EFFECT OF PROVIDERS' PROCEDURAL VOLUME COMPLEXITY ON IN-HOSPITAL COMPLICATIONS AND LENGTH OF STAY FOR GASTRIC BYPASS SURGERY

by

Shital P. Kamble

A dissertation submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
Health Services Research

Charlotte

2009

Approved by:

_____
Dr. James Studnicki

_____
Dr. Jennifer Troyer

_____
Dr. Larissa Huber

_____
Dr. Jacek Dmochowski

_____
Dr. Susan Sell

ABSTRACT

SHITAL KAMBLE. Effect of providers' procedural volume complexity on in-hospital complications and length of stay for gastric bypass surgery. (Under the direction of DR. JAMES STUDNICKI)

Obesity and morbid obesity represent one of the major public health problems in the United States (U.S.) that affects nearly one-third of the adult American population. Gastric bypass (GB) is a complex operation, performed in a high-risk morbidly obese population, requiring well-trained surgeons and well-equipped hospital facilities to ensure optimal surgical outcomes. The volume-outcomes relationship is well-established for providers (both surgeons and hospitals) performing GB procedures. However, the findings of improved outcomes after GB for high volume providers have been attributed only to the high volume of GB and not the volume of other non-gastric bypass (non-GB) procedures. The studies in this dissertation were undertaken to examine the effect of provider's (general surgeon and hospital) non-GB complex (non-GB_C) and non-complex (non-GB_{NC}) volume on in-hospital complications and length of stay (LOS) for patients undergoing GB.

The population-based studies used a combination of various existing retrospective data to address the research objectives. The datasets used include: a two-year (2003-2004) Florida hospital inpatient discharge data as the main analytic dataset, the 2003-2005 work Relative Value Units (RVU) data (available from the Physician Fee Schedule from the Centers of Medicare and Medicaid, to segment the provider's non-GB case load into non-GB_C and non-GB_{NC} procedures performed by a provider per year), 2005 Florida hospital characteristics file, 2005 Florida surgeon characteristics file, and 2004 Area

Resource File data. Separate generalized estimating equation (GEE) regression models, adjusting standard errors for the non-nested surgeon and hospital cluster effect, were constructed for each outcome: composite complications (one or more complications), technical complications (including unexpected reoperations, splenic injury, hemorrhage, anastomotic leaks, small bowel obstructions, and wound), systemic complications (including pulmonary, cardiac, thromboembolic, genitourinary tract, and postoperative shock), and LOS. Covariates included were patient characteristics, year, surgeon GB volume, and hospital characteristics.

In adjusted analyses, the gastric bypass patients operated by general surgeons with high non-GB_{NC} volume (>142 procedures/year) had 70% and 88% higher likelihood of composite and systemic complications, respectively. In contrast, those operated at hospitals with high non-GB_{NC} volume (>6,478 procedures/year) had 49% and 40% lower likelihood of composite and technical complications, respectively. There was no clear association between providers' high non-GB_{C} volume and adverse outcomes. Furthermore, patients operated by general surgeons with high GB volume (>50 GBs/year) had 27% and 41% lower likelihood of composite and systemic complications, respectively. However, those operated at hospital's with high GB volume (>125 GBs/year) had 30% lower likelihood of technical complications. The study findings suggest that while provider GB volume matters for in-hospital complications, the complexity of overall surgical load also matters for general surgeons but the overall scale matters for hospitals to deliver better in-hospital outcomes for GB. In particular, the outcomes may improve if GB patients avoided general surgeons with a high volume of non-complex procedures and if GB patients avoided hospitals with low total volume.

DEDICATION

To my family

ACKOWLEDGEMENTS

First, I would like to express my sincerest gratitude to my committee members, Dr. James Studnicki, Dr. Jennifer Troyer, Dr. Larissa Huber, Dr. Jacek Dmochowski, and Dr. Susan Sell for their insightful comments, guidance, and support. I would like to thank Dr. Keith Gersin at the Carolinas Medical Center, Charlotte, NC, for providing his thoughtful suggestions and for helpful discussions. I extend special thanks to my advisor, Dr. James Studnicki for his invaluable mentorship, continued encouragement, and advice throughout my graduate career to help me become a researcher. I would like to express my appreciation to the faculty and staff for their support and care throughout the years. I would also like to thank my fellow graduate students for making my time at UNCC a memorable experience. Finally, I would like to thank my family. Thanks to my parents, Prashant and Asha, my sister, Ashwini, my lovely niece, Kriti, my parents-in-law, Manoj and Mita, and my brother-in-law, Niraj, for their love, patience, and never-ending encouragement to do my best. And thank you to my husband, Harshal, for always believing in me, supporting me, and loving me, through all the good and bad times I had during this period. Thank you all!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: BACKGROUND AND LITERATURE REVIEW

Introduction

There is more than three decade of literature focusing on the volume-outcome relationship, i.e., providers performing more surgical procedures of a particular type have better outcomes for that procedure. Most of the research work is focused on the volume of a high-risk complex procedure, including gastric bypass, and the improved outcomes are attributed only to the volume of that "specific" procedure. There are a few studies examining the association of hospital volume of different complex procedures (non-specific volume) and outcomes for a certain high-risk complex procedure. For example, the studies only focused on the effect of hospital volume for pancreatic resection on outcomes for colorectal resection. Procedures for studying hospital non-specific volume-outcome relationship included colorectal resection, pancreatic resection, lung resection, esophagectomy, coronary artery bypass graft, percutaneous coronary intervention, and abdominal aortic aneurysm repair. However, none of these studies included provider non-complex procedure volume and none have studied gastric bypass.

Gastric bypass is one of the target procedures for volume-based regionalization and is typically done by general surgeons at hospitals performing several other non-gastric bypass procedures. The population-based studies in this dissertation demonstrate the effect of providers' (surgeons and hospitals) non-specific (i.e., non-gastric bypass) volume on in-hospital complications and total length of stay for gastric bypass patients.

The studies in this dissertation use work Relative Value Units component as a proxy for procedural complexity, from the Centers for Medicare and Medicaid Physician Fee Schedule, to segment providers' total surgical practice into complex and non-complex procedures. This allows studying the effect of providers' non-gastric bypass (both complex and non-complex procedural volume) on adverse in-hospital outcomes for gastric bypass patients.

Obesity and Morbid Obesity in the United States

Obesity and morbid obesity represent one of the major public health problems in the United States (U.S.) that affects nearly one-third of the adult American population (approximately 60 million obese and 9 million morbidly obese).[1] One of the most common and biologically relevant measurement tool to determine obesity is body mass index (BMI), defined as weight in kilograms (kg)/height^2 in meters (m^2). Obesity is defined as BMI $\geq$30 kg/m^2 and morbid obesity (also known as extreme obesity or clinically severe obesity) is defined as BMI $\geq$40 kg/m^2. Morbid obesity is a disease of excess energy stores in the form of fat.[2] According to the National Health and Examination Survey (NHANES), about 32.2% of adults in the U.S. were obese and approximately 4.8% adults were morbidly obese during 2003-2004.[3] The prevalence of morbid obesity has increased between the years 1986 and 2005.[4-6] According to the Behavioral Risk Factor Surveillance System (BRFSS), the prevalence of individuals with a BMI $\geq$40 kg/m^2 quadrupled from 1:200 in 1986 to 1:50 in 2000 and the prevalence of individuals with a BMI $\geq$50 kg/m^2 quintupled from 1:2000 to 1:400.[4, 5] In addition, from 2000 to 2005, the prevalence of individuals with a BMI $\geq$40 kg/m^2 increased by 50% and

the prevalence of individuals with a BMI ≥50 kg/m^2 increased by 75%, two and three times faster, respectively.[6]

Accompanied with the increasing burden of obesity and morbid obesity, are major health consequences and rising economic costs. Obesity and morbid obesity are known risk factors for mortality,[7-14] with approximately 112,000 excess deaths associated with obesity each year in the U.S.,[11] and a number of chronic diseases including type-2 diabetes,[14-21] coronary heart disease (CHD)[13, 22-25] and mortality from CHD[22], hypertension,[14, 26-28] hypertrophic cardiomyopathy,[14, 29] hyperlipidemia,[14, 30] stroke,[31, 32] sleep apnea,[33-36] gall bladder disease,[14, 37-40] liver disease,[41-44] osteoarthritis,[14, 45-47] breast cancer,[48, 49] endometrial cancer,[50, 51] colon cancer,[52-54] hypoventilation,[14, 55] and psychosocial impairments[14, 56] including depression[14, 57, 58] The total annual medical spending for overweight (defined as BMI between 25 and 29.9) or obesity is estimated to be $92.6 billion in 2002 dollars.[59] Obesity solely accounted for 5.3% of medical spending for the adult population in the U.S.[59] The total medical expenditures for obese adults ranged from $26.8 billion (estimates from 1998 Medical Expenditure Panel Survey data) to $47.5 billion (estimates from National Health Accounts data).[59] The majority of spending for obese patients can be attributed to treatment of heart disease, hyperlipidemia, and diabetes.[60]

Bariatric Surgery (Gastric Bypass) Procedures in the United States

Bariatric Surgery as a treatment for Morbid Obesity

Bariatric surgery has been identified as the only effective treatment associated with documented, substantial, and maintained weight loss as well as the amelioration of obesity comorbid conditions in persons with morbid obesity or for those with a BMI ≥35

kg/m^2 who have a significant comorbidity, such as hypertension, diabetes, and/or sleep apnea.[61-68]

In the 1950s, bariatric surgery was evolved from the jejunoileal (JI) bypass, a prototype of the malabsorptive (described below) obesity operations. Although the JI bypass was a highly effective weight-reduction operation, it was associated with several complications including gas-bloat syndrome, steatorrhea, electrolyte imbalance, nephrolithiasis, hepatic fibrosis, cutaneous eruptions, and impaired mentation.[69-71] More extensive malabsorptive variations were developed that consisted of gastric bypasses with a long Roux limb. The first gastric bypass (GBP) was developed by Mason and Ito[71, 72] in 1966, where the stomach was divided horizontally and a loop gastrojejunostomy was created between the proximal gastric pouch and the proximal jejunum. Due to bile reflux problems associated with loop, Mason and Printen[71, 73] later reduced the pouch size to ≤50 ml to increase weight loss, and reduced ulcer formation by including the acid-secreting mucosa in the distal stomach. There were several variations and advances in the gastric bypass procedures over time[71, 74-81] and the varied types of bariatric procedures are described below.

Depending on the mechanism by which weight loss is promoted, bariatric procedures are divided into the following groups: (1) restrictive, (2) a combination of restrictive and malabsorptive, or (3) malabsorbtive.[82] Restrictive surgical procedures decrease the capacity of the stomach, thereby limiting the volume of food consumed before the feeling of satiety occurs. Gastroplasty, including vertical banded gastroplasty (VBG) and silastic ring vertical gastroplasty (SRVG) and gastric banding procedures such as adjustable silicone gastric banding (ASGB) are examples of restrictive

procedures. Combination surgical procedures are those that bypass part of the digestive tract, usually with a decrease in stomach capacity. Such procedures combine malabsorption and diminished stomach capacity as mechanisms for weight reduction. Roux-en-Y gastric bypass (RYGBP) and distal (extended) Roux-en-Y gastric bypass (RYGBP-E) are examples of combination procedures. Malabsorptive procedures are those that reduce nutrient absorption, typically by bypassing a part of the small intestine. Some of the examples of malabsorptive procedures are duodenal switch, biliopancreatic diversion, and isolated intestinal bypass procedures.[4, 82]

Current research shows that there are potential long-term health benefits to bariatric surgery including gastric bypass. A recent systematic review and meta-analysis of the literature found that the percentage of excess weight loss was 47.5% under gastric banding, 61.6% under gastric bypass, 68.2% under gastroplasty, and 70.1% under biliopancreatic diversion or duodenal switch bypass. Additionally, diabetes was completely resolved in 76.8% of the patients while hyperlipidemia and hypertension were improved in 70% and 61.7% of the bariatric surgery patients, respectively.[83]

Trends in Bariatric Surgeries (including Gastric Bypass) in the United States

The American Society for Bariatric Surgery estimated approximately 140,000 gastric bypass procedures were performed in the U.S. in 2005.[84] Although there is increasing prevalence of morbid obesity and growth of bariatric surgeries in the past few years in the U.S.[4] the surgeries are performed in less than 1% of the eligible individuals.[85] Santry et al. used the Nationwide Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project (HCUP) to identify U.S. bariatric surgery admissions from 1998 to 2002.[4] The researchers found that the estimated number of bariatric surgical procedures

increased from 13,365 in 1998 to 72,177 in 2002. The authors projected approximately 102,794 bariatric surgical procedures in 2003. Gastric bypass procedures accounted for more than 80% of all bariatric surgical procedures.[4] Another study using NIS data from 1998 to 2002 reported that although the estimated number of bariatric surgeries grew 400% between 1998 and 2002 and the overall bariatric surgery rate per 100,000 covered lives increased from 26.8 to 43.7 between 2001 and 2005,[83] such surgeries were performed on 0.6% of the 11.5 million adults clinically eligible (i.e., BMI ≥40 or BMI≥35 with obesity related most common comorbidity such as diabetes mellitus) in 2002.[85]

Despite the apparent long-term benefits, gastric bypass procedures are high-risk surgeries with low mortality but considerable postoperative morbidity. Santry et al. used 1998-2002 data from NIS and indicated that the adjusted in-hospital death rate for bariatric surgery, particularly gastric bypass, ranged from 0.1% to 0.2%. Some of the postoperative early complications associated with gastric bypass include anastomotic leak, pulmonary embolism, wound infection, gastrointestinal hemorrhage, cardiac complications, unexpected reoperations, and pulmonary complications.[4, 84] For example, the rates of unexpected reoperations for surgical complications ranged from 6% to 9% and pulmonary complications ranged from 4% to 7% in 1998 to 2002.[4] Encinosa et al. found an initial surgical complication rate for gastric bypass surgery in 2001-2002 of 23.8%.[86] In addition, gastric bypass is a high cost procedure. Results from 1998-2002 NIS data indicated that the national hospital costs for bariatric surgeries escalated more than six-fold, from an estimated $157 million in 1998 to $948 million in 2002 in the U.S.[85] Finally, gastric bypass procedures (1) require proficiency with the use of complex equipment, (2) are associated with an increased risk of clinically significant

complications, including death, and (3) are potential targets for volume-based regionalization, whereby patients who need a high risk procedure travel to hospitals that do a high volume (i.e., the number of surgeries that a particular hospital performs) of that procedure.[87, 88]

Provider Volume-Outcomes Relationship

Policymakers, patients, insurers, and corporate purchasers consider provider volume (hospital and/or surgeon) as a proxy for quality. Over the past three decades, many studies have demonstrated an inverse relationship between provider (hospital and/or surgeon) volume and postoperative mortality and morbidity rates for a variety of complex surgical procedures and medical conditions.[89-106] Two systematic reviews have evaluated the methodology and results of many of these studies across a broad range of conditions.[107, 108] In 2000, Dudley et al.[107] found that, among 128 studies examining 40 different procedures or conditions, approximately 79% reported a statistically significant relationship between higher hospital case volume and lower mortality outcomes; none of the published studies reported an association between higher volume and worse outcomes. In 2002, Halm et al[108] examined 135 studies for 27 procedures or conditions, many of which were also included in the previous review. This study subsequently served as a focus of the Institute of Medicine's (IOM) sponsored workshop examining the volume-outcome relationship in the context of healthcare quality.[108, 109] The authors concluded that 77% of the studies examining either hospital or physician case volume noted a statistically significant relationship between higher volume and better health outcomes; however, none of the reports found the opposite to be true.

In addition, previous studies have demonstrated that there is an effect of surgeon years of surgical experience and board certification on procedural outcomes.[110] The improved outcomes could be related to the experience and skill of the operating surgeon, which is gained by performing more procedures ("learning-by-doing" or "practice-makes-perfect" hypothesis) or to selectively referring patients to hospitals and surgeons performing more procedures.[111-113] The idea of "practice-makes-perfect" or "learning-by-doing" makes particular sense for complex surgical procedures, which often require judicious decision making and a high level of technical skill that comes with experience.[113, 114] The "volume-outcomes" studies based on the "practice-makes-perfect" hypothesis has led the Leapfrog group, a consortium of healthcare purchasers focused on patient's quality and safety, to establish minimum volume standards for surgeons for specific high-risk procedures. These procedures are: pancreatic resection, elective AAA repair, coronary artery by-pass graft (CABG), esophagectomy, percutaneous coronary intervention (PCI), aortic valve replacement, and bariatric surgery (including gastric bypass).[114] The standards act as a supplement to the performance criteria established at the hospital level. The Leapfrog group's recommendations rely on the use of the number of procedures performed by a surgeon, a structural characteristic, as a marker of quality.

Although the volume-outcome relationship is more pronounced in complex procedures, except CABG and PCI surgeries, many high-risk procedures are done infrequently (i.e., in overall low volumes).[115] In addition, such high-risk procedures are performed by hospitals and surgeons with different specialties including board certified cardiothoracic surgeons, thoracic surgeons, vascular surgeons, general surgeons or non-board certified surgeons. Also, total surgical practice is often composed of both high and

low proportions of complexity procedures. This proportion may vary depending upon the type of surgeon performing operations. In short, while some of these surgeon specialties might have a relatively homogeneous profile of operations performed, others - especially, general surgeons- might have a relatively heterogeneous profile of operations performed.[116]

The Relationship between Provider Volume and Adverse Outcomes for Bariatric (including Gastric Bypass) Procedures

Similar to many high-risk surgeries, provider volume has been demonstrated in most studies to be an important correlate of the outcomes of bariatric surgery including gastric bypass.[117-122] For example, in a study by Liu et al. the risk of serious complications including life threatening cardiac, respiratory, or medical events was 2.5 times greater in hospitals performing fewer than 50 gastric bypass procedures per year compared to hospitals that performed more than 200 gastric bypass procedures per year.[119] Table 1 represents the risk of serious complications with gastric bypass procedures by hospital procedure volume in California from 1996 to 2000.[119]

TABLE 1: Adjusted odds ratios for serious complications, by hospital volume, among patients undergoing a gastric bypass procedure in California, 1996-2000

Hospital volume (cases/year)	Hospitals, n (total n=101)	Patients, n (total n=16,232)	Adjusted Odds Ratio* (95% CI)
Very low (<50)	81	2,314	2.72 (1.57 – 4.73)
Low (50-99)	9	3,067	2.70 (1.41 – 5.20)
Medium (100-199)	7	4,240	1.30 (0.74 – 2.29)
High (200+), ref[#]	4	6,611	1.0

*Based on hospital-level cluster corrected logistic regression models adjusted for age, gender, race, and comorbidities (Deyo adaptation of the Charlson Comorbidity Score). The following patient risk factors were pronounced in each of the models: male gender, Charlson score. [#]ref, reference category.

Adapted from Liu J, et al. Characterizing the performance and outcomes of obesity surgery in California. The American Surgeon, 2003; 69(10):823-828.

Likewise, more recently, Weller and colleagues used 2003 New York inpatient discharge data and reported that there was a considerably higher likelihood of postoperative complications among surgeons performing ≤100 (vs. >100) bariatric procedures and for those performing ≤ 150 (vs. >150) after risk adjustment.[105] Table 2 represents the main findings of this study.

TABLE 2: Adjusted odds ratios for one or more postoperative complications versus no complications, by surgeon volume, among patients undergoing a bariatric procedure in New York State, 2003

Surgeon volume	surgeons, n (total n=147)	n (total n=7,868)	Adjusted Odds Ratio* (95% CI)
>25	65	7,232	1.0
≤25	82	636	1.35 (0.90 - 2.0)
>50	49	6,631	1.0
≤50	98	1,237	1.15 (0.79 - 1.66)
>100	29	5,298	1.0
≤100	118	2,570	2.39 (1.59 - 3.59)
>150	16	3,751	1.0
≤150	131	4,117	2.05 (1.29 - 3.25)

*Based on generalized estimating equations models that were adjusted for age, gender, race/ethnicity, and comorbidities (congestive heart failure, cardiac arrhythmia, uncomplicated hypertension, other neurologic disorders, COPD, uncomplicated diabetes, liver disease, and peptic ulcer disease). The following patient risk factors were pronounced in each of the models: male gender, black race/ethnicity, and congestive heart failure, cardiac arrhythmia, and other neurologic disorders. ref, reference category.

Adapted from Weller WE and Hannan EL. Relationship between provider volume and postoperative complications for bariatric procedures in New York State. J Am Coll Surg 2006; 202:753–761.

The Relationship between Provider Volume of Non-Specific Procedures and Adverse Outcomes for High-Risk Surgical Procedure(s)

Prior studies have demonstrated that improved outcomes of a high-risk surgical procedure have been attributed to hospitals and surgeons performing high volume of that "specific" procedure[96, 98-103, 109, 123] but very few studies have focused their work on the association of provider volume for "non-specific" procedures and risk of mortality/other adverse outcomes related to a particular high-risk procedure. This section reviews the

volume-outcome studies focused on the hospital/surgeon volume of non-specific complex procedures.

In 2004, Urbach et al. investigated the association between procedure-specific/unrelated procedure volume and 30-day mortality following esophagectomy (ESO), excision of a segment of the colon or rectum for colorectal cancer, major lung resection (lobectomy or pneumonectomy) for lung cancer, repair of unruptured abdominal aortic aneurysm (AAA), and pancreaticoduodenectomy.[124] The researchers abstracted electronic records to identify hospital discharges in Ontario, Canada between 1 April 1994 and 31 March 1999 and linked these records to a database of vital statistics to obtain the vital status of the individual patients. Average hospital volume of each surgical procedure was calculated on the basis of the number of identical procedures done at the hospital over the five year study period. Hospital volume was further dichotomized into two volume categories (high volume hospitals and low volume hospitals) at the median cutoff of the average annual hospital volume. The estimates were adjusted for age, sex, Charlson comorbidity score (based on 19 conditions with weights on each and is widely used in administrative claims datasets as a means of adjusting for the higher mortality risks associated with comorbidities),[125] and accounted for hospital-level clustering. 30 day mortality appeared to be inversely related not only to the hospital volume of the same procedure, but also to the hospital volume of most of the other procedures with the exception of colorectal resection. In addition, the association of hospital volume of lung resection and mortality from pancreaticoduodenectomy (OR=0.36, 95% CI: 0.23, 0.57 for death in hospitals with a high volume of lung resection compared with low volume) was

much stronger than the association of hospital volume of pancreaticoduodenectomy and mortality from pancreaticoduodenectomy (OR=0.76, 95% CI: 0.44, 1.32).[124]

This study had several limitations. First, the authors were not able to control for potential confounding factors such as a patient's race/ethnicity, insurance status, admit-type, and whether the hospital was urban/rural hospital. Second, the authors did not account for the surgeon volume in their model. As surgeon volume is inversely associated with the adverse outcomes after the surgery, it could be an effect modifier. At the same time, it is possible that surgeon and hospital volumes are positively correlated, thus the surgeon volume could be a confounder which might under/over-estimate the true association. Third, the authors have only considered the effect of hospital volume of an individual non-specific complex procedure on 30-day mortality for one of the above five surgical procedures as opposed to considering the hospital volume of non-specific complex procedures in totality. By doing this, one may not be able to gauge the overall impact of all non-specific complex procedures done at the hospital.

