a DRG of 331 spent 7.1% fewer days, on average. These results concurred with the description of the sample with respect to the nominal-level LOS variable. In this study sample, 41.8% (*n*=69) of subjects with a DRG of 331 stayed longer than the national average LOS for that DRG, while only 17.8% (*n*=36) and 17.5% (*n*=74) of subjects with a DRG of 329 and 330, respectively, stayed in the hospital longer than the national average LOS for these DRGs.

Analysis of Research Questions

Research Question 1

What are the patterns of patient acuity, LOS, and DD for open colorectal surgery patients with a DRG of 329, 330, or 331?

Patient acuity. The pattern of patient acuity after open colorectal surgery patients was examined by calculating the average of the patient acuity scores by DRG at each data collection time after open colorectal surgery. Graphs were created that displayed the data collection time on the x-axis, the average patient acuity score for the data collection time on the left y-axis, and the number of subjects on the right y-axis. These graphs appear in Appendices G, H, and I.

The pattern of patient acuity was apparent after reviewing the visual display of the data. For subjects with a DRG of 329, patient acuity was highest during Day 1 after surgery, steadily declined during Days 2 through 4, plateaued on Day 5 and 6, then increased again on Day 7. For subjects with a DRG of 330, patient acuity was highest during Day 1 after surgery, steadily declined during Days 2 through 4, then plateaued on Day 5. For subjects with a DRG of 331, patient acuity was highest during Day 1 after surgery, steadily declined during Days 2 through 4, then increased again on Day 5.

The pattern of patient acuity for each DRG was again presented graphically in Figures 2, 3 and 4. This time, the number of subjects was removed and the average patient acuity scores were only presented for data collection times up to and including the national average LOS for each DRG (Covidien, 2015). The data were presented for 14 days for subjects with DRG 329, eight days for subjects with DRG 330, and five days for subjects with DRG 331.

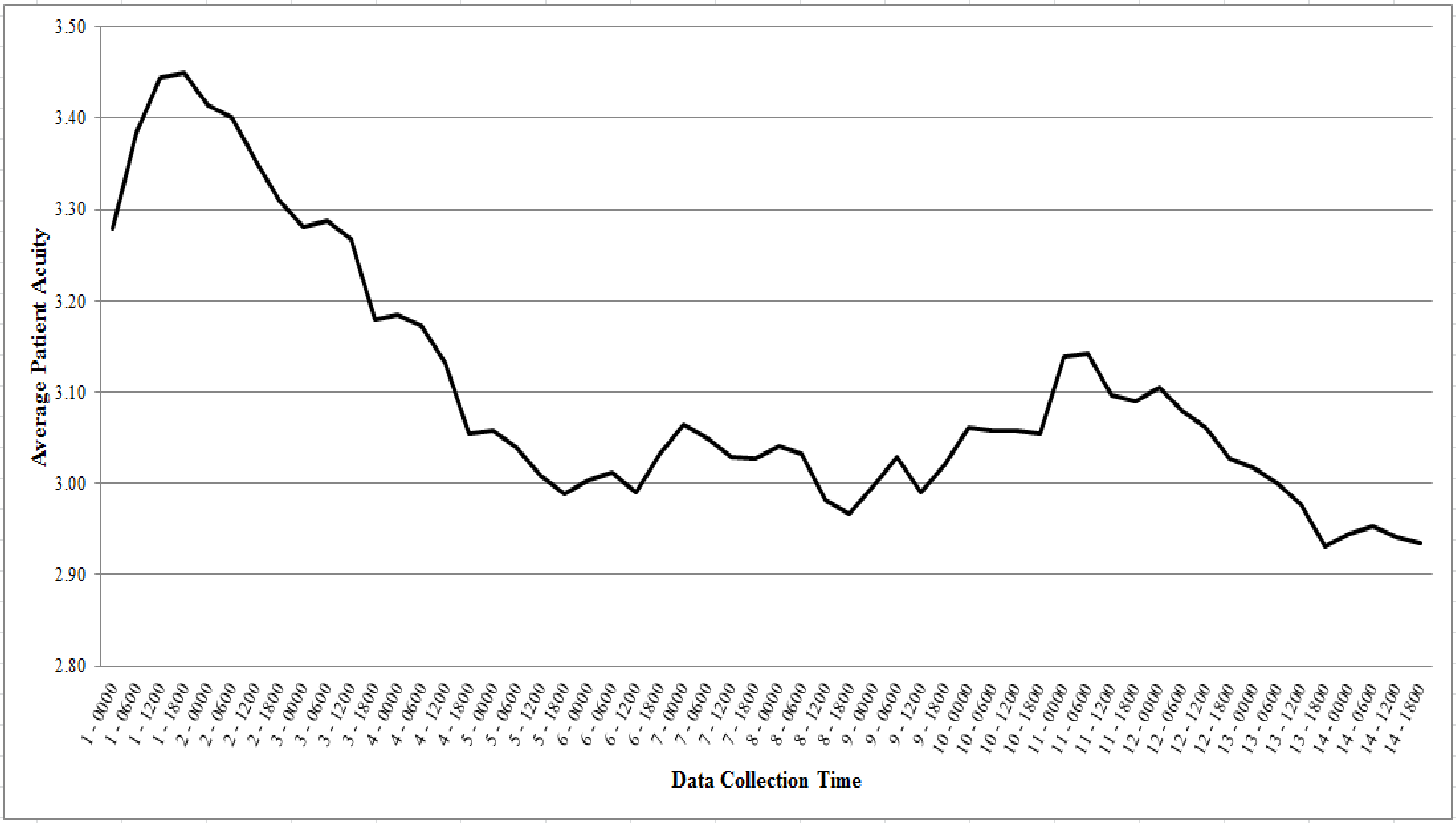


Figure 2

Average patient acuity scores per data collection time for 14 days, DRG 329 (*n*=202)

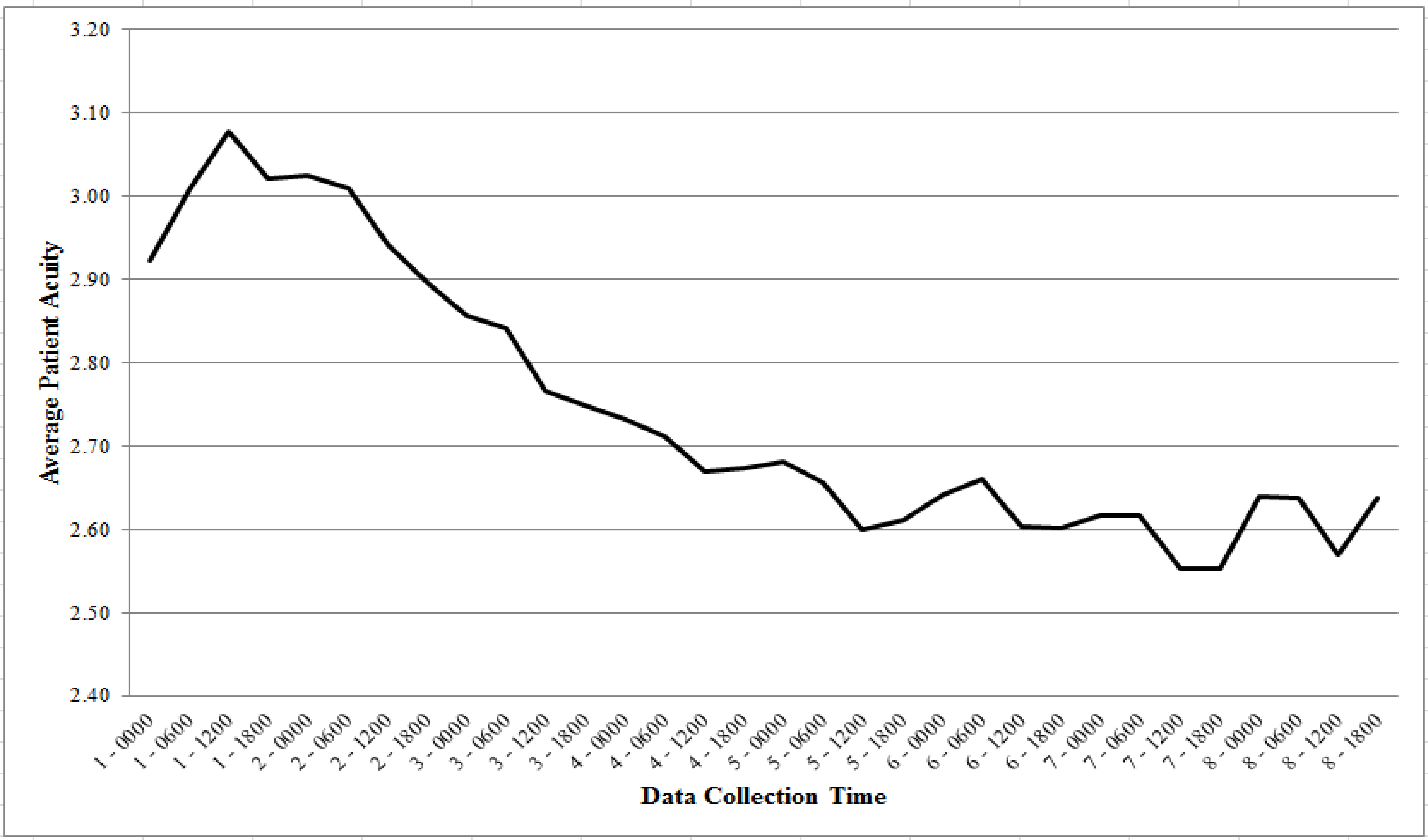


Figure 3

Average patient acuity scores per data collection time for 8 days, DRG 330 (*n*=422)

Figure 4

Average patient acuity scores per data collection time for 5 days, DRG 331 (*n*=165)

Length of Stay (LOS). The pattern of LOS after open colorectal surgery for the whole sample and the sample stratified by DRG was examined as both a ratio-level and nominal-level variable. The nominal variable had two categories: subjects whose LOS was below the national average LOS per DRG, and subjects whose LOS was greater than the national average LOS.

LOS as a ratio-level variable. The measures of central tendency and distribution of LOS for the total sample and for the sample stratified by DRG were presented in Tables 4. The mean LOS for subjects with a DRG of 329 was 9.94 days (*SD*=4.87); 6.29 days (*SD*=2.53) days for subjects with a DRG of 330 and 4.46 days (*SD*=1.42) for subjects with a DRG of 331. The LOS data were normally distributed for each DRG. To further display patterns of LOS for the sample stratified by DRG, histograms with normal curves superimposed upon them are presented in figures 5, 6, and 7.

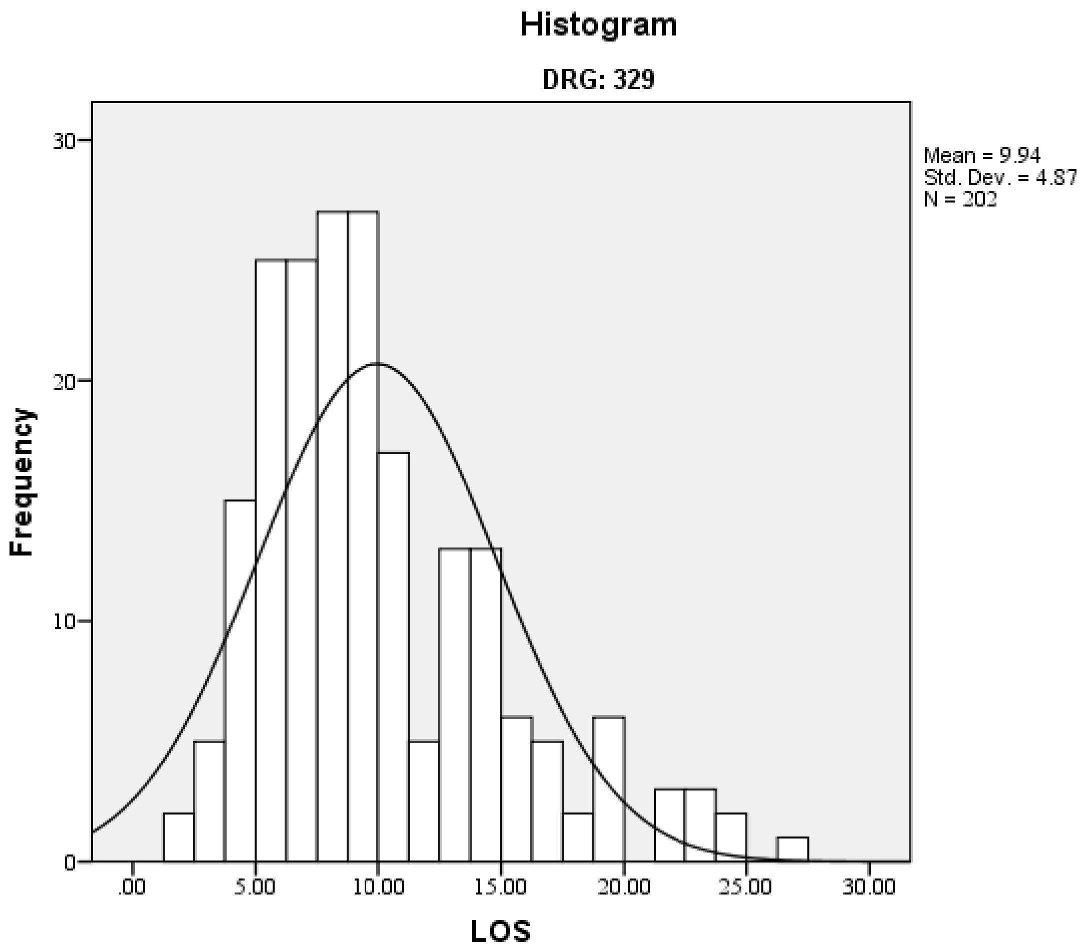


Figure 5

Frequency of LOS for DRG 329 (*n*=202)

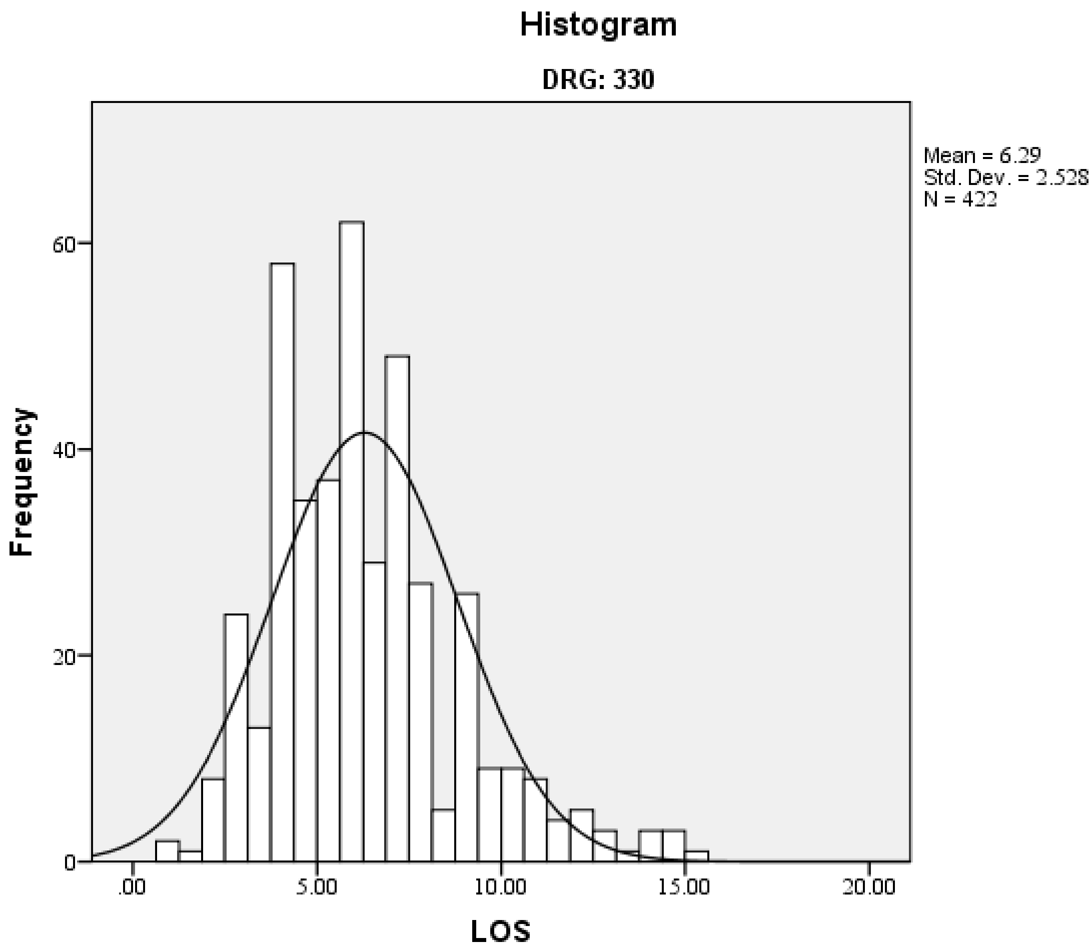


Figure 6

Frequency of LOS for DRG 330 (n=422)

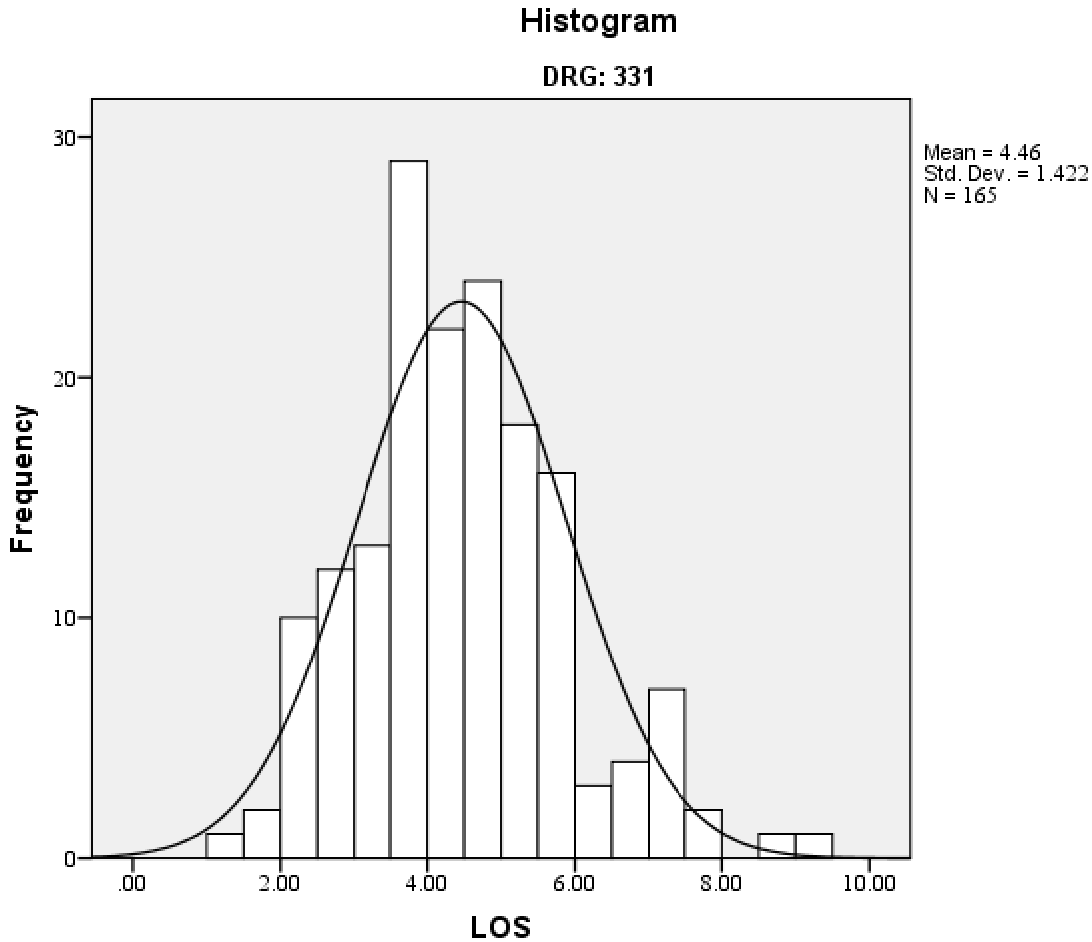


Figure 7

Frequency of LOS for DRG 331 (*n*=165)

A review of the visual display of the data confirmed the pattern of normal distribution of LOS for the sample stratified by DRG. The skewness values were reported in Table 4, all of which were under 2.0. This finding also confirmed that the distribution of LOS was normal for all DRGs (Meyers et al., 2013).

LOS as a nominal-level variable. LOS as a nominal variable was used to describe the sample (see Appendix F) and to further examine the pattern of LOS. The frequencies and percentages of patients whose LOS was above or below the national average LOS by DRG appear in Table 4.7. The same data are displayed in a bar chart in Figure 8. The national average LOS for DRG 329 was 14.4 days, 8.4 days for DRG 330, and 4.8 days for DRG 331 (Covidien, 2015).

Table 4.7

Frequencies and percentages of subjects whose LOS was below or above the national average LOS, by DRG

DRG	329 (*n*=202)		330 (*n*=422)		331 (*n*=165)	
Categorical LOS	*n*	(%)	*n*	(%)	*n*	(%)
LOS Below National Average LOS	166	(82.2%)	348	(82.5%)	96	(58.2%)
LOS Above National Average LOS	36	(17.8%)	74	(17.5%)	69	(41.8%)

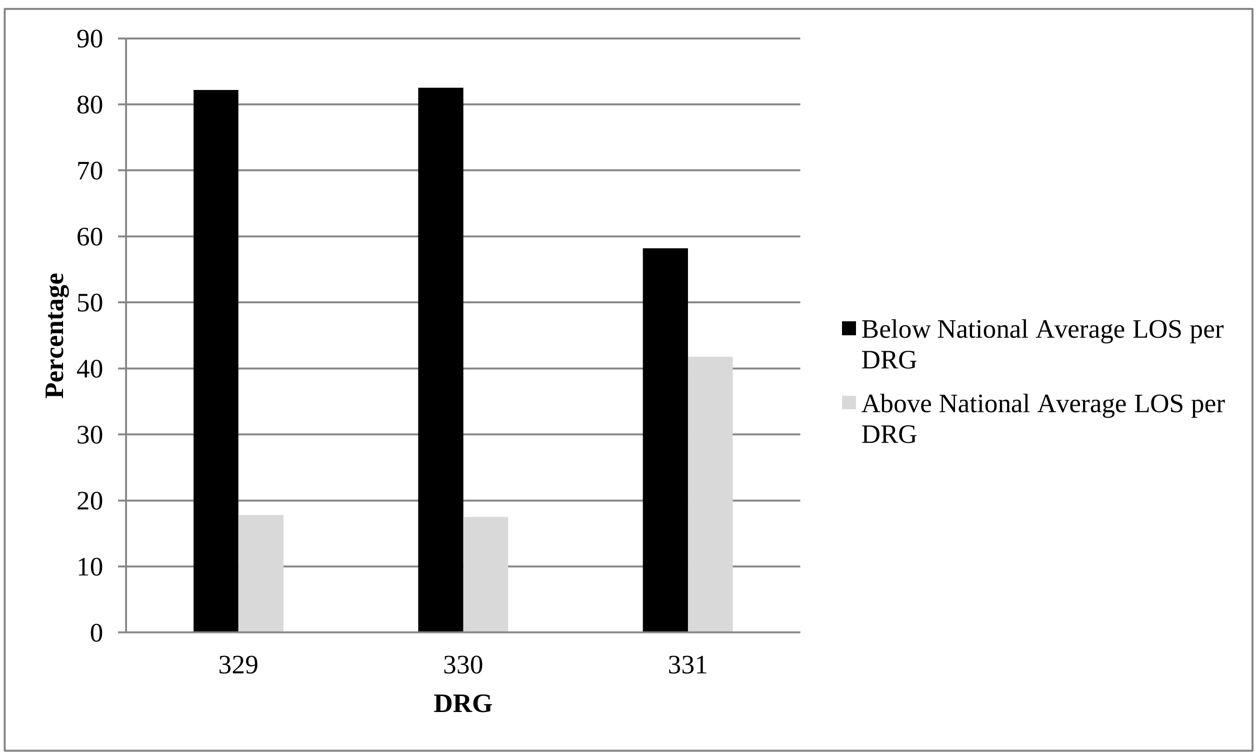


Figure 8

Percent of subjects whose length of stay (LOS) was below or above the national average LOS (Covidien, 2015), by DRG

There was a notable result regarding the pattern of LOS as a nominal-level variable. For DRGs 329 and 330, only 17.8% (*n*=74) and 17.5% (*n*=36) subjects, respectively, stayed in the hospital longer than the national average LOS for each DRG (Covidien, 2015). Yet, 41.8% (*n*=69) of subjects with a DRG of 331, stayed in the hospital longer than the national average LOS for that DRG (Covidien, 2015).

Discharge disposition (DD). The pattern of DD for the sample stratified by DRG was examined by calculating frequencies and percentages for this nominal-level variable. The two groups were (a) discharged to home without healthcare services and (b) discharged to home care or other healthcare setting (DHCS). The frequencies and percentages of DD appear in Table 4.8. The same data are displayed in a bar chart in Figure 9.

Table 4.8

Frequencies and percentages of discharge disposition (DD), by DRG

DRG	329 (*n*=202)	330 (*n*=422)	331 (*n*=165)
Discharge Disposition	*n* (%)	*n* (%)	*n* (%)
Home without healthcare services	61 (30.2%)	257 (60.9%)	140 (84.8%)
Home care or other healthcare setting (DHCS)	141 (69.8%)	65 (39.1%)	25 (15.2%)

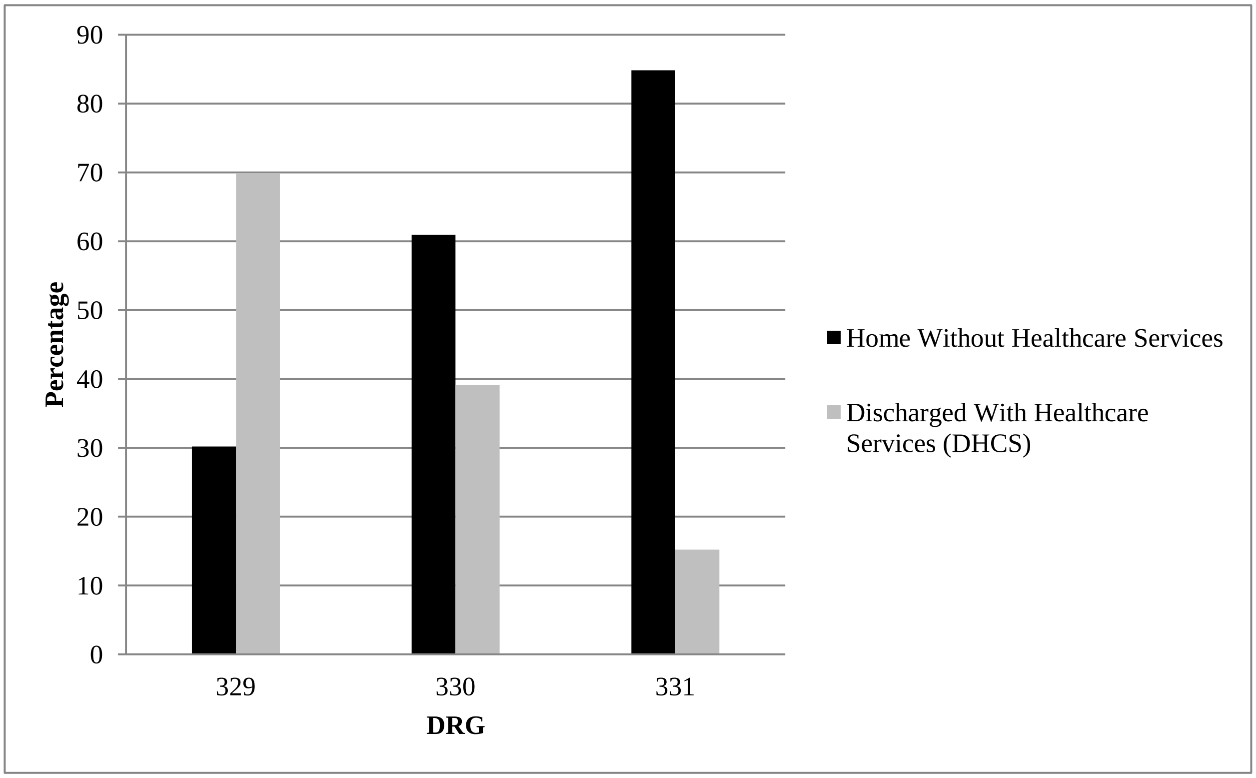


Figure 9

Percent of subjects by discharge disposition (DD), by DRG

The pattern of DD for each DRG was as follows: the percent of subjects who were DHCS was highest for DRG 329 (69.8%) and lowest for DRG 331 (15.2%); the percent of subjects who were discharged to home without healthcare services was lowest for DRG 329 (30.2%) and highest for 331 (84.8%).

Summary of analysis of Question 1. The pattern of patient acuity for each DRG was that patient acuity was highest within the first two or three days after surgery, plateaued for another two or three days, then decreased steadily until discharge. The pattern for LOS as a ratio-level variable was that the patients with DRG 329 had the highest mean LOS (*M*=6.84 days, *SD*=3.70) and the patients with DRG 331 had the lowest (*M*=4.46 days, *SD*=1.42). Furthermore, each mean LOS was statistically significantly lower than the national average LOS per DRG ($p<0.05$). The pattern for LOS as a nominal-level variable was that the percent of subjects who stayed in hospital below the national average LOS was higher than the percent of subjects who stayed longer than the national average LOS for each DRG. The pattern for DD was that the percent of subjects who were DHCS was highest for DRG 329 (69.8%) and lowest for DRG 331 (16.3%).

Research Question 2

What are the relationships among patient acuity, LOS, DD, and select patient trait characteristics for open colorectal surgery patients with a DRG of 329, 330, or 331?

Correlation matrices were created for each DRG to analyze the relationships between each variable pair in the study. Correlation matrices were also created to determine if there was multicolinearity among the independent variables. Patient acuity was defined as the average patient acuity score, which was measured every six hours, for each subject over the course of their hospitalization. Other variables that were included in the correlation matrices were LOS as a ratio-level variable, DD, LOS in the ICU (for DRG 329), ICU stay (for DRG 330 and 331), gender, race, age, BMI, ASA Score, marital status, primary payor, admission type, admission source, and primary diagnosis.

The correlation matrices for the three DRGs are presented in Appendices J, K, and L. Correlation coefficients are flagged with one asterisk (*) when the relationship between the variables was statistically significant at the two-tailed alpha level of 0.05, and with two asterisks (**) when the relationship was statistically significant at the two-tailed alpha level of 0.01.

DRG 329. Patient acuity was statistically significantly correlated with LOS (r=0.254, p<0.01), DD (r=0.416, p<0.01), gender (r= -0.186, p<0.01), age (r=0.344, p<0.01), BMI (r=0.172, p<0.05), ASA Score (r=0.323, p<0.01) , LOS in ICU (r=0.618, p<0.01), admission type (r=0.150, p<0.05), and primary payor (r=0.296, p<0.01). LOS was statistically significantly related to patient acuity, as well as DD ($r=0.270$, $p<0.01$) and LOS in the ICU ($r=0.182$, $p<0.05$). DD was statistically significantly related to patient acuity and LOS, as well as race ($r=0.157$, $p<0.05$), age ($r=0.331$, $p<0.01$), ASA Score ($r=0.182$, $p<0.01$), LOS in ICU($r=0.217$, $p<0.01$), admission type ($r=0.171$, $p<0.05$), and primary payor ($r=0.241$, $p<0.01$). There were no significant relationships among patient acuity, LOS, and DD and the study variables of marital status, admission source, and primary diagnosis.

Marital status and admission source were the only predictor variables that were independent of all other study variables for subjects with a DRG of 329. There were statistically significant relationships among or between all remaining independent variables. However, because the strength of the relationships among any two study variables was less than $r = 0.700$, there was no collinearity or multicolinearity (Meyers et al., 2013). All predictor variables, therefore, were included in the regression analyses for subjects with a DRG of 329.

DRG 330. Patient acuity was statistically significantly correlated with LOS ($r=0.289$, $p<0.01$), DD ($r=0.348$, $p<0.01$), age ($r=0.164$, $p<0.01$), ASA score ($r=0.223$, $p<0.01$), ICU stay ($r=0.199$, $p<0.01$), admission type ($r=0.170$, $p<0.01$), and primary payor ($r=0.206$, $p<0.01$). LOS was statistically significantly related to patient acuity, as well as to DD ($r=0.240$, $p<0.01$), ICU stay ($r=0.139$, $p<0.01$), admission type ($r=0.235$, $p<0.01$), and primary payor ($r=0.113$, $p<0.05$). DD was statistically significantly related to patient acuity and LOS, as well as gender ($r=-0.113$, $p<0.05$), race ($r=0.164$, $p<0.01$), age ($r=0.278$, $p<0.01$), ASA score ($r=0.227$, $p<0.01$), ICU stay ($r=0.108$, $p<0.05$), admission type ($r=0.248$, $p<0.01$), and primary payor ($r=0.236$, $p<0.01$). There were no significant relationships among patient acuity, LOS, and DD and the study variables of BMI, marital status, admission source, and primary diagnosis.

There were statistically significant relationships among or between all of the independent variables. However, because the strength of the relationships was less than r = 0.700, there was no collinearity or multicolinearity (Meyers et al., 2013). All predictor variables, therefore, were included in the regression analyses for subjects with a DRG of 330.

DRG 331. Patient acuity was statistically significantly correlated with LOS (r=0.150, p<0.05), DD (r=0.323, p<0.01), ASA score (r=0.202, p<0.01), admission type (r=0.161, p<0.05), primary payor (r=0.201, p<0.01), and primary diagnosis (r=0.163, p<0.05). LOS was statistically significantly related to patient acuity, as well as DD (r=0.189, p<0.05), ASA score (r=0.203, p<0.01), ICU stay (r=0.202, p<0.01), admission type (r=0.168, p<0.05), and primary payor (r=0.179, p<0.05). DD was statistically significantly related to patient acuity and LOS, as well as primary payor (r=0.190, p<0.05). There were no significant relationships among patient acuity, LOS, and DD and the study variables of gender, race, age, BMI, marital status, and admission source.

A summary of the relationships among the three main study variables of patient acuity, LOS, and DD, and the remaining study variables by DRG is presented in Table 4.9. An ‘x’ in a cell denotes that a statistically significant relationship existed between study variables. N/A indicates that the relationship was not examined (e.g., LOS in ICU was included in the correlation matrix for DRG 329, but was not included in the correlation matrices for DRG 330 and 331).

Table 4.9

Statistically significant relationships among patient acuity, LOS, DD, and remaining predictor variables, by DRG

	DRG 329 (*n*=202)			DRG 330 (*n*=422)			DRG 331 (*n*=165)		
	Patient Acuity	LOS	DD	Patient Acuity	LOS	DD	Patient Acuity	LOS	DD
Patient Acuity									
LOS	x			x			x		
DD	x	x		x	x		x	x	
Gender	x					x			
Race			x			x			
Age	x		x	x		x			
BMI	x								
ASA Score	x		x	x		x	x	x	
LOS in ICU	x	x	x	N/A	N/A	N/A	N/A	N/A	N/A
ICU Stay	N/A	N/A		x	x	x		x	
Marital Status									
Admission Type	x		x	x	x	x	x	x	
Admission Source									
Primary Payor	x		x	x	x	x	x	x	x
Primary Diagnosis							x		

Summary of analysis of Question 2. There were statistically significant relationships among the three main study variables of patient acuity, LOS, and DD. Because the correlation coefficients (*r*) were less than 0.700, there was no collinearity or multicolinearity. Marital status and admission source were the only predictor variables that were independent of patient acuity, LOS, and DD for subjects in each of the DRG categories.

Research Question 3

Which combination of patient acuity and select patient trait characteristics predict LOS for open colorectal surgery patients with a DRG of 329, 330, or 331?

Multiple regression. Standard multiple regression analyses were conducted to determine which patient trait characteristics, along with patient acuity, predicted the ratio-level variable of LOS for subjects by DRG. Stepwise and hierarchical multiple regression analyses were also conducted, but the results are not reported here because they did not yield results that were different from those obtained with standard multiple regression analysis.

The assumptions for multiple regression analysis, as outlined in Chapter 3, were met. The F statistic was calculated to determine if the multiple regression model significantly predicted the dependent variable, prolonged LOS. Adjusted R^2 was calculated to determine the extent to which the variation in LOS was explained by the model. Standardized beta coefficients (β) and their p-values were calculated to determine which predictor values were statistically significant. Unstandardized beta coefficients (B) were calculated to determine the change in LOS predicted by statistically significant independent variables (Meyers et al., 2013).

Patient acuity collection times. The patient acuity information collection days and times that were used in the multiple regression analysis for each DRG were selected based on three main factors. First, the data collection time was within the first three days of open colorectal surgery. It was logical to select a day shortly after the surgery because the goal of the regression analysis was to determine if patient acuity was a significant predictor of LOS. Second, the time of 1200 was selected because nurses working the day shift would likely have completed documentation of the patient assessment by then. Third, the results of this researcher's pilot study revealed that patient acuity was higher, on average, during the day than at night (Badger, 2016).

DRG 329. For subjects with DRG 329, patient acuity on Day 3 at 1200, DD, age, gender, race, LOS in ICU, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a standard multiple regression analysis to predict prolonged LOS.

The prediction model was statistically significant, $F(14,185)=1.974$, $p<0.05$, indicating that at least one of the independent variables was a significant predictor of prolonged LOS. The adjusted R^2 was 0.062, indicating that 6.2% of the variance in LOS was explained by the model. The remaining 94.8% of variance in LOS was due to factors that were not examined in this study.

The independent variables that were statistically significant predictors of prolonged LOS in this model were patient acuity on Day 3 at 1200 (B = 1.985, $p<0.05$) and DD (B = 1.769, $p<0.05$). Thus, for each one-point increase in patient acuity score on Day 3 at 1200 for subjects with a DRG of 329, an increase in LOS of 1.985 days was predicted, when other predictor variables were held constant. Also, subjects with a DRG of 329 who were DHCS were predicted to have a LOS that was 1.769 days longer than subjects who were discharged to home without home health care, when other predictor variables were held constant.

The unstandardized beta coefficients (*B*) and standard errors (*SE*s), the standardized beta coefficients (β), the *t*-test statistic and the *p* value for each of the variables in the multiple regression analysis for LOS for DRG 329 are displayed in Table 4.10. The independent variables that were statistically significant predictors of prolonged LOS appear in bold.