A similar study performed by Allareddy et al. (2007) focused on examining the association between procedure volume and in-hospital mortality after CABG, PCI, elective AAA repair, PAN, and ESO (5 Leapfrog group- specified procedures).[126] The researchers examined the procedure-specific volume–outcome association as well as unrelated procedure volume–outcome association using data from the Nationwide Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project for the years 2000 through 2003. The analysis sample contained all patients aged ≥18 years who underwent CABG, PCI, AAA, PAN, or ESO as the primary procedure during the hospitalization. In-hospital mortality was the outcome variable of interest. Hospital volume was computed

based on the average number of cases performed by a hospital per year- cases who were ≥18 years of age and who underwent the procedure of interest during their hospitalization (either as primary procedure or any of the secondary procedures). Hospitals were designated as either meeting or not meeting Leapfrog Group-recommended volume thresholds.

The Generalized Estimating Equation method was used to adjust for possible clustering of similar outcomes within hospitals. The models were adjusted for covariates including age, sex, admission type (elective vs. nonelective), Charlson comorbid severity index, primary diagnosis, extent/type of primary procedure, year of procedure, hospital teaching status, and hospital bed size. For all 5 procedures, hospitals that did not meet Leapfrog Group volume thresholds were associated with significantly higher odds for in-hospital mortality when compared with hospitals that met Leapfrog Group volume thresholds ($p < 0.05$). Hospital volume levels for PAN or ESO did not influence outcomes following CABG, PCI, and AAA. Similarly, hospital volumes for CABG, PCI, and AAA did not influence the outcomes for PAN or ESO.[126] Although a wide range of confounders were used in the analysis, the researchers did not adjust for race/ethnicity as a potential confounder in the multivariable models. In addition, the study was focused only on one clinical outcome, i.e., in-hospital mortality. Also, surgeon volume was not accounted for in the analysis.

Summary and Closing Remarks

The volume-outcome relationship is attributed to economies of scale.[127, 128] The quality enhancing economies of scale are based on the underlying mechanism of "learning-by-doing".[127-130] The mechanism of "learning-by-doing" a specific procedure

more frequently could be extended to the transferability of learning effects or spillover effects across the practice spectrum, i.e., performing unrelated/non-specific procedures (both complex and non-complex), depending upon the type of procedure performed by a surgeon specialty in a hospital.[129]

There is a paucity of studies examining the association between non-specific procedure volume of the provider and adverse outcomes. The recent studies focusing on the effect of hospital volume of non-specific complex procedures on in-hospital mortality of a particular high-risk surgery[124, 126] showed inconsistent results. In addition, none are focused on the effect of surgeon volume of non-specific complex procedures on adverse outcomes of a specific procedure. Moreover, previous studies are limited in considering only a few non-specific complex procedures from the entire spectrum of complex high-risk surgeries performed in the U.S.

Gastric bypass is one of the target procedures for volume-based regionalization and is typically done by general surgeons performing several other non-gastric bypass procedures. Considering the relatively heterogeneous practice profile of general surgeons and given the limited time and resource constraints the surgeons might trade-off between performing non-gastric bypass complex procedures and non-gastric bypass non-complex procedures, it would be important to understand the effect of non-specific procedural volume (both complex and non-complex procedures) on the outcomes of gastric bypass. There is no previous research related to the impact of provider's (hospital and surgeon) non-specific volume of both complex and non-complex procedures on adverse outcomes after gastric bypass.

The current study will investigate the effect of the surgeon and the hospital volume of selected non-gastric bypass surgeries (both complex and non-complex) on in-hospital clinical and resource use outcomes after gastric bypass surgery, controlling for patient-level covariates and hospital-level covariates. The current study will use 2-year data (2003-2004) and will assume a relatively steady historical volume of non-gastric bypass surgeries. In the analysis, all surgeries (excluding gastric bypass) done by surgeons or at hospitals in a year will be examined. Work Relative Value Units (Work RVUs), a proxy measure of surgical complexity,[131] obtained from Centers for Medicare and Medicaid[132] will be used to allow for the selection of non-gastric bypass procedures with complexities at least equivalent to gastric bypass. This study will use Elixhauser comorbidities in the analysis as opposed to the Charlson comorbidity index used in previous studies focused on non-specific volume. Elixhauser comorbidity measures have been shown to have better performance with administrative data compared to Charlson comorbidity index.[133] Finally, the current study will use hospital-surgeon non-nested clustering to account for surgeon non-nested structure (i.e., one surgeon may have privileges to more than one hospital), as opposed to only hospital-level clustering used in previous literature on non-specific procedural volume.

As the rates of bariatric surgery continue to rise in the U.S. and providers performing gastric bypass also perform many other non-gastric bypass procedures, it is important to determine whether the providers' non-gastric bypass procedural volume is associated with clinical and length of stay outcomes after gastric bypass. Findings from this study may (1) enhance current understanding of the volume-outcome relationship providing insights into the specificity aspect, and (2) aid policymakers, health insurers

and healthcare providers in decision-making of selectively referring patients to hospitals and surgeons with low adverse outcomes for a “specific” high-risk procedure, based upon the above mentioned provider’s non-specific volume considerations. Thus, the development of population-based information on the relationship between “non-specific” volume and outcomes would be helpful to identify potential areas for quality improvement.

CHAPTER 2: OBJECTIVES AND HYPOTHESES

The main objective of this study is to examine the association of provider (hospital and surgeon) volume of non-gastric bypass (both complex and noncomplex) procedures and the likelihood of adverse clinical and resource use events for patients undergoing gastric bypass surgery. The specific objectives and hypotheses are listed below.

OBJECTIVE # 1: To examine whether there is an association between surgeon's volume of non-gastric bypass procedures (both complex and noncomplex) and the likelihood of adverse clinical and resource use events for patients undergoing gastric bypass surgery.

$H_{1.1}$: Surgeon's high volume of *non-gastric bypass complex procedures* (Surgeon non-GB_C volume) is associated with decreased likelihood of in-hospital mortality, existence of in-hospital complications, and composite outcomes (one or more complications and death or any in-hospital complications) *for patients undergoing gastric bypass,* after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{1.2}$: Surgeon's high non-GB_C volume is associated with decreased total length of stay (LOS) *for patients undergoing gastric bypass,* after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{1.3}$: Surgeon's high volume of *non-gastric bypass noncomplex procedures* (Surgeon non-GB_{NC} volume) is associated with decreased likelihood of in-hospital mortality, existence of in-hospital complications, and composite outcomes (one or more

complications and death or any in-hospital complications) *for patients undergoing gastric bypass,* after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{1.4}$: Surgeon's high volume non-GB_{NC} volume is associated with decreased total LOS *for patients undergoing gastric bypass,* after controlling for patient-level, surgeon-level and hospital-level factors.

OBJECTIVE # 2: To examine whether there is an association between hospital's volume of non-gastric bypass procedures (both complex and noncomplex) and the likelihood of adverse clinical and resource use events for patients undergoing gastric bypass surgery.

$H_{2.1}$: Hospital's high volume of *non-gastric bypass complex procedures* (Hospital non-GB_C volume) is associated with decreased likelihood of in-hospital mortality, existence of in-hospital complications, and composite outcomes (any complication and death or in-hospital complications) *for patients undergoing gastric bypass*, after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{2.2}$: Hospital's high non-GB_C volume is associated with decreased total LOS *for patients undergoing gastric bypass*, after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{2.3}$: Hospital's high volume of *non-gastric bypass noncomplex procedures* (Hospital non-GB_{NC} volume) is associated with decreased likelihood of in-hospital mortality, existence of in-hospital complications, and composite outcomes (any complication and death or in-hospital complications) *for patients undergoing gastric bypass*, after controlling for patient-level, surgeon-level and hospital-level factors.

$H_{2.4}$: Hospital's high non-GB_{NC} volume is associated with decreased total LOS *for patients undergoing gastric bypass*, after controlling for patient-level, surgeon-level and hospital-level factors.

Note- 1) A negative direction of the association between the non-GB non-complex procedural volume and adverse outcomes was speculated in hypotheses $H_{1.3}$, $H_{1.4}$, $H_{2.3}$, and $H_{2.4}$ because (a) there is no empirical evidence focused on non-specific non-complex volume for GB or other procedures in the literature, and (b) based on the broaden concept of "learning-by-doing" mechanism and the type of procedure under study, higher non-specific non-complex procedural volume for providers may be attributed to fewer complications, lower total LOS per patient, and thus, better patient outcomes, indicating that non-specific volume matters. On the other hand, providers with higher non-specific non-complex procedural volume may be associated with worse outcomes as a consequence of distracting the provider from the core task of performing more GB procedures, indicating that volume specificity matters. Thus, increase in non-specific non-complex procedural volume effect could possibly be bi-directional.

2) Bariatric procedures, other than gastric bypass, will be allocated to the appropriate non-gastric bypass category. Based on the previous work[4, 117, 134-146] and Agency for Healthcare Research and Quality (AHRQ) patient safety indicators,[147] the in-hospital complications that occurred during the admission stay for gastric bypass surgery are classified based on ICD-9-CM codes, into two categories: technical and systemic complications. Technical complications include small bowel obstruction,[4] unexpected reoperations for surgical complications,[4, 147] postoperative hemorrhage or hematoma,[4, 147] splenic complications,[4] anastomotic complications,[4, 137, 147] and wound: *postoperative*

infection, seroma, or dehiscence.[4, 137, 147] Systemic complications include pulmonary complications: *respiratory failure or postoperative pneumonia (aspiration)*,[4, 147] cardiac complications: *cardiac arrest or insufficiency, cardiorespiratory failure or heart failure during or resulting from a procedure*,[4, 147] thromboembolism: *deep vein thrombosis (DVT) and/or pulmonary embolism*,[117, 137, 146] postoperative shock,[4, 147] and genitourinary complications.[4, 147]

The innovative feature of this research is the examination of the quality of care in a cohort of gastric bypass patients, with a focus on the relationship of providers' volume of non-specific complex procedures and clinical and resource-use outcomes using inpatient discharges. In addition, use of work relative value units, as a proxy measure of complexity, to derive provider volume for non-gastric bypass complex procedures will provide a unique perspective to understand provider's overall surgical experience.

Theoretical Framework

Objectives #1 and # 2 investigate the quality of care in patients with gastric bypass surgery by examining the association between the structure of surgical care and outcomes. These objectives are characterized by measures and methods applied in the field of health services research with a focus on the concept of Structure, Process, and Outcome. Figure 1 represents the theoretical framework that will guide the research objectives in this study.

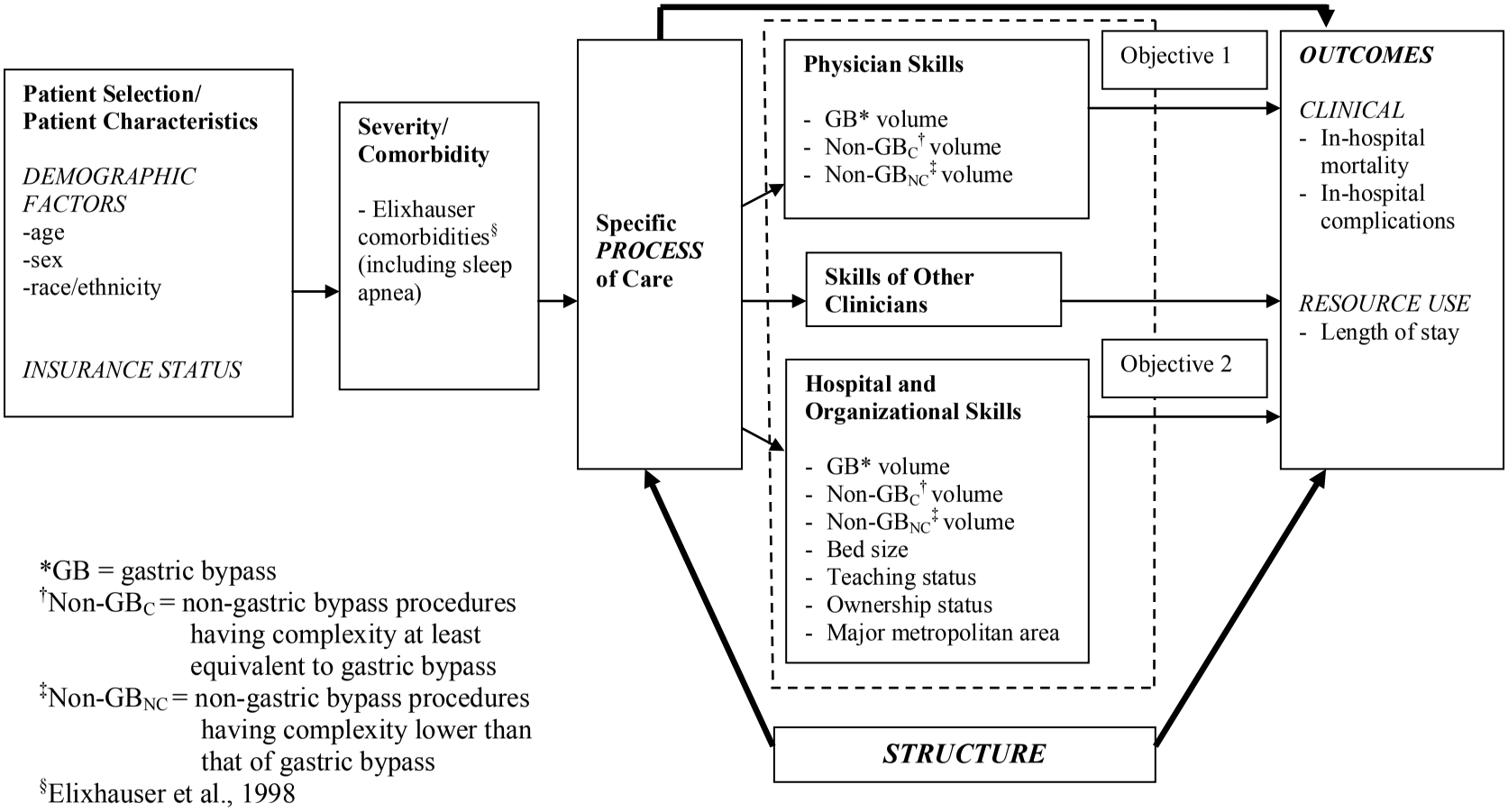


FIGURE 1: Framework for specificity aspect of provider volume-outcome association

The theoretical framework is based on the paradigm of Structure, Process, Outcome originated by Donabedian to evaluate quality of care.[148] Elements of the IOM volume-quality model have been added that allow incorporation of patient selection and patient-level characteristics that might impact surgical outcomes.[109]

Structure- could be defined as attributes of the institution where care is delivered. Structural parameters refer to inherent characteristics of the provider that could be associated with variation in quality. Provider volume is a widely studied structural measure of quality in medical/surgical care. The volume-outcome relationship varies depending upon the complexity of procedures. For high-risk complex procedures, such as pancreatic resections and esophagectomy that are performed relatively infrequently, even at high volume hospitals or by high volume surgeons, the "specific" volume-outcome association is strong.[92] In contrast, for some frequently performed and relatively standardized high-risk complex procedures such as CABG, where hospital volumes may range from 100 to more than 1000 cases per year, the "specific" volume-outcome relationship is weak.[92, 149-153] The weak relationship, where the difference in high (vs. low) provider volume effect is attenuated, could be explained by certificate of need (CON) laws and other influences which concentrate CABG cases in fewer high volume hospitals and surgeons.

Process- could be defined as whether or not good medical practices are followed, i.e., the process parameters reflect the extent to which a provider complies with the guidelines for evidence-based care.

Outcome- could be defined as the impact of the care on patient's health status. Outcomes are historically used measures of quality. For example, medical/surgical

outcomes can be in-hospital mortality, LOS, short- and long-term morbidities, and long-term survival.

In the current study, provider's (hospital and surgeon) gastric bypass volume, and non-gastric bypass volume (for both complex and non-complex procedures) will comprise the structure of care leading to the clinical outcomes of in-hospital mortality and in-hospital complications, and resource use outcomes such as LOS. From the theoretical model, it is clear that factors other than structure of care can affect clinical outcomes. Patient factors that may affect outcomes include demographic factors such as age, race/ethnicity or gender, insurance status, and comorbidities. These will be controlled for in analyses to the extent that these variables are available in the secondary databases. Patient (level-1) factors that are not available in the data and thus, will not be controlled for include lifestyle or behavioral factors such as smoking, medications, dietary interventions or exercise, or other patient self-management techniques that occur in the community outside the influence of the health care system, or possibly as a result of interactions between the patient and the health care system.

Surgeon/hospital (level 2) unmeasured factors might also be possible confounders in the study. Surgeon's years from board certification might be positively correlated to surgeon's high volume, as more number of years from board certification is indicative of more experience and potentially high volume. Similarly, surgeon's years from board certification might be negatively correlated to in-hospital mortality for their patients, i.e., surgeons with more experience will have lesser adverse outcomes for their patients.

In summary, the Donabedian quality of care framework and IOM volume quality model provides the backbone in constructing the study objectives and thereby provides guidance for analysis of the specificity aspect of volume-outcome relationship.

CHAPTER 3: METHODS

Study Design and Data Sources

The population-based cross-sectional study used a combination of retrospective data and other administrative data to address the research objectives.

Data Sources

The following existing data sources were used:

- Florida Hospital Inpatient Discharge Files (IPF) – to obtain main inpatient discharge data
- Florida Surgeon Characteristics File (SCF) – to identify board certified general surgeons
- Florida Hospital Characteristics File (HCF) – to obtain hospital variables
- Area Resource File (ARF) - to obtain hospital major metropolitan area status variable
- CMS Physician Fee Schedule Relative Value Files (RVF) – to obtain work relative value units (work RVU)- a measure for procedure complexity
- ICD-9-CM procedure/CPT procedure crosswalk – to apply work RVUs to the Florida hospital discharge data.
- CMS Florida Carrier Files (FCF) –to obtain weighted work RVUs for each ICD-9-CM procedure code in the hospital inpatient discharge file.

The gastric bypass discharges were identified using calendar year 2003 and 2004 inpatient discharge records. The inpatient records from the Florida Hospital Inpatient Discharge Files (IPF) include diagnosis and procedure information in the form of ICD-9-CM codes, demographics (age, sex, race/ethnicity, insurance), admit type, admit source, county, LOS and discharge status, as well as hospital identifier and surgeon identifier. Florida Surgeon Characteristics File (SCF) includes surgeon identifier, surgeon certification board, specialty certification area, and specialty certificate (if any). The Florida Hospital Characteristics File (HCF) includes hospital identifier, bed size, ownership status, and teaching status. The Area Resource File (ARF) includes county and major metropolitan area status variables.

All of the files listed above contain a common physician identifier and /or hospital identifier so that they can be linked. In addition, ICD9-CM procedure/ CPT crosswalk was used to link the work RVU from the CMS Physician Relative Value Files (RVF) to the Florida Hospital Inpatient Discharge Files (IPF). General descriptions of the databases are given below.

Florida Hospital Inpatient Discharge Files (IPF)

The Florida hospital inpatient discharge data is obtained from Florida's Agency for Health Care Administration (AHCA) database. The Hospital Inpatient Data Program collects discharge data from 269 inpatient healthcare facilities including Acute Care Hospitals and Short-term Psychiatric Inpatient facilities, Comprehensive Rehabilitation Inpatient facilities and Long-term Psychiatric Hospitals. Reportable events include all acute, intensive care, and psychiatric live discharges including newborn live discharges and deaths.[154] The hospital inpatient data file layout consists of the following variables

for the de-indentified patient-discharges: reporting year, reporting quarter, hospital identifier, admission type, admission source, discharge status, patient race, patient sex, zip code, principal diagnosis code, up to nine secondary diagnosis codes, principal procedure code, up to nine secondary procedure codes, principal payer, charges by revenue, total gross charges, attending physician identifier, operating physician identifier, diagnosis related group (DRG) code, refined DRG, i.e., r-DRG (if available), adjacent DRG, i.e., ADRG (if available), severity of illness (if available), risk of mortality (if available), patient age at admission, length of stay, day of the week admitted, days to procedure, patient county (Florida only), and patient State of residence. The diagnosis and procedure codes in the dataset are based on ICD-9-CM coding.[154]

Florida Surgeon Characteristics File (SCF)

The Florida practice profile data is obtained from the "Licensee Profile Master Table (All Professions)" and "Certification Supplemental File"[155] from the State of Florida Department of Health (DOH). In addition, the practice profile information[156] is available on the following websites- http://www.doh.state.fl.us/MQA/profiling/profile_about.html and http://www.doh.state.fl.us/MQA/profiling/guide.pdf. The data and /or website contain self-reported information from licensed Medical Physicians, Osteopathic Physicians, Podiatric Physicians, Chiropractic Physicians, and Advanced Registered Nurse Practitioners.[156] The practitioner's information is comprised of the following: education and training (including other health related degrees), professional and post graduate training specialty, current practice and mailing addresses, staff privileges and faculty appointments, reported financial responsibility, reported legal actions, and any board

final disciplinary action taken against the practitioner.[156] The Florida DOH website indicates that the practitioner profile data submitted by the practitioner has not been verified by the Department unless otherwise indicated.[156]

Florida Hospital Characteristics File (HCF)

Several data sources were used to build the hospital characteristics file. Data from Florida Hospital Association provides information on hospital identifier, institution name, type, address, ownership, parent system, county, beds, and congressional/house/senate districts for all 291 hospitals in Florida (http://www.fha.org/hospdir.html).[157] Data from Florida Compare Care provides information on hospital identifier, institution name, address, type of facility, teaching status, county, license type, and license expiry (http://www.floridahealthfinder.gov/CompareCare/ListFacilities.aspx).[158] Florida Agency for Health Care administration maintains facility information on the above two websites.

Area Resource File (ARF)

The basic county-specific Area Resource File (ARF) is a database containing more than 6,000 variables for each of the nation's counties. ARF contains information on health facilities, health professions, measures of resource scarcity, health status of the county, economic activity, health training programs, and socioeconomic and environmental characteristics. In addition, the basic file contains geographic codes and descriptors which enable it to be linked to many other files and to aggregate counties into various geographic groupings.[159] ARF 2004 release was be used to obtain hospital's major metropolitan area variable for the study purposes.