Table 4.10

Results of multiple regression analysis for predicting prolonged LOS, DRG 329 (*n*=200)

		Unstandardized Coefficients		Standardized Coefficients		
Model 1	Predictor	*B*	*SE*	β	*t*	*p*
	Patient Acuity - Day 3 at 1200	**1.985**	**.880**	**.199**	**2.256**	**.025**
	DD	**1.769**	**.811**	**.168**	**2.180**	**.031**
	Admission Source	1.152	.894	.091	1.288	.199
	Primary Payor	-1.159	.915	-.110	-1.267	.207
	Neoplasm Diagnosis	.856	.853	.082	1.003	.317
	Marital Status	-.664	.704	-.069	-.944	.346
	Gender	-.659	.700	-.068	-.941	.348
	Diverticulitis Diagnosis	.677	.854	.065	.792	.429
	Admission Type	-.464	.799	-.043	-.580	.562
	ASA Score	.361	.657	.043	.549	.584
	LOS in ICU	.039	.131	.024	.298	.766
	Race	-.351	1.194	-.021	-.294	.769
	BMI	.015	.057	.019	.257	.797
	Age	-.006	.032	-.016	-.172	.863
	Intercept	2.517	3.474		.724	.470

Adjusted $R^2 = 0.062$
$F(14,185)=1.974$*

*$p<0.05$

DRG 330. For subjects with DRG 330, patient acuity on Day 2 at 1200, DD, age, gender, race, ICU Stay, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a standard multiple regression analysis to predict LOS.

The prediction model was statistically significant, $F(14, 405) = 8.006$, $p<0.01$, indicating that at least one of the independent variables was a significant predictor of LOS. The adjusted R^2 was 0.190, indicating that 19% of the variance in LOS was explained by the model. The remaining 81% of variance in LOS was due to factors that were not examined in this study.

The independent variables that were statistically significant predictors of prolonged LOS in this model were patient acuity on Day 2 at 1200 ($B = 1.956$, $p<0.01$), admission type ($B = 0.743$, $p<0.01$), and DD ($B = 0.566$, $p<0.05$). Thus, for each one-point increase in patient acuity score on Day 2 at 1200, an increase in LOS of 1.956 days was predicted for subjects with a DRG of 330, when other predictor variables were held constant. Subjects who had an urgent admission type were predicted to have a LOS that was 0.743 days longer than subjects who had a non-urgent admission type, when other predictor variables were held constant. Finally, subjects with a DRG of 330 who were DHCS were predicted to have a LOS that was 0.556 days longer than subjects who were discharged to home without home health care, when other predictor variables were held constant. Finally,

The unstandardized beta coefficients (*B*) and standard errors (*SE*s), the standardized beta coefficients (β), the *t*-test statistic and the *p* value for each of the variables in the multiple regression analysis for LOS for DRG 330 are displayed in Table 4.11. The independent variables that were statistically significant predictors of LOS appear in bold.

Table 4.11

Results of multiple regression analysis for predicting prolonged LOS, DRG 330 (*n*=420)

		Unstandardized Coefficients		Standardized Coefficients		
Model 1	Predictor	*B*	*SE*	β	*t*	*p*
	Patient Acuity - Day 2 at 1200	**1.956**	**.271**	**.338**	**7.219**	**.000**
	Admission Type	**.743**	**.259**	**.138**	**2.873**	**.004**
	DD	**.556**	**.254**	**.108**	**2.183**	**.030**
	Gender	.431	.232	.085	1.856	.064
	Neoplasm Diagnosis	-.490	.280	-.095	-1.750	.081
	ICU Stay	.405	.295	.064	1.372	.171
	Admission Source	-.317	.364	-.039	-.872	.383
	BMI	.013	.018	.035	.744	.458
	Race	-.229	.393	-.027	-.583	.560
	Marital Status	-.134	.232	-.027	-.576	.565
	ASA Score	-.091	.213	-.022	-.426	.670
	Age	.003	.010	.019	.304	.762
	Primary Payor	.034	.299	.007	.113	.910
	Diverticulitis Diagnosis	.005	.301	.001	.018	.986
	Intercept	-.013	1.107		-.012	.990

Adjusted R^2 = 0.190
$F(14, 405) = 8.006^{**}$

$^{**}p<0.01$

DRG 331. For subjects with DRG 331, patient acuity on Day 2 at 1200, DD, age, gender, race, ICU Stay, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a standard multiple regression analysis to predict prolonged LOS.

The prediction model was statistically significant, $F(14, 149) = 3.451$, $p<0.01$, indicating that at least one of the independent variables was a significant predictor of LOS. The adjusted R^2 was 0.174, indicating that 17.4% of the variance in LOS was explained by the model. The remaining 82.6% of variance in LOS was due to factors that were not examined in this study.

The independent variables that were significant predictors of prolonged LOS in this model were patient acuity on Day 2 at 1200 ($B = 0.967$, $p<0.01$) and a primary diagnosis of neoplasm ($B = 0.542$, $p<0.05$). Thus, for each one-point increase in patient acuity score on Day 2 at 1200 for subjects with a DRG of 331, an increase in LOS of 0.967 days was predicted, when other predictor variables were held constant. Also, subjects with a DRG of 331 whose primary diagnosis was neoplasm were predicted to have a LOS that was 0.542 days longer than subjects with a diagnosis of diverticulitis or other disorders of the colon or rectum, when other independent variables were held constant.

The unstandardized beta coefficients (*B*) and standard errors (*SE*s), the standardized beta coefficients (β), the *t*-test statistic and the *p* value for each of the variables in the multiple regression analysis for LOS for DRG 331 are displayed in Table 4.12. The independent variables that were statistically significant predictors of LOS appear in bold.

Table 4.12

Results of multiple regression analysis for predicting prolonged LOS, DRG 331 (*n*=164)

		Unstandardized Coefficients		Standardized Coefficients		
Model 1	Predictor	*B*	*SE*	β	*t*	*p*
	Patient Acuity - Day 2 at 1200	**.967**	**.267**	**.298**	**3.620**	**.000**
	Neoplasm Diagnosis	**.542**	**.254**	**.192**	**2.137**	**.034**
	Admission Type	.621	.318	.151	1.951	.053
	ICU Stay	.595	.372	.119	1.601	.111
	ASA Score	.302	.190	.127	1.588	.114
	Marital Status	-.292	.215	-.102	-1.360	.176
	Diverticulitis Diagnosis	.278	.283	.085	.984	.327
	Age	.008	.009	.073	.859	.392
	Race	.321	.383	.062	.838	.403
	DD	.244	.310	.063	.788	.432
	Admission Source	-.250	.500	-.038	-.500	.618
	BMI	-.008	.020	-.031	-.421	.674
	Primary Payor	.083	.250	.029	.333	.740
	Gender	-.058	.217	-.021	-.266	.790
	Intercept	.316	1.063		.297	.767

Adjusted R^2 = 0.174
$F(14, 149) = 3.451$**

**p<0.01

Summary of statistical analysis of Question 3. High patient acuity within the first few days after open colorectal surgery was a statistically significant predictor of prolonged LOS for subjects in each DRG. For subjects with a DRG of 329, high patient acuity on Day 3 at 1200 and DHCS were significant predictors of prolonged LOS in a multiple regression model that explained 6.2% of the variance in LOS after open colorectal surgery. For subjects with a DRG of 330, high patient acuity on Day 2 at 1200, urgent admission type, and DHCS were significant predictors of prolonged LOS in a model that explained 19.0% of the variance in LOS. And for subjects with a DRG of 331, high patient acuity on Day 2 at 1200 and a primary diagnosis of neoplasm were significant predictors of prolonged LOS in a multiple regression model that explained 17.4% of the variance in LOS. Analytical models for predicting prolonged LOS and DHCS for each DRG appear in appendices M, N, and O.

Research Question 4

Which combination of patient acuity and select patient trait characteristics predict DD for open colorectal surgery patients with a DRG of 329, 330, or 331?

Logistic regression. Logistic regression analyses were conducted to determine which patient trait characteristics, along with patient acuity, predicted the value of the dichotomous nominal-level dependent variable of DD for subjects in each DRG. The DD values were "Discharge to home without home healthcare services" and "Discharge to home care or other healthcare setting (DHCS)." A standard binary logistic regression analysis was used to model the dichotomous variable of DD, and DHCS was used as the reference category, i.e., its coded value was 0, while DHCS was coded 1 (Meyers et al., 2013). The assumptions for logistic regression analysis, as outlined in Chapter 3, were met.

The chi-square (χ^2) statistic was calculated to determine if the logistic regression model significantly predicted the dependent variable, DD, based on a classification threshold predicted probability of target group membership of 0.5. Nagelkerke pseudo R^2 was calculated to determine the extent to which the variation in DD was explained by the model. Partial regression coefficients (B), in log-odds units, were calculated to determine the extent to which each independent variable predicted DD. The Wald χ^2 value, degrees of freedom (*df*), and 2-tailed *p*-value were calculated to determine if the partial regression coefficients (B) were statistically significantly different from 0. The odds ratios [Exp(β)] and the 95% confidence interval (CI) were calculated to determine the likelihood of the DD based on one-unit increments in the predictor variables (Meyers et al., 2013).

Patient acuity collection times. For consistency and ease of comparison, the patient acuity information collection days and times that were included in the logistic regression analysis for each DRG were the same as those used in the multiple regression analyses to answer Question 3.

Goodness-of-fit. The goodness-of-fit of the logistic regression model and the data for predicting DD was evaluated in two ways. First, the classification success for the cases based on a classification cutoff value of 0.500 for predicting DD was determined. An overall success rate for DD was calculated, as well as success rates for each of the DD values, i.e., discharge to home without home healthcare and discharge to home care or other healthcare setting (DHCS). Second, the Hosmer and Lemeshow's goodness of fit test was conducted. This statistic tests the hypothesis that the observed data are statistically significantly different for the predicted value of the model. Thus, the desired result is a non-significant value, which indicates that the model fits the data (Meyers et al., 2013).

DRG 329. For subjects with DRG 329, patient acuity on Day 3 at 1200, LOS, age, gender, race, LOS in ICU, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a logistic regression analysis to predict DD.

Predicting DD. Based on a classification threshold predicted probability of target group membership as 0.5, results of the logistic analysis indicated that the model provided a statistically significant prediction of DD, χ^2 (14, 200) = 49.966, p<0.01. The Nagelkerke pseudo R^2 was 0.313, indicating that the model accounted for approximately 30% of the total variance in

DD. The remaining 70% of variance in DD was due to factors that were not examined in this study.

The results of the Wald tests indicated that patient acuity on Day 3 at 1200, LOS, and age were statistically significant predictors of DD for subjects with a DRG of 329. For each single point increase in patient acuity on Day 3 at 1200, subjects had a 3.655 times greater likelihood of DHCS (Odds ratio [OR] = 3.655; 95% CI [1.392, 9.595]), when other predictor variables were held constant. For each one-day increase in LOS, subjects had a 9.2% increase in the likelihood of DHCS (OR = 1.092; 95% CI [1.003, 1.190]), when other predictor variables were held constant. And for each one-year increase in age, subjects had a 3.4% increase in the likelihood of DHCS (OR = 1.034; 95% CI [1.001, 1.068]), when other predictor variables were held constant.

Goodness-of-fit. Classification success for the cases based on a classification cutoff value of 0.50 for predicting DD was moderately high, with an overall prediction success rate of 76.5% and correct prediction rates of 89.3% for DHCS and 46.7% for subjects discharged to home without home healthcare services. The Hosmer and Lemeshow goodness-of-fit test was not statistically significant, χ^2 (8, N=200) = 9.670, p=0.289, indicating that the model fit the data.

The partial regression coefficients [*B* with standard error (*SE)*], the Wald Test, *df*, odds ratio [Exp(β)], and the 95% CI for odds ratios for each predictor variable are presented in Table 4.13. The independent variables that were statistically significant predictors of DHCS appear in bold.

Table 4.13

Results of logistic regression analysis for predicting discharge to home care or other healthcare setting (DHCS), DRG 329 (*n*=200)

								95% CI for Exp(β)	
Step 1	Predictor	*B*	*SE*	Wald	*df*	*p*	Exp(β)	Lower	Upper
	Patient Acuity - Day 3 at 1200	**1.296**	**0.492**	**6.926**	**1**	**.008**	**3.655**	**1.392**	**9.595**
	LOS	**0.088**	**0.044**	**4.079**	**1**	**.043**	**1.092**	**1.003**	**1.190**
	Age	**0.033**	**0.017**	**3.962**	**1**	**.047**	**1.034**	**1.001**	**1.068**
	Race	1.008	0.595	2.868	1	.090	2.739	0.853	8.789
	Primary Payor	0.534	0.447	1.421	1	.233	1.705	0.710	4.097
	Admission Type	0.387	0.404	0.915	1	.339	1.472	0.667	3.250
	Diverticulitis Diagnosis	-0.274	0.447	0.376	1	.540	0.760	0.317	1.825
	Gender	-0.203	0.372	0.298	1	.585	0.816	0.394	1.692
	Marital Status	-0.198	0.383	0.267	1	.605	0.821	0.387	1.738
	Neoplasm Diagnosis	-0.716	0.478	0.136	1	.712	0.839	0.329	2.139
	BMI	-0.006	0.030	0.037	1	.848	0.994	0.937	1.055
	Admission Source	0.052	0.490	0.011	1	.916	1.053	0.403	2.749
	LOS in ICU	0.007	0.081	0.008	1	.927	1.007	0.859	1.182
	ASA Score	-0.020	0.359	0.003	1	.955	0.980	0.485	1.979
	Intercept	-8.255	0.939	77.294	1	.000	.000		

Nagelkerke pseudo $R^2 = 0.313$
χ^2 (14, 200) = 49.966**

**p<0.01

DRG 330. For subjects with DRG 330, patient acuity on Day 2 at 1200, LOS, age, gender, race, ICU Stay, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a logistic regression analysis to predict DD.

Predicting DD. Based on a classification threshold predicted probability of target group membership as 0.5, results of the logistic analysis indicated that the model provided a statistically significant prediction of DD, χ^2 (14, 420) = 107.498, p<0.01. The Nagelkerke pseudo

R^2 was 0.306, indicating that the model accounted for approximately 30% of the total variance in DD. The remaining 70% of variance in DD was due to factors that were not examined in this study.

The results of the Wald tests indicated that patient acuity on Day 2 at 1200, race, admission type, age, ASA Score, and LOS were statistically significant predictors of DD for subjects with a DRG of 330. For each single point increase in patient acuity on Day 2 at 1200, there was a 2.859 times greater likelihood of DHCS (OR = 2.859; 95% CI [1.584, 5.160]), when other predictor variables were held constant. Subjects with a race of White had a 5.355 times greater likelihood of DHCS than non-White subjects (OR = 5.355; 95% CI [1.951, 14.696]), when other predictor variables were held constant. Subjects with an urgent admission type had a 2.160 times greater likelihood of DHCS than subjects with a non-urgent admission type (OR = 2.160; 95% CI [1.301, 3.589]), when other predictor variables were held constant. For each one-year increase in age, there was a 2.7% increase in the likelihood of DHCS (OR = 1.027; 95% CI [1.005, 1.050]), when other predictor variables were held constant. For each one-level increase in ASA Score, there was a 1.707 times greater likelihood of DHCS (OR = 1.707; 95% CI [1.101, 2.647]), when other predictor variables were held constant. And for each one-day increase in LOS, there was a 1.117 times greater likelihood of DHCS (OR = 1.117; 95% CI [1.011, 1.235]), when other predictor variables were held constant.

Goodness-of-fit. Classification success for the cases based on a classification cutoff value of 0.50 for predicting DD was moderately high, with an overall prediction success rate of 70.2% and correct prediction rates of 52.1% for DHCS and 82.0% for subjects discharged to home without home healthcare services. The Hosmer and Lemeshow goodness-of-fit test was not statistically significant, χ^2 (8, N=420) = 5.584, p=0.694, indicating that the model fit the data.

The partial regression coefficients [*B* with standard error (*SE*)], the Wald Test, *df*, odds ratio [Exp(β)], and the 95% CI for odds ratios for each predictor variable are presented in Table 4.14. The independent variables that were statistically significant predictors of DHCS appear in bold.

Table 4.14

Results of logistic regression analysis for predicting discharge to home care or other healthcare setting (DHCS), DRG 330 (*n*=420)

								95% CI for Exp(β)	
Step 1	Predictor	*B*	*SE*	Wald	*df*	*p*	Exp(β)	Lower	Upper
	Patient Acuity - Day 2 at 1200	**1.050**	**0.301**	**12.147**	**1**	**.000**	**2.859**	**1.584**	**5.160**
	Race	**1.678**	**0.515**	**10.615**	**1**	**.001**	**5.355**	**1.951**	**14.696**
	Admission Type	**0.770**	**0.259**	**8.852**	**1**	**.003**	**2.160**	**1.301**	**3.589**
	Age	**0.027**	**0.011**	**5.962**	**1**	**.015**	**1.027**	**1.005**	**1.050**
	ASA Score	**0.535**	**0.224**	**5.712**	**1**	**.017**	**1.707**	**1.101**	**2.647**
	LOS	**0.111**	**0.051**	**4.715**	**1**	**.030**	**1.117**	**1.011**	**1.235**
	Gender	-.0394	0.242	2.636	1	.104	0.675	0.419	1.085
	Admission Source	0.491	0.372	1.744	1	.187	1.634	0.788	3.388
	Neoplasm Diagnosis	-0.309	0.290	1.135	1	.287	0.734	0.416	1.296
	Marital Status	-0.208	0.240	0.754	1	.385	0.812	0.508	1.299
	ICU Stay	-0.256	0.300	0.728	1	.394	0.774	0.430	1.394
	Diverticulitis Diagnosis	-0.209	0.310	0.455	1	.500	0.811	0.442	1.490
	BMI	-0.010	0.019	0.297	1	.586	0.990	0.954	1.027
	Primary Payor	0.094	0.315	0.090	1	.764	1.099	0.593	2.036
	Intercept	-7.129	1.224	33.929	1	.000	.001		

Nagelkerke pseudo $R^2 = 0.306$
χ^2 (14, 420) = 107.498**
**p < 0.01

DRG 331. For subjects with DRG 330, patient acuity on Day 2 at 1200, LOS, age, gender, race, ICU Stay, ASA score, BMI, marital status, admission type, admission source, primary payor, and primary diagnosis were included in a logistic regression analysis to predict DD.

Predicting DD. Based on a classification threshold predicted probability of target group membership as 0.5, results of the logistic analysis indicated that the model provided a statistically significant prediction of DD, χ^2 (14, 164) = 35.310, p<0.01. The Nagelkerke pseudo R^2 was 0.337, indicating that the model accounted for approximately 33% of the total variance in DD. The remaining 67% of variance in DD was due to factors that were not examined in this study.

The results of the Wald tests indicated that patient acuity on Day 2 at 1200 and a primary diagnosis of diverticulitis were statistically significant predictors of DD for subjects with a DRG of 331. For each single point increase in patient acuity on Day 2 at 1200, there was an 8.621 times greater likelihood of DHCS (OR = 8.621; 95% CI [2.037, 36.480]), when other predictor variables were held constant. Subjects with primary diagnosis of diverticulitis were 9.6% *less* likely to be DHCS (OR = 0.096; 95% CI [0.011, 0.826]) than subjects with a primary diagnosis of neoplasm or other disorders of the colon or rectum, when other predictor variables were held constant.