CMS Physician Fee Schedule Relative Value Files (RVF)

The relative value file contains information on services covered by the Medicare Physician Fee Schedule (MPFS) from years 2003-2008. For more than 10,000 physician services, the file contains the CMS HealthCare Common Procedure Coding System (HCPCS) that includes American Medical Association's Current Procedural Terminology (CPT) codes that are used primarily to identify medical services and procedures performed by physicians and other health care professionals, the associated relative value units (RVUs), a fee schedule status indicator, and various payment policy indicators needed for payment adjustment (i.e., payment of assistant at surgery, team surgery, bilateral surgery, etc.). The Medicare physician fee schedule amounts are adjusted to reflect the variation in practice costs from area to area. A geographic practice cost index (GPCI) has been established for every Medicare payment locality for each of the three components of a procedure's relative value unit (i.e., the RVUs for work, practice expense, and malpractice). The GPCIs are applied in the calculation of a fee schedule payment amount by multiplying the RVU for each component times the GPCI for that component.[160]

This study used 2003-2005 RVF files to obtain work RVUs associated with CPT codes.[132] The 2005 file is incorporated to obtain work RVUs for new procedures, for example, laparoscopic gastric bypass. The ICD-9-CM procedure codes for laparoscopic gastric bypass were available in 2004 in the Florida Hospital inpatient discharge. However, the work RVUs for laparoscopic gastric bypass procedure is available only in 2005 RVF.

ICD-9-CM procedure/CPT crosswalk

The crosswalk between CPT codes and ICD-9-CM procedure codes for years 2004 and 2005, obtained from a commercial organization, EMC Captiva, was used to link Florida hospital inpatient discharge data (IPF) to the CMS relative value file (RVF).[161]

CMS Florida Carrier Specific - Part B Physician/Supplier Procedure Summary Master Record (PSMR)

One ICD-9-CM procedure code is associated with more than one CPT codes. Therefore, Florida specific Part B summary master record (PSMR) for year 2004 was obtained from CMS to compute weighted average of work RVU, so that each ICD-9-CM procedure is assigned a unique weighted work RVU value. This PSMR file is a 100% summary of all Part B Carrier and DMERC Claims processed through the Common Working File and stored in the National Claims History Repository. The file is arrayed by carrier, pricing locality, HCPCS codes, modifier 1, modifier 2, specialty, type of service, and place of service. The summarized fields are total submitted services and charges, total allowed services and charges, total denied services and charges, and total payment amounts. This file is produced annually (1991-2007) and is usually available in July. The main variables used to obtain weighted average work RVU values for each HCPCS/CPT code included physician supplier specialty code for providing the service, type of service, place of service, and the total services count.[162]

Ethical Considerations

Permission for the use of the secondary sources of information which contain de-identified patient-discharge data in the Florida hospital in-patient database, Florida physician profile data, and Florida hospital characteristics data was obtained from the Committee of Use of Human Subjects in Research at University of North Carolina at

Charlotte, Charlotte, North Carolina, USA.

Study Population

The study population included patient-discharges (n=11,897) undergoing gastric bypass surgeries using a two-year (2003-2004) Florida hospital inpatient discharge data. Figure 2 represents the inclusion/exclusion for the study.

Inclusion

The study population included patient-discharges undergoing gastric bypass as a principal procedure performed for morbid obesity in Florida (ICD-9-CM principal procedure codes 44.31 or 44.39 with primary diagnosis ICD-9-CM codes 278.0, 278.00, 278.01, 278.1, V85.35, V85.36, V85.37, V85.38, V85.39, or V85.4)[163] or DRG code 288.[4, 120, 164]

Exclusion

i) To increase the homogeneity of gastric bypass patient cohort, discharges that were unlikely to be elective weight-loss procedures based on diagnosis codes for gastrointestinal tract neoplasm (150.0-159.9), inflammatory bowel disease (555.0-556.9), or noninfectious colitis (557.0-558.9) were excluded,[4, 120, 164]

ii) Discharges less than 18 years of age, “new born”, “urgent”/ “emergent” admit-type, and/or hospital transfer or emergency room as the admit-source was excluded from the analysis.[4, 120, 164]

As gastric bypass procedures among other gastrointestinal procedures are typically performed by general surgeons, this study considered only those patients on whom gastric bypass procedures are performed by board certified general surgeons only.

Table 3 represents the distribution of gastric bypass patients treated by surgeons at hospitals in Florida in 2003 and 2004.

TABLE 3: Distribution of gastric bypass patients, surgeons, and hospitals by year in Florida, 2003-2004

Year	Number of patients/ surgeons/ hospitals (all age groups)	Number of patients/ surgeons/ hospitals (patient age ≥18 years)
2003	6,714/ 121/ 70	6,690/ 120/ 70
2004	5,183/ 129/ 76	5,167/ 128/ 76

For the two-year period (2003-2004), there were 11,857 gastric bypass patients (age ≥18 years) operated by 160 surgeons and 81 hospitals.

Note: Gastric bypass patient-discharges were also referred to as gastric bypass patients in this dissertation.

Identification of Surgeons

The study identified an operating surgeon for gastric bypass procedures using the unique provider identification number listed in the "MD_operating" field of the inpatient file. Previous research has indicated the reliability of this approach in identifying operating surgeons.[165] The unique operating surgeon identifier in the hospital discharge database was further linked to Florida practitioners profile information to obtain the board certification information for each surgeon.[166] A surgeon was determined to be a general surgeon if the practitioners profile database indicated that he/she was certified by the American Board of Surgery or had "general surgery" as a specialty program area during his/her graduate medical education. Surgeon records containing no information regarding board certification were verified for general surgery board/specialty using the American Board of Medical Specialties (ABMS) database.[167]

The ABMS was established in 1933. It is a not-for-profit organization comprising 24 medical specialty Member Boards and it oversees the certification of physician specialists in the United States.[168] The primary function of ABMS is to assist its Member Boards in developing and implementing educational and professional standards to evaluate and certify physician specialists. The official 24 ABMS Member Boards and Associate Members are (year approved in parentheses): (1) Allergy and Immunology (1971), (2) Anesthesiology (1941), (3) Colon and Rectal Surgery (1949), (4) Dermatology (1932), (5) Emergency Medicine (1979), (6) Family Medicine (1969), (7) Internal Medicine (1936), (8) Medical Genetics (1991), (9) Neurological Surgery (1940), (10) Nuclear Medicine (1971), (11) Obstetrics and Gynecology (Incorporated 1930) , (12) Ophthalmology (Incorporated 1916), (13) Orthopedic Surgery (1935), (14) Otolaryngology (Incorporated 1924), (15) Pathology (1936), (16) Pediatrics (1935), (17) Physical Medicine and Rehabilitation (1947), (18) Plastic Surgery (1941), (19) Preventive Medicine (1949), (20) Psychiatry and Neurology (1935), (21) Radiology (1935), (22) Surgery (1937), (23) Thoracic Surgery (1971), and (24) Urology (1935).[168]

Assignment of Work Relative Value Units (RVUs) to Each Inpatient Discharge Record

Description of Work RVU

The Resource-Based Relative Value Scale (RBRVS), implemented in 1992 as a payment system for physician services provided to Medicare beneficiaries, is used by Medicare and many other third-party payers is a common source of RVUs.[169-171] The RVUs were first developed by Hsiao et al. for fair reimbursement purposes, as certain evaluation- and-management services (for example, outpatient clinic visits, inpatient consultation, etc.) used same resource inputs as certain invasive procedures but under the

customary and prevailing charge-based system, such invasive procedures were typically reimbursed at much higher rates than the evaluation- and-management services.[171, 172] The RVUs are considered as the measure of physicians' productivity, as these are values assigned to each CPT code based on the amount of physician work, practice expense, and malpractice expense involved in that CPT code.

Hsiao and colleagues conducted a telephone survey of a stratified random sample of physicians from the 1986 Physician Masterfile from American Medical Association (AMA) to determine the relative work involved in providing physician services.[173] The researchers conducted both a pilot survey and a national survey. A pilot survey had an overall response rate of 73.1% among 90 physicians surveyed and a national survey had an overall response rate of 62.5% among 3,164 physicians surveyed.[171] The dimensions of work included in the work-based scale are (1) time required to perform the procedure, (2) mental effort and judgment, (3) technical skill and physical effort, and (4) psychological stress associated with the physician's concern about the iatrogenic risk to the patient.[169-171, 174-176] Work RVUs are assigned to physicians' services in relation to standard reference procedures designed to link the scale across subspecialties.[171, 175-177] Hsiao et al. found that physicians could rate the relative amount of work of the services within their specialty directly, taking into account all the dimensions of work. Additionally, the work RVU ratings were shown to be reproducible and consistent among physicians.[171]

Previous studies have used work RVU as proxy measure for procedural complexity. For example, Davenport et al. applied the work component of RVUs as a proxy measure of operation complexity to the National Surgical Quality Improvement

Program (NSQIP) data to study whether the preoperative factors and surgical complexity are predictors of hospital costs.[131] The current study, thus, assessed the complexity of procedures performed by board certified surgeons using work RVUs.

Assignment of Work RVUs to Each ICD-9-CM Procedural Code and Discharge Record

The work RVUs were assigned to each ICD-9-CM procedural code as follows:

1) Dataset 1: The Florida hospital in-patient discharge data contains ICD-9-CM diagnostic and procedure codes but not CPT codes. Thus, the EMC Captiva ICD-9-CM Procedures/ CPT® crosswalk was used to assign CPTs to each ICD-9-CM procedure code. Dataset 1 contained all ICD-9-CM procedure codes and CPT codes associated with each ICD-9-CM procedural code from the crosswalk.
2) Dataset 2: The CMS physician fee schedule RVU files contained a unique work RVU associated with a unique CPT code.

From datasets 1 and 2: As more than one CPT codes and thus more than one work RVUs were matched with one ICD-9-CM procedure code, a weighted average of work RVU was assigned to each ICD-9-CM procedural code. The weighted average of work RVU was computed below:

3) Dataset 3: The number of times each unique CPT code performed as an inpatient surgery in Florida was obtained from Florida carrier specific PSMR file from CMS.
4) The above CPT frequency data were then linked with the ICD-9-CM codes/ CPT matched dataset containing work RVU values for each CPT codes (using combined dataset 1 and 2) to obtain a dataset containing ICD-9-CM codes, CPT codes, work RVUs, frequency for each CPT code.

5) Finally, a weighted average of work RVU was computed for each ICD-9-CM procedural code, as the frequency of CPT code procedures performed in Florida could vary.

The above steps were performed using years 2003, 2004, and 2005 work RVU data files. The 2005 RVU data file is incorporated to obtain work RVU's for new procedures, for example- laparoscopic gastric bypass. The ICD-9-CM procedure codes for laparoscopic gastric bypass were available in 2004 in Florida Hospital inpatient discharge. However, the work RVUs for laparoscopic gastric bypass procedure is available only in 2005 RVF.

The ICD-9-CM and CPT coding schemes are similar for most common procedures. However, if there are coding differences (e.g., specification of surgical detail within the CPT scheme, which is not encoded in the ICD-9-CM codes) then those CPTs were not assigned to ICD-9-CM codes.[177] Given that the ICD-9-CM/CPT procedural code crosswalk is not a one-to-one crosswalk, approximately 29.47% (913 of 3,098 ICD-9-CM codes) of missing weighted work RVU values were generated for at least one particular year. Thus, imputation of missing work RVUs was performed as follows:

1) If the weighted work RVU value was available in only one particular year (say 2005), then the same value was applied to the ICD-9-CM codes for two other years (i.e., 2003 and 2004).
2) If the weighted work RVU value was available for any two years (say 2003 and 2005), then an average work RVU value was obtained for the remaining year (i.e., 2004).

After the missing value imputation process, only 21.76% (674 of 3,098) ICD-9-CM codes with missing weighted work RVU information remained. These procedures were confirmed, for having at least equivalent complexity as gastric bypass, with Dr. Keith Gersin, a board certified general surgeon (bariatric surgeon), from Carolinas Medical Center, Charlotte, North Carolina.

Finally, the weighted work RVU for year 2003 was assigned to each Florida hospital inpatient record from 2003 and the weighted work RVU for year 2004 was assigned to each Florida hospital inpatient record from 2004.

There were 128 types of non-GB_C procedures and 341 types of non-GB_{NC} procedures done by general surgeons who performed gastric bypass as a primary procedure. The examples of non-GB_C procedures are listed below:

(1) upper gastrointestinal procedures - for example- esophagectomy not specified, partial esophagectomy, total esophagectomy, esophagostomy, pyloromyotomy, pyloroplasty, thoracic interposition, suture esophageal laceration, etc.,

(2) gastrointestinal procedures- for example- partial hepatectomy, hepatic lobectomy, choledocoenterostomy, partial gastrectomy, total gastrectomy, abdominal perineal resection, splenectomy, partial pancreatectomy, total pancreatectomy, radical pancreaticoduodenectomy, etc.,

(3) lower gastrointestinal procedures- for example- duodenal fistula closure, anal anastomosis, small bowel segment isolation, permanent ileostomy, colostomy, rectal resection, large bowel to large bowel anastomosis, etc.,

(4) other procedures- This set included few procedures related to heart (heart and pericardium repair, aorta resection and anastomosis), lung (lung lobectomy),

thyroid (for example- thyroidectomy), kidney (for example- nephroureterectomy, removal of renal dialysis shunt, etc.), vessels (for example- abdominal endarterectomy, abdominal vessel resection/anastomosis, etc.), urinary procedures (for example- bladder repair), hip procedures (for example- disarticulation of hip), oopherectomy, and musculoskeletal procedure (for example- finger reattachment).

The examples of non-GB_{NC} procedures are listed below:

(1) upper gastrointestinal procedures - for example- endoscope dilate pylorus, gastrostomy closure, replace gastrostomy tube, esophagoscopy, gastroscopy, etc.,

(2) gastrointestinal procedures- for example- mesenteric repair, cholecystostomy, cholecystectomy, peritoneal incision, etc.,

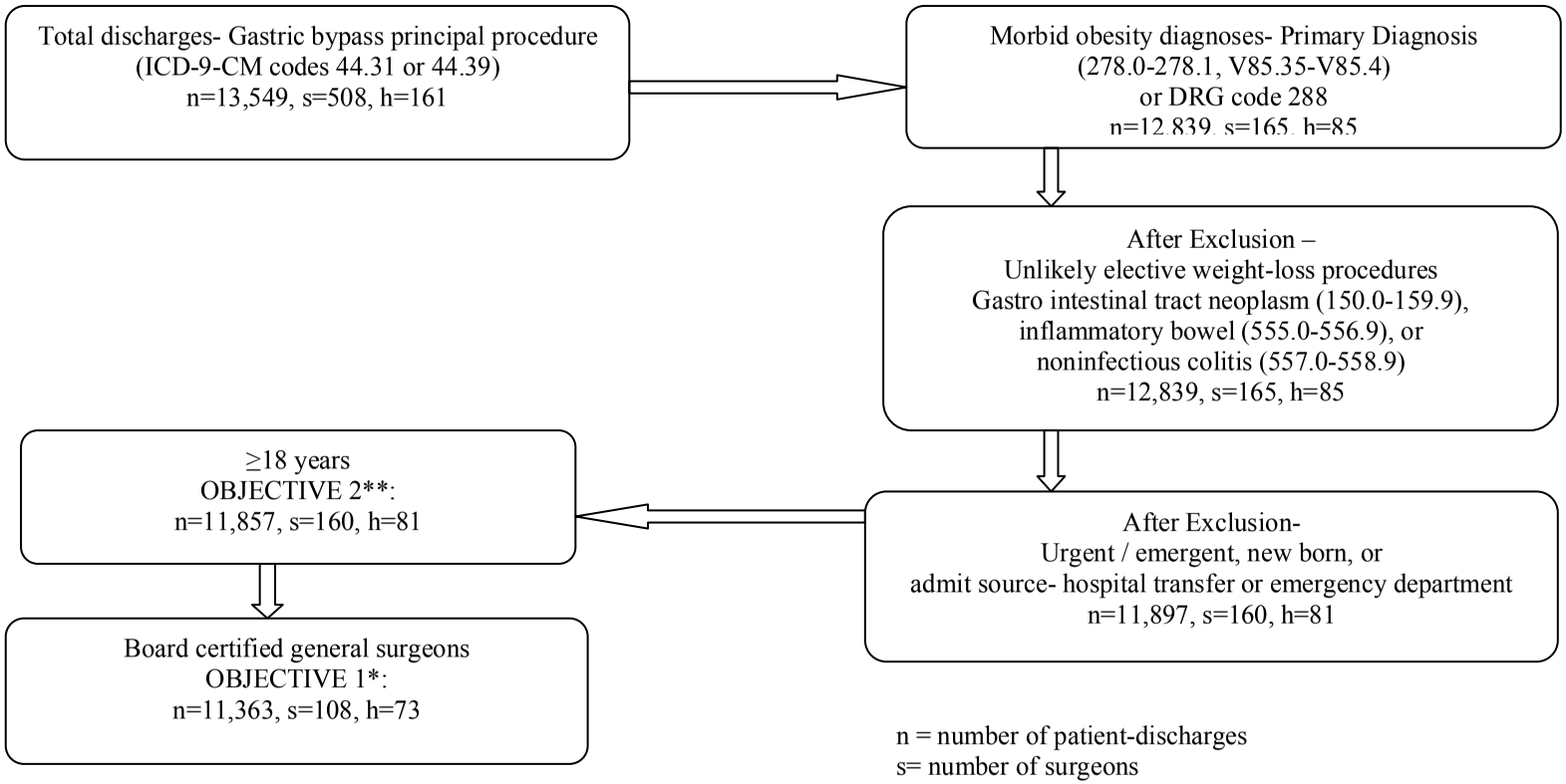
(3) lower gastrointestinal procedures- for example- dilation of anal sphincter etc., laser destruction of rectal lesion, dilation of rectum, small bowel incision, large bowel incision, etc.,

(4) diagnostic procedures- for example- diagnostic ultrasound digestive, open lung biopsy, open liver biopsy, bronchoscopy through stoma, chest wall biopsy, mediastinoscopy, open mediastinal biopsy, tibia fibula biopsy, pericardial biopsy, blood vessel biopsy, open peripheral nerve biopsy, open pancreatic biopsy, etc.,

(5) other procedures- This set included few procedures related to heart (open chest cardiac massage), lung (exploratory thoracotomy), trachea procedures (for example- tracheostomy), thyroid (for example- excision thyroid lesion),

parathyroid (for example- parathyroid reimplant), breast (for example- aspiration of breast, mastotomy, etc.), vessels (for example- freeing of vessel, suture of vein, suture of artery, etc.), pacemaker (revise or remove pacemaker, etc.), and muscle procedures (for example- myotomy, tendon sheath suture, fasciotomy, etc.)

Similarly, there were 441 types of non-GB_C procedures and 1,630 types of non-GB_{NC} procedures done in hospitals where gastric bypass was performed as a primary procedure.



NOTE:
*For OBJECTIVE 1, 78.13% (n=125) of surgeons operated only in one hospital, 14.38% (n=23) of surgeons operated in two hospitals, and 7.50% (n=12) of surgeons operated in three or more hospitals.
**For OBJECTIVE 2, 71.30% (n=77) of board certified general surgeons operated only in one hospital, 19.44% (n=21) of general surgeons operated in two hospitals, and 9.26% (n=10) of general surgeons operated in three or more hospitals.

FIGURE 2: Representation of inclusion/exclusion for the study

Main Independent Variables: Volume Assessment

Descriptions of the volume variables are given below (Table 4a).

1. Surgeon Volume of Non-gastric Bypass Procedures:

   a) Surgeon's volume of non-gastric bypass complex procedures (Non-GB_C Volume): was measured as the total number of non-gastric bypass procedures having at least equivalent complexity (work RVU $\geq$ 16.21) as gastric bypass performed by each board certified general surgeon per year.

   b) Surgeon's volume of non-gastric bypass non-complex procedures (Non-GB_{NC} Volume): was measured as the total number of non-gastric bypass procedures with complexity value less than gastric bypass (work RVU < 16.21) performed by each board certified general surgeon per year.

Only primary non-gastric bypass complex and non-complex procedures were included for computing surgeon's non-GB_C and non-GB_{NC} volume. This is because an operating surgeon can be associated only to primary procedure in the hospital discharge data.

Surgeon's non-GB_C and non-GB_{NC} volume was assessed using varied cut points shown below; as there is no evidence in the literature to use a specific recommended surgeon's non-GB_C and non-GB_{NC} volume cut point(s):

Dichotomous (top-tertile approach):

(1) low non-GB_C volume (bottom 66th percentile- reference category) vs. high volume (top 33rd percentile).

(2) low non-GB_{NC} volume (bottom 66th percentile- reference category) vs. high volume (top 33rd percentile).

For sensitivity analysis, the surgeon's non-GB_C and non-GB_{NC} volume was divided into tertiles: low, medium and high volume groups. The volume groups were created by ranking surgeons in order of increasing total volume and selecting cutoff points that most closely sort patients into three evenly sized groups with low, medium, and high volume.[12]

2. Hospital's Volume of Non-Gastric Bypass Procedures:

a) Hospital's non-GB_C volume: was measured as the total number of non-gastric bypass procedures having at least equivalent complexity (work RVU $\geq$ 16.21) as gastric bypass performed at each hospital per year.

b) Hospital's non-GB_{NC} volume: was measured as the total number of non-gastric bypass procedures with complexity value lesser than gastric bypass (work RVU < 16.21) performed at each hospital per year.

Hospital's non-GB_C volume and non-GB_{NC} volume was computed based on the primary non-gastric bypass complex and non-complex procedures done in hospital per year for the analysis purposes, as primary procedure is typically associated with the reason for hospital admission. For the additional analysis, hospital's non-GB_C volume and non-GB_{NC} volume was computed based on both primary (i.e., principal procedure) and secondary (i.e., up to nine non-principal procedures) non-gastric bypass complex and non-complex procedures done in hospital per year. This is because a hospital can be associated with any procedure (primary/secondary) performed within the same hospital in the hospital discharge data. Hospital's non-GB_C and non-GB_{NC} volume were assessed using similar measurements as those used for evaluating surgeon's non-GB_C and non-GB_{NC} volume, respectively.

Outcomes Assessment

Descriptions of the outcome/dependent variables are given below (Table 4b).

In-hospital mortality- The reported in-hospital mortality after gastric bypass ranges from 0.1 to 0.2%[37]. In-hospital mortality, defined as the mortality at any time during the hospital admission after gastric bypass procedure, was identified from discharge status variable as discharge status= 20. In the current study, the overall in-hospital mortality for gastric bypass was 0.18% (n=21 of 11,857). In addition, there were only 3 (out of 21) deaths with no complications. Thus, in-hospital mortality was not modeled either as a separate outcome variable or as a composite measure of death and/or any complications.

Postoperative In-Hospital Complications

Based on the review of previous studies related to gastric bypass complications,[4, 117, 134-146] and Agency for Healthcare Research and Quality (AHRQ) patient safety indicators,[147] the in-hospital complications based on ICD-9-CM codes were categorized into Technical and Systemic complications.

Technical Complications included unexpected reoperations for surgical complications,[4, 147] postoperative hemorrhage or hematoma,[4, 147] anastomotic complications,[4, 137, 147] small bowel obstruction,[4] splenic complications,[4] and/ or wound: *postoperative infection, seroma, or dehiscence*.[4, 137, 147] Technical complications variable was measured as a dichotomous variable (1= technical complication, 0= none) for the analysis purposes.

Unexpected reoperations for surgical complications- The rate of unexpected reoperations for surgical complications ranges from 6 to 9%.[37] Reoperations were identified as secondary procedure codes for wound dehiscence, lysis of adhesions, removal of foreign

body, laparotomy or drainage of intraperitoneal abscess (ICD-9-CM codes: 54.61, 54.51, 54.59, 54.92, 54.12 or 54.19).[37] The variable was denoted as reoperation.

Hemorrhagic complication – Hemorrhage is one of the potential complications of Roux-en-Y gastric bypass, with an incidence ranging from 0.6% to 4.4%.[75-78] Hemorrhagic complications were identified as secondary diagnosis and/or procedure codes for hemorrhage, hematoma, or blood transfusion (ICD-9-CM codes: 998.11, 998.12, 99.04, or 99.09).[37] The variable was denoted as hem.

Anastomotic complications- The incidence of leak has varied (0%–5%) in both open and laparoscopic gastric bypass.[33,85,91] For surgeons performing beyond 75 to 100 cases, the likelihood of gastrointestinal leak may be significantly reduced (0% to 1.6%).[80,33] Anastomotic complications were identified as secondary diagnosis codes for intestinal (internal) anastomosis and bypass, not elsewhere classified, persistent postoperative fistula (leak), percutaneous abdominal drainage, surgical operation with anastomosis, bypass, or graft, or other gastric/duodenal prolapse and/or rupture (ICD-9-CM codes: 997.4, 998.6, 54.91, E878.2, or 537.89).[34,37,79] The variable was denoted as leak.

Small bowel obstruction- The incidence of small bowel obstruction is up to 0.7% for open gastric bypass procedures.[4, 178] Small bowel obstruction was identified as secondary diagnosis codes in the discharge data (ICD-9-CM codes: 560, 560.0, 560.1, 560.2, 560.8, 560.81, 560.9).[4, 179] The variable was denoted as smbowel_obst.

Splenic complications- The incidence of iatrogenic splenic injuries leading to splenectomy after open gastric bypass is quite low (up to 0.41%).[4, 180] Splenic complications were identified as secondary diagnosis codes for splenic injury, and

partial/complete splenectomy (ICD-9-CM codes: 412, 414.3, 415).[4] The variable was denoted as splenic_comp.

Wound infection- The rate of wound infection following open gastric bypass may approach 25% .[83] Infection was identified as secondary diagnosis codes for postoperative infection, seroma, and dehiscence (ICD-9-CM codes: 998.5, 998.51, 998.59, 998.13, 998.3).[37] This variable was denoted as infect.

Systemic complications included pulmonary complications: *respiratory failure or postoperative pneumonia (aspiration)*,[4, 147] cardiac complications: *cardiac arrest or insufficiency, cardiorespiratory failure or heart failure during or resulting from a procedure*,[4, 147] thromboembolism: *deep vein thrombosis (DVT) and/or pulmonary embolism*,[117, 137, 146] postoperative shock,[4, 147] and/ or genitourinary complications.[4, 147] Systemic complications variable was measured as a dichotomous variable (1= systemic complication, 0= none) for the analysis purposes.

Pulmonary complications- Pulmonary complications following gastric bypass are frequent (1.4–5.8%).[80,81] Respiratory complications including prolonged mechanical ventilation for more than 96 hours (ICD-9-CM code 96.72), tracheostomy (519.0, 519.00, 519.01, 519.02, 519.09, 31.1, 31.2, 31.21, 31.29, 96.55, 97.23), pneumonia or aspiration (519.8, 997.3), respiratory failure (518.5, 518.81, 518.82, 518.84), postoperative acute pneumothorax (512.1), respiratory arrest (799.1), pulmonary edema (514, 518.4), and collapsed lung (518.0) were identified as secondary diagnosis/procedure codes for patient-discharges after gastric bypass.[37,44,79,82] The variable was denoted as resp_comp.

Cardiac complications- Cardiac complications are rare after gastric bypass. Cardiac complications were identified as secondary diagnosis codes for cardiac

arrest/insufficiency during or resulting from a procedure, acute myocardial infarction, postoperative stroke, phlebitis or thrombophlebitis from a procedure (ICD-9-CM codes: 997.1, 410, 410.0-410.9, 997.02, or 997.2).[37,79] The variable was denoted as cardiac.

Thromboembolism- Pulmonary embolus remains a leading cause of mortality following gastric bypass.[32] Studies involving open gastric bypass have demonstrated an incidence of pulmonary embolus and venous thromboembolism in the range of 0.25% to 3%.[85-90] Thromboembolism was identified as secondary diagnosis codes for acute deep vein thrombosis (DVT) and/or acute pulmonary embolism, or vascular complications for other vessels (ICD-9CM codes: 453.8, 453.9, 415.1, 415.11, 415.19, or 997.79).[37,79] The variable was denoted as pe_dvt.

Postoperative shock- Although postoperative shock is a rare outcome after open gastric bypass, previous studies and AHRQ has considered it as one of the patient safety indicators.[4, 147] Postoperative shock was identified as secondary diagnosis code (ICD-9-CM codes: 998.0) in the discharge data. [4, 147] The variable was denoted as shock.

Genitourinary complications- Although genitourinary is a rare outcome after open gastric bypass, previous studies and AHRQ has considered it as one of the patient safety indicators.[4, 147] Genitourinary complications were identified as secondary diagnosis codes for urinary tract complications, acute renal failure, acute dialysis, and/or insertion of dialysis catheter (ICD-9-CM codes: 997.5, 584, 584.5, 584.6, 584.7, 584.8,or 584.9) in the discharge data. [4, 147] The variable was denoted as genito_comp.

Composite Complications- Composite measure included one or more complications (both technical and/or systemic). Composite complications variable was measured as a dichotomous variable (1= any complication, 0= none) for the analysis purposes.

LOS- The reported means for LOS ranged from 2 to 4.5 days.[4, 117, 146, 181] LOS was defined as the number of days elapsed from the admission date to the discharge date. LOS was measured as a count variable for the analysis purposes.

Covariate Assessment

Factors known or suspected to be related to both provider (hospital and surgeon) volume and clinical and resource use outcomes were identified in the dataset.

1) Patient-discharge demographic factors included: age, sex, race/ethnicity, and payer type.

2) Patient-discharge comorbidities- The Elixhauser comorbidity algorithm was used for identifying relevant comorbid conditions.[133] The comorbidity software, version 3.0, was obtained from the Agency for Healthcare Research and Quality (http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp#download). In the health services literature, there is an extensive review of the adequacy of claims data for measurement of comorbidity and risk adjustment.[182-185] Most of the concern involves accuracy and completeness of the coding of diagnoses. Although primary data collection has advantages, the enormous expense associated with it makes it infeasible for this study.[185]

Several of the 30 comorbidities were excluded for the analysis purposes because they were the focus of the study (obesity, weight loss), or could be the result of surgery rather than a condition existing before the gastric bypass surgery (renal failure, anemia from blood loss, deficiency anemias, fluid and electrolyte disorders), or had total sample sizes less than 20 (AIDS, metastatic cancer, lymphoma, solid tumor without metastasis, peptic ulcer, alcohol abuse, drug abuse, and paralysis). In addition to Elixhauser comorbidities, sleep apnea, one of the major comorbidities for morbidly obese patients[35,

[36], was included in the analysis. Sleep apnea was identified using secondary diagnosis codes in the Florida hospital discharge data (ICD-9-CM codes: 780.51, 780.53, or 780.57).

2) Surgeon factors included surgeon gastric bypass volume. Surgeon's gastric bypass volume was measured as total number of gastric bypass procedures performed by each board certified general surgeon in a year.

3) Hospital factors included hospital gastric bypass volume, bed size, major metropolitan area (hospital county with population at least 1 million was defined as major metropolitan area), teaching status (teaching and non-teaching), and ownership status (private, government, and not-for-profit).

Hospital's gastric bypass volume was measured as the total number of primary gastric bypass procedures done in a hospital in a year. Hospital's gastric bypass volume was also measured as the total number of primary or secondary gastric bypass procedures done in a hospital in a year for the additional analysis purposes.

The hospital- and surgeon- gastric bypass volume were assessed as dichotomous variables (low vs. high) using Leapfrog Group provider volume guideline cut points.[88] Furthermore, year as a binary variable was considered as an additional covariate in the model. This is because the overall patient discharges after open gastric bypass have decreased from 2003 to 2004 (shown in the Study Population section above) in Florida, indicating the shift to laparoscopic gastric bypass surgeries. The definition and measurement of covariates incorporated in the analysis is presented in Table 4c-4e.

Data Analysis Plan

All analyses were conducted with the individual patient as the unit of analysis. Patients are nested within hospitals, patients are nested within surgeons, and a surgeon can have privileges at more than one hospital. Analyses of all clinical and resource use outcomes used the non-nested Generalized Estimating Equation (GEE) model which adjusted for the non-nested effects (surgeons and hospitals).[186-190] SAS 9.1.3 was used for data management and creating variables and STATA 10 was used for analyses purposes. For all analyses an *a priori* alpha value of 5% was considered.

For hypotheses $H_{1.1}$ through $H_{2.2,}$ the common variables considered in the models were:

Dependent variables: technical complications, systemic complications, composite complications, and LOS.

Control variables: age, sex, race/ethnicity, payer type, Elixhauser comorbidities, year, surgeon GB volume, hospital GB volume, hospital bed size, hospital major metropolitan area status, teaching status, and ownership status.

For hypotheses $H_{1.1}$ and $H_{1.2}$

Main Independent variables: surgeon non-GB_C volume and surgeon non-GB_{NC} volume.

For hypotheses $H_{2.1}$ and $H_{2.2}$:

Main Independent variables: hospital non-GB_C volume and hospital non-GB_{NC} volume.

Descriptive Statistics

For hypotheses $H_{1.1}$ through $H_{2.2}$:

Summary statistics including frequencies n (%) and means (SD) were calculated for selected characteristics for all patient-discharges, year, surgeon volumes, and hospital characteristics.

Outcomes: n (%) were for technical complications, systemic complications, composite complications, and mean (SD) as well as n (%) was computed for LOS.

Comparison of Patient-, Surgeon-, and Hospital- Characteristics by Provider Non-GB Volume

For hypotheses $H_{1.1}$ through $H_{2.4}$:

The comparison of baseline patient demographic, patient comorbidities, year, surgeon GB volume, and hospital characteristics by surgeon volume (both non-GB_C and non-GB_{NC}) categories was performed for hypotheses $H_{1.1}$ to $H_{1.4}$. Similarly, the comparison of baseline patient demographic, patient comorbidities, year, surgeon GB volume, and hospital characteristics by hospital volume (both non-GB_C and non-GB_{NC}) categories was performed for hypotheses $H_{2.1}$ to $H_{2.4}$. Chi-square statistics for categorical variables and t-test for continuous variables was used for the comparison purposes for all hypotheses.

Comparison of In-Hospital Complications and LOS Across Patient-, Surgeon-, and Hospital Characteristics

For hypotheses $H_{1.1}$ through $H_{2.4}$:

To compare the adverse outcomes across each independent variable, chi-square statistics for categorical variables and t-test for continuous variables were used. Additionally, one-way ANOVAs were used to obtain the mean LOS across independent variables with more than two categories.

Unadjusted Association Between Provider Non-GB Volume and Adverse Outcomes

For hypotheses $H_{1.1}$ through $H_{2.4}$:

To obtain the unadjusted association between provider (i.e., hospital and/or surgeon) non-GB_C and non-GB_{NC} volume and each adverse outcome for gastric bypass,

GEE model with binomial distribution and logit link function was used for dichotomous outcomes (technical complications, systemic complications, and composite complications) to obtain unadjusted odds ratios (OR) and 95% confidence intervals (CI). Likewise, unadjusted association was also obtained between each selected covariate and each adverse outcome for gastric bypass. For LOS outcome, GEE model with log link and negative binomial distribution was used to obtain unadjusted beta estimates and 95% CI for LOS.

Additionally for the sensitivity analysis purposes (for all hypotheses $H_{1.1}$ to $H_{2.4}$), the unadjusted associations between provider non-GB (both complex and non-complex procedures) volume and each adverse outcomes were obtained using the provider non-GB volume categorized as tertiles: low, medium, and high volume.

All regression analyses used surgeon and hospital non-nested clustering to obtain unadjusted effect of surgeon non-GB_C and non-GB_{NC} volume, and hospital non-GB_C and non-GB_{NC} volume on adverse outcomes.

Confounding

For hypotheses $H_{1.1}$ through $H_{2.4}$:

The known and potential confounders for the association between surgeon volume (both non-GB_C and non-GB_{NC}) and/or hospital volume (both non-GB_C and non-GB_{NC}) and the risk of adverse outcomes were selected based on the literature review. The selected confounders used in previous gastric bypass provider volume studies were reflected in the adjusted model of association[191] and are addressed in the "covariate assessment" section above.

Multivariate Analysis

For hypotheses $H_{1.1}$ through $H_{2.4}$:

Separate generalized estimating equation (GEE) regression models, adjusting standard errors for the non-nested surgeon and hospital cluster effect, were constructed to examine the effect of surgeon's non-GBC and non-GBNC volumes on technical complications, systemic complications, and composite complications, controlling for the patient-level, surgeon-level, hospital-level, and year as covariates in the model. Similarly, a multivariate GEE model with log link and negative binomial distribution was used to model the association between surgeon volume (both non-GB_C and non-GB_{NC}) and hospital volume (non-GB_C and non-GB_{NC}) and LOS, controlling for the patient-level, surgeon-level, and hospital-level and year as covariates in the model.

For hypotheses $H_{1.1}$ and $H_{2.4}$, a generic marginal regression GEE model structure can be represented as[192]:

$$\mu_i^{PA} = E(y_i)$$

So the responses are characterized by

$$g(\mu_i^{PA}) = x_i \beta^{PA}$$

$$V(y_i) = \ ^{\prime}(\mu_i^{PA}) a(\phi$$

Where,

y_i = outcome

x_i = vector of covariates associated with the parameter vector β

PA = marginal outcome averaged over the population of individuals and β^{PA} have an interpretation in terms of the response averaged over the population

V = variance matrix

μ_i = marginal expectation of the outcome

$a(\phi$ = scale parameter

g = link function

i = patient-discharge

For hypotheses $H_{1.1}$ through $H_{1.4,}$ the general form of equation is given below:

g (mean Outcome) = β_0 + β_1* (surgeon non-GB_C volume) + β_2* (surgeon non-GB_{NC} volume) + β3*(patient-level covariates) + β_4*(surgeon-level covariates) + β_5*(hospital-level covariates excluding hospital non-GB_C volume and hospital non-GB_{NC} volume) ----(I)

For hypotheses $H_{2.1}$ through $H_{2.4}$, the general form of equation is given below:

g (mean Outcome) = β_0 + β_1* (hospital non-GB_C volume) + β_2*(hospital non-GB_{NC} volume) + β_3*(patient-level covariates) + β_4*(hospital-level covariates) + β_5*(surgeon-level covariates excluding surgeon non-GB_C volume and surgeon non-GB_{NC} volume) ----(II)

For equations (I) and (II), *logit link*: logit $P(Y_i=1|X_i)$ with *binomial distribution* was used for dichotomous outcome, and *log link*: log $(Y_i|X_i)$ with *negative binomial distribution* was employed for LOS.

In all adjusted analyses, the assessment of working correlation structure and the model fit for the GEE models was based on the quasilikelihood under independence

criterion (QIC).[193] The robust standard errors, 95% CI, and p-values were computed accounting for non-nested surgeon-hospital cluster effect.

Additionally for the sensitivity analysis purposes (for all hypotheses $H_{1.1}$ to $H_{2.4}$), separate adjusted GEE regression models for each outcome were developed using the provider (hospital and surgeon) non-GB (both complex and non-complex procedures) volume as tertiles: low, medium, and high volume.

Sub-Analysis

For hypotheses $H_{1.1}$ and $H_{1.4}$:

Stratified analysis was conducted to obtain the association between surgeon non-GB volume (both non-GB_C and non-GB_{NC}) and adverse outcomes (composite measure for one or complications and LOS) by surgeon GB volume (used as a dichotomous variable with Leapfrog Group cut points) in the study population. The Breslow-Day test for homogeneity of effects (i.e., Odds Ratios) was performed for one or more complications outcome.

For hypotheses $H_{2.1}$ and $H_{2.4}$:

Stratified analysis was conducted to obtain the association between hospital non-GB volume (both non-GB_C and non-GB_{NC}) and adverse outcomes (composite measure for one or complication and LOS) by hospital GB volume (used as a dichotomous variable with Leapfrog Group cut points) in the study population. The Breslow-Day test for homogeneity of effects (i.e., Odds Ratios) was performed for one or more complications outcome.

TABLE 4a: Primary independent variables for the gastric bypass study in Florida, 2003-2004

Variable Name	Description	Type
Surgeon non-GB_C volume	Number of non-gastric bypass procedures of at least equivalent complexity than gastric bypass performed by a general surgeon in a year 0=low (≤66th percentile), 1= high (>66th percentile) 0=low volume (<33rd percentile), 1= medium volume (between 33rd and 66th percentile), 2=high volume (>66th percentile)	dichotomous/ categorical
Surgeon non-GB_{NC} volume	Number of non-gastric bypass procedures with lower complexity than gastric bypass performed by a general surgeon in a year 0=low (≤66th percentile), 1= high (>66th percentile) 0=low volume (<33rd percentile), 1= medium volume (between 33rd and 66th percentile), 2=high volume (>66th percentile)	dichotomous/ categorical
Hospital non-GB_C volume*	Number of non-gastric bypass procedures of at least equivalent complexity than gastric bypass performed in hospital in a year 0=low (≤66th percentile), 1= high (>66th percentile) 0=low volume (<33rd percentile), 1= medium volume (between 33rd and 66th percentile), 2=high volume (>66th percentile)	dichotomous/ categorical
Hospital non-GB_{NC} volume*	Number of non-gastric bypass procedures with lower complexity than gastric bypass performed in hospital in a year 0=low (≤66th percentile), 1= high (>66th percentile) 0=low volume (<33rd percentile), 1= medium volume (between 33rd and 66th percentile), 2=high volume (>66th percentile)	dichotomous/ categorical

*For main analysis, only primary procedures were counted towards volume computation. For additional analysis, primary/secondary procedures were counted towards volume computation.

TABLE 4b: Dependent variables for the gastric bypass study in Florida, 2003- 2004

Variable Name	Description	Type
technical	technical complications 1= yes, 0= no	Nominal
systemic	systemic complications 1= yes, 0= no	Nominal
any_comp	composite: one or more complications 1= yes, 0= no	Nominal
LOS	length of stay	Count

TABLE 4c: Patient demographics for the gastric bypass study in Florida, 2003- 2004

Patient-level Demographics	Description	Type
Age	Patient's age	continuous
Sex	Patient's sex 1= Male, 0= Female	Nominal
Race	Patient's race/ethnicity 1= Non-Hispanic White, 2= Non-Hispanic Black, 3=Hispanic, 4= Other	Nominal
Payer	Principal payer type 1=Medicare, 2= Medicaid, 3= Commercial, 4= Selfpay/underinsured, 5= other	Nominal

TABLE 4d: Patient comorbidities for the gastric bypass study in Florida, 2003- 2004

Patient-level Comorbidities	Description	Type
Elixhauser Comorbidities	Based on ICD-9-CM codes	
chf	congestive heart failure 1= Yes, 0= No	Nominal
arryth	cardiac arrythmia 1= Yes, 0= No	Nominal
valve	valvular disease 1= Yes, 0= No	Nominal
pulmcirc	pulmonary circulation disease 1= Yes, 0= No	Nominal
perivasc	peripheral vascular disease 1= Yes, 0= No	Nominal
htn_c	hypertension 1= Yes, 0= No	Nominal
neuro	other neurologic disorder 1= Yes, 0= No	Nominal
chrnlung	chronic pulmonary disease 1= Yes, 0= No	Nominal
dm	diabetes mellitus without chronic complications 1= Yes, 0= No	Nominal
dmcx	diabetes mellitus with chronic complications 1= Yes, 0= No	Nominal
hypothy	hypothyroidism 1= Yes, 0= No	Nominal
liver	liver disease 1= Yes, 0= No	Nominal
arth	rheumatoid arthritis 1= Yes, 0= No	Nominal
coag	coagulopathy 1= Yes, 0= No	Nominal
psych	psychoses 1= Yes, 0= No	Nominal
depress	depression 1= Yes, 0= No	Nominal
sleep_apnea	sleep apnea 1= Yes, 0= No	Nominal

TABLE 4e: Surgeon, hospital, and year variables for the gastric bypass study in Florida, 2003-2004

Variables	Description	Type
Surgeon-level		
surgeon GB volume	surgeon's gastric bypass volume/year based on Leapfrog group standards 1= high (>50 procs/yr), 0= low (≤50 procs/yr)	dichotomous
Hospital-level		
hospital GB volume	hospital's gastric bypass volume/year based on Leapfrog group standards 1= high (>125 procs/yr), 0= low (≤125 procs/yr)	dichotomous
bed size	number of beds in a hospital	continuous
teaching hospital	teaching status 1=teaching, 0=non-teaching	dichotomous
hospital location	major metropolitan area 1=hospital county population<1 million, 0=hospital county population≥1 million	dichotomous
ownership	ownership status 1= not-for-profit/government, 0=for-profit	categorical
Year_dummy	Year 1=2004, 0=2003	dichotomous

CHAPTER 4: RESULTS

Descriptive Statistics

Tables 5-7 present the summary statistics for gastric bypass patients used in the analyses of general surgeon non-GB (both non-GB_C and non-GB_{NC}) volume effect (hypotheses $H_{1.1}$ through $H_{1.4}$) and hospital non-GB (both non-GB_C and non-GB_{NC}) volume effect (hypotheses $H_{2.1}$ through $H_{2.4}$). A total of 11,363 and 11,857 patients were used in the analyses of general surgeon non-GB volume effect and hospital non-GB volume effect, respectively.