Goodness-of-fit. Classification success for the cases based on a classification cutoff value of 0.500 for predicting DHCS was moderately high, with an overall prediction success rate of 87.2% and correct prediction rates of 28.0% for DHCS and 97.8% for subjects discharged to home without home healthcare services. The Hosmer and Lemeshow goodness-of-fit test was not statistically significant, χ^2 (8, 164) = 12.141, p=0.145, indicating that the model fit the data.

The partial regression coefficients [*B* with standard error (*SE*)], the Wald Test, *df*, odds ratio [Exp(β)], and the 95% CI for odds ratios for each predictor variable are presented in Table 4.15. The independent variables that were statistically significant predictors of DHCS appear in bold.

Table 4.15

Results of logistic regression analysis for predicting discharge to home care or other healthcare setting (DHCS), DRG 331 (*n*=164)

								95% CI for Exp(β)	
Step 1	Predictor	*B*	*SE*	Wald	*df*	*p*	Exp(β)	Lower	Upper
	Patient Acuity - Day 2 at 1200	**2.154**	**0.736**	**8.566**	**1**	**.003**	**8.621**	**2.037**	**36.480**
	Diverticulitis Diagnosis	**-2.348**	**1.101**	**4.551**	**1**	**.033**	**0.096**	**0.011**	**0.826**
	Primary Payor	0.850	0.611	1.934	1	.164	2.340	0.706	7.756
	BMI	-0.065	0.052	1.575	1	.209	0.937	0.847	1.037
	Admission Source	-1.573	1.354	1.351	1	.245	0.207	0.015	2.944
	Race	-0.941	0.826	1.298	1	.255	0.390	0.077	1.970
	Admission Type	0.868	0.790	1.207	1	.272	2.383	0.506	11.215
	Gender	-0.605	0.559	1.171	1	.279	.0546	0.183	1.634
	LOS	0.176	0.184	0.917	1	.338	1.192	.0832	1.710
	Neoplasm Diagnosis	-0.369	0.574	0.414	1	.520	0.691	0.224	2.192
	Age	-0.009	0.022	0.173	1	.677	0.991	0.949	1.034
	ASA Score	0.107	0.482	0.049	1	.825	1.113	0.432	2.864
	ICU Stay	0.137	0.960	0.202	1	.886	1.147	0.175	7.522
	Marital Status	0.050	0.554	0.008	1	.928	1.051	0.355	3.117
	Intercept	-6.471	2.551	6.434	1	.011	.002		

Nagelkerke pseudo $R^2 = 0.337$
χ^2 (14, 164) = 35.310**

**p < 0.01

Summary of statistical analysis for Question 4. High patient acuity within the first two or three days after open colorectal surgery was a statistically significant predictor of DHCS for subjects in each DRG. For subjects with a DRG of 329, high patient acuity on Day 3 at 1200, prolonged LOS, and advanced age were significant predictors of DHCS in a binary logistic regression model that explained 31.3% of the variance in DD after open colorectal surgery. For subjects with a DRG of 330, high patient acuity on Day 2 at 1200, White race, urgent admission type, age, high ASA Score, and prolonged LOS were significant predictors of DHCS in a model that explained 30.6% of the variance in DD. And for subjects with a DRG of 331, high patient acuity on Day 2 at 1200 and a primary diagnosis of diverticulitis were significant predictors of DHCS in a model that explained 33.7% of the variation in LOS. Of note, subjects with a DRG of 331 and a primary diagnosis of diverticulitis were statistically significantly *less* likely to be DHCS than subjects with the same DRG whose primary diagnosis was neoplasm or other disorders of the colon or rectum. Analytical models for predicting prolonged LOS and DHCS after open colorectal surgery appear in appendices M, N, and O.

Summary of Major Findings

The data and information that were collected for this study were of high quality according to Weiskopf and Weng's (2013) data quality assessment framework. There were statistically significant differences ($p<0.05$) between the three DRGs with respect to patient acuity, LOS, DD, age, LOS in the ICU, marital status, BMI, ASA score, primary diagnosis, admission type, admission source, primary payor. Data visualization revealed that there was variability in the main independent variable of patient acuity after open colorectal surgery. Statistically significant relationships were found among the three main study variables of patient acuity, LOS, and DD. High patient acuity scores on Day 2 or 3 after open colorectal surgery was the strongest predictor of prolonged LOS and DHCS for patients in each DRG. However, the analytical models for predicting prolonged LOS for the three DRGs, while statistically significant, accounted for a small amount of the variability (6.2% - 19.0%) in this patient outcome. The analytical models for predicting DHCS for the three DRGs accounted for nearly one-third (30.6% - 33.7%) of the variability in DD.

CHAPTER 5 - DISCUSSION OF STUDY FINDINGS

This chapter begins with a discussion of the consistency of the study findings with the literature regarding factors that predict prolonged length of stay (LOS) and discharge to home care or other healthcare settings (DHCS) for open colorectal surgery patients. The implications of the study findings for the nursing profession and healthcare policy are then discussed. Finally, recommendations for further nursing research based on the study findings are suggested.

Consistency of Study Findings with Literature

Length of Stay (LOS)

This study confirmed the finding by Kelly et al. (2012), Ngui et al. (2010), and Reddy et al. (2003) that DHCS was a significant predictor of LOS after open colorectal surgery. This study did not support the findings by other researchers that age (Kelly et al.; Ngui et al.), ASA Score (Ahmed et al., 2010; Campos Lobato et al., 2013; Ngui et al.; Schmelzer et al., 2008), gender (Campos Lobato et al.), marital status (Kelly et al., Ngui et al.), and BMI (Tapper et al., 2013; Wick et al., 2011) were significant predictors of LOS.

This study added to the nursing knowledge base by identifying other patient state and trait characteristics that were predictors of prolonged LOS for open colorectal surgery patients. These predictors included high patient acuity, urgent admission type, and a primary diagnosis of neoplasm. Further research is recommended to explore these patient state and trait characteristics as predictors of prolonged LOS for the open colorectal surgery patient population.

Discharge Disposition (DD)

The literature concerning predictors of DHCS consisted of studies about patients who had undergone total joint arthroplasty (TJA) surgery. The findings of this study concurred with Sharareh et al.'s (2014) study of TJA patients that LOS was a significant predictor of DHCS. The findings also matched studies of TJA patients that reported that advanced age (Bozic et al., 2006; Halawi et al., 2015; Vochteloo et al., 2012) and high ASA Score (Bozic et al.; Sharareh et al.) were significant predictors of DHCS. However, the results of this study, unlike the studies regarding TJA patients, did not indicate that gender (Barsoum et al., 2010; Bozic et al.; Halawi et al.; Vochteloo et al.), marital status (Titler et al., 2006; Vochteloo et al.), or BMI (Halawi et al.; Titler et al.) were significant predictors of DHCS.

This study added to the nursing knowledge base by identifying other patient state and trait characteristics that were predictors of DHCS for open colorectal surgery patients. These predictors included high patient acuity, White race, urgent admission type, and high ASA Score. A primary diagnosis of diverticulitis, as opposed to neoplasm or other disorder of the colon or rectum, was found to be a protective of DHCS. Further research is recommended to explore these patient state and trait characteristics as predictors of DHCS for the open colorectal surgery patient population.

Nursing Implications of Study Findings

Polit and Beck (2012) suggested that the significance of nursing research should be evaluated based on its contribution to nursing practice and to the discipline of nursing's body of knowledge, i.e., nursing science. In this section, select major findings of this study are reviewed with respect to their implication for nursing science, nursing informatics, nursing education, nursing practice, and healthcare policy.

Nursing Science

It was useful to apply a data quality assessment when reusing clinical data and information from electronic sources based on the electronic health record (EHR). Nurse researchers should include in their study design a plan to assess the quality of reused data and information from clinical and administrative healthcare sources, such as the EHR. Applying a data quality assessment framework to the reuse of clinical data that were not originally collected for the purpose of research can increase the rigor of nursing studies (Johnson, Speedie, Simon, Kumar, & Westra, 2016).

The study findings also implied that the adapted version of Radwin and Fawcett's (2002) R-QHOM conceptual framework, which was created for this study, was useful in guiding the examination of the relationships among patient acuity, LOS, and DD in open colorectal surgery patients. Independent variables were labeled as either patient state characteristics or patient trait characteristics, allowing this researcher to focus on patient acuity, the only patient state characteristic in this study. The conceptual framework also served as a reminder that patient acuity was likely to change during the course of a patient's hospital stay as a result of, among other factors, nursing interventions (Radwin & Fawcett, 2002). This conceptual framework could be appropriate for further nursing studies that examine the relationships among patient state and trait characteristics, nursing interventions, and patient outcomes.

Nursing Informatics

According to the American Nurses Association (ANA) (2015), nursing informatics is the nursing specialty that "integrates nursing science with multiple information management and analytical sciences to identify, define, manage, and communicate data, information, knowledge, and wisdom in nursing practice" (p. 1). Informatics nurses recognize that electronic healthcare systems are a "veritable gold mine" of clinical data and information (Gall, Grossman, Duftschmid, Wrba, & Dorda, 2008, p. 430). At the healthcare system where this study took place, nursing assessment documentation, medication infusion administration, and laboratory values in the patient's EHR supplied *data*, which were mapped to a patient acuity software program, Clairvia®, to provide *information* about 15 patient acuity items. Clairvia® was designed as a decision support tool for inpatient nurse managers (Clairvia®, n.d.). The software program reused select clinical data and discrete nursing assessment documentation data fields in the patient's EHR to generate information about patient acuity. Nurse managers used this information to make evidence-based unit staffing decisions (Birmingham, 2010).

The patient acuity scores generated by Clairvia® were reused in this study to examine the relationships among patient acuity, LOS, and DD. Informatics nurses recognize that the caveat for the reuse of clinical data and information from electronic sources for purposes other than which they were originally intended is that they need to be reliable and valid (Johnson et al., 2016).

Three groups of experts must work together to ensure that data in electronic healthcare systems is of high quality. First, information technology (IT) staff design appropriate patient assessment data fields in the EHR so that staff nurses are able to document comprehensive patient assessments. Second, staff nurses need to document patient assessments in the EHR in a timely, complete, and accurate manner. Finally, informatics nurses facilitate communication between IT and staff nurses to ensure that they each have the information necessary to maximize data reliability and validity (Hunter, McGonigle, & Hebda, 2011).

At the healthcare system where this study took place, a team of informatics nurses, staff nurses, and IT staff worked together for almost a year to map data fields in nursing assessment documentation in the EHR to the 15 patient acuity items in Clairvia®. All potential users of a new electronic software tool should be involved in its development, implementation, and ongoing evaluation. Informatics nurses should be encouraged to share their strategies at conferences or through publication.

Nursing Education

As noted above, reusing clinical data and information in electronic sources for a purpose other than which it was originally collected requires that the data and information are reliable and valid (Johnson et al., 2016). Thus, nurses who enter patient assessment data and information into the EHR need to know (a) how to document in the EHR in a timely, complete, and accurate manner, and (b) why doing so is of value to the discipline of nursing (Technology Informatics Guiding Education Reform [T.I.G.E.R.], 2007).

In this study, nursing documentation data in the EHR were reused to examine the relationships among patient acuity, LOS, and DD. The importance of why and how to document in the EHR in a timely, complete, and accurate manner should be stressed to assure reliable and valid communication of data during a patient's hospital stay and reuse of data for ongoing research. This type of research supports the inclusion of nursing informatics into nursing education curricula at all education levels. These include baccalaureate-, masters-, and doctoral-level nursing education. Nurse faculty, therefore, need to be proficient at nursing documentation in the EHR (Choi & De Martinis, 2013). The results of this study also suggest that EHR documentation competency should be included in new employee orientation and in continuing education for all nurses.

Nursing Practice

The results of this study had implications for at least three inpatient nurse roles. These were the hospital staff nurses, nurse managers, and nurse administrators.

Hospital staff nurses. Staff nurses who care for open colorectal surgery patients at the healthcare system where this study took place are expected to document select patient assessment data in the EHR at least three times each day: in the morning, in the afternoon, and at bedtime . They are also expected to create and maintain nursing care plans in the EHR for their patients (R. McIntosh, personal communication, October 22, 2015). Nursing care plans include nursing diagnoses, nursing interventions, and expected patient outcomes (Gulanick & Myers, 2013).

The results of this study indicated that high patient acuity on day two or three after open colorectal surgery, depending on the patient's diagnostic-related group (DRG), was a statistically significant predictor of prolonged LOS and DHSA. The results also indicated a pattern of patient acuity whereby patient acuity was highest for two or three days after surgery, plateaued on day four or five, and fell steadily until the patient was discharged. Based on these results, it could be worthwhile to expand upon the current functionality of the patient acuity system to include clinical decision support for staff nurses. For example, an algorithm based on the findings in this study could drive the identification of patients whose acuity remains higher than expected on day 2 or 3 after surgery. Based on this algorithm, an alert could trigger in the EHR. The staff nurse could respond to the alert by reviewing the patient's acuity history after surgery and examining other patient trait characteristics that this study found were predictors of prolonged LOS or DHCS. This clinical decision support functionality could provide the staff nurse with the functionality could provide staff nurses with a rationale for implementing interventions to reduce patient acuity and to begin discharge planning early in the patient's hospital stay after open colorectal surgery.

The staff nurses at the healthcare system where this study took place do not currently have access to their patients' acuity scores in Clairvia®. Providing staff nurses with access to patient acuity scores in Clairvia® to use for clinical decision support could reinforce their understanding of the value of accurate, complete, and timely nursing assessment documentation in the EHR.

Inpatient unit nurse managers. Patient acuity information in Clairvia® is currently used by nurse managers to guide inpatient unit staffing decisions. Results of a pilot study indicated that there was a significant relationship between patient acuity and nurse staffing levels when examined in the aggregate, i.e., at the unit level (Badger, 2016). This study further examined the relationship between patient acuity, LOS, and DD for open colorectal surgery patients on an individual patient level. An implication of the results of this study for nurse unit managers is that individual patient acuity could be used to guide a patient-centered approach to nurse staffing. Thus, patient assignments for staff nurses would be based on acuity data and information rather than on, for example, predetermined nurse-to-patient ratios (Welton, 2007). In addition, rather than simply adding an extra nurse to a unit based on its aggregate patient acuity, extra nursing hours could be added for specific patients based on their acuity scores.

Nurse administrators. Nurse administrators need to be familiar with and act upon the ANA (2008) and the American Organization of Nurse Executives (AONE) (2009) that patient acuity should be evidence-based and measured in real time based on nursing documentation in the HER. Nurse administrators are ultimately responsible for ensuring that patients receive the highest quality nursing care and that healthcare costs are contained. Findings from this study support the need for evidence-based clinical decision-making at the staff nurse level. Nurse administrators should advocate for the implementation of EHRs and clinical software systems that can assist nurses with clinical decision-making.

Healthcare Policy

In this section, the healthcare policies that were supported by the results of this study are reviewed. This is followed by a discussion of the results of the study with respect to their implications for healthcare quality, cost, and access.

Policies supported by study results. The results of the study supported current healthcare policies related to patient acuity (ANA, 2008; AONE, 2009) and EHR Meaningful Use (HealthIT.gov, 2015). The ANA and ANOE proposed that patient acuity should be evidence-based and measured in real time based on nursing documentation in the EHR. The study results also suggested that patient acuity information could be reused to predict patient outcomes, including prolonged LOS and DHCS after open colorectal surgery.

The results of the study also have the potential to contribute to the healthcare system's achievement of EHR Meaningful Use Stage III. One requirement of Stage III is that data and information in the EHR should be analyzed in an effort to improve clinical outcomes (HealthIT.gov, 2015). Understanding the relationships among patient acuity, LOS, and DD could prompt nursing interventions aimed at improving clinical outcomes in the open colorectal surgery patient population.

Study implications regarding healthcare cost, quality, and access. A common way to evaluate the success of healthcare policies is to examine whether they result in decreased healthcare cost, improved quality of care, and increased patient access to care (US Department of Health and Human Services, 2015). This study did not specifically examine healthcare cost, quality of care, or access for patients with open colorectal surgery. Moreover, the study data would be too limited for the results to have meaningful, generalizable implications regarding these three factors. Nonetheless, they were considered when studying the reuse of data and information in the healthcare system data warehouse and in Clairvia® to examine relationships among patient acuity, LOS and DD.

Cost. The DRG-driven Acute Inpatient Prospective Payment System (IPPS) is in use at the healthcare system where this study took place (D. Kastenholz, personal communication, May 23, 2016). Under this system, hospital administrators negotiate with Medicare, Medicaid, and private insurance companies on an annual basis to arrive at an agreement regarding predetermined payment rates based on DRG, regardless of the length of the patient's acute care hospital stay (Hamavid et al., 2016).

One study finding that could have implications regarding healthcare cost was that the mean LOS for open colorectal surgery patients in each DRG group in this study was shorter than the national average LOS for patients with same DRGs (Covidien, 2015). The mean LOS for subjects in this study with a DRG of 329 was 9.94 days (*SD* = 4.87 days); 6.29 days (*SD* = 2.53 days) days for subjects with a DRG of 330 and 4.46 days (*SD* = 1.42 days) for subjects with a DRG of 331. The national average LOS for patients with a DRG of 329 is 14.4 days, 8.4 days for patients with a DRG of 330, and 4.8 days for DRG 331 (Covidien, 2015) (see Table 4.6). However, concluding that the healthcare system experienced cost savings under IPPS for open colorectal surgery patients during the study period was beyond the scope of this study. Sixty percent (*n* = 1217) patients were removed from original dataset of 2006 patients due to exclusion criteria, outliers, and missing data. Thus, the LOS for these 1217 subjects was not included in the data analysis. Further research could examine the cost implications for this group of subjects.

Another study finding that could have implications regarding healthcare cost was that more than half (58.2%) of the patients with a DRG of 331 in this study to stayed in the hospital longer than the national average LOS for patients with the same DRG (Covidien, 2015). In contrast, only 17.8% of patients in this study with a DRG of 329 and 17.5% of patients with a DRG of 330 stayed in the hospital longer than the national average LOS. The national average reimbursement (Covidien, 2015) for the three DRGs in this study, as well as the state of Wisconsin average reimbursement and the healthcare system average reimbursement (Centers for Medicare and Medicaid Services [CMS], 2016b) appear in Table 5.1. The healthcare system received lower average reimbursement than the national and state average for patients with DRGs of 329 and 330, but it received a higher average reimbursement than the national and state average for patients with a DRG of 331. Again, further research is needed to examine the cost for this healthcare system regarding the open colorectal surgery patients in the study.

Table 5.1

National average reimbursement (Covidien, 2015), state average reimbursement (CMS 2016c), and healthcare system average reimbursement (CMS, 2016b) for DRGs 329, 330, and 331 (FY 2014)

Discharge DRG Code	National Average Reimbursement	State Average Reimbursement	Healthcare System Average Reimbursement
329	$29,819.83	$32,313.29	$29,475.88
330	$14,970.41	$14,565.21	$13,500.69
331	$9,737.14	$9,806.79	$10,122.06

Quality. Just as this study did not specifically examine healthcare cost implications, nor did it examine implications of the results on the quality of health care for open colorectal surgery patients. The length of time a patient stays in an acute care hospital can have both positive and negative effects on patients' health and the quality of healthcare they receive (Bartel et al., 2014; Phillips et al., 2004; Zimlichman et al., 2013). Similarly, DD can have either positive or negative effects on patients' health and the quality of healthcare they receive. Ideally, patients would stay in the hospital long enough to avoid postoperative complications, and would be discharged to home without healthcare services. Further research is needed to examine healthcare quality outcomes for open colorectal surgery patients, as well as patient perceptions of the quality of care they receive.

***Access*.** This study did not specifically address access to care. However, there were potential implication of the study based on the findings that the mean LOS for open colorectal surgery patients in each DRG in this study was shorter than the national average LOS for patients with same DRGs (Covidien, 2015). For example, a shorter LOS increases access to hospital services for other patients. Patient could be less likely to be held in emergency departments, in long-term care, or are admitted to inappropriate facilities or hospital units (Brasel et al., 2007). Further research is needed to examine objective predictors of healthcare access, as well as patient perceptions of their access to healthcare services.

Recommendations for Future Research

In this section, recommendations for future research are presented. First, future studies that could be conducted by reusing the data and information collected for this study are discussed. Second, future research related to this study that would use different data sets is suggested.

Reusing Data Collected for this Study

The data and information that were collected for this study were determined to be reliable and valid and could be used for further research. There are a number of studies that could be conducted as a follow up to this study that explored the relationship among patient acuity, LOS, and DD for open colorectal surgery patients.

Statistical analysis methods. The analytical models that were generated to examine predictors of prolonged LOS using multiple regression were statistically significant. However, they accounted for a small amount of the variability in this patient outcomes, i.e., 6.2% to 19.0%, depending on the DRG. Possible explanations for this study finding include (a) that factors that were not examined in the study accounted for most of the variance in prolonged LOS, and (b) that the statistical analysis method used to examine predictors of prolonged LOS was not very sensitive. Further research using different statistical analysis methods is recommended. For example, survival analysis could be used to examine factors that predict the length of time between open colorectal surgery and hospital discharge (Meyers et al., 2013).

Readmission within 30 days. The independent variable of readmission within 30 days of discharge could be included in the regression analyses to further examine predictors of the patient outcomes of prolonged LOS and DHCS for patients after open colorectal surgery. These studies could be justified because of the consequences of hospital readmission on both healthcare quality and cost.

Outliers. Subjects that were excluded from this study due to having outlier values for LOS or intensive care unit (ICU) LOS could be studied to examine patient state and trait characteristics that might have influenced their extended LOS after open colorectal surgery. Examining outliers could reveal different factors that are associated with these subjects' LOS.

Individual hospitals. A study could be conducted at each of the 10 hospitals in the healthcare system where open colorectal surgery was performed. These separate studies by setting would result in more tailored results regarding predictors of prolonged LOS and DHCS after open colorectal surgery for each hospital.

Individual patient acuity items. The relationships among individual acuity item scores, rather than the total patient acuity score, and prolonged LOS and DHCS could be examined. A study could focus on the individual acuity items that were only mapped to nursing assessment documentation in the patient's EHR, and not to medication infusion administration or laboratory results. The individual acuity items of Coping, Fall Prevention Behavior, Knowledge: Treatment Regimen, Self-Care: Activities of Daily Living (ADL), and Tissue Integrity: Skin and Mucous Membrane (Clairvia®, n.d.) could studied because they appear to be the most nurse-sensitive, i.e., likely to be impacted by nursing interventions (Doran, Sidani, & DiPietro, 2010). Understanding the individual acuity items that are related to prolonged LOS and DHCS for open colorectal surgery patients support nursing care planning to increase healthcare quality and decrease costs.

Research Using Different Data Sets

There is value in repeating a study to determine if the results are reproducible (Polit & Beck, 2012). For example, this study could be repeated using a different time frame during which open colorectal surgery patients with a DRG of 329, 330, or 331 were admitted and discharged from hospitals in the healthcare system. This study could also be repeated for open colorectal surgery patients at a different healthcare organization that uses Clairvia® patient acuity software or a different patient acuity system.

It could be worthwhile to conduct similar studies at the same healthcare system but with different patient populations. For example, relationships among patient state and trait characteristics and the patient outcomes of prolonged LOS and DHCS could be examined for patients who were admitted to the hospital for heart disease, kidney disease, diabetes, or dementia.

Follow-up Studies

Studies could be designed to follow up recommendations based on the study findings. For example, a study could be conducted to determine if implementing a patient acuity alert system in the EHR results in a change to patterns of patient acuity and the outcomes of LOS and DD for open colorectal surgery patients. Another study could be conducted to determine if nursing education results in a change in the timeliness, completeness, and accuracy of nursing documentation. A qualitative study could be designed to examine if staff nurses' access to patient acuity scores makes a difference regarding their perception of the value nursing documentation in the EHR.

Conclusion

The value of using LOS as a predictor variable for DHCS, and conversely the use of DD as a predictor of prolonged LOS, is limited because information about LOS and DHCS are not available until after discharge. Nonetheless, knowledge about the relationships among patient acuity, LOS, and DD is important to guide nursing practice. Early intervention to assess discharge needs and begin discharge planning have been highlighted as important aspects of hospital nursing care (Holland, Knafl, & Bowles, 2013; Zhu, Liu, Hu, & Wang, 2015).

Further research is recommended to continue to explore predictors of prolonged LOS and DHCS for open colorectal surgery patients. Further research is also recommended to examine the value of patient acuity information in supporting nurses' evidence-based clinical decision-making, with the goal of improving the quality of patient care and reducing healthcare costs.

References

Agency for Healthcare Research and Quality. (2016). Statistical Brief No. 204: National inpatient hospital costs: The most expensive conditions by payor, 2013. Retrieved from https://www.hcup-us.ahrq.gov/reports/statbriefs/sb204-Most-Expensive-Hospital-Conditions.jsp

Ahmed, J., Lim, M., Khan, S., McNaught, C., & MacFie, J. (2010). Predictors of length of stay in patients having elective colorectal surgery with an enhanced recovery protocol. *International Journal of Surgery, 8*, 628-632.

Ahmed Ali, U., Dunner, T., Gurland, B., Vogel, J.D., & Kiran, R.P. (2014). Actual versus estimated length of stay after colorectal surgery: Which factors influence a deviation? *American Journal of Surgery, 208*, 663-669.

American College of Surgeons. (2015). NSQIP Surgical Risk Calculator. Retrieved from http://riskcalculator.facs.org/

American Hospital Association. (2015, March). Rethinking the Hospital Readmissions Reduction Program. *Trendwatch*, 1-12.

American Nurses Association. (2008). *Principles for nurse staffing*. Silver Spring, MD: Author.

American Nurses Association. (2015). *Nursing informatics: Scope and standards of practice* (2nd ed.). Silver Spring, MD: Author.

American Organization of Nurse Executives. (2009). Guiding principles for the nurse executive to enhance clinical outcomes by leveraging technology. Retrieved from http://www.aone.org/resources/PDFs/AONE_GP_Leveraging_Technolgoy.pdf

American Recovery and Reinvestment Act, Pub. L. No. 111-5, 123 Stat. 115 (2009).

American Society of Anesthesiologists. (2014). ASA Physical Status Classification System. Retrieved from https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system

Badger, M.K. (2016, April). Using a computerized information system to examine the relationship between inpatient unit acuity and nurse staffing: A pilot study. Poster presented at annual American Nursing Informatics Association Conference, San Francisco, CA.

Baird, G., Maxson, P. Wrobleski, D., & Luna, B.S. (2010). Fast-track colorectal surgery program reduces length of stay. *Clinical Nurse Specialist, 24*, 202-208.

Barsoum, W.K., Murray, T.G., Klika, A.K., Green, K., Miniaci, S.L., Wells, B.J., & Kattan, M.W. (2010). Predicting patient discharge disposition after total joint arthroplasty in the United States. *The Journal of Arthroplasty, 25*(6), 885-892.

Bartel, A.P., Chan, C.W., & Kim, S. (2014). *Should hospitals keep their patients longer? The role of inpatient and outpatient care in reducing readmissions* (No. w20499). National Bureau of Economics Research.

Barton, N. (2013). Acuity-based staffing: Balancing cost, satisfaction, quality, and outcomes. *Nurse Leader, 11*, 47-50.

Beswick, S., Hill, P.D., & Anderson, M.A. (2010). Comparison of nurse workload approaches. *Journal of Nursing Management, 18*, 592-598.

Birmingham, S.E. (2010). Evidence-based staffing: The next step. *Nurse Leader, 8*(3), 24-26.

Bozic, K.J., Wagie, A., Naessens, J.M., Berry, D.J., & Rubash, H.E. (2006). Predictors of discharge to an inpatient extended care facility after total hip or knee arthroplasty. *The Journal of Arthroplasty, 21*(6), Suppl. 2, 151-156.

Brasel, K.J., Lim H.J., Nirula, R., & Weigelt, J.A. (2007). Length of stay: An appropriate quality measure? *Archives of Surgery, 142*, 461-466.

Campos, N.K. (2009). The legalities of nursing documentation. *Nursing Management, 40*(8), 16-19.

Campos Lobato, L.F.D., Ferreira, P.C.A., Wick, E.C., Kiran, R.P, Remzi, F.H., Kalady, M.F., & Vogel, J.D. (2013). Risk factors for prolonged length of stay after colorectal surgery. *Journal of Coloproctology, 33*(1), 22-27.

Centers for Disease Control and Prevention. (2016a). About adult BMI. Retrieved from http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/

Centers for Disease Control and Prevention. (2016b). Healthcare-associated infections (HAIs). Retrieved from http://www.cdc.gov/HAI/surveillance/

Centers for Disease Control and Prevention. (2016c). Health Expenditures. Retrieved from https://www.cdc.gov/nchs/fastats/health-expenditures.htm

Centers for Disease Control and Prevention. (2015). Inpatient surgery: Data for the U.S. Retrieved from http://www.cdc.gov/nchs/fastats/inpatient-surgery.htm

Centers for Medicare and Medicaid Services. (2015). CMS Bundled Payments for Cost Improvement (BPCI) initiative models 2-4: Year 1 evaluation and monitoring report. Retrieved from https://innovation.cms.gov/Files/reports/BPCI-EvalRpt1.pdf

Centers for Medicare and Medicaid Services. (2016a). Acute care hospital inpatient prospective payment system: Payment system fact sheet series. Retrieved from https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/downloads/AcutePaymtSysfctsht.pdf

Centers for Medicare and Medicaid Services. (2016b). Medicare provider utilization and payment data: Inpatient. Retrieved from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Provider-Charge-Data/Inpatient.html

Centers for Medicare and Medicaid Services. (2016c). Readmissions Reduction Program (HRRP). Retrieved from https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html

Cerner. (2016). PowerChart®. Retrieved from http://www.cerner.com/solutions/Hospitals_and_Health_Systems/Acute_Care_EMR/PowerChart/?LangType=2057

Cheevakasemsook, A., Chapman, Y., Francis, K., & Davies, C. (2006). The study of nursing documentation complexities. *International Journal of Nursing Practice, 12,* 366-374.

Choi, J., & De Martinis, J.E. (2013). Nursing informatics competencies: Assessment of undergraduate and graduate nursing students. *Journal of Clinical Nursing, 22,* 1970-1976.

Clairvia®. (n.d.). CVM™ Outcomes-driven patient acuity: A Clairvia® Care Value Management Solution. Retrieved from http://www.clairvia.com-wp/ content/uploads/2010/02/OUTCOMES_DRIVEN_PATIENT_ACUITY.pdf

Covidien. (2015). 2015 Colorectal surgery Medical reimbursement coding guide: Effective January 1, 2015. Retrieved from http://www.covidien.com/imageServer.aspx/doc336876.pdf?contentID=76482&contenttype=application/pdf

Dent, R.L., & Bradshaw, P. (2012). Building the business case for acuity-based staffing. *Nurse*

Leader, 10(2), 26-28.

Douglas, K. (2011). What every nurse executive should know about staffing and scheduling technology initiatives. *Nursing Economic$, 29*, 273-275.

Doran, D.M., Sidani, S., & DePietro, T. (2010). Nurse-sensitive outcomes. In J.S. Fulton, B.L. Lyon, & K.A. Goudreau (Eds.), *Foundations of clinical nurse specialist practice* (2nd ed.) (pp. 35-57). New York, NY: Springer Publishing Company.

Epic. (2016). Smart Chart®. Retrieved from https://www.epic.com/Software#Clinicals

Eskicioglu, C., Forbes, S.S., Aarts, M.A., Orainec, A., & McLeod, R.S. (2009). Enhanced recovery after surgery (ERAS) programs for patients having colorectal surgery: A meta-analysis of randomized control trials. *Journal of Gastrointestinal Surgery, 13*, 2321-2329.

Executive Order No. 13,335, 3 C.F.R. 160 (2005 comp.).

Fasoli, D.R., & Haddock. K.S. (2011). Results of an integrative review of patient classification systems. *Annual Review of Nursing Research, 28*, 295-316.

Fitzgerald, J. (2012). Enhanced recovery for colorectal surgery: A large NHS trust experience. *Gastrointestinal Nursing, 10*(5), S3-S6.

Gall, W., Grossman, W., Duftschmid, G., Wrba, T., & Dorda, W. (2008). Analysis of EHRs for research, quality management and health politics. *Technology and Informatics, 136*, 425-430.

Gouvas, N., Tan, E., Windsor, A., Xynos, E., & Tekkis, P.P. (2009). Fast-track vs. standard care in colorectal surgery: A meta-analysis update. *International Journal of Colorectal Disease, 24,* 1119-1131.

Gravante, G., & Elmussareh, M. (2012). Enhanced recovery for colorectal surgery: Practical hints, results and future challenges. *World of Gastrointestinal Surgery, 4*, 190-198.

Gulanick, M., & Myers, J.L. (2013). *Nursing care plans: Diagnoses, interventions, and outcomes* (8th ed.). St. Louis, MO: Elsevier Mosby.

Halawi, M.J., Vovos, T.J., Green, C.L., Wellman, S.S., Attarian, D.E., & Bolognesi, M.P. (2015). Patient expectation is the most important predictor of discharge destination after primary total joint arthroplasty. *The Journal of Arthroplasty, 30*, 539-542.

Hamavid, H., Birger, M., Bulchis, A.G., Lomsadze, L., Joseph, J., Baral, R., Bui, A.L., Horst, C., Johnson, E., & Dieleman, J.L. (2016). Assessing the complex and evolving relationship between charges and payments in U.S. hospitals: 1996 – 2012. *PLoS One, 11*(7): e0157912.

Harper, P.R. (2002). A framework for operational modeling of hospital resources. *Health Care Management Science, 5*, 165-173.

HealthIT.gov. (2015). How to attain Meaningful Use. Retrieved from http://www.healthit.gov/providers-professionals/how-attain-meaningful-use

Higgs, S., Henry, R., & Glackin, M. (2014). Acute pain services following surgery for colorectal cancer. *British Journal of Nursing, 23*(4), S4-S11.

Hines, A.L., Barrett, M.L., Jiang, H.J., & Steiner, C.A. (2014). Conditions with largest number of acute hospital readmissions by payer, 2011. Healthcare Cost and Utilization Project Statistical Brief #172. Agency for Healthcare Research and Quality, Rockville, MD. Retrieved from http://www.hcup-us.ahrq.gov/reports/statbriefs/sb172-Conditions-Readmissions-Payer.pdf

Holland, D.E., Knafl, G.J., & Bowles, K.H. (2013). Targeting hospitalized patients for early discharge planning intervention. *Journal of Clinical Nursing, 22*, 2696-2703.

Hulley, S.B., Cummings, S.R., Browner, W.S., Grady, D.G., & Newman, T.B. (Eds.) (2013).

Designing clinical research (4th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Hunter, K., McGonigle, D., & Hebda, T. (2011). The importance of INSs: Informatics nurse specialists bridge patients, IT and executives. *Health Management Technology, 32*(11), 10.

IBM®. (n.d.) SPSS software: Predictive analytics software and solutions. Retrieved from http://www-01.ibm.com/software/analytics/spss/

Johnson, S.G., Speedie, S., Simon, G., Kumar, V., & Westra, B.L. (2016). Application of an ontology for characterizing data quality for a secondary use of EHR data. *Applied Clinical Informatics, 7*(1), 69-88.

Keenan, J.E., Speicher, P.J., Thacker, J.K.M., Walter, M., Kuchibhatla, M., & Mantyh, C.R. (2014). The preventive surgical site infection bundle in colorectal surgery: An effective approach to surgical site infection reduction and health care cost savings. *JAMA Surgery, 149*(10), 1045-1052.

Keller, D., & Stein, S.L. (2013). Facilitating return of bowel function after colorectal surgery: Alvimopan and gum chewing. *Clinics in Colon and Rectal Surgery, 26*, 186-190.

Kelly, M., Sharp, L., Dwane, F. Kelleher, T., & Comber, H. (2012). Factors predicting hospital length-of-stay and readmission after colorectal resection: A population-based study of elective and emergency admissions. BMC Health Services Research, 12, 77.

Kempson, D. (2008) The needs of the many: A Phoenix-based medical center implements an automated patient acuity staffing and scheduling solution. *Health Management Technology, 29*(10), 22-25.

Kidd, M., Grove, K., Kaiser, M., Swoboda, B., & Taylor, A. (2014). A new patient-acuity tool promotes equitable nurse-patient assignments. *American Nurse Today, 9*(3), 1-4.

Kim, H., Harris, M.R., Savova, G.K., Speedie, S.M., & Chute, C.G. (2007). Toward near real-time acuity estimation: A feasibility study. *Nursing Research, 56*, 288-294.

Kontio, E., Airola, A., Pahikkala, T., Lundgren-Laine, H., Junttila, K., Korvenranta, H., Salakoski, T., & Slanatera, S. (2014). Predicting patient acuity from electronic patient records. *Journal of Biomedical Informatics, 51*, 35-40.

Kossman, S.P., & Scheidenhelm, S.L. (2008). Nurses' perceptions of the impact of electronic health records on work and patient outcomes. *CIN: Computers, Informatics, Nursing, 26*(2), 69-77.

Lien, D., & Balakrishnan, N. (2005). On regression analysis with data cleaning via trimming, Winsorization, and dichotomization. *Communications in Statistics, 34*(4), 839-849.

Malloch, K. (2012). Changing tides: Increasing evidence to embrace a patient classification system. *Nursing Economic$, 30*, 356-358.

Mayo Clinic. (2016). Colon and rectal surgery. Retrieved from http://www.mayo.edu/pmts/mc15100-mc15199/mcs15156.pdf

McClellan, M. (1997). Hospital reimbursement incentives: An empirical analysis. *Journal of Economics and Management Strategy, 6*(1), 91-128.

Melnyk, B.M., & Fineout-Overholt, E. (Eds.). (2011). *Evidence-based practice in nursing and healthcare: A guide to best practice*. Baltimore, MD: Lippincott Williams & Wilkins.

Meyers, L., Gamst, G., & Guarino, A.J. (2013). *Applied multivariate research: Design and interpretation.* Thousand Oaks, CA: Sage Publications.

Microsoft® Office. (2016). Excel. Retrieved from https://products.office.com/en-us/excel

Miller, B.F., & Keane, C.B. (2005). *Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health* (7th ed.). Philadelphia, PA: Saunders.

Mitchell, C.L., Anderson, E.R., & Braun, L. (2003). Billing for inpatient hospital care. *American Journal of Health-System Pharmacy, 60*(Suppl 6), S8-S11.

Mitchell, P., Ferketich, S., & Jennings, B. (1998). Quality health outcomes model. *Image: Journal of Nursing Scholarship, 30*, 43-46.

Moorhead, S., Johnson, M., Mass, M.L., & Swanson, E. (Eds.) (2013). *Nursing Outcomes Classification (NOC)* (5th ed.). St. Louis, MO: Elsevier.