Demographic Characteristics

The demographic characteristics – age, sex, race/ethnicity, and insurance- of the study population used in the analyses are described below (table 5).

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Overall, the gastric bypass patients operated by board certified general surgeons had a mean (Standard Deviation: SD) age of 42.5 (10.8) years, and a majority (71.35%) of patients were less than 50 years of age. In addition, a majority of gastric bypass patients were females (81.38%), white (69.82%), and had private insurance (80.32%).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

Overall, the gastric bypass patients operated at hospital had a mean (Standard Deviation: SD) age of 42.5 (10.8) years, and a majority (71.58%) of patients were less than 50 years of age. In addition, a majority of gastric bypass patients were females

(81.25%), white (69.22%), and had private insurance (79.83%).

Patient Comorbidities

The patient comorbidities- selected Elixhauser comorbidities- for the study population used in analyses are described below (Table 5).

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Overall, 79.00% of gastric bypass patients operated by general surgeons had at least one comorbidity among the selected comorbidities determined by Elixhauser et al.[133] The major comorbidities for gastric bypass patients operated by board certified general surgeons were hypertension (51.08%), sleep apnea (32.76%), and diabetes mellitus both with and without chronic complications (26.27%), depression (15.22%), chronic pulmonary disease (14.60%), and liver disease (9.82%).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

Overall, 79.24% of gastric bypass patients operated at hospitals had at least one comorbidity among the selected comorbidities determined by Elixhauser et al.[133] The major comorbidities for gastric bypass patients operated at hospitals were hypertension (51.24%), sleep apnea (33.36%), diabetes mellitus- both with and without chronic complications (26.28%), depression (15.43%), chronic pulmonary disease (14.71%), and liver disease (9.87%). These results were similar to the above analysis restricted only to patients operated by general surgeons.

Year

For hypotheses $H_{1.1}$ through $H_{2.4}$:

Approximately a higher proportion of gastric bypass patients (56.60% and 56.42%) were operated in 2003 when considering surgeon non-GB volume analysis

(hypotheses $H_{1.1}$ through $H_{1.4}$) and hospital non-GB volume analysis (hypotheses $H_{2.1}$ through $H_{2.4}$) respectively (Table 5).

Surgeon Volume Characteristics (at patient-level)

The surgeon volume characteristics - non-GB_C, non-GB_{NC}, and GB volume- of the study population used in analyses are described below (Table 6).

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Overall, the gastric bypass patients were operated by board certified general surgeons who had a non-GB_C volume with a mean (SD) of 41.51 (31.45) non-GB_C procedures per year, non-GB_{NC} volume with a mean (SD) of 112.08 (81.65) non-GB_{NC} procedures per year and GB volume with a mean (SD) of 174.63 (107.66) GB procedures per year. A majority of patients were operated by general surgeon with low non-GB_C volume with ≤50 procedures per year (73.84%), low non-GB_{NC} volume with ≤142 procedures per year (75.72%), and high GB volume with >50 procedures per year (85.05%).

Note- The surgeon's non-GB_C and non-GB_{NC} volume (low vs. high) cut-points were based on top-tertile (upper 33rd percentile) approach and the GB volume cut-points were based on volume standards indicated by Leapfrog Group.[194]

For hypotheses $H_{2.1}$ through $H_{2.4}$:

Overall, the gastric bypass patients were operated by surgeons in hospitals having a mean (SD) GB volume of 169.10 (108.81) procedures per year. A majority (83.36%) of patients were operated by surgeons in hospitals with high GB volume (>50 GB procedures per year).

Note- The hospital's non-GB_C and non-GB_{NC} volume (low vs. high) cut-points were based on top-tertile (upper 33rd percentile) approach and the GB volume cut-points were based on volume standards indicated by Leapfrog Group.[194]

Hospital Characteristics (at patient-level)

The hospital characteristics- hospital GB volume, teaching status, ownership status, major metropolitan area status, and bed size - of the study population used in analyses are described below (Table 6).

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Overall, the gastric bypass patients were operated by board certified general surgeons in hospitals having a mean (SD) GB volume of 240.80 (158.96) procedures per year. A majority (67.40%) of patients were operated by general surgeon in hospitals with high GB volume (>125 GB procedures per year).

Note- The above results presents binary hospital volume cut-points for GB volume based on volume standards indicated by Leapfrog Group.[194]

In addition, a majority of gastric bypass patients were operated at non-teaching hospitals (94.53%), hospitals with county population ≥1 million (65.10%), and those hospitals with for-profit ownership status (56.35%), and had mean (SD) bed size of 389.26 (213.72) beds.

For hypotheses $H_{2.1}$ through $H_{2.4}$:

The results presented for hospital volumes were computed using principal procedures only.

Overall, the gastric bypass patients were operated at hospitals having a mean (SD) non-GB_C volume of 2,766.10 (1970.93) non-GB_C procedures per year, non-GB_{NC} volume

of 6,178.16 (3411.02) non-GB_{NC} procedures per year and GB volume of 234.58 (159.90) GB procedures per year. A majority of patients were operated at hospitals with low non-GB_C volume with ≤2,743 procedures per year (61.33%), low non-GB_{NC} volume with ≤6,478 procedures per year (59.53%), and high GB volume with >125 procedures per year (65.46%). The results were similar when hospital volumes computed using both principal and secondary procedures were considered.

In addition, a majority of gastric bypass patients were operated at non-teaching hospitals (94.55%), hospitals with county population ≥1 million (66.44%), and those hospitals with for-profit ownership status (56.51%), and had mean (SD) bed size of 386.83 (211.10) beds.

Outcomes

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Overall, the in-hospital mortality for gastric bypass patients operated by general surgeon was low (0.18%). There were considerable composite (one or more complications), technical, and systemic complications (18.13%, 10.95%, and 9.97% respectively) and a mean (SD) length of stay of 3.41 (3.40) observed for gastric bypass patients operated by general surgeons (Table 7).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

Likewise, the overall in-hospital mortality for gastric bypass patients operated at hospitals was low (0.19%). There were considerable composite (one or more complications), technical, and systemic complications (18.39%, 11.24%, and 9.97% respectively) and a mean (SD) length of stay of 3.45 (3.49) observed for gastric bypass patients operated by general surgeons (Table 7).

Comparison of Patient-Discharge Characteristics, Surgeon Gastric Bypass Volume, and Hospital Characteristics, by Surgeon Volume of Non-Gastric Bypass Procedures (Hypotheses $H_{1.1}$ through $H_{1.4}$)

Demographic Characteristics

Tables 8 and 10 represent the comparison of demographic characteristics by surgeon volume of non-GB procedures.

Among gastric bypass patients operated by surgeons with high non-GB_C volume (>50 non-GB_C procedures/year), approximately 81.80% were females and had mean±SE age 43.12±0.20 years. Approximately 69.61% (vs. 71.97%, p=0.029) patients operated by low (vs. high) non-GB_C volume were less than 50 years of age. Compared to gastric bypass patients operated by surgeons with low non-GB_C volume, those operated by surgeons with high non-GB_C volume were more likely to be non-Hispanic White (74.53% vs. 68.16%, p<0.0001) and insured (91.76% vs. 88.75%, p<0.0001) (Table 8).

While a greater percentage of gastric bypass patients operated by surgeons with high (vs. low) non-GB_{NC} volume (>142 non-GB_{NC} procedures/year) were females (81.23%), younger having mean±SE age of 42.57±0.21 years with 71.51% of patients having less than 50 years of age, the results were not statistically significant. Compared to gastric bypass patients operated by surgeons with low non-GB_{NC} volume, those operated by surgeons with high non-GB_{NC} volume were more likely to be Hispanic (23.09% vs. 13.74%, p<0.0001) and insured (93.48% vs. 88.27%, p<0.0001) (Table 10).

Patient Comorbidities

Tables 8 and 10 represent the comparison of patient comorbidities by surgeon volume of non-GB procedures.

Among gastric bypass patients operated by surgeons with high non-GB_C volume, approximately 79.34% had the presence of one or more comorbidities. Compared to gastric bypass patients operated by surgeons with low non-GB_C volume, those operated by surgeons with high non-GB_C volume were more likely to have congestive heart failure (2.02% vs. 0.85%, $p<0.0001$), peripheral vascular disease (2.05% vs. 0.94%, $p<0.0001$), diabetes mellitus without chronic complications (26.65% vs. 24.61%, $p=0.028$), liver disease (2.12% vs. 1.55%, $p<0.0001$), and psychoses (1.11% vs. 0.69%, $p=0.028$) (Table 8).

Among gastric bypass patients operated by surgeons with high non-GB_{NC} volume, approximately 78.76% had presence of one or more comorbidities. Compared to gastric bypass patients operated by surgeons with low non-GB_{NC} volume, those operated by surgeons with high non-GB_{NC} volume were more likely to have congestive heart failure (1.88% vs. 0.92%, $p<0.0001$), hypertension (53.46% vs. 50.31%, $p=0.004$), diabetes mellitus without chronic complications (27.76% vs. 24.30%, $p=0.028$), psychoses (1.12% vs. 0.70%, $p=0.029$), sleep apnea (35.27% vs. 31.96%, $p=0.001$) and less likely to have peripheral vascular disease (0.51% vs. 1.46%, $p<0.0001$), liver disease (3.26% vs. 11.92%, $p<0.0001$), and depression (10.08% vs. 16.88%, $p<0.0001$) (Table 10).

Year

Tables 8 and 10 represent the comparison of gastric bypass patients across year, by surgeon volume of non-GB procedures.

Approximately, 68.64% (vs. 52.33%, $p<0.0001$) of gastric bypass patients were operated by surgeons with high (vs. low) non-GB_C volume in 2003 (Table 8). In contrast,

53.06% (vs. 40.31%, p<0.0001) of gastric bypass patients were operated by surgeons with high (vs. low) non-GB_{NC} volume in 2004 (Table 10).

Surgeon Volume Characteristics (at patient-level)

Tables 9 and 11 represent the comparison of gastric bypass patients across surgeon GB volume, by surgeon volume of non-GB procedures.

Among gastric bypass patients operated by surgeons with high (vs. low) non-GB_C volume, 59.22% (vs. 11.91%, p <0.0001) of patients were operated by surgeons performing >142 non-GB_{NC} procedures per year (Table 9).

Likewise, among gastric bypass patients operated by surgeons with high (vs. low) non-GB_{NC} volume, 63.79% (vs. 14.09%, p <0.0001) of patients were operated by surgeons performing >50 non-GB_C procedures per year (Table 11).

Hospital Characteristics (at patient-level)

Tables 9 and 11 represent the comparison of gastric bypass patients across hospital characteristics, by surgeon volume of non-GB procedures.

Compared to gastric bypass patients operated by surgeons with low non-GB_C volume, those operated by surgeons with high non-GB_C volume went to hospitals performing ≤125 GB as principal procedures per year (35.16% vs. 31.69%, p<0.0001) with mean±SE bed size of 355.96±3.21 (vs. 400.36±2.45, p<0.0001). When comparing the distribution of hospital beds, only 16.72% (vs. 29.65%, p<0.0001) of patients operated by surgeons with high (vs. low) non-GB_C volume went to hospitals with 500+ beds. In addition, patients operated by surgeons with high non-GB_C volume were less likely to go to teaching hospitals (2.79% vs. 6.43%, p<0.0001) and hospitals with county

population ≥1 million (57.57% vs. 67.76%) but more likely to go to hospitals having for-profit ownership status (65.07% vs. 53.13%, p<0.0001) (Table 9).

Similarly, compared to gastric bypass patients operated by surgeons with low non-GB_{NC} volume, those operated by surgeons with high non-GB_{NC} volume went to hospitals performing ≤125 GB as principal procedures per year (42.95% vs. 29.28%, p<0.0001) with mean±SE bed size of 423.14±5.24 (vs. 377.72±2.03, p<0.0001). When comparing the distribution of hospital beds, approximately 24.94% (vs. 26.70%, p<0.0001) of patients operated by surgeons with high (vs. low) non-GB_{NC} volume went to hospitals with 500+ beds. In addition, patients operated by surgeons with high non-GB_{NC} volume were more likely to go to hospitals located in the major metropolitan area with county population ≥1 million (76.51% vs. 61.44%, p<0.0001) (Table 11).

Comparison of Patient-Discharge Characteristics, Surgeon Gastric Bypass Volume, and Hospital Characteristics, by Hospital Volume of Non-Gastric Bypass Procedures (Hypotheses $H_{2.1}$ through $H_{2.4}$)

Demographic Characteristics

Tables 12 and 14 represent the comparison of demographic characteristics by hospital volume of non-GB procedures.

Among gastric bypass patients operated at hospitals with high non-GB_C volume (>2,743 non-GB_C procedures/year), approximately 81.70% were females and had mean±SE age 42.37±0.16 years. Approximately 71.89% patients operated at hospitals with high non-GB_C volume were younger (less than 50 years of age). Compared to gastric bypass patients operated at hospitals with low non-GB_C volume, those operated at hospitals with high non-GB_C volume were less likely to be non-Hispanic Black (10.53%

vs. 12.53%, p<0.0001) and more likely to be insured (92.83% vs. 87.80%, p<0.0001) (Table 12).

While a greater percentage of gastric bypass patients operated at hospitals with high (vs. low) non-GB_{NC} volume (>142 non-GB_{NC} procedures/year) were females (81.33%), with mean±SE age of 42.57±0.16 years and with70.74% of patients having less than 50 years of age, the result was not statistically significant. Compared to gastric bypass patients operated at hospitals with low non-GB_{NC} volume, those operated at hospitals with high non-GB_{NC} volume were less likely to be non-Hispanic Black (10.71% vs. 12.47%, p<0.0001) and insured (92.67% vs. 87.74%, p<0.0001) (Table 14).

Patient Comorbidities

Tables 12 and 14 represent the comparison of patient comorbidities by hospital volume of non-GB procedures.

Among gastric bypass patients operated at hospitals with high non-GB_C volume, approximately 81.66% had the presence of one or more comorbidities. Compared to gastric bypass patients operated by surgeons with low non-GB_C volume, those operated by surgeons with high non-GB_C volume were more likely to have valvular disease (2.09% vs. 1.49%, p=0.013), peripheral vascular disease (2.51% vs. 0.36%, p<0.0001), depression (17.56% vs. 14.10%, p<0.0001) and sleep apnea (38.65% vs. 30.03%, p<0.0001) (Table 12).

Among gastric bypass patients operated at hospitals with high non-GB_{NC} volume, approximately 82.08% had presence of one or more comorbidities. Compared to gastric bypass patients operated at hospitals with low non-GB_{NC} volume, those operated at hospitals with high non-GB_{NC} volume were more likely to have arrythmia (3.65% vs.

2.75%, p<0.0001), peripheral vascular disease (2.38% vs. 0.38%, p<0.0001), liver disease (14.82% vs. 6.50%, p<0.0001), depression (16.76% vs. 14.53%, p=0.001) and sleep apnea (35.64% vs. 31.82%, p<0.0001) (Table 14).

Year

Tables 12 and 14 represent the comparison of gastric bypass patients across year, by hospital volume of non-GB procedures.

Approximately, 63.90% (vs. 51.71%, p<0.0001) of gastric bypass patients were operated at hospitals with high (vs. low) non-GB_C volume in 2003 (Table 12). Likewise, 61.80% (vs. 52.77%, p<0.0001) of gastric bypass patients were operated at hospitals with high (vs. low) non-GB_{NC} volume in 2003 (Table 14).

Surgeon Volume Characteristics (at patient-level)

Tables 13 and 15 represent the comparison of gastric bypass patients across surgeon GB volume, by hospital volume of non-GB procedures.

Among gastric bypass patients operated at hospitals with high (vs. low) non-GB_C volume, a higher proportion (19.50% vs. 14.84%, p <0.0001) of patients were operated by surgeons with low GB volume (≤50 GB procedures per year) (Table 13).

Likewise, among gastric bypass patients operated at hospitals with high (vs. low) non-GB_{NC} volume, a higher proportion (17.51% vs. 16.05%, p <0.0001) of patients were operated by surgeons with low GB volume (≤50 GB procedures per year) (Table 15).

Hospital Characteristics (at patient-level)

Tables 13 and 15 represent the comparison of gastric bypass patients across hospital characteristics, by hospital volume of non-GB procedures.

Compared to gastric bypass patients operated at hospitals with low non-GB_C volume, a higher proportion of those operated at hospitals with high non-GB_C volume went to hospitals performing high volume of non-GB_{NC} procedures (>6,478 procedures) per year (87.31% vs. 10.93%, p<0.0001) and having large hospital bed size (mean±SE) 530.58±1.57 (vs. 296.20±3.39, p<0.0001). When comparing the distribution of hospital beds, a larger proportion of patients operated at hospitals with high (vs. low) non-GB_C volume went to hospitals with 500+ beds (50.40% vs. 10.48%, p<0.0001). In addition, patients operated at hospitals with high non-GB_C volume were less likely (64.89% vs. 67.42%) to go to hospitals in the major metropolitan area with county population ≥ 1 million and hospitals having for-profit ownership status (22.49% vs. 77.96%, p<0.0001) (Table 13).

Similarly, compared to gastric bypass patients operated at hospitals with low non-GB_{NC} volume, a higher proportion of those operated at hospitals with high non-GB_{NC} volume went to hospitals performing high volume of non-GB_C procedures (>2,743 procedures) per year (83.43% vs. 8.24%, p<0.0001) hospitals performing >125 GB as principal procedures per year (69.38% vs. 62.80%, p<0.0001), and large hospital bed size (mean±SE) 536.51±3.19 (vs. 285.09±1.50, p<0.0001). When comparing the distribution of hospital beds, a larger proportion of patients operated at hospitals with high (vs. low) non-GB_{NC} volume went to hospitals with 500+ beds (53.86% vs. 6.93%, p<0.0001). In addition, the patients operated at hospitals with high non-GB_C volume were less likely to go to hospitals with for-profit ownership status (31.18% vs. 73.72%, p<0.0001) (Table 15).

Comparison of In-Hospital Complications and LOS Across Patient-, Surgeon-, and Hospital-Characteristics (Hypotheses $H_{1.1}$ through $H_{2.4}$)

Tables 16 – 19 present the comparisons of the independent variables for each outcome of interest.

Composite Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

A greater proportion of patients having a composite complication (vs. no complication) was non-Hispanic White (71.50% vs. 69.45%, p=0.042), had Medicare (10.19% vs. 6.11%, p<0.0001), had at least one of the selected Elixhauser comorbidities[133] (85.78% vs. 77.50%, p<0.0001), and were operated in the year 2003 (59.51% vs. 55.95%, p=0.003). In addition, compared to patients with no complications, those having a composite complication were operated by high non-GB_C, high non-GB_{NC}, and low GB volume surgeons (28.93% vs. 25.54%, p=0.002; 33.11% vs. 22.33%, p<0.0001; 18.88% vs. 14.08%, p<0.0001, respectively). Furthermore, the patients having a composite complication (vs. no complication) were operated at hospitals with low GB volume with GB as a principal procedure, teaching hospital, hospitals with county population≥1 million, and hospitals with not-for-profit or government status (37.09% vs. 31.60%, p<0.0001; 7.6% vs. 5.00%, p<0.0001; 73.98% vs. 63.13%, p<0.0001; 49.13% vs. 42.56%, p<0.0001, respectively) (Tables 16 and 17).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

A greater proportion of patients having a composite complication (vs. no complication) had Medicare (10.73% vs. 6.21%, p<0.0001), had at least one of the selected Elixhauser comorbidities[133] (85.97% vs. 77.73%, p<0.0001), was operated by surgeons with low GB volume (20.82% vs. 15.70%, p<0.0001), was operated at hospitals

with high non-GB_C, low non-GB_{NC}, and low GB volume- based on principal procedures (40.76% vs. 38.20%, p=0.026; 61.90% vs. 59.00%, p=0.013; and 39.11% vs. 33.51%, p<0.0001, respectively), teaching hospital (7.87% vs. 4.91%, p<0.0001), hospital county population≥1 million (75.24% vs. 64.46%, p<0.0001), and with not-for-profit or government status (48.56% vs. 42.35%), (Tables 18 and 19).

Technical Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

A greater proportion of patients having a technical complication (vs. no complication) was non-Hispanic White (72.59% vs. 69.48%, p=0.016), had Medicare (9.73% vs. 6.49%, p<0.0001), and had at least one of the selected Elixhauser comorbidities[133] (83.36% vs. 78.47%, p<0.0001). In addition, compared to patients with no complications, those having a technical complication were operated by high non-GB_{NC} and low GB volume surgeons (28.22% vs. 23.80%, p=0.001; 19.29% vs. 14.42%, p<0.0001, respectively). Furthermore, the patients having a technical complication (vs. no complication) were operated at hospitals with low GB volume with GB as a principal procedure, teaching hospital, and hospitals with county population≥1 million (40.76% vs. 31.59%, p<0.0001; 9.69% vs. 4.95%, p<0.0001; 71.38% vs. 64.32%, p<0.0001, respectively) (Tables 16 and 17).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

A greater proportion of patients having a technical complication (vs. no complication) was non-Hispanic White (71.27% vs. 68.97%, p=0.031), had Medicare (10.28% vs. 6.63%, p<0.0001), and had at least one of the selected Elixhauser comorbidities[133] (83.57% vs. 78.70%, p<0.0001). Additionally compared to patients with

no complications, those having a technical complication were operated by surgeons with low GB volume (21.16% vs. 16.07%, p<0.0001) and at hospitals with low non-GB_{NC} and low GB volume- based on principal procedures (63.92% vs. 58.98%, p=0.001; 43.44% vs. 33.41%, p<0.0001, respectively). Furthermore, patients having a technical complication (vs. no complication) were operated at teaching hospitals (10.11% vs. 4.86%, p<0.0001), hospitals with county population ≥1 million (73.29% vs. 65.57%, p<0.0001), and hospitals having not-for-profit or government status (45.54% vs. 43.23%), (Tables 18 and 19).