Ng, W.Q., & Neill, J. (2006). Evidence for early oral feeding of patients after elective open colorectal surgery: A literature review. *Journal of Clinical Nursing, 15*(6), 696-709.

Ngui, N.K., Hitos, K., & Ctercteko, G. (2010). Predictive factors for prolonged length of stay in elective colorectal surgery. *ANZ Journal of Surgery, 81*, 624-628.

Nguyen, A. (2015). Acuity-based staffing: Reducing costs, increasing quality. *Nursing Management, 46*(1), 35-39.

Office of the National Coordinator for Health Information Technology. (2015). Health IT Dashboard. Retrieved from http://dashboard.healthit.gov/quickstats

Oracle®. (2016). Business Intelligence Discoverer Plus. Retrieved from http://www.oracle.com/technetwork/developer-tools/discoverer/overview/index.html

Phillips, C.O., Wright, S.M., Kern, D.E., Singa, R.M., Shepperd, S., & Rubin, H.R. (2004). Comprehensive discharge planning with postdischarge support for older patients with congestive heart failure: A meta-analysis. *Journal of the American Medical Association, 291*, 1358-1367.

Polit, D.F., & Beck, C.T. (2012). *Nursing research: Generating and assessing evidence for nursing practice* (9th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Presidential Documents. (2004). Executive Order 13335 of April 27, 2004: Incentives for the use of health information technology and establishing the position of the National Health Information Technology Coordinator. Federal Register, 69, 24057-24061.

Radwin, L., & Fawcett, J. (2002). A conceptual model-based programme of nursing research: Retrospective and prospective applications. *Journal of Advanced Nursing, 40*(3), 355-360.

Rawlinson, A., Kang, P., Evans, J., & Khanna, A. (2011). A systematic review of enhanced recovery protocols in colorectal surgery. *Annals of the Royal College of Surgeons of England, 93*, 583-588.

Reddy, K.M., Meyere, C.E.R., Palazzo, F.F., Conaghan, P., Blunt, M.C., Stebbings, W.S.L., Leiceser, R.J., & Cullen, P.T. (2003). Postoperative stay following colorectal surgery: A study of factors associated with prolonged hospital stay. *Annals of the Royal College of Surgeons of England, 85*, 111-114.

Reinhardt, U.E. (1996). Spending more through 'cost control:' Our obsessive quest to gut the hospital. *Health Affairs, 15*, 145-154.

Rosenbaum, S. (2011). The Patient Protection and Affordable Care Act: Implications for public health policy and practice, *Public Health Reports, 126*(1), 130-135.

Schmelzer, T.M., Mostafa, G., Lincourt, A.E., Camp, S.M., Kercher, K.W., Kuwada, T.S., & Heniford, B.T. (2008). Factors affecting length of stay after colorectal surgery. *Journal of Surgical Research, 146*, 195-201.

Sharareh, B., Le, N.B., Hoang, M.T., & Schwarzkopf, R. (2014). Factors determining discharge destination for patients undergoing total joint arthroplasty. *The Journal of Arthroplasty, 29*, 1355-1358.

Soley-Bori, M. (2013). *Dealing with missing data: Key assumptions and methods for applied* *analysis.* Technical Report No. 4. Boston University School of Public Health.

Tapper, R., Dixon, L., Frampton, C., & Frizelle, F. (2013). Impact of obesity on the cost of major colorectal surgery. *British Journal of Surgery, 100*(2), 293-298.

Technology Informatics Guiding Education Reform (T.I.G.E.R.). (2007). The TIGER Initiative: Evidence and informatics transforming nursing: 3-year action steps toward a 10-year vision. Retrieved from http://www.aacn.nche.edu/education-resources/TIGER.pdf

Teeuwen, P.H.E., Bleichrodt, R.P., Strik, C., Goenewoud, J.J.M., Brikert, W., van Laarohoven, C.J.H.M., van Goor, H., & Bremers, A.J.A. (2010). Enhanced recovery after surgery (ERAS) versus conventional postoperative care in colorectal surgery. *Journal of Gastrointestinal Surgery, 14*, 88-95.

The Joint Commission. (2012). Specifications manual for Joint Commission national quality measures (v2013A1). Retrieved from https://manual.jointcommission.org/releases/TJC2013A/DataElem0537.html

The Shorter Oxford English Dictionary (5th ed.). (2002). Oxford, England: Oxford University Press.

The World Bank. (2016). Health expenditure, total (% of GDP). Retrieved from http://data.worldbank.org/indicator/SH.XPD.TOTL.ZS

Thiele, R.H., Rea, K.M., Turrentine, F.E., Friel, C.M., Hassinger, T.E., Goudreau, B.J., Umapathi, B.A, Kron, I.L., Sawyer, R.G., Hedrick, T.L., & McMurry, T.L. (2015). Standardization of care: Impact of an enhanced recovery protocol on length of stay, complications, and direct costs after colorectal surgery. *Journal of the American College of Surgeons, 220*, 430-443.

Titler, M., Dochterman, J., Xie, X., Kanak, M., Fei, Q., Picone, D.M., & Shever, L. (2006).

Nursing interventions and other factors associated with discharge disposition in older patients after hip fractures. *Nursing Research, 55*(4), 231-242.

United States Code. (2010). Title 42: The public health and welfare. United States House of Representatives, Title 42, 1-17901. Retrieved from http://uscode.house.gov/download/title_42.shtml

University of Pittsburgh. (2016) Honest broker guidance. Retrieved from http://www.irb.pitt.edu/honest-broker-guidance

U.S. Department of Health and Human Services. (2015). The Affordable Care Act is working. Retrieved from http://www.hhs.gov/healthcare/facts-and-features/fact-sheets/aca-is-working/index.html

Vochteloo, A.J.H., Tuinebreijer, W.E., Maier, A.B., Nelissen, R.G.H.H., Bloem, R.M., & Pilot, P. (2012). Predicting discharge location of hip fracture patients: The new discharge of hip fracture patients score. *International Orthopaedics, 36*, 1709-1714.

Wallstrom, A., & Frisman, G.H. (2013). Facilitating early recovery of bowel motility after colorectal surgery: A systematic review. *Journal of Clinical Nursing, 23*, 24-44.

Waltz, C.F., Strickland, O.L., & Lenz, E.R. (2010). *Measurement in nursing and health research.* New York, NY: Springer Publishing Company.

Weiskopf, N.G., & Weng, C. (2013). Methods and dimensions of electronic health record data quality assessment: Enabling reuse for clinical research. *Journal of the American Medical Informatics Association, 20*(1), 144-151.

Welton, J. (2007). Mandatory nurse to patient staffing ratios: Time to take a different approach. *Online Journal of Nursing Issues, 12*(3).

Wick, E.C., Hirose, K., Shore, A.D., Clarke, J.M., Gearhart, S.L., Efron, J., & Makary, M.A.

(2011). Surgical site infections and cost in obese patients undergoing colorectal surgery. *Archives of Surgery*, *146*(9), 1068-1072.

Wilmore, D.W., & Kehlet, H. (2001). Management of patients in fast track surgery. *British Medical Journal*, *322*, 473-476.

Wisconsin Nurse Practice Act. (2014). Wis. Stat. ch. 441. Retrieved from https://docs.legis.wisconsin.gov/statutes/statutes/441

Yee, T., Needleman, J., Pearson, M., Parkerton, P. Parkerton, M., & Wolstein, J. (2012). The influence of integrated electronic medical records and computerized nursing notes on nurses' time spent in documentation. *CIN: Computers, Informatics, Nursing, 30*(6), 287-292.

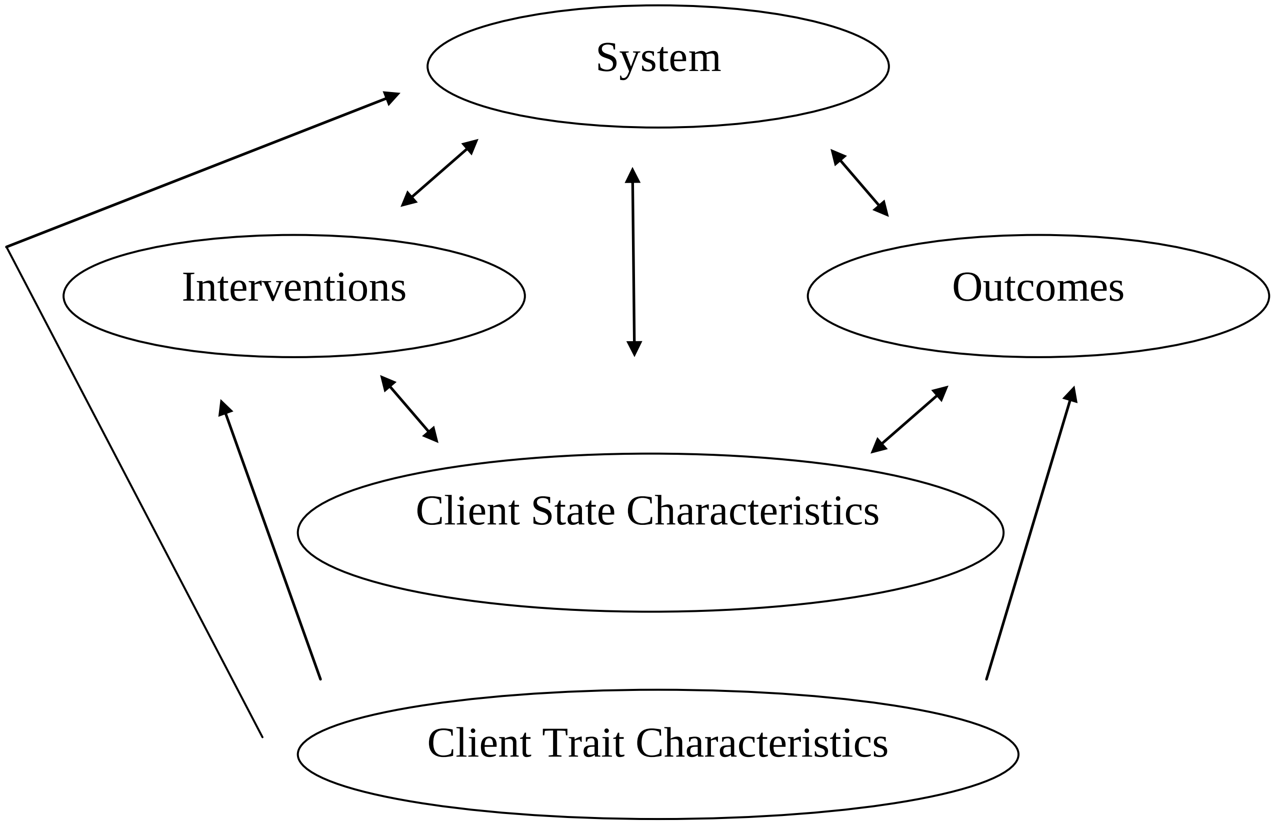
Yin, X., Zhao, Y., & Zhu, X. (2014). Comparison of fast track protocol and standard care in patients undergoing elective open colorectal resection: A meta-analysis update. *Applied Nursing Research*, *27*, e20-e26.

Zhu, Q., Liu, J., Hu, H., & Wang, S. (2015). Effectiveness of nurse-led early discharge programs for hospital inpatients with chronic disease or rehabilitation needs: A systematic review and meta-analysis. *Journal of Clinical Nursing*, *24*, 2993-3005.

Zimlichman, E., Henderson, D., Tamir, O., Franz, C., Song, P., Yamin, C.K., Keohane, C., Denham, C.R., & Bates, D.W. (2013). Health care-associated infections: A meta-analysis of cost and financial impact on the US health care system. *JAMA Internal Medicine, 173*, 2039-2046.

Appendix A

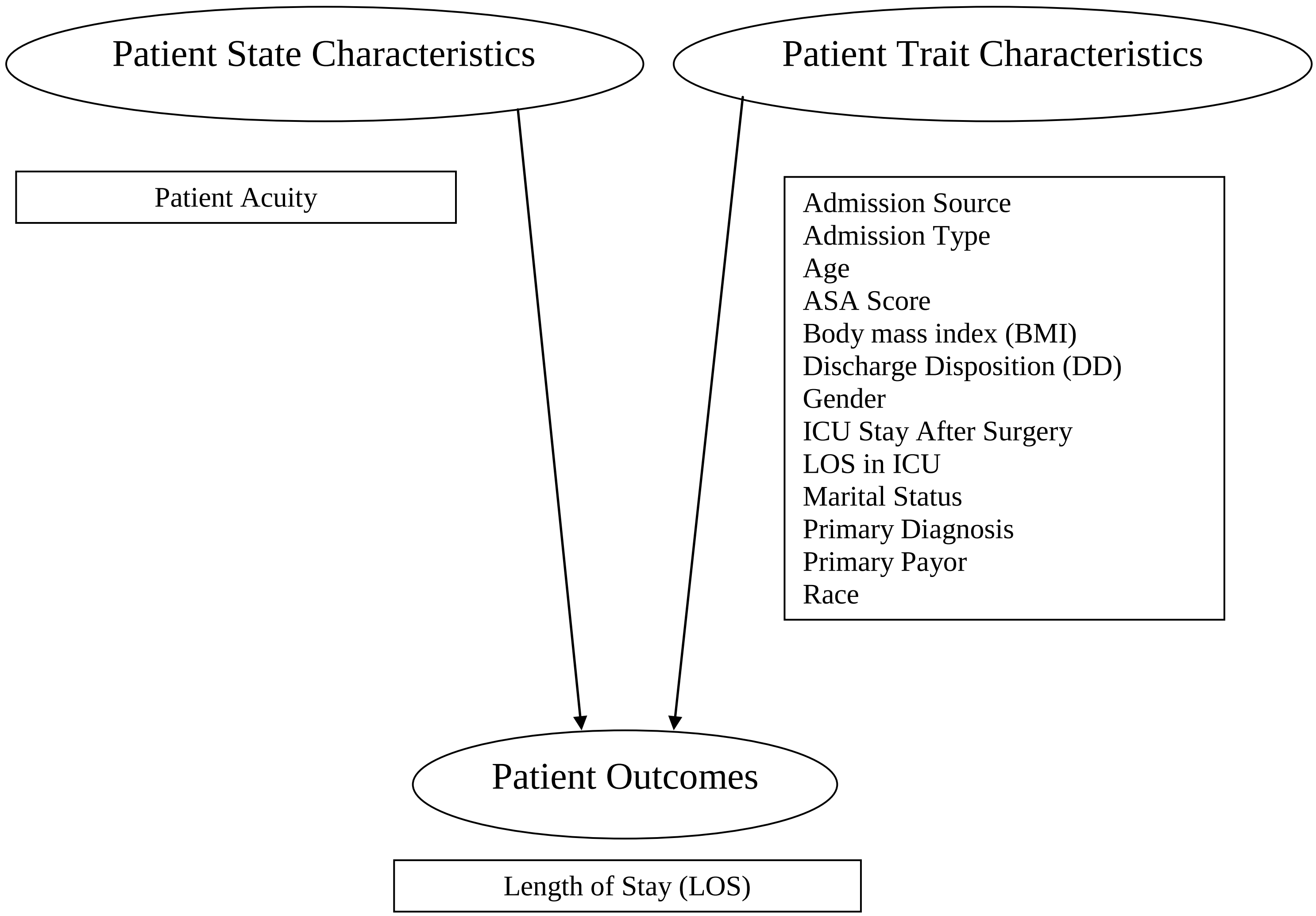
Radwin and Fawcett's (2002) Refined Quality Health Outcomes Model (R-QHOM)



From:
Radwin & Fawcett (2002), Figure 2, p. 357

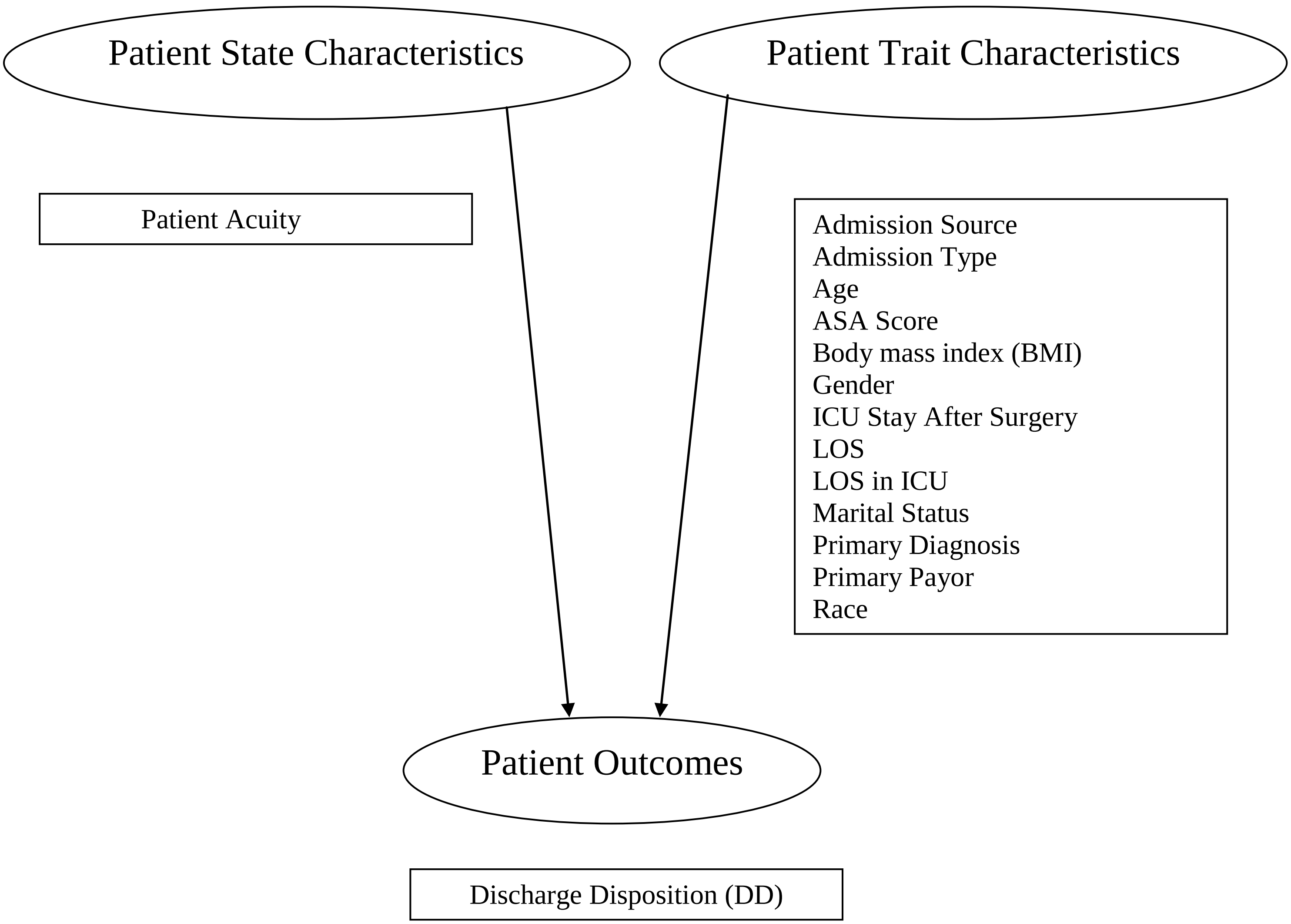
Appendix B

Adaptation of Radwin and Fawcett's (2002) R-QHOM with Length of Stay (LOS) as Outcome Variable



Appendix C

Adaptation of Radwin and Fawcett's (2002) R-QHOM with Discharge Disposition (DD) as Outcome Variable



Appendix D

Select Nursing Assessment, Laboratory Value, and Medication Infusion Administration Values Mapped from the Electronic Health Record (EHR) to 15 Patient Acuity Measures in Clairvia®

I. Cardiac Pump Effectiveness: Adequacy of blood volume ejected from the left ventricle to support systemic perfusion pressure (Moorhead, Johnson, Mass, & Swanson, 2013)

Nursing Assessment Additional Cardio/Peripheral Vascular Monitoring: Chest Pain; Cardiac Output (l/min): 0-1000; Chest Pain Intensity (Pain Score 0-10): 7, 8, 9, 10; CVP: 0-1000 mmHG; Ectopy: Torsades, V tach, Heart Rhythm: 3rd degree heart block, Asystole, V Fib.
Laboratory Results Hematocrit – HH Value, Hematocrit – LL Value, Hemoglobin – HH Value, Hemoglobin – LL Value.
Medication Infusion Administration Volume (ml) Diltiazem (high), Volume (ml) Epinephrine (high), Volume (ml) Nitroglycerin (high).

II. Coping: Personal actions to manage stressors that tax an individual's resources (Moorhead et al., 2013)

Nursing Assessment Coping Deficits – family, No safe discharge plan, Suicide Precautions.

III. Discomfort Level: Severity of observed or reported mental or physical discomfort (Moorhead, et al., 2013)

Nursing Assessment Pain Behaviors Evaluation: Increase in behaviors, initiate additional interventions; Pain level unacceptable - collaborate with provider.
Medication Infusion Administration Volume (ml) Fentanyl, Volume (ml) Morphine.

IV. Electrolyte and Acid-Base Balance: Balance of electrolytes and non-electrolytes in the intracellular and extracellular compartments of the body (Moorhead et al., 2013)

Nursing Assessment Fluid Removal Rate, Insulin Algorithm 1, Insulin Algorithm DKA.
Laboratory Results Calcium – LL Value, Magnesium – LL Value, Potassium – HH Value, Potassium – LL Value.
Medication Infusion Administration Glucagon Volume (high), Volume (ml) Insulin (high), Volume (ml) Magnesium Sulfate.

V. Fall Prevention Behavior: Personal of family caregiver actions to minimize risk factors that might precipitate falls in the personal environment (Moorhead et al., 2013)

Nursing Assessment
Maintain bed/chair exit alert, Provide 1:1 observation, Use low height bed.

VI. Gastrointestinal Function: Ability of the gastrointestinal tract to ingest and digest food products, absorb nutrients, and eliminate waste (Moorhead et al., 2013)

Nursing Assessment
Bowel Sounds All Quadrants: Absent or Rare.

Medication Infusion Administration
Volume (ml) Pantoprazole.

VII. Infection Severity: Severity of signs and symptoms of infection (Moorhead et al., 2013)

Nursing Assessment
Precautions: Isolation or Neutropenic, Temperature: 0-96, 103-110.

Laboratory Results
WBC: HH or, LL.

Medication Infusion Administration
Trimeth/Sulfa, Vancomycin, Vancomycin trough.

VIII. Kidney Function: Ability of kidneys to regulate body fluids, filter blood and eliminate waste products through the formation of urine (Moorhead et al., 2013)

Nursing Assessment
ArterioVenous fistula assessment, Hemodialysis catheter assessment, Peritoneal dialysis.

Laboratory Results
BUN Value of HH, BUN Post Dialysis Value of HH, Creatinine Value of HH.

Medication Infusion Administration
Bumetadine Volume, Conivaptan Volume.

IX. Knowledge - Treatment Regimen: Extent of understanding conveyed about a specific treatment regimen (Moorhead et al., 2013)

Nursing Assessment
Confidence in Filling Out Medical Forms: Not at all, Symptoms of Delirium: Yes.

X. Neurological Status: Ability of the peripheral and central nervous systems to receive, process, and respond to internal and external stimuli (Moorhead et al., 2013)

Nursing Assessment
Seizure, Perceptions: Auditory hallucination, Visual hallucination*, Posturing to Pain/Noxious Stimuli Either Upper Extremity: Decerebrate posture, Decorticate posture, No response to pain, Swallow: Abnormal (absent/weak) gag reflex.

Medication Infusion Administration Lorazepam Volume (high), Volume Methylprednisolone (high).

XI. Nutritional Status - Food and Fluid Intake: Amount of food and fluid taken into the body over a 24-hour period (Moorhead et al., 2013)

Nursing Assessment MI Calculated value: 41-100; Intubated, NPO Order.
Medication Infusion Administration Type of Formula/Solution, Volume (ml) Lipids.

XII. Respiratory Status: Movement of air in and out of the lungs and exchange of carbon dioxide and oxygen at the alveolar level (Moorhead et al., 2013)

Nursing Assessment Trach/stoma, Ventilator, Respiratory Pattern: Agonal, Apneic (comment on number of seconds), Bradypneic, Cheyne-stokes, Gasping, Kussmaul.
Laboratory Results Arterial CO2 – HH Value, Arterial CO2 – LL Value.
Medication Infusion Administration Theophylline Volume (high).

XIII. Self-Care - Activities of Daily Living: Personal actions to perform the most basic physical tasks and personal care activities independently with or without assistive devices (Moorhead et al., 2013)

Nursing Assessment Non-ambulatory, Level of Assistance: Maximal assist or Total assist, Oral Care Q 2 hours (based on patient assessment).

XIV. Tissue Integrity - Skin and Mucous Membranes: Structural intactness and normal physiological function of skin and mucous membranes (Moorhead et al., 2013)

Nursing Assessment Pressure Ulcer Staging: Pressure ulcer on mucous membrane, Stage I, Stage II, Stage III, Stage IV, Suspected deep tissue injury, Unstageable/necrotic tissue.

XV. Tissue Perfusion – Peripheral: Adequacy of blood flow through the small vessels of the extremities to maintain tissue function (Moorhead et al., 2013)

Nursing Assessment Central Perfusion: Cold, Cyanosis, Dusky, Mottled; Color: Acrocyanosis, Cyanosis, Mottled.
Medication Infusion Administration Blood Mass Transfusion Volume (Intake)

Appendix E

Descriptive Statistics for Nominal-Level Variables for Total Sample (*N*=789)

Nominal-Level Variable	*n*	%
Gender		
Female	439	55.6%
Male	350	44.4%
Race		
White	716	90.7%
Black	46	5.8%
Hispanic/Latino	15	1.9%
Asian	6	0.8%
American Indian or Alaskan Native	2	0.3%
Other	4	0.5%
Marital Status		
Married or significant other	415	52.2%
Single	147	18.9%
Widowed	141	18.1%
Divorced or legally separated	84	10.6%
Other	2	0.2%
Admission Type		
Non-Urgent	485	61.5%
Emergency	248	31.4%
Urgent	56	7.1%
Admission Source		
Non-healthcare point of origin	701	88.8%
Clinic or provider's office	39	4.9%
Transfer from another hospital	32	4.1%
Other	6	0.8%
Transfer from another healthcare facility	5	0.6%
Transfer from ambulatory surgery center	2	0.3%
Transfer from distinct unit within hospital	2	0.3%
Transfer from skilled nursing facility, intermediate care, or assisted living facility	2	0.2%
Primary Diagnosis		
Neoplasm of colon or rectum	294	37.3%
Diverticulitis of colon	208	26.4%
Other disorders of colon or rectum	103	13.2%
Obstruction of colon or rectum	38	4.8%
Rectal prolapse	29	3.7%

Fistula involving colon or rectum	28	3.6%
Colonic volvulus	28	3.6%
Acute appendicitis	15	1.9%
Perforation of colon or rectum	15	1.9%
Ulcerative colitis	15	1.9%
Crohn's disease of colon	7	0.9%
C. difficile infection	5	0.7%
Intussusception of colon	4	0.1%
Discharge Disposition		
Home without healthcare services	458	58.0%
Home with health care services	140	17.9%
Skilled nursing facility	104	13.6%
Inpatient hospice	20	2.7%
Inpatient rehabilitation	17	2.3%
Home hospice	13	1.8%
Long-term acute care hospital	12	1.5%
Acute care hospital	10	1.4%
Intermediate care facility	9	1.1%
Assisted living	6	0.9%
Primary Payor		
Commercial	323	40.9%
Medicare Traditional	235	29.8%
Medicare Managed Care	160	20.3%
Medicaid Managed Care	43	5.4%
Medicaid Traditional	14	1.8%
Self-Pay	9	1.1%
Government	5	0.6%
ICU Stay		
No	583	73.9%
Yes	206	26.1%
LOS Longer than National Average for DRG		
No	610	77.3%
Yes	179	23.7%
Readmission Within 30 Days of Discharge		
No	582	73.8%
Yes	207	26.2%

Appendix F

Descriptive Statistics for Nominal-Level Variables, by DRG

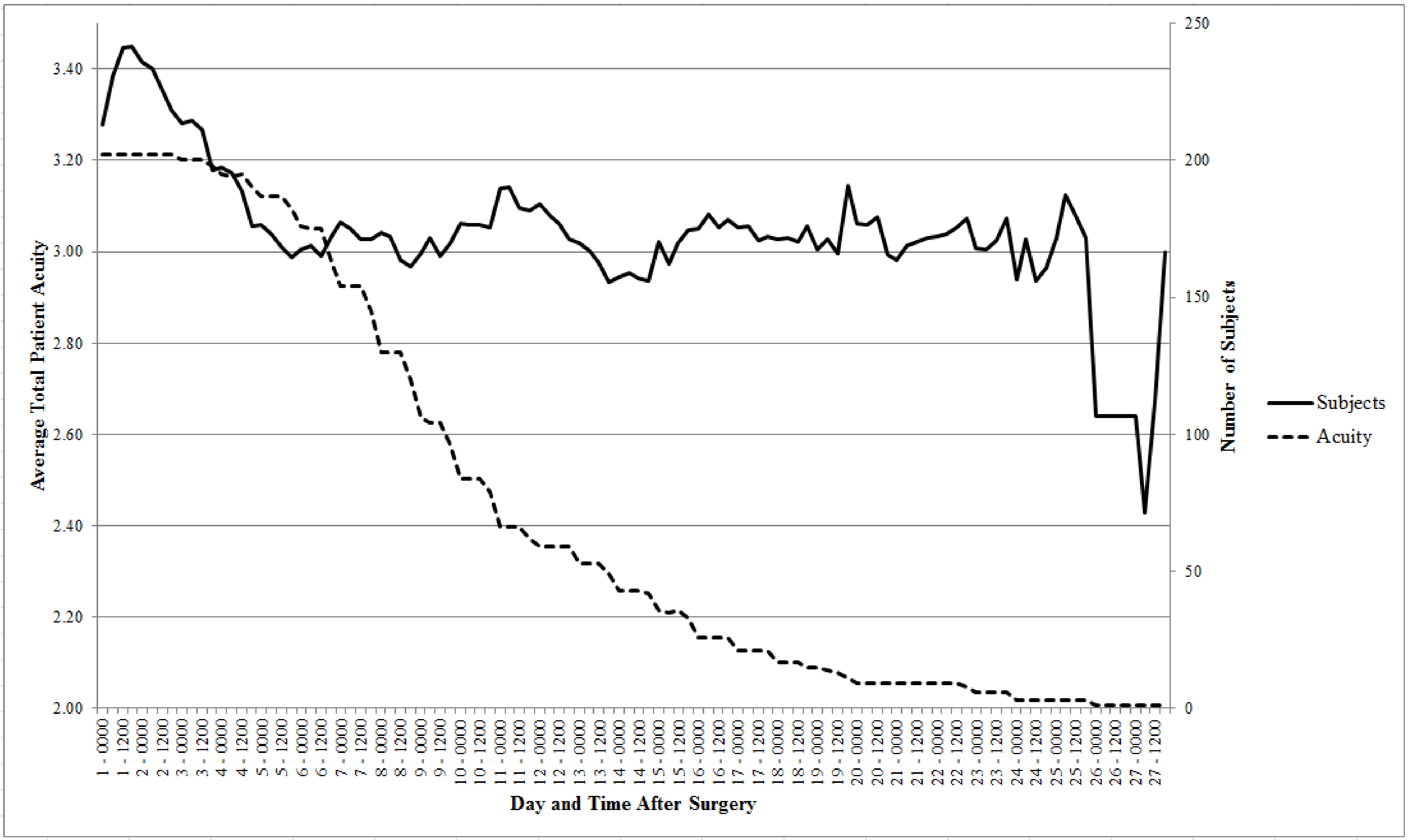
DRG	329 (*n*=202)		330 (*n*=422)		331 (*n*=165)	
Nominal-Level Variable	n	(%)	n	(%)	n	(%)
Gender						
Female	106	(52.5%)	247	(58.5%)	86	(52.1%)
Male	96	(47.5%)	175	(41.5%)	77	(47.9%)
Race						
White	183	(90.6%)	381	(90.3%)	152	(92.1%)
Black	14	(6.9%)	24	(5.7%)	8	(4.8%)
Hispanic/Latino	1	(0.5%)	10	(2.3%)	4	(2.5%)
Other	3	(1.5%)	0	(0%)	1	(0.6%)
Asian	1	(0.5%)	5	(1.2%)	0	(0%)
American Indian or Alaskan Native	0	(0%)	2	(0.5%)	0	(0%)
Marital Status*						
Married or significant other	95	(47.0%)	219	(51.9%)	101	(61.2%)
Single	31	(15.4%)	85	(20.1%)	31	(18.8%)
Widowed	48	(23.8%)	80	(19.0%)	13	(7.9%)
Divorced or legally separated	27	(13.3%)	37	(8.8%)	20	(12.1%)
Other or unknown	1	(0.5%)	1	(0.2%)	0	(0%)
Admission Type**						
Non-Urgent	56	(27.7%)	286	(67.8%)	143	(86.7%)
Emergency	124	(61.4%)	108	(25.6%)	16	(9.7%)
Urgent	22	(10.9%)	28	(6.6%)	6	(3.6%)
Admission Source**						
Non-healthcare point of origin	167	(82.7%)	377	(89.3%)	157	(95.2%)
Clinic or provider's office	16	(7.9%)	19	(4.5%)	4	(2.4%)
Transfer from another hospital	13	(6.4%)	15	(3.6%)	4	(2.4%)
Other	1	(0.5%)	5	(1.2%)	0	(0%)
Transfer from another healthcare facility	0	(0%)	5	(1.2%)	0	(0%)
Transfer from ambulatory surgery center	2	(1.0%)	0	(0%)	0	(0%)
Transfer from distinct unit within hospital	1	(0.5%)	1	(0.2%)	0	(0%)
Transfer from skilled nursing facility, intermediate care, or assisted living facility	2	(1.0%)	0	(0%)	0	(0%)
Primary Diagnosis**						
Neoplasm of colon or rectum	62	(30.7%)	161	(38.2%)	71	(43.1%)
Diverticulitis of colon	61	(30.2%)	107	(25.3%)	40	(24.3%)

Other disorders of colon or rectum	31	(15.2%)	58	(13.8%)	20	(12.1%)
Obstruction of colon or rectum	10	(4.9%)	19	(4.5%)	6	(3.6%)
Rectal prolapse	3	(1.5%)	13	(3.1%)	13	(7.9%)
Fistula involving colon or rectum	6	(3.0%)	20	(4.7%)	2	(1.2%)
Colonic volvulus	8	(4.0%)	15	(3.6%)	4	(2.4%)
Acute appendicitis	6	(3.0%)	8	(1.9%)	1	(0.6%)
Perforation of colon or rectum	8	(4.0%)	3	(0.7%)	3	(1.8%)
Ulcerative colitis	4	(2.0%)	6	(1.4%)	4	(2.4%)
Crohn’s disease of colon	0	(0%)	7	(1.6%)	0	(0%)
C. difficile infection	2	(1.0%)	2	(0.5%)	1	(0.6%)
Intussusception of colon	1	(0.5%)	3	(0.7%)	0	(0%)
Discharge Disposition**						
Home without home healthcare services	61	(30.2%)	257	(60.9%)	140	(84.7%)
Home care	53	(26.2%)	71	(16.9%)	16	(9.6%)
Skilled nursing facility	50	(24.6%)	49	(11.7%)	5	(2.9%)
Inpatient hospice	8	(4.0%)	12	(2.8%)	0	(0%)
Inpatient rehabilitation	5	(2.5%)	11	(2.6%)	1	(0.6%)
Home hospice	9	(4.5%)	4	(0.9%)	0	(0%)
Long-term acute care hospital	6	(3.0%)	5	(1.2%)	1	(1.2%)
Acute care hospital	3	(1.5%)	6	(1.4%)	1	(0.6%)
Intermediate care facility	4	(2.0%)	4	(0.9%)	1	(0.6%)
Assisted living	3	(1.5%)	3	(0.7%)	0	(0%)
LOS Longer than National Average for DRG**						
No	166	(82.2%)	348	(82.5%)	96	(58.2%)
Yes	36	(17.8%)	74	(17.5%)	69	(41.8%)
ICU Stay**						
No	90	(44.6%)	342	(81.0%)	151	(91.5%)
Yes	112	(55.4%)	80	(19.0%)	14	(8.5%)
Primary Payor**						
Commercial	57	(28.2%)	167	(39.6%)	99	(60.0%)
Medicare Traditional	78	(38.6%)	129	(30.6%)	28	(17.0%)
Medicare Managed Care	46	(22.8%)	90	(21.3%)	24	(14.5%)
Medicaid Managed Care	16	(7.9%)	20	(4.7%)	7	(4.2%)
Medicaid Traditional	3	(1.5%)	8	(1.9%)	3	(1.8%)
Self-Pay	2	(1.0%)	4	(0.9%)	3	(1.8%)
Government	0	(0%)	4	(0.9%)	1	(0.6)
Readmission Within 30 Days of Discharge**						
No	124	(61.4%)	332	(78.7%)	126	(76.4%)
Yes	78	(38.6%)	90	(21.3%)	39	(23.6%)

*The difference among the DRGs is significant at the 0.05 level.
** The difference among the DRGs is significant at the 0.01 level.