Systemic Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

A greater proportion of patients having a systemic complication (vs. no complication) was non-Hispanic White (71.67% vs. 69.62%, p=0.016), had Medicare (11.21% vs. 6.36%, p<0.0001), had at least one of the selected Elixhauser comorbidities[133] (88.08% vs. 78.00%, p<0.0001), and were operated in 2003 (63.64% vs. 55.82%, p<0.0001). In addition, compared to patients with no complications, those having a systemic complication were operated by high non-GB_C, high non-GB_{NC}, and low GB volume surgeons (33.19% vs. 25.38%, p<0.0001; 37.61% vs. 22.80%, p<0.0001; 19.42% vs. 14.46%, p<0.0001, respectively). Furthermore, the patients having a systemic complication (vs. no complication) were operated at hospitals with larger bed size, hospitals with county population≥1 million, and not-for-profit or government status (mean±SD: 417.63±211.51 vs. 385.55±213.34, p<0.0001; 77.05% vs. 663.77%, p<0.0001; 53.13% vs. 42.71%, p<0.0001, respectively) (Tables 16 and 17).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

A greater proportion of patients having a systemic complication (vs. no complication) was male (24.70% vs. 18.09%), but lesser proportion was non-Hispanic Black (8.04 % vs. 12.17%, p<0.0001), had Medicare (11.76% vs. 6.52%, p<0.0001), had at least one of the selected Elixhauser comorbidities[133] (88.32% vs. 78.34%, p<0.0001). Additionally compared to patients with no in-hospital complications, those having a systemic complication were operated by surgeons with low GB volume (21.24% vs. 16.13%, p<0.0001) and at hospitals with high non-GB_C volume- based on principal procedures (45.09% vs. 37.96%, p<0.0001). Moreover, patients having a systemic complication (vs. no complication) were operated at hospitals with county population≥1 million (77.66% vs. 65.20%, p<0.0001) and hospitals with not-for-profit or government status (52.54% vs. 42.49%) (Tables 18 and 19).

LOS

For hypotheses $H_{1.1}$ through $H_{1.4}$:

Patients with higher LOS were females with mean (SD) of 3.36(3.36) days, non-Hispanic White with mean (SD) of 3.52 (3.61) days, had Medicare with mean (SD) of 4.59 (6.47) days , had at least one Elixhauser comorbidities[133] with mean (SD) of 3.45 (3.09) days, and were operated in the year 2003 with a mean (SD) of 3.53 (3.46) days. In addition, patients operated by surgeons with high non-GB_C, high non-GB_{NC}, and low GB had a higher mean (SD) LOS of 3.73 (2.50), 3.87 (3.36), and 3.79 (4.08) days respectively. Furthermore, those operated at hospitals with low volume GB as a principal procedure, teaching hospitals, hospitals with county population≥1 million, and hospitals

with not-for-profit or government status had a higher mean (SD) LOS of 3.44 (3.52), 4.86 (6.19), 3.50 (3.14), and 3.62 (4.16) days respectively (Tables 16 and 17).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

Patients with higher LOS were males with mean (SD) of 3.69 (3.51) days, non-Hispanic White with mean (SD) of 3.54 (3.66) days, had Medicare with mean (SD) of 4.68 (6.45) days, had at least one of the selected Elixhauser comorbidities[133] with mean (SD) of 3.45 (3.09) days, were operated in the year 2003 with mean (SD) of 3.56 (3.51) days. In addition, patients operated by surgeons with low GB volume, hospitals with high non-GB_C volume, and hospitals non-GB_{NC} volume- based on principal procedures had a high mean (SD) LOS of 3.80 (4.38) days, 3.77 (4.10) days, and 3.68 (3.75) respectively. Furthermore, those operated at teaching hospitals, hospitals with county population≥1 million, hospitals with not-for-profit or government status had a high mean (SD) LOS of 4.76 (6.10) days, 3.62 (3.14) days, and 3.62 (4.16) days respectively (Tables 18 and 19).

Note- Appendix A shows the graphical representation of in-hospital complication rates and LOS for gastric bypass patients treated by general surgeons and hospitals with high (vs. low) GB, non-GB_C, and non-GB_{NC} volumes.

Unadjusted Results for the Independent Variables and Each Outcome
(Hypotheses $H_{1.1}$ through $H_{2.4}$)

Tables 20 – 27 present the unadjusted results for the independent variables and each outcome of interest.

Composite Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

The gastric bypass patients operated by general surgeons with high non-GB_C volume had a slight increased odds of having a composite complication (OR=1.19, 95%

CI: 0.74 -1.91). However, gastric bypass patients operated by general surgeons with high non-GB_{NC} volume had 1.72 times the odds of having a composite complication and this result was statistically significant (95% CI: 1.14-2.60) (Table 20).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

The patients who had gastric bypass procedures done at hospitals with high non-GB_C volume had slight increased odds of having a composite complication (OR=1.11, 95% CI: 0.71-1.74) and non-GB_{NC} volume had slight decreased odds of having a composite complication (OR=0.89, 95% CI: 0.56-1.40) but neither of these results were statistically significant (Table 24).

Technical Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

The gastric bypass patients operated by general surgeons with high non-GB_C volume had slight decreased odds of having a technical complication (OR=0.94, 95% CI: 0.64-1.37). However, gastric bypass patients operated by general surgeons with high non-GB_{NC} volume had slight increased odds of having a technical complication (OR=1.26, 95% CI: 0.85-1.86) but this result was not statistically significant (Table 21).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

The patients who had gastric bypass procedures done at hospitals with high non-GB_C volume and non-GB_{NC} volume had slight decreased odds of having a technical complication (OR=0.92, 95% CI: 0.63-1.34; OR=0.82, 95% CI: 0.54-1.22, respectively) but these results were not statistically significant (Table 25).

Systemic Complications

For hypotheses $H_{1.1}$ through $H_{1.4}$:

The gastric bypass patients operated by general surgeons with high non-GB_C volume had a slight increased odds of having a systemic complication (OR=1.46, 95% CI: 0.80 -2.68). However, patients operated by general surgeons with high non-GB_{NC} volume had 2.05 times the odds of having a systemic complication and this result was statistically significant (95% CI: 1.11-3.77) (Table 22).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

The patients who had gastric bypass procedures done at hospitals with high non-GB_C volume and non-GB_{NC} volume had slight increased odds of having a systemic complication (OR=1.34, 95% CI: 0.69-2.60; OR=1.03, 95% CI: 0.55-1.96, respectively) but neither of these results were statistically significant (Table 26).

LOS

For hypotheses $H_{1.1}$ through $H_{1.4}$:

The patients who had gastric bypass procedures done by surgeons with high non-GB_C volume and non-GB_{NC} volume had slight increased LOS (Parameter Estimate: 1.13, 95% CI: 0.94-1.37 and Parameter Estimate: 1.18, 95% CI: 0.99-1.42, respectively) but these results were not statistically significant (Table 23).

For hypotheses $H_{2.1}$ through $H_{2.4}$:

The patients who had gastric bypass procedures done at hospitals with high non-GB_C volume and non-GB_{NC} volume had slight increased LOS (Parameter Estimate: 1.16, 95% CI: 0.98-1.39 and Parameter Estimate: 1.12, 95% CI: 0.91-1.37, respectively) but these results were not statistically significant (Table 27).

Model Working Correlation Fit Assessment (Hypotheses $H_{1.1}$ through $H_{2.4}$)

Based on the relatively smaller values obtained using the quasilikelihood under independence criterion (QIC), independent working correlation structure was selected for the analysis purposes for all outcome variables -composite complications, technical complications, systemic complications, and LOS for both objective 1 (surgeon non-GB volume study), and objective 2 (hospital non-GB volume study) (Tables 28 and 29).

Adjusted Results for the Association between Surgeon's Non-GB Volumes and Each Adverse Outcome (Hypotheses $H_{1.1}$ through $H_{1.4}$)

Tables 30-33 present the results of multivariate analyses for the association between surgeon's high non-GB volumes and each outcome. In addition, Tables 30-33 present adjusted results for the association of surgeon- and hospital-GB volume and each outcome of interest.

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high non-GB_C volume and composite complications, technical complications, systemic complications, and LOS (OR: 0.91, 95% CI: 0.66 - 1.27, p= 0.595; OR: 0.81, 95% CI: 0.63-1.05, p= 0.106; OR: 1.12, 95% CI: 0.70 - 1.80, p= 0.641; and Parameter Estimate: 1.05, 95% CI: 0.856 - 1.279, p= 0.656, respectively). However, after adjusting for covariates, patients who had gastric bypass procedures done by surgeons with high non-GB_{NC} volume had 1.70 times increased odds of having a composite complication (95% CI: 1.16 - 2.51, p= 0.007) and 1.88 times

increased odds of having a systemic complication (95% CI: 1.13 - 3.13, p=0.016) (Model 3 in Tables 30 and 32).

In contrast, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high GB volume had odds of having a composite complication and a systemic complication decreased by 27% and 41% respectively (OR: 0.73, 95% CI: 0.57 - 0.95, p=0.021; OR: 0.59, 95% CI: 0.36 -0.97, p=0.036, respectively), and these results were statistically significant. In addition, the adjusted GEE model showed that patients who had gastric bypass procedures done at hospitals with high GB volume (based on principal procedures) had odds of having a technical complication decreased by 28% (OR: 0.72, 95% CI: 0.52 - 0.98, p= 0.039) (Model 3 in Tables 30-32).

For the additional analysis using hospital GB volume based on primary and secondary procedures in the model, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high non-GB_{NC} volume had 1.70 times increased odds of having a composite complication (95% CI: 1.16 - 2.51, p= 0.007) and 1.88 times increased odds of having a systemic complication (95% CI: 1.13 - 3.13, p=0.015) (Model 4 in Tables 30 and 32). Similar to the results obtained by using hospital GB volume based on principal procedures, the adjusted GEE model using hospital GB volume based on principal and secondary procedures showed that patients who had gastric bypass procedures done by surgeons with high GB volume had odds of a composite complication and a systemic complication decreased by 27% and 42% (OR: 0.73, 95% CI: 0.57 - 0.95, p=0.017; OR: 0.58, 95% CI: 0.36 -0.95, p=0.0290) (Model 4 in Tables 30 and 32). In addition, the adjusted GEE model showed that patients who had

gastric bypass procedures done at hospitals with high GB volume (based on principal and secondary procedures) had odds of a technical complication decreased by 29% (OR: 0.71, 95% CI: 0.51 - 0.98, p= 0.039) (Model 4 in Table 31).

Adjusted Results for the Association between Hospital's Non-GB Volumes and Each Adverse Outcome (Hypotheses $H_{2.1}$ through $H_{2.4}$)

Tables 34-37 present the results of multivariate analyses for the association between hospital's high non-GB volumes and each outcome. In addition, Tables 31-34 present adjusted results for the association of surgeon- and hospital-GB volume and each outcome of interest.

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between hospital's high non-GB_C volume (based on principal procedures) and composite complications, technical complications, systemic complications, and LOS. However, after adjusting for covariates, patients who had gastric bypass procedures done at hospitals with high non-GB_{NC} volume (based on principal procedures) had odds of having a composite, technical and systemic complication decreased by 49%, 40%, 44% respectively (OR: 0.51, 95% CI: 0.33-0.80, p= 0.003; OR: 0.60, 95% CI: 0.42-0.88, p= 0.008; OR: 0.56, 95% CI: 0.28-1.07, p= 0.077, respectively) but the effect did not reach the level of statistical significance for a systemic complication. There was no clear association between patients operated at hospitals with high non-GB_{NC} volume (based on principal procedures) and LOS (Model 3 in Tables 34-36).

In contrast, the adjusted GEE model showed that patients who had gastric bypass procedures done at hospitals with high GB volume had odds of having a technical complication decreased by 30% (OR: 0.70, 95% CI: 0.52 - 0.95, p=0.022). In addition, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high GB volume had odds of having a composite and systemic complication decreased by 23% and 36% respectively (OR: 0.77, 95% CI: 0.61 - 0.98, p= 0.032; OR: 0.64, 95% CI: 0.43 - 0.94, p= 0.024) (Model 3 in Table 34-36).

For the additional analysis using hospital GB and non-GB volumes based on primary and secondary procedures in the model, the adjusted GEE model showed that patients who had gastric bypass procedures at hospitals with high non-GB_{NC} volume had odds of a composite, technical, and systemic complication decreased by 49%, 38%, and 48% respectively (OR: 0.51, 95% CI: 0.34 - 0.77, p= 0.001; OR: 0.62, 95% CI: 0.45 - 0.85, p= 0.003; OR: 0.52, 95% CI: 0.28 - 0.98, p= 0.043, respectively) (Model 4 in Table 31-33). Likewise, the patients who had gastric bypass procedures at hospitals with high GB volume (based on principal and secondary procedures) had odds of a technical complication decreased by 31% (OR: 0.69, 95% CI: 0.50-0.96, p=0.026) (Model 4 in Table 32). In addition, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high GB volume had odds of a composite complication and a systemic complication decreased by 34% and 37% (OR: 0.76, 95% CI: 0.60 - 0.96, p=0.0215; OR: 0.63, 95% CI: 0.43 -0.92, p=0.018) (Model 4 in Tables 34 and 37). Thus, the results were similar to those obtained by using hospital GB and non-GB volumes based on principal procedures. In contrast, the adjusted GEE model using hospital GB and non-GB volumes based on principal and secondary procedures showed

that the patients who had gastric bypass procedures done at hospitals with high (vs. low) non-GB_C volume had 1.55 and 1.90 times increased odds of having a composite and a systemic complication (95% CI: 1.09 - 2.20, p= 0.016; 95% CI: 1.09 – 3.30, p= 0.023, respectively). The gastric bypass patients operated at hospitals with high (vs. low) non-GB_C volume had 38% higher length of stay (Parameter Estimate: 1.38, 95% CI: 1.12-1.70, p=0.002) (Model 4 in Tables 34, 36 and 37).

Sub-Analysis

Unadjusted Association between Surgeon's Non-GB Volumes and Composite Complications and LOS Outcome, Stratified by Surgeon GB Volume - (Hypotheses $H_{1.1}$ through $H_{1.4}$)

The Breslow-Day statistic testing the null hypothesis of homogeneous odds ratio for composite complications stratified by surgeon's GB volume showed a significant result (chi-square value= 11.69, p= 0.0006).

Within surgeon's low GB volume strata, although patients who had gastric bypass procedures done by high non-GB_C volume surgeons had lower odds of a composite complication and had increased LOS than those patients who had their procedures done by low non-GB_C volume surgeons, the results were not significant (OR: 0.78, 95% CI: 0.53-1.15, p=0.218 and Parameter Estimate: 1.10, 95% CI: 0.90-1.35, p=0.336, respectively). Similarly, the patients who had gastric bypass procedures done by high non-GB_{NC} volume surgeons had higher odds of a composite complication and had increased LOS than those patients who had their procedures done by low non-GB_{NC} volume surgeons, the results were not significant (OR: 1.12, 95% CI: 0.78-1.60, p=0.537 and Parameter Estimate: 1.02, 95% CI: 0.86-1.22, p=0.800, respectively) (Tables 38 and 39).

Within Surgeon's high GB volume strata, although patients who had gastric bypass procedures done by high non-GB_C volume surgeons had higher odds of a composite complication and had increased LOS than those patients who had their procedures done by low non-GB_C volume surgeons, the results were not significant (OR: 1.29, 95% CI: 0.72-2.29, p=0.390 and Parameter Estimate: 1.13, 95% CI: 0.90-1.44, p=0.293, respectively). In contrast, the patients who had gastric bypass procedures done by high non-GB_{NC} volume surgeons had statistically significant higher odds of a composite complication (OR: 1.87, 95% CI: 1.12-3.15, p=0.018). However, although those patients who had gastric bypass procedures done by high non-GB_{NC} volume surgeons had increased LOS, the results were not significant (Parameter Estimate: 1.22, 95% CI: 0.97-1.52, p=0.086, respectively) (Tables 38 and 39).

Unadjusted Association between Hospital's Non-GB Volumes and Composite Complications and LOS Outcome, Stratified by Hospital GB Volume - (Hypotheses $H_{2.1}$ through $H_{2.4}$)

The Breslow-Day statistic testing the null hypothesis of homogeneous odds ratio for composite complications stratified by hospital's GB volume (based on principal procedures) did not show a significant result (chi-square value= 1.82, p= 0.1770).

For both hospital's low GB and high GB volume strata, there was no clear association between patients who had gastric bypass procedures done at hospitals with high (vs. low) non-GB_C volume, high (vs. low) non-GB_{NC} volume and composite complication as well as LOS outcomes (Tables 40 and 41).

Adjusted Association between Surgeon's Non-GB Volumes and Composite Complications and LOS Outcome, Stratified by Surgeon GB Volume - (Hypotheses $H_{1.1}$ through $H_{1.4}$)

Within Surgeon's low GB volume strata, the GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital

GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high non-GB_C volume and composite complications (OR: 0.90, 95% CI: 0.64-1.25, p=0.515) and LOS (Parameter Estimate: 1.11, 95% CI: 0.89-1.38, p=0.374), and between surgeon's high non-GB_{NC} volume and composite complications (OR: 0.91, 95% CI: 0.62-1.32, p=0.607) and LOS (Parameter Estimate: 1.03, 95% CI: 0.80-1.31, p=0.837) for gastric bypass patients (Tables 42 and 43).

Within Surgeon's high GB volume strata, the adjusted GEE model showed no clear association between surgeon's high non-GB_C volume and composite complications (OR: 0.91, 95% CI: 0.62-1.32, p=0.607) and LOS (Parameter Estimate: 1.03, 95% CI: 0.80-1.31, p=0.837) for gastric bypass patients. In contrast, patients who had gastric bypass procedures done by surgeons with high non-GB_{NC} volume had higher odds of a composite complication (OR: 1.97, 95% CI: 1.30-2.99, p=0.001) and had increased LOS (Parameter Estimate: 1.26, 95% CI: 1.02-1.55, p=0.032) (Tables 42 and 43).

Adjusted Association between Hospital's Non-GB Volumes and Composite Complications and LOS Outcome, Stratified by Hospital GB Volume - (Hypotheses $H_{2.1}$ through $H_{2.4}$)

For both low GB volume and high GB volume hospital strata, the GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure showed no clear association between hospital's high non-GB_C volume and composite complication as well LOS outcomes (Table 44).

Within hospital's low GB volume strata, the adjusted GEE model showed that patients who had gastric bypass procedures done at hospitals with high non-GB_{NC} volume had lower odds of a composite complication (OR: 0.56, 95% CI: 0.37-0.85, p=0.006). Likewise, within hospital's high GB volume strata, the adjusted GEE model showed that patients who had gastric bypass procedures done at hospitals with high non-GB_{NC} volume had lower odds of a composite complication (OR: 0.42, 95% CI: 0.20-0.91, p=0.027) (Table 45).

Sensitivity Analysis

Adjusted Results for Surgeon's Non-GB Volume Variables and Each Outcome- (Hypotheses $H_{1.1}$ through $H_{1.4}$)

The sensitivity analysis was performed using both surgeon's non-GB_C and non-GB_{NC} volume as a categorical variable (low- referent, medium, and high volume) based on the volume tertile approach.

Composite Complications

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high (vs. low) non-GB_C volume, surgeon's medium (vs. low) non-GB_C volume and composite complications for gastric bypass patients.

However, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high (vs. low) non-GB_{NC} volume had higher odds of a composite complication (OR: 1.74, 95% CI: 1.10-2.78, p=0.018) (Table 46).

Technical Complications

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high (vs. low) non-GB_C volume, surgeon's medium (vs. low) non-GB_C volume, and technical complications for gastric bypass patients. In addition, there was no association between surgeon's high (vs. low) non-GB_{NC} volume, surgeon's medium (vs. low) non-GB_{NC} volume, and technical complications (Table 46).

Systemic Complications

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high (vs. low) non-GB_C volume, surgeon's medium (vs. low) non-GB_C volume and systemic complications for gastric bypass patients.

However, the adjusted GEE model showed that patients who had gastric bypass procedures done by surgeons with high (vs. low) non-GB_{NC} volume had higher odds of a systemic complication (OR: 1.95, 95% CI: 1.08-3.50, p=0.025) (Table 46).

LOS

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed no clear association between surgeon's high (vs. low) non-GB_C volume, surgeon's medium (vs. low) non-GB_C volume, and LOS for gastric bypass patients. In addition, although patients who had gastric bypass procedures done by surgeons with high (vs. low) non-GB_{NC} volume had higher LOS, the results were not statistically significant (Parameter Estimate: 1.15, 95% CI: 0.81-1.61, p=0.435) (Table 46).

Adjusted Results for Hospital's non-GB Volume Variables and Each Outcome- (Hypotheses $H_{2.1}$ through $H_{2.4}$)

The sensitivity analysis was performed using both hospital's non-GB_C and non-GB_{NC} volume as a categorical variable (low- referent, medium, and high volume) based on the volume tertile approach.

The GEE model adjusting for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure, showed that patients who had gastric bypass procedures done at hospitals with high (vs. low) non-GB_{NC} volume had decreased odds of a composite, technical and systemic complication (OR: 0.46, 95% CI: 0.20-1.05, p=0.066; OR: 0.58, 95% CI: 0.33-1.03, p=0.062; OR: 0.46, 95% CI: 0.13-1.64, p=0.233). However, the results were not statistically significant for all three complications (Table 47).

TABLE 5: Patient characteristics for gastric bypass discharges in Florida, 2003-2004

Patient Characteristics	**Objective 1** All Adults (n=11,363, s=108, h=73) n (%)	**Objective 2** All Adults (n= 11,857, s=160, h=81) n (%)
Age, mean (SD)*; Median (range)	42.5 (10.8); 42 (18-75)	42.5 (10.8); 42 (18-80)
Age (in years)		
18-29	1,408 (12.39)	1,476 (12.45)
30-39	3,257 (28.66)	3,426 (28.89)
40-49	3,443 (30.30)	3,585 (30.24)
50-59	2,592 (22.81)	2,680 (22.60)
≥60	663 (5.83)	690 (5.82)
Gender		
Male	2116 (18.62)	2,223 (18.75)
Female	9247 (81.38)	9,634 (81.25)
Race/Ethnicity		
Non-Hispanic White	7,934 (69.82)	8,208 (69.22)
Non-Hispanic Black	1,302 (11.46)	1,394 (11.76)
Hispanic	1,819 (16.01)	1,932 (16.29)
Other	308 (2.71)	323 (2.72)
Payer Type		
Medicare	778 (6.85)	835 (7.04)
Medicaid	269 (2.37)	342 (2.88)
Private	9,127 (80.32)	9,465 (79.83)
Self pay/ underinsured	707 (6.22)	731 (6.17)
Other	482 (4.24)	484 (4.08)
Elixhauser Comorbidities		
Presence of comorbidities	8,977 (79.00)	9,396 (79.24)
Congestive heart failure	131 (1.15)	140 (1.18)
Arrythmia	352 (3.10)	369 (3.11)
Valvular disease	197 (1.73)	204 (1.72)
Peripheral vascular disease	140 (1.23)	141 (1.19)
Hypertension	5,804 (51.08)	6,075 (51.24)
Pulmonary circulation disease	36 (0.32)	38 (0.32)
Other neurologic disorder	55 (0.48)	57 (0.48)
Chronic pulmonary disease	1,659 (14.60)	1,744 (14.71)
Diabetes mellitus without chronic complications	2,857 (25.14)	2,983 (25.16)
Diabetes mellitus with chronic complications	128 (1.13)	133 (1.12)
Hypothyroidism	1,016 (8.94)	1,063 (8.97)
Liver disease	1,116 (9.82)	1,170 (9.87)
Rheumatoid arthritis	126 (1.11)	132 (1.11)
Coagulopathy	44 (0.39)	50 (0.42)
Psychoses	91 (0.80)	99 (0.83)
Depression	1,730 (15.22)	1,830 (15.43)
Sleep apnea	3,723 (32.76)	3,956 (33.36)
Year		
2003	6,431 (56.60)	6,690 (56.42)
2004	4,932 (43.40)	5,167 (43.58)

*SD= standard deviation; n= patients; s=surgeons; h=hospitals

TABLE 6: Distribution of gastric bypass discharges across provider characteristics in Florida, 2003-2004

Characteristics	**Objective 1** All Adults (n=11,363, s=108, h=73) n (%)	**Objective 2** All Adults (n= 11,857, s=160, h=81) n (%)
Surgeon characteristics		
Surgeon non-GB_C volume, mean(SD*); Median	41.51 (31.45); 32.0 (range=0-258)	-
≤50 procs/yr (lower 66th percentile)	8,391 (73.84)	-
>50 procs/yr (upper 33rd percentile)	2,972 (26.16)	-
low volume, <26 procs/yr (<33rd percentile)- complex procedure	4,182 (36.80)	-
medium volume, between 26 and 50 procs/yr (between 33rd and 66th percentile)- complex procedure	4,209 (37.04)	-
high volume, >50 procs/yr (>66th percentile)- complex procedure	2,972 (26.16)	-
Surgeon non-GB_{NC} volume, mean, (SD); Median)	112.08 (81.65); 92.0 (range= 0-474)	-
≤142 procs/yr (lower 66th percentile)	8,604 (75.72)	-
>142 procs/yr (upper 33rd percentile)	2,759 (24.28)	-
low volume, <78 procs/yr (<33rd percentile)- complex procedure	4,925 (43.34)	-
medium volume, between 78 and 142 procs/yr (between 33rd and 66th percentile)- complex procedure	3,679 (32.38)	-
high volume, >142 procs/yr (>66th percentile)- complex procedure	2,759 (24.28)	-
Surgeon GB volume (mean, SD*/Median)	174.63 (107.66), 163.0 (range= 1-377)	169.10 (108.81), 155.0 (range=1-377)
≤50 procs/yr	1,699 (14.95)	1,973 (16.64)
>50 procs/yr	9,664 (85.05)	9,884 (83.36)

TABLE 6 (continued)

Characteristics	**Objective 1** All Adults (n=11,363, s=108, h=73) n (%)	**Objective 2** All Adults (n= 11,857, s=160, h=81) n (%)
Hospital Characteristics		
Hospital volumes based on principal procedures		
Hospital non-GB_C volume, mean(SD*); median (range)	-	2,766.10 (1,970.93), 2,065.00 (range=7-11,425)
≤2,743 procs/yr (lower 66th percentile)	-	7,272 (61.33)
>2,743 procs/yr (upper 33rd percentile)	-	4,585 (38.67)
low volume, <1,271 procs/yr (<33rd percentile)- complex procedure	-	2,234 (18.84)
medium volume, between 1,271 and 2,743 procs/yr (between 33rd and 66th percentile)- complex procedure	-	5,038 (42.49)
high volume,>2,743 procs/yr (>66th percentile)- complex procedure	-	4,585 (38.67)
Hospital non-GB_{NC} volume, mean(SD*); median (range)	-	6,178.16 (3411.02), 5,458 (range=138-20,372)
≤6,478 procs/yr (lower 66th percentile)	-	7,059 (59.53)
>6,478 procs/yr (upper 33rd percentile)	-	4,798 (40.47)
low volume, <3,376 (<33rd percentile)- complex procedure	-	2,710 (22.86)
medium volume, between 3,376 and 6,478 procs/yr (between 33rd and 66th percentile)- complex procedure	-	4,349 (36.68)
high volume, >6,478 procs/yr (>66th percentile)- complex procedure	-	4,798 (40.47)
Hospital GB volume, mean(SD*); median (range)	240.80 (158.96), 225.0 (range=1-643)	234.58 (159.90), 213.0 (range=1-643)
≤125 procs/yr	3,704 (32.60)	4,095 (34.54)
>125 procs/yr	7,659 (67.40)	7,762 (65.46)

TABLE 6 (continued)

Characteristics	**Objective 1** All Adults (n=11,363, s=108, h=73) n (%)	**Objective 2** All Adults (n= 11,857, s=160, h=81) n (%)
Hospital volumes based on principal and secondary procedures		
Hospital non-GB_C volume, mean(SD*); median (range)	-	4,586.97(3,190.35), 3,365 (range=29-18,196)
≤4,617 procs/yr (lower 66th percentile)	-	7,246 (61.11)
>4,617 procs/yr (upper 33rd percentile)	-	4,611 (38.89)
Hospital non-GB_{NC} volume, mean(SD*); median (range)	-	17,594.80 (10,931.91), 15,257 (range=1189-69,468)
≤18,082 procs/yr (lower 66th percentile)	-	7,354 (62.02)
>18,082 procs/yr (upper 33rd percentile)	-	4,503 (37.98)
Hospital GB volume, mean(SD*); median (range)	240.80 (158.96), 225.0 (range=1-643)	238.39 (159.68), 219.0 (range=1-647)
≤125 procs/yr	3,704 (32.60)	3,922 (33.08)
>125 procs/yr	7,659 (67.40)	7,935 (66.92)
Bed size (mean [SD], median)	389.26 (213.72), 378	386.83 (211.10), 353
Bed size, categorical		
less than 200	2, 072 (18.23)	2,111 (17.8)
200-299	2, 497 (21.97)	2,722 (22.96)
300-399	1,789 (15.74)	1,895 (15.98)
400-499	2,020 (17.78)	2,056 (17.34)
500+	2,985 (26.27)	3,073 (25.92)
Teaching status		
Teaching	619 (5.47)	643 (5.45)
Non-teaching	10,692 (94.53)	11,149 (94.55)
Major metropolitan area		
Hospital county population≥1 million	7,397 (65.10)	7,878 (66.44)
Hospital county population<1 million	3,966 (34.90)	3,979 (33.56)
Ownership		
Categorical		
For profit	6,392 (56.51)	6,700 (56.51)
Government	448 (3.96)	448 (3.78)
Not-for-profit	4,471 (39.53)	4,709 (39.71)
Dichotomous		
For profit	6,392 (56.25)	6,700 (56.51)
Not-for-profit or government	4,971 (43.75)	5,157 (43.49)

*SD= standard deviation; n= patients; s=surgeons; h=hospitals

TABLE 7: In-hospital outcomes for gastric bypass discharges in Florida, 2003-2004

Outcomes	**Objective 1** All Adults (n=11,363, s=108, h=73) n (%)	**Objective 2** All Adults (n= 11,857, s=160, h=81) n (%)
In-hospital mortality	21 (0.18)	22 (0.19)
Complications		
Technical	**1,244 (10.95)**	**1,333 (11.24)**
Small bowel obstruction	168 (1.48)	172 (1.45)
Splenic	35 (0.31)	35 (0.30)
Unexpected reoperations	620 (5.46)	670 (5.65)
Wound	83 (0.73)	92 (0.78)
Hemorrhage/hematoma	354 (3.12)	384 (3.24)
Anastomotic leak	317 (2.79)	326 (2.75)
Systemic	**1,133 (9.97)**	**1,182 (9.97)**
Thromboembolism (PE/DVT)	24 (0.21)	24 (0.20)
Pulmonary	979 (8.62)	1,019 (8.59)
Cardiac	101 (0.89)	112 (0.94)
Postoperative shock	8 (0.07)	8 (0.07)
Genitourinary	120 (1.06)	128 (1.08)
Composite- Any complications	**2,060 (18.13)**	**2,181 (18.39)**
Composite- death/any complication	2,063 (18.16)	2,184 (18.42)
LOS in days, mean(SD*); median	**3.41 (3.40), 3.0**	**3.45 (3.49), 3.0**

*SD= standard deviation; n= patients; s=surgeons; h=hospitals

TABLE 8: Comparison of patient characteristics, according to surgeon volume of non-gastric bypass complex procedures in Florida, 2003-2004

	Surgeon non-GB_C volume		
Patient Characteristics	**Low** (≤50 procs/year) (n=8,391)	**High** (>50 procs/year) (n= 2,972)	**p-value**
Age, mean(SE*)	42.31±0.12	43.12±0.20	0.0005
Age, yrs n (%)			0.029
18-29	1,075 (12.81)	333 (11.20)	
30-39	2,436 (29.03)	821 (27.62)	
40-49	2,528 (30.13)	915 (30.79)	
50-59	1,877 (22.37)	715 (24.06)	
≥ 60	475 (5.66)	188 (6.33)	
Gender, n (%)			0.495
Male	1,575 (18.77)	541 (18.20)	
Female	6,816 (81.23)	2,431 (81.80)	
Race/Ethnicity, n (%)			<0.0001
Non-Hispanic White	5,719 (68.16)	2,215 (74.53)	
Non-Hispanic Black	989 (11.79)	313 (10.53)	
Hispanic	1,473 (17.55)	346 (11.64)	
Other	210 (2.50)	98 (3.30)	
Payer Type, n (%)			<0.0001
Medicare	521 (6.21)	257 (8.65)	
Medicaid	174 (2.07)	95 (3.20)	
Commercial	6,752 (80.47)	2,375 (79.91)	
Self pay/ uninsured	563 (6.71)	144 (4.85)	
Other	381 (4.54)	101 (3.40)	
Elixhauser Comorbidities, n (%)			
Presence of comorbidities	6,619 (78.88)	2,358 (79.34)	0.598
Congestive heart failure	71 (0.85)	60 (2.02)	<0.0001
Arrythmia	251 (2.99)	101 (3.40)	0.271
Valvular disease	151 (1.80)	146 (1.55)	0.366
Peripheral vascular disease	79 (0.94)	61 (2.05)	<0.0001
Hypertension	4,246 (50.60)	1,558 (52.42)	0.088
Pulmonary circulation disease	27 (0.32)	9 (0.30)	0.874
Other neurologic disorder	38 (0.45)	17 (0.57)	0.421
Chronic pulmonary disease	1,231 (14.67)	428 (14.40)	0.721
Diabetes mellitus without chronic complications	2,065 (24.61)	792 (26.65)	0.028
Diabetes mellitus with chronic complications	92 (1.10)	36 (1.21)	0.61
Hypothyroidism	743 (8.85)	273 (9.19)	0.587
Liver disease	1,053 (1.55)	63 (2.12)	<0.0001
Rheumatoid arthritis	89 (1.06)	37 (1.24)	0.41
Coagulopathy	32 (0.38)	12 (0.40)	0.866
Psychoses	58 (0.69)	33 (1.11)	0.028
Depression	1,257 (14.98)	473 (15.92)	0.223
Sleep apnea	2,779 (33.12)	944 (31.76)	0.176

TABLE 8 (continued)

	Surgeon non-GB_C volume		
Patient Characteristics	**Low** (≤50 procs/year) (n=8,391)	**High** (>50 procs/year) (n= 2,972)	**p-value**
Year			<0.0001
2003	4,391 (52.33)	2,040 (68.64)	
2004	4,000 (47.67)	932 (31.36)	

*SE= standard error; total number of surgeons=108; total number of hospitals=73

TABLE 9: Comparison of provider characteristics (at patient-level), according to surgeon volume of non-gastric bypass complex procedures in Florida, 2003-2004

	Surgeon non-GB_C volume		
	Low (≤50 procs/year) (n=8,391)	**High** (>50 procs/year) (n= 2,972)	**p-value**
Surgeon Characteristics			
Surgeon GB volume, n(%)			0.051
>50 procs/yr	7,169 (85.44)	2,495 (83.95)	
≤50 procs/yr	1,222 (14.56)	477 (16.05)	
Surgeon non-GB_{NC} volume, n(%)			<0.0001
≤142 procs/yr (lower 66th percentile)	7,392 (88.09)	1,212 (40.78)	
>142 procs/yr (upper 33rd percentile)	999 (11.91)	1,760 (59.22)	
Hospital Characteristics			
Hospital GB volume (principal procedures), n(%)			0.001
>125 procs/yr	5,732 (68.31)	1,927 (64.84)	
≤125 procs/yr	2,659 (31.69)	1,045 (35.16)	
Hospital GB volume (all procedures), n(%)			0.069
>125 procs/yr	5,823 (69.40)	2,009 (67.60)	
≤125 procs/yr	2,568 (30.60)	963 (32.40)	
Bed size, mean±SE	400.36±2.45	355.96±3.21	<0.0001
Bed size, n(%)			<0.0001
less than 200	1,467 (17.48)	605 (20.36)	
200-299	1,769 (21.08)	728 (24.50)	
300-399	1,139 (13.57)	650 (21.87)	
400-499	1,528 (18.21)	492 (16.55)	
500+	2,488 (29.65)	497 (16.72)	
Teaching hospital, n(%)	536 (6.43)	83 (2.79)	<0.0001
Major metropolitan area, n(%)	5,686 (67.76)	1,711 (57.57)	<0.0001
Ownership, n(%)			<0.0001
For profit	4,458 (53.13)	1,934 (65.07)	
Government	434 (5.17)	14 (0.47)	
Not-for-profit	3,499 (41.70)	1,024 (34.45)	
Dichotomous			<0.0001
For profit	4,458 (53.13)	1,934 (65.07)	
Not-for-profit or government	3,933 (46.87)	1,038 (34.93)	

*SE= standard error; total number of surgeons=108; total number of hospitals=73

TABLE 10: Comparison of patient characteristics, according to surgeon volume of non-gastric bypass non-complex procedures in Florida, 2003-2004

	Surgeon non-GB_{NC} volume		
Patient Characteristics	**Low** (≤142 procs/year) (n=8,604)	**High** (>142 procs/year) (n=2,759)	**p-value**
Age, mean(SE*)	42.51±0.12	42.57±0.21	0.7873
Age, yrs n(%)			0.805
18-29	1,054 (12.25)	354 (12.83)	
30-39	2,480 (28.82)	777 (28.16)	
40-49	2,601 (30.23)	842 (30.52)	
50-59	1,974 (22.94)	618 (22.40)	
≥ 60	495 (5.75)	168 (6.09)	
Gender, n(%)			0.812
Male	1,598 (18.57)	518 (18.77)	
Female	7,006 (81.43)	2,241 (81.23)	
Race/Ethnicity, n(%)			<0.0001
Non-Hispanic White	6,205 (72.12)	1,729 (62.67)	
Non-Hispanic Black	1,016 (11.81)	286 (10.37)	
Hispanic	1,182 (13.74)	637 (23.09)	
Other	201 (2.34)	107 (3.88)	
Payer Type, n(%)			<0.0001
Medicare	524 (6.09)	254 (9.21)	
Medicaid	159 (1.85)	110 (3.99)	
Private	6,912 (80.33)	2,215 (80.28)	
Self pay/ underinsured	574 (6.67)	133 (4.82)	
Other	435 (5.06)	47 (1.70)	
Elixhauser Comorbidities, n(%)			
Presence of comorbidities	6,804 (79.08)	2,173 (78.76)	0.72
Congestive heart failure	79 (0.92)	52 (1.88)	<0.0001
Arrythmia	256 (2.98)	96 (3.48)	0.184
Valvular disease	143 (1.66)	54 (1.96)	0.301
Peripheral vascular disease	126 (1.46)	14 (0.51)	<0.0001
Hypertension	4,329 (50.31)	1,575 (53.46)	0.004
Pulmonary circulation disease	26 (0.30)	10 (0.36)	0.624
Other neurologic disorder	42 (0.49)	13 (0.47)	0.911
Chronic pulmonary disease	1,245 (14.47)	414 (15.01)	0.488
Diabetes mellitus without chronic complications	2,091 (24.30)	766 (27.76)	<0.0001
Diabetes mellitus with chronic complications	98 (1.14)	30 (1.09)	0.823
Hypothyroidism	777 (9.03)	239 (8.66)	0.555
Liver disease	1026 (11.92)	90 (3.26)	<0.0001
Rheumatoid arthritis	97 (1.13)	29 (1.05)	0.739
Coagulopathy	33 (0.38)	11 (0.40)	0.911
Psychoses	60 (0.70)	31 (1.12)	0.029
Depression	1,452 (16.88)	278 (10.08)	<0.0001
Sleep apnea	2,750 (31.96)	973 (35.27)	0.001

TABLE 10 (continued)

	Surgeon non-GB_{NC} volume		
Patient Characteristics	**Low** (≤142 procs/year) (n=8,604)	**High** (>142 procs/year) (n=2,759)	**p-value**
Year			<0.0001
2003	5,136 (59.69)	1,295 (46.94)	
2004	3,468 (40.31)	1,464 (53.06)	

*SE= standard error; total number of surgeons=108; total number of hospitals=73

TABLE 11: Comparison of provider characteristics and year (at patient-level), according to surgeon volume of non-gastric bypass non-complex procedures in Florida, 2003-2004

	Surgeon non-GB_{NC} volume		
	Low (≤142 procs/year) (n=8,604)	**High** (>142 procs/year) (n=2,759)	**p-value**
Surgeon Characteristics			
Surgeon GB volume, n(%)			<0.0001
>50 procs/yr	7,394 (85.94)	2,270 (82.28)	
≤50 procs/yr	1,210 (14.06)	489 (17.72)	
Surgeon non-GB_C volume, n(%)			<0.0001
≤50procs/yr (lower 66th percentile)	7,392 (85.91)	999 (36.21)	
>50 procs/yr (upper 33rd percentile)	1,212 (14.09)	1,760 (63.79)	
Hospital Characteristics			
Hospital GB volume (principal procedures), n(%)			<0.0001
>125 procs/yr	6,085 (70.72)	1,574 (57.05)	
≤125 procs/yr	2,519 (29.28)	1,185 (42.95)	
Hospital GB volume (all procedures), n(%)			<0.0001
>125 procs/yr	6,220 (72.29)	1,612 (58.43)	
≤125 procs/yr	2,384 (27.71)	1,147 (41.57)	
Bed size, mean±SE	377.72±2.03	423.14±5.24	<0.0001
Bed size, n(%)			<0.0001
less than 200	1,713 (19.91)	359 (13.01)	
200-299	2,027 (23.56)	470 (17.04)	
300-399	992 (11.53)	797 (28.89)	
400-499	1,575 (18.31)	445 (16.13)	
500+	2,297 (26.70)	688 (24.94)	
Teaching hospital, n(%)	468 (5.47)	151 (5.47)	0.999
Major metropolitan area, n(%)	5,286 (61.44)	2,111 (76.51)	<0.0001
Ownership, n(%)			0.002
For profit	4,828 (56.11)	1,564 (56.69)	
Government	310 (3.60)	138 (5.00)	
Not-for-profit	3,466 (40.28)	1,564 (56.29)	
Dichotomous			0.597
For profit	4,828 (56.11)	1,564 (56.69)	
Not-for-profit or government	3,776 (43.89)	1,195 (43.31)	

*SE= standard error; total number of surgeons=108; total number of hospitals=73

TABLE 12: Comparison of patient characteristics, according to hospital volume of non-gastric bypass complex procedures in Florida, 2003-2004

	Hospital non-GB_C volume		
Patient Characteristics	**Low** (≤2,743 procs/yr) (n=7,272)	**High** (>2,743 procs/yr) (n= 4,585)	**p-value**
Age, mean±SE*	42.52 ±0.13	42.37±0.16	0.4791
Age, yrs n (%)			0.309
18-29	904 (12.43)	572 (12.48)	
30-39	2099 (28.86)	1,372 (28.94)	
40-49	2,188 (30.09)	1,397 (30.47)	
50-59	1,631 (22.43)	1,049 (22.88)	
≥ 60	450 (6.19)	240 (5.23)	
Gender, n (%)			0.319
Male	1,384 (19.03))	839 (18.30)	
Female	5,888 (80.97)	3,746 (81.70)	
Race/Ethnicity, n (%)			<0.0001
Non-Hispanic White	4,999 (68.74)	3,209 (69.99)	
Non-Hispanic Black	911 (12.53)	483 (10.53)	
Hispanic	1,115 (15.33)	817 (17.82)	
Other	247 (3.40)	76 (1.66)	
Payer Type, n (%)			<0.0001
Medicare	532 (7.32)	303 (6.61)	
Medicaid	230 (3.16)	112 (2.44)	
Private	5,623 (77.32)	3,842 (83.78)	
Self pay/ uninsured	472 (6.49)	259 (5.65)	
Other	415 (5.71)	69 (1.50)	
Elixhauser Comorbidities, n(%)			<0.0001
Presence of comorbidities	5,652 (77.72)	3,744 (81.66)	
Congestive heart failure	87 (1.20)	53 (1.16)	0.843
Arrythmia	220 (3.03)	149 (3.25)	0.493
Valvular disease	108 (1.49)	96 (2.09)	0.013
Peripheral vascular disease	26 (0.36)	115 (2.51)	<0.0001
Hypertension	3,702 (50.91)	2,373 (51.76)	0.368
Pulmonary circulation disease	18 (0.25)	20 (0.44)	0.077
Other neurologic disorder	32 (0.44)	25 (0.55)	0.420
Chronic pulmonary disease	1,063 (14.62)	681 (14.85)	0.725
Diabetes mellitus without chronic complications	1,823 (25.07)	1,160 (25.30)	0.778
Diabetes mellitus with chronic complications	93 (1.28)	40 (0.87)	0.041
Hypothyroidism	634 (8.72)	429 (9.36)	0.236
Liver disease	723 (9.94)	447 (9.75)	0.731
Rheumatoid arthritis	83 (1.14)	49 (1.07)	0.713
Coagulopathy	31 (0.43)	19 (0.41)	0.922
Psychoses	61 (0.84)	38 (0.83)	0.953
Depression	1,025 (14.10)	805 (17.56)	<0.0001
Sleep apnea	2,184 (30.03)	1,772 (38.65)	<0.0001

TABLE 12 (continued)

Patient Characteristics	Hospital non-GB_C volume: Low (≤2,743 procs/yr) (n=7,272)	Hospital non-GB_C volume: High (>2,743 procs/yr) (n= 4,585)	p-value
Year			<0.0001
2003	3,760 (51.71)	2,930 (63.90)	
2004	3,512 (48.29)	1,655 (36.10)	

*SE= standard error; total number of surgeons=160; total number of hospitals=81

TABLE 13: Comparison of gastric bypass provider characteristics (at patient-level), according to hospital volume of non-gastric bypass complex procedures in Florida, 2003-2004