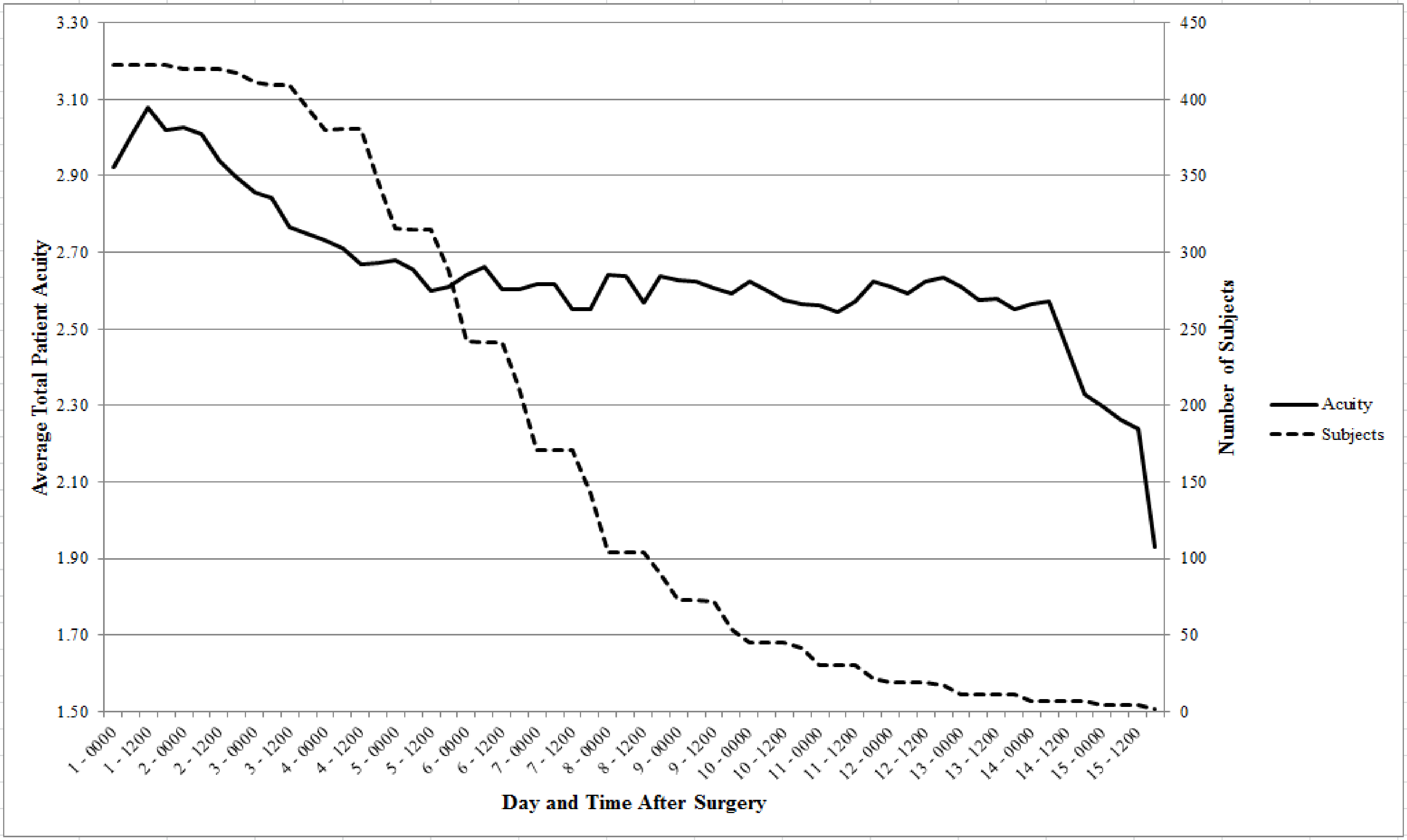
Appendix G

Average Patient Acuity Scores and Number of Subjects Per Data Collection Time, DRG 329 (*n*=202)



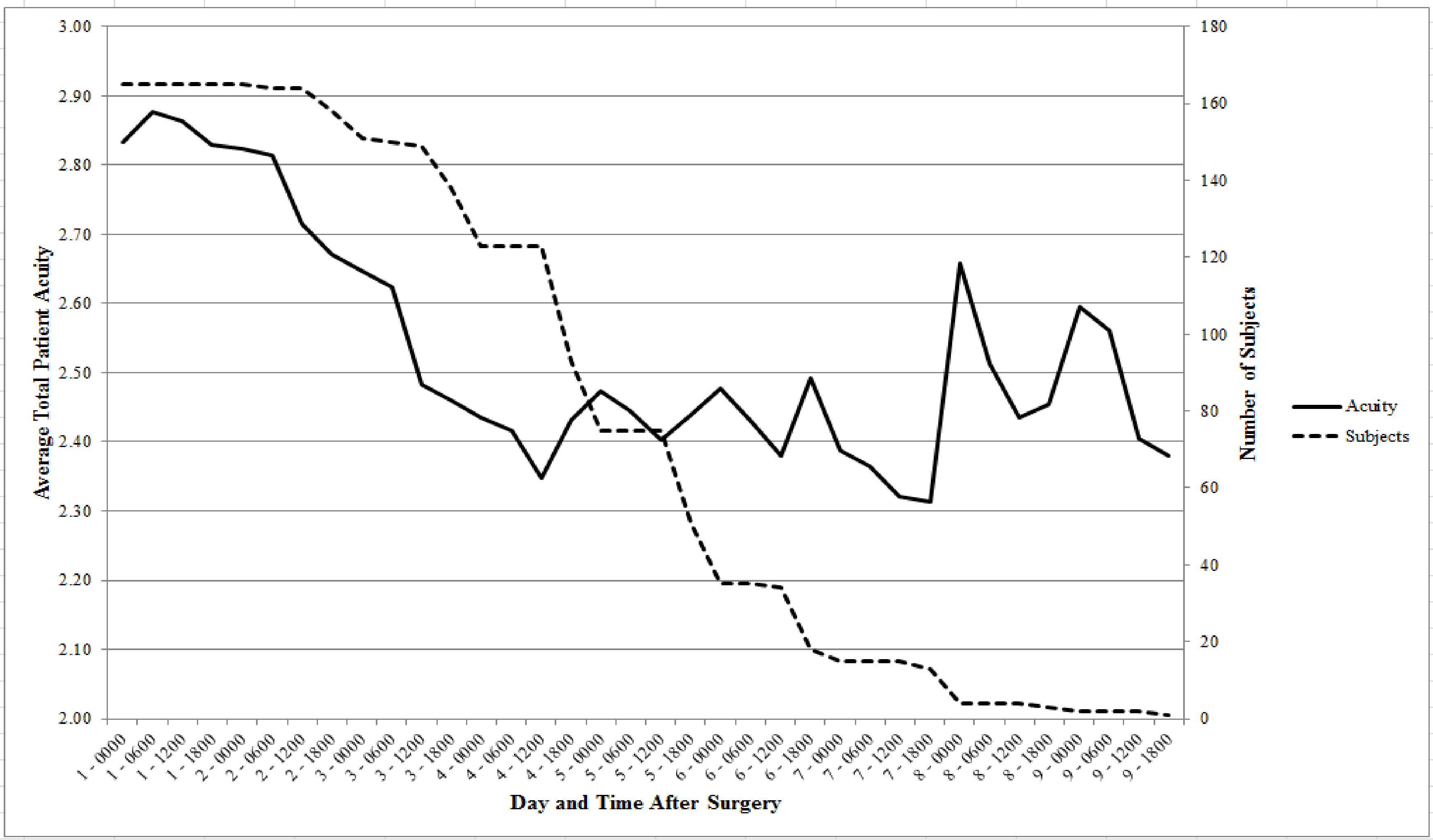
Appendix H

Average Patient Acuity Scores and Number of Subjects Per Data Collection Time, DRG 330 (*n*=422)



Appendix I

Average Patient Acuity Scores and Number of Subjects Per Data Collection Time, DRG 331 (*n*=165)



Appendix J

Correlation Matrix for Patient State and Trait Characteristics, DRG 329 (*n*=202)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1-Patient Acuity	1												
2-LOS	.254**	1											
3-DD	.416**	.270**	1										
4-Gender	-.186**	-.066	-.130	1									
5-Race	.102	.015	.157*	.001	1								
6-Age	.344**	.060	.331**	-.152*	.099	1							
7-BMI	.172*	.131	.098	-.152*	.121	.050	1						
8-ASA Score	.323**	.080	.182**	-.084	.065	.378**	.043	1					
9-LOS in ICU	.618**	.182*	.217**	-.099	.058	.210**	.147*	.193*	1				
10-Marital Status	-.129	-.067	-.072	.176*	.134	-.092	-.036	-.122	-.074	1			
11-Admission Type	.150*	.082	.171*	-.075	.066	.118	.008	.185**	.108	.074	1		
12-Admission Source	.029	.088	.016	.036	-.121	-.012	-.072	-.004	-.027	.014	-.067	1	
13-Primary Payor	.296**	-.007	.241**	-.174*	-.020	.584**	.040	.373**	.150*	-.202**	.089	.006	1
14-Primary Diagnosis	.029	-.048	.017	-.017	.051	-.193**	-.113	-.015	-.050	-.017	.125	-.047	.003

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Appendix K

Correlation Matrix for Patient State and Trait Characteristics, DRG 330 (*n*=424)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1-Patient Acuity	1												
2-LOS	.289**	1											
3-DD	.348**	.240**	1										
4-Gender	-.083	.039	-.113*	1									
5-Race	.001	-.017	.164**	.016	1								
6-Age	.164**	.085	.278**	-.107*	.165**	1							
7-BMI	.004	.065	-.056	.059	-.016	-.095	1						
8-ASA Score	.223**	.090	.227**	-.051	.056	.356**	.164**	1					
9-ICU Stay	.199**	.139**	.108*	-.064	.077	.212**	.015	.188**	1				
10-Marital Status	-.068	-.012	-.094	.156**	.052	-.134**	.145**	-.082	-.067	1			
11-Admission Type	.170**	.235**	.248**	-.014	-.048	.161**	-.146**	.150**	.119**	-.057	1		
12-Admission Source	.064	.051	.085	-.057	-.068	.074	-.073	-.040	.088	-.021	.123*	1	
13-Primary Payor	.206**	.113*	.236**	-.109*	.039	.656**	-.157**	.316**	.153**	-.244**	.197**	.066	1
14-Primary Diagnosis	.078	.070	.060	-.128**	.013	-.220**	-.102*	-.095	-.089	-.045	.172**	.024	.000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix L

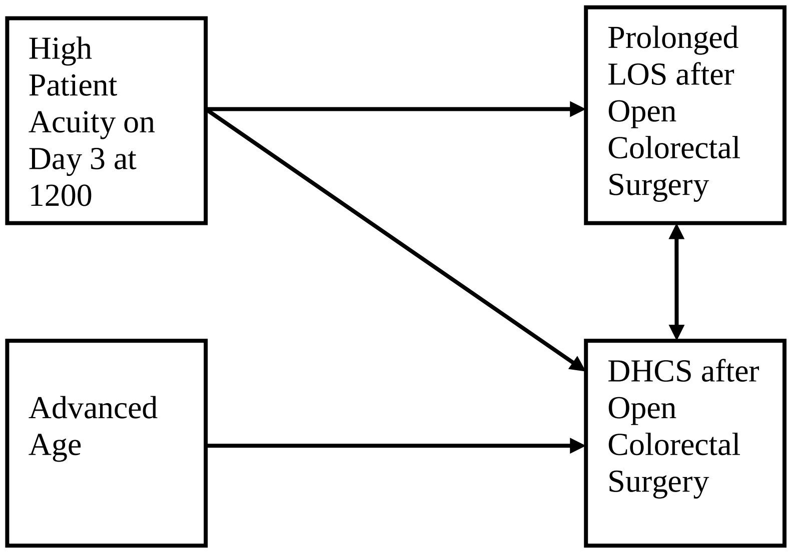
Correlation Matrix for Patient State and Trait Characteristics, DRG 331 (*n*=165)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1-Patient Acuity	1												
2-LOS	.150*	1											
3-DD	.323**	.189*	1										
4-Gender	.113	.098	-.067	1									
5-Race	.036	.077	-.065	-.035	1								
6-Age	.068	.142	.049	-.129	.080	1							
7-BMI	.067	-.020	-.070	.051	-.014	.093	1						
8-ASA Score	.202**	.203**	.121	.098	-.149	.182*	.198*	1					
9-ICU Stay	.084	.202**	.114	.056	.089	.014	-.058	.026	1				
10-Marital Status	-.140	-.133	-.080	-.133	-.048	-.042	.015	-.024	.064	1			
11-Admission Type	.161*	.168*	.083	.124	.049	-.142	-.058	-.023	.136	-.027	1		
12-Admission Source	.118	.040	-.017	.123	-.039	-.034	.091	.191*	.033	-.052	.243**	1	
13-Primary Payor	.201**	.179*	.190*	-.054	-.048	.492**	.094	.291**	.119	-.142	-.051	.113	1
14-Primary Diagnosis	.163*	-.096	.081	-.161*	.046	-.197*	-.040	-.082	.037	-.040	.193*	.092	-.069

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

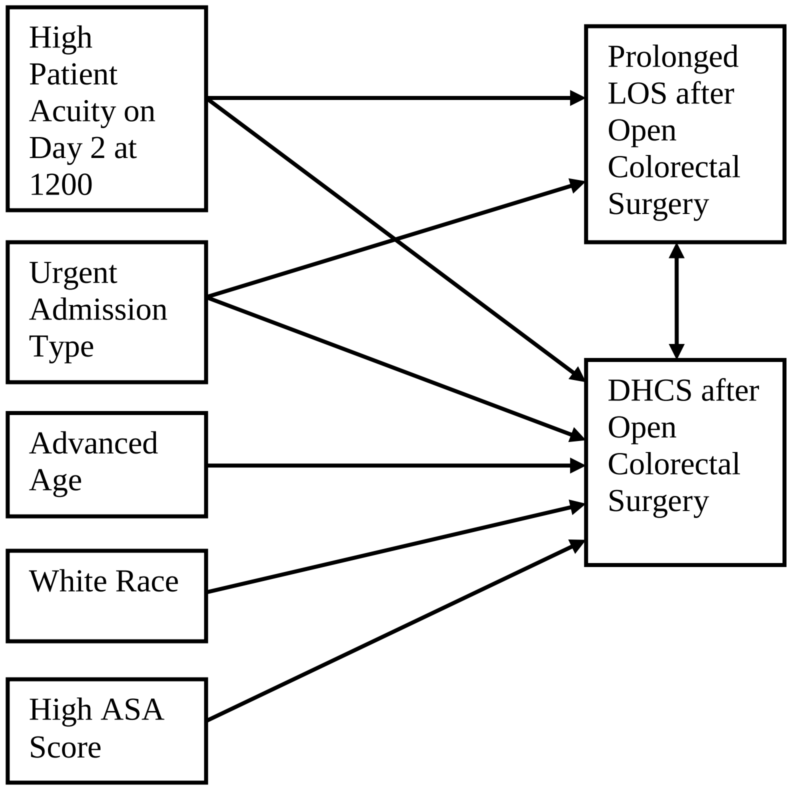
Appendix M

Analytic Model for Predicting Prolonged LOS and DHCS for DRG 329 (n=200)



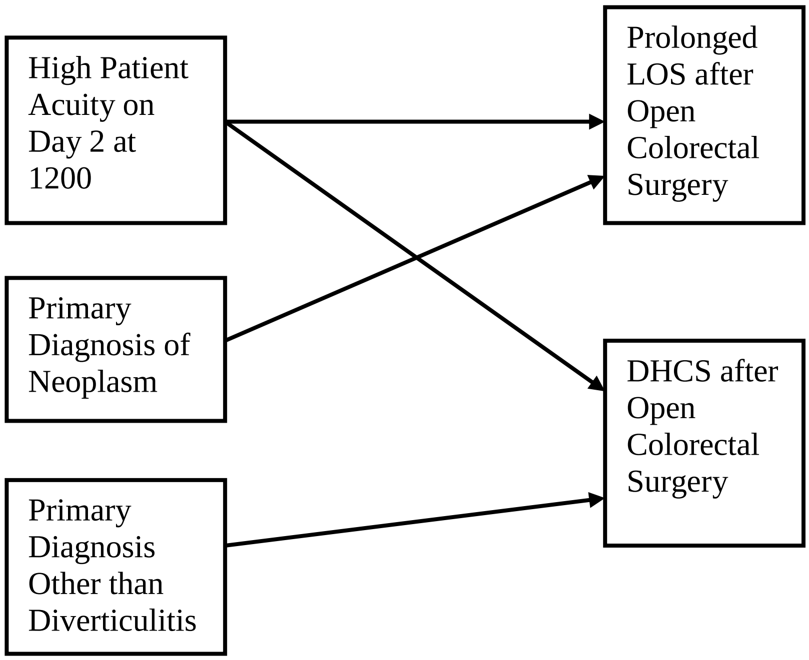
Appendix N

Analytic Model for Predicting Prolonged LOS and DHCS for DRG 330 (n=420)



Appendix O

Analytic Model for Predicting Prolonged LOS and DHCS for DRG 331 (*n*=164)



CURRICULUM VITAE

Martha Kimpton Badger

Place of birth: Peoria, IL

Education:

R.N., Halifax Infirmary Hospital School of Nursing, July 1991
Major: RN Diploma

B.N., Western Sydney University, April 1996
Major: Bachelor of Nursing

B.S.N., University of Massachusetts Boston, December 2001
Major: Bachelor of Science in Nursing

M.S.N., Walden University, April 2013
Major: Nursing Informatics

Dissertation Title: Patient Acuity as a Predictor of Length of Hospital Stay and Discharge Disposition After Open Colorectal Surgery

Awards/Honors:

Chancellor's Graduate Student Award, 2013-2017
Graduate Student Scholarship, 2013-2014
Distinguished Graduate Student Fellowship, 2014-2015
Harriet Werley Informatics Research Fellowship, 2014-2015
Nurses Educational Funds, Inc., Scholarship, 2014-2016
Sigma Theta Tau International Honor Society of Nursing Graduate Scholarship, 2015
Graduate Student Excellence Fellowship, 2016-2017
Phi Kappa Phi Honor Society

Publications:

Coenen, A., Bartz, C.B., & Badger, M.K. (2015). Global eHealth and Informatics. In V. Saba & K. McCornmick (Eds.), *Essentials of nursing informatics* (6th ed.)(pp. 727-738). New York, NY: McGraw-Hill Education.

Topaz, M., Ronquillo, C., Pruinelli, L., Ramos, R., Peltonen, L., Siirala, E., Atique, S., Hamann, G., & Badger, M.K. (2015). Central trends in nursing informatics: Students' reflections from International Congress on Nursing Informatics 2014 (Taipei, Taiwan). *CIN: Computers, Informatics, Nursing, 33*(3), 85-89. doi: 10.1097/CIN.0000000000000139.

Presentations:

Hook, M.L., & Badger, M.K. (2015, April). Using implementation theory to evaluate the impact of technology to support evidence-based practice and patient outcomes in acute care. Poster presented at annual Midwest Nursing Research Society Conference, Indianapolis, IN.

Badger, M.K. (2016, April). Using a computerized information system to examine the relationship between inpatient unit acuity and nurse staffing: A pilot study. Poster presented at annual American Nursing Informatics Association Conference, San Francisco, CA.

Mielkarek, F., Badger, M.K. (2016, June). EHR downtime and recovery planning: Panic prevention. Summer Institute of Nursing Informatics (SINI), University of Maryland School of Nursing, Baltimore, MD.

Topaz, M., Ronquillo, C., Badger, M.K., et al., (2016, November). Nurse Informaticians Report Low Satisfaction and Multi-level Concerns with Electronic Health Records: Results from an International Survey. American Medical Informatics Association (AMIA) Annual Conference, Chicago, IL.

Badger, M.K. (2016, November). Cerner Clairvia®: Trends and Innovations in Managing Workforce. Podium presentation at annual Cerner Healthcare Conference, Kansas City, MO.

University Service:

- Graduate School Scholastic Appeals Committee, 2015-2017
- Doctoral Nurses Student Organization, 2013-2017

Affiliations/Memberships:

- The Honor Society of Phi Kappa Phi
- Sigma Theta Tau International Honor Society of Nursing, Eta Nu Chapter
- University of Wisconsin Milwaukee Doctoral Nurses' Student Organization
- American Nurse Informatics Association (ANIA)
- Health Information and Management Systems Society (HIMSS)
- International Health Terminology Standards Development Organization (IHTSDO)
- Clinical and Translational Science Institute (CTSI) of Southeast Wisconsin
- International Medical Informatics Association (IMIA) – Nursing Informatics Students' Working Group, Executive Committee Member
- Midwest Nursing Research Society (MNRS)
  - Research Interest Group: Health Systems Policy and Informatics
  - Research Interest Group: Research Through Academic-Clinical Partnerships