	Hospital non-GB_C volume		
	Low (≤2,743 procs/yr) (n=7,272)	**High** (>2,743 procs/yr) (n= 4,585)	**p-value**
Surgeon Characteristics			
Surgeon GB volume, n(%)			<0.0001
>50 procs/yr	6,193 (85.16)	3,691 (80.50)	
≤50 procs/yr	1,079 (14.84)	894 (19.50)	
Hospital Characteristics **Hospital volume based on principal procedures**			
Hospital non-GB_{NC} volume, n(%)			<0.0001
>6,478 procs/yr	795 (10.93)	4,003 (87.31)	
≤6,478 procs/yr	6,477 (89.07)	582 (12.69)	
Hospital GB volume, n(%)			0.565
>125 procs/yr	4,746 (65.26)	3,016 (65.78)	
≤125 procs/yr	2,526 (34.74)	1,569 (34.22)	
Bed size, Mean±SE	296.20 (3.39)	530.58 (1.57)	
Bed size, n(%)			<0.0001
Less than 200	2,111 (29.03)	0 (0.00)	
200-299	1,897 (26.09)	825 (17.99)	
300-399	1,534 (21.09)	361 (7.87)	
400-499	968 (13.31)	1,088 (23.73)	
500+	762 (10.48)	2,311 (50.40)	
Teaching hospital, n(%)	0 (0.00)	643 (14.02)	<0.0001
Major metropolitan area- county population ≥1 million, n(%)	4,903 (67.42)	2,975 (64.89)	0.004
Ownership, n(%)			<0.0001
For profit	5,699 (77.96)	1,031 (22.49)	
Government	264 (3.63)	184 (4.01)	
Not-for-profit	1,339 (18.41)	3,370 (73.50)	
Dichotomous			<0.0001
For profit	5,669 (77.96)	1,031 (22.49)	
Not-for-profit or government	1,603 (22.04)	3, 554 (77.51)	

*SE= standard error; total number of surgeons=160; total number of hospitals=81

TABLE 14: Comparison of patient characteristics, according to hospital volume of non-gastric bypass non-complex procedures in Florida, 2003-2004

	Hospital non-GB_{NC} volume		
Patient Characteristics	**Low** (≤6,478 procs/yr) (n=7,059)	**High** (> 6,478 procs/yr) (n=4,798)	**p-value**
Age, mean(SE*)	42.38±0.13	42.57±0.16	0.341
Age, yrs n(%)			0.201
18-29	860 (12.18)	616 (12.84)	
30-39	2,088 (29.58)	1,338 (27.89)	
40-49	2,145 (30.39)	1,440 (30.01)	
50-59	1,562 (22.13)	1,118 (23.30)	
≥ 60	404 (5.72)	286 (5.96)	
Gender, n(%)			0.865
Male	1327 (18.8)	896 (18.67)	
Female	5,732 (81.20)	3,902 (81.33)	
Race/Ethnicity, n(%)			<0.0001
Non-Hispanic White	4,816 (68.22)	3,392 (70.70)	
Non-Hispanic Black	880 (12.47)	514 (10.71)	
Hispanic	1,119 (15.85)	813 (16.94)	
Other	244 (3.46)	79 (1.65)	
Payer Type, n(%)			<0.0001
Medicare	490 (6.94)	345 (7.19)	
Medicaid	227 (3.22)	115 (2.40)	
Private	5,479 (77.62)	3,986 (83.08)	
Self pay/ uninsured	470 (6.66)	261 (5.44)	
Other	393 (5.57)	91 (1.90)	
Elixhauser Comorbidities, n(%)			
Presence of comorbidities	5,458 (77.32)	3,938 (82.08)	<0.0001
Congestive heart failure	85 (1.20)	55 (1.15)	0.775
Arrythmia	194 (2.75)	175 (3.65)	0.006
Valvular disease	111 (1.57)	93 (1.94)	0.133
Peripheral vascular disease	27 (0.38)	114 (2.38)	<0.0001
Hypertension	3,590 (50.86)	2,485 (51.79)	0.317
Pulmonary circulation disease	17 (0.24)	21 (0.44)	0.063
Other neurologic disorder	29 (0.41)	28 (0.58)	0.182
Chronic pulmonary disease	1,029 (14.58)	715 (14.90)	0.624
Diabetes mellitus without chronic complications	1,767 (25.03)	1,216 (25.34)	0.701
Diabetes mellitus with chronic complications	88 (1.25)	45 (0.94)	0.117
Hypothyroidism	624 (8.84)	439 (9.15)	0.562
Liver disease	459 (6.5)	711 (14.82)	<0.0001
Rheumatoid arthritis	78 (1.10)	54 (1.13)	0.917
Coagulopathy	36 (0.51)	14 (0.29)	0.072
Psychoses	66 (0.93)	33 (0.69)	0.147
Depression	1,026 (14.53)	804 (16.76)	0.001
Sleep apnea	2,246 (31.82)	1,710 (35.64)	<0.0001

TABLE 14 (continued)

Patient Characteristics	Hospital non-GB_{NC} volume: Low (≤6,478 procs/yr) (n=7,059)	Hospital non-GB_{NC} volume: High (>6,478 procs/yr) (n=4,798)	p-value
Year			<0.0001
2003	3,725 (52.77)	2,965 (61.80)	
2004	3,334 (47.23)	1,833 (38.20)	

*SE= standard error; total number of surgeons=160; total number of hospitals=81

TABLE 15: Comparison of provider characteristics (at patient-level), according to hospital volume of non-gastric bypass non-complex procedures in Florida, 2003-2004

	Hospital non-GB_{NC} volume		
	Low (≤6,478 procs/yr) (n=7,059)	**High** (>6,478 procs/yr) (n=4,798)	**p-value**
Surgeon Characteristics			
Surgeon GB volume, n (%)			0.037
>50 procs/yr	5,926 (83.95)	3,958 (82.49)	
≤50 procs/yr	1,133 (16.05)	840 (17.51)	
Hospital Characteristics			
Hospital volume based on principal procedures			
Hospital non-GB_C volume, n (%)			<0.0001
>2,743 procs/yr	582 (8.24)	4,003 (83.43)	
≤2,743 procs/yr	6,477 (91.76)	795 (16.57)	
Hospital GB volume, n (%)			<0.0001
>125 procs/yr	4,433 (62.80)	3,329 (69.38)	
≤125 procs/yr	2,626 (37.20)	1,469 (30.62)	
Bed size, mean±SE	285.09±1.50	536.51±3.19	<0.0001
Bed size, n (%)			<0.0001
less than 200	2,111 (29.91)	0 (0.00)	
200-299	2,016 (28.56)	706 (14.71)	
300-399	1,506 (21.33)	389 (8.11)	
400-499	937 (13.27)	1,1119 (23.32)	
500+	489 (6.93)	2,584 (53.86)	
Teaching hospital, n (%)	0 (0.00)	643 (13.40)	<0.0001
Major metropolitan area- county population ≥1 million, n (%)	4,703 (66.62)	3,175 (66.17)	0.610
Ownership, n (%)			<0.0001
For profit	5,204 (73.72)	1,496 (31.18)	
Government	192 (2.72)	256 (5.34)	
Not-for-profit	1,663 (23.56)	3,046 (63.48)	
Dichotomous			<0.0001
For profit	5,204 (73.72)	1,496 (31.18)	
Not-for-profit or government	1,855 (26.28)	3,302 (68.82)	

*SE= standard error; total number of surgeons=160; total number of hospitals=81

TABLE 16: Patient characteristics according to in-hospital complications and length of stay for gastric bypass in Florida, 2003 – 2004 (for the surgeon volume study)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
Patient Characteristics	No (n=9,303)	Yes (n=2,060)	p-value	No (n=10,119)	Yes (n=1,244)	p-value	No (n=10,230)	Yes (n=1,133)	p-value	(n=11,363)	p-value
Age, mean(SD)	41.95 (10.75)	45.13 (10.88)	<0.0001	42.12 (10.81)	45.86 (10.50)	<0.0001	42.28 (10.75)	44.74 (11.37)	<0.0001	r**= 0.10	-
Gender, n (%)			0.143			0.08			<0.0001		0.0003
Male	1,709 (18.37)	407 (19.76)		1,907 (18.85)	209 (16.80)		1,842 (18.01)	274 (24.18)		3.36 (3.36)	
Female	7,594 (81.63)	1,653 (80.24)		8,212 (81.15)	1,035 (83.20)		8,388 (81.99)	859 (75.82)		3.65 (3.40)	
Race/Ethnicity, n (%)/ mean(SD)			0.042			0.016			<0.0001		<0.0001
Non-Hispanic White	6,461 (69.45)	1,473 (71.50)		7,031 (69.48)	903 (72.59)		7,122 (69.62)	812 (71.67)		3.52 (3.61)	
Non-Hispanic Black	1,096 (11.78)	206 (10.00)		1,156 (11.42)	146 (11.74)		1,215 (11.88)	87 (7.68)		3.28 (2.15)	
Hispanic	1,503 (16.16)	316 (15.34)		1,659 (16.39)	160 (12.86)		1,622 (15.86)	197 (17.39)		3.03 (3.27)	
Other	243 (2.61)	65 (3.16)		273 (2.70)	35 (2.81)		271 (2.65)	37 (3.27)		3.51 (3.57)	
Payer Type, n (%)/ mean(SD)			<0.0001			<0.0001			<0.0001		<0.0001
Medicare	568 (6.11)	210 (10.19)		657 (6.49)	121 (9.73)		651 (6.36)	127 (11.21)		4.59 (6.47)	
Medicaid	229 (2.46)	40 (1.94)		246 (2.43)	23 (1.85)		248 (2.42)	21 (1.85)		3.51 (2.72)	
Private	7,484 (80.45)	1,643 (79.76)		8,134 (80.38)	993 (79.82)		8,227 (80.42)	900 (79.44)		3.35 (3.04)	
Self pay/ underinsured	597 (6.42)	110 (5.34)		640 (6.32)	67 (5.39)		651 (6.36)	56 (4.94)		3.08 (3.06)	
Other	425 (4.57)	57 (2.77)		442 (4.37)	40 (3.22)		453 (4.43)	29 (2.56)		3.03 (2.90)	

TABLE 16 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
Patient Characteristics	No (n=9,303)	Yes (n=2,060)	p-value	No (n=10,119)	Yes (n=1,244)	p-value	No (n=10,230)	Yes (n=1,133)	p-value	(n=11,363)	p-value
Elixhauser Comorbidities, n (%)/ mean(SD)			<0.0001			<0.0001			<0.0001		0.0121
Present	7,210 (77.50)	1,767 (85.78)		7,940 (78.47)	1,037 (83.36)		7,979 (78.00)	998 (88.08)		3.45 (3.09)	
Absent	2,093 (22.50)	293 (14.22)		2,179 (21.53)	207 (16.64)		2,251 (22.00)	135 (11.92)		3.26 (4.36)	
Year			0.003			0.429			<0.0001		<0.0001
2003	5,205 (55.95)	1,226 (59.51)		5,740 (56.72)	691 (55.55)		5,710 (55.82)	721 (63.64)		3.53 (3.46)	
2004	4,098 (44.05)	834 (40.49)		4,379 (43.28)	553 (44.45)		4,520 (44.18)	412 (36.36)		3.26 (3.30)	

*SD= standard deviation; total number of surgeons=108; total number of hospitals=73; **r= Pearson correlation coefficient; SD= Standard deviation is reported for t-test results; Standard Deviation is reported for one-way ANOVA results

TABLE 17: Provider characteristics according to in-hospital complications and length of stay for gastric bypass in Florida, 2003 -2004 (for the surgeon volume study)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,303)	Yes (n=2,060)	p-value	No (n=10,119)	Yes (n=1,244)	p-value	No (n=10,230)	Yes (n=1,133)	p-value	(n=11,363)	p-value
Surgeon Characteristics											
Surgeon non-GB_C volume, n (%)			0.002			0.361			<0.0001		<0.0001
≤50 procs/yr	6,927 (74.46)	1,464 (71.07)		7,459 (73.71)	932 (74.92)		7,634 (74.62)	757 (66.81)		3.30 (3.65)	
>50 procs/yr	2,376 (25.54)	596 (28.93)		2,660 (26.29)	312 (25.08)		2,596 (25.38)	376 (33.19)		3.73 (2.50)	
Surgeon non-GB_{NC} volume, n (%)			<0.0001			0.001			<0.0001		<0.0001
≤142 procs/yr	7,226 (77.67)	1,378 (66.89)		7,711 (76.20)	893 (71.78)		7,898 (77.20)	706 (62.31)		3.27 (3.39)	
>142 procs/yr	2,077 (22.33)	682 (33.11)		2,408 (23.80)	351 (28.22)		2,332 (22.80)	427 (37.61)		3.87 (3.36)	
Surgeon GB volume, n (%)			<0.0001			<0.0001			<0.0001		<0.0001
≤50 procs/yr	1,310 (14.08)	389 (18.88)		1,459 (14.42)	240 (19.29)		1,479 (14.46)	220 (19.42)		3.79 (4.08)	
>50 procs/yr	7,993 (85.92)	1,671 (81.12)		8,660 (85.58)	1,004 (80.71)		8,751 (85.54)	913 (80.58)		3.35 (3.26)	

TABLE 17 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,303)	Yes (n=2,060)	p-value	No (n=10,119)	Yes (n=1,244)	p-value	No (n=10,230)	Yes (n=1,133)	p-value	(n=11,363)	p-value
Hospital Characteristics											
Hospital Volumes (principal procedures)											
Hospital GB volume (mean, SD*/median)			<0.0001			<0.0001			0.562		0.48
≤125 procs/yr	2,940 (31.60)	764 (37.09)		3,197 (31.59)	507 (40.76)		3,326 (32.51)	378 (33.36)		3.44 (3.52)	
>125 procs/yr	6,363 (68.40)	1,296 (62.91)		6,922 (68.41)	737 (59.24)		6,904 (67.49)	755 (66.64)		3.40 (3.32)	
Hospital Volumes (all procedures)											
Hospital GB volume (mean, SD*/median)			<0.0001			<0.0001			0.592		0.0525
≤125 procs/yr	2,802 (30.12)	729 (35.39)		3,050 (30.14)	481 (38.67)		3,171 (31.00)	360 (31.77)		3.45 (3.62)	
>125 procs/yr	6,501 (69.88)	1,331 (64.61)		7,069 (69.86)	763 (61.33)		7,059 (69.00)	773 (68.23)		3.32 (2.82)	
Bed size, mean (SD)	383.14 (207.27)	414.07 (237.36)	<0.0001	386.07 (207.31)	410.50 (256.44)	0.0001	385.55 (213.34)	417.63 (211.51)	<0.0001	r=0.06	-
Teaching hospital, n(%)			<0.0001			<0.0001			0.487		<0.0001
Teaching	463 (5.00)	156 (7.60)		499 (4.95)	120 (9.69)		552 (5.42)	67 (5.92)		4.86 (6.19)	
Non-teaching	8,795 (95.00)	1,897 (92.40)		9,574 (95.05)	1,118 (90.31)		9,627 (94.58)	1,065 (94.08)	3.33 (3.15)		

TABLE 17 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,303)	Yes (n=2,060)	p-value	No (n=10,119)	Yes (n=1,244)	p-value	No (n=10,230)	Yes (n=1,133)	p-value	(n=11,363)	p-value
Major metropolitan area, n (%)			<0.0001			<0.0001			<0.0001		0.0002
Hospital county population≥1 million	5,873 (63.13)	1,524 (73.98)		6,509 (64.32)	888 (71.38)		6,524 (63.77)	873 (77.05)		3.50 (3.14)	
Hospital county population<1 million	3,430 (36.87)	536 (26.02)		3,610 (35.68)	356 (28.62)		3,706 (36.23)	260 (22.95)		3.25 (3.82)	
Ownership, n (%)			<0.0001			0.105			<0.0001		<0.0001
For profit	5,344 (57.44)	1,048 (50.87)		5,719 (56.52)	673 (54.10)		5,861 (57.29)	531 (46.87)		3.25 (2.64)	
Not-for-profit or government	3,959 (42.56)	1,012 (49.13)		4,400 (43.48)	571 (45.90)		4,369 (42.71)	601 (53.13)		3.62 (4.16)	

*SD= standard deviation; total number of surgeons= 108; total number of hospitals=73; **r= Pearson correlation coefficient; SE= Standard error- is reported for t-test results; Standard Deviation is reported for one-way ANOVA results

TABLE 18: Patient characteristics according to in-hospital complications and length of stay for gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
Patient Characteristics	No (n=9,676)	Yes (n=2,181)	p-value	No (n=10,524)	Yes (n=1,333)	p-value	No (n=10,675)	Yes (n=1,182)	p-value	(n=11,857)	p-value
Age, mean(SD)	41.88 (10.75)	45.01 (10.90)	<0.0001	42.05 (10.82)	45.66 (10.54)	<0.0001	42.21 (10.76)	44.69 (11.38)	<0.0001	r**= 0.10	-
Gender, n(%)			0.077			0.103			<0.0001		0.0002
Male	1,785 (18.45)	438 (20.08)		1,995 (18.96)	228 (17.10)		1,931 (18.09)	292 (24.70)		3.69 (3.39)	
Female	7,891 (81.55)	1,743 (79.92)		8,529 (81.04)	1,105 (82.90)		8,744 (81.91)	890 (75.30)		3.39 (3.51)	
Race/Ethnicity, n(%)/ mean(SD)			0.188			0.031			<0.0001		<0.0001
Non-Hispanic White	6,673 (68.96)	1,535 (70.38)		7,258 (68.97)	950 (71.27)		7,370 (69.04)	838 (70.09)		3.54 (3.66)	
Non-Hispanic Black	1,162 (12.01)	232 (10.64)		1,227 (11.66)	167 (12.53)		1,299 (12.17)	95 (8.04)		3.35 (3.26)	
Hispanic	1,585 (16.38)	347 (15.91)		1,752 (16.65)	180 (13.50)		1,721 (16.12)	211 (17.85)		3.10 (3.61)	
Other	256 (2.65)	67 (3.07)		287 (2.73)	36 (2.70)		285 (2.67)	38 (3.21)		3.54 (2.54)	
Payer type, n(%)/ mean(SD)			<0.0001			<0.0001			<0.0001		<0.0001
Medicare	601 (6.21)	234 (10.73)		698 (6.63)	137 (10.28)		696 (6.52)	139 (11.76)		4.68 (6.45)	
Medicaid	281 (2.90)	61 (2.80)		305 (2.90)	37 (2.78)		310 (2.90)	32 (2.71)		3.72 (2.56)	
Private	7.749 (80.08)	1,716 (78.68)		8,416 (79.97)	1,049 (78.69)		8,539 (79.99)	926 (78.34)		3.38 (3.18)	
Self pay/ underinsured	619 (6.40)	112 (5.14)		662 (6.29)	69 (5.18)		675 (6.32)	56 (4.74)		3.09 (3.02)	
Other	426 (4.40)	58 (2.66)		443 (4.21)	41 (3.08)		455 (4.26)	29 (2.45)		3.03 (2.90)	

TABLE 18 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
Patient Characteristics	No (n=9,676)	Yes (n=2,181)	p-value	No (n=10,524)	Yes (n=1,333)	p-value	No (n=10,675)	Yes (n=1,182)	p-value	(n=11,857)	p-value
Elixhauser Comorbidities, n(%)/ mean(SD)			<0.0001			<0.0001			<0.0001		0.0045
Present	7,521 (77.73)	1,875 (85.97)		8,282 (78.70)	1,1114 (83.57)		8,352 (78.24)	1,044 (88.32)		3.49 (3.23)	
Absent	2,155 (22.27)	306 (14.03)		2,242 (21.30)	219 (16.43)		2,323 (21.76)	138 (11.68)		3.27 (4.35)	
Year			0.003			0.316			<0.0001		<0.0001
2003	5,398 (55.79)	1,292 (59.24)		5,955 (56.58)	735 (55.14)		5,939 (55.63)	751 (63.54)		3.56 (3.51)	
2004	4,278 (44.21)	889 (40.76)		4,569 (43.42)	598 (44.86)		4,736 (44.37)	431 (36.46)		3.30 (3.46)	

*SD= standard deviation; total number of surgeons=160; total number of hospitals=81; **r= Pearson correlation coefficient; SE= Standard error- is reported for t-test results; Standard Deviation is reported for one-way ANOVA results

TABLE 19: Provider characteristics according to in-hospital complications and length of stay for gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,676)	Yes (n=2,181)	p-value	No (n=10,524)	Yes (n=1,333)	p-value	No (n=10,675)	Yes (n=1,182)	p-value	(n=11,857)	p-value
Surgeon Characteristics											
Surgeon GB volume, n(%)/ mean (SD)			<0.0001			<0.0001			<0.0001		<0.0001
≤50 procs/yr	1,519 (15.70)	454 (20.82)		1,691 (16.07)	282 (21.16)		1,722 (16.13)	251 (21.24)		3.80 (4.38)	
>50 procs/yr	8,157 (84.30)	1,727 (79.18)		8,833 (83.93)	1,051 (78.84)		8,953 (83.87)	931 (78.86)		3.38 (3.49)	
Hospital Characteristics											
Hospital Volumes (principal procedures)											
Hospital non-GB_C volume, n(%)/ mean (SD)			0.026			0.144			<0.0001		<0.0001
≤2,743 procs/yr	5,980 (61.80)	1,292 (59.24)		6,430 (61.10)	842 (63.17)		6,623 (62.04)	649 (54.91)		3.24 (3.03)	
>2,743 procs/yr	3,696 (38.20)	889 (40.76)		4,094 (38.90)	491 (36.83)		4,052 (37.96)	533 (45.09)		3.77 (4.10)	
Hospital non-GB_{NC} volume, n(%)/ mean (SD)			0.013			0.001			0.587		<0.0001
≤6,478 procs/yr	5,709 (59.00)	1,350 (61.90)		6,207 (58.98)	852 (63.92)		6,364 (59.62)	695 (58.80)		3.29 (3.30)	
>6,478 procs/yr	3,964 (41.00)	831 (38.10)		4,317 (41.02)	481 (36.08)		4,311 (40.38)	487 (41.20)		3.68 (3.75)	

TABLE 19 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,676)	Yes (n=2,181)	p-value	No (n=10,524)	Yes (n=1,333)	p-value	No (n=10,675)	Yes (n=1,182)	p-value	(n=11,857)	p-value
Hospital GB volume, n(%)/ mean (SD)			<0.0001			<0.0001			0.886		0.1182
≤125 procs/yr	3,242 (33.51)	853 (39.11)		3,516 (33.41)	579 (43.44)		3,689 (34.56)	406 (34.35)		3.52 (3.72)	
>125 procs/yr	6,434 (66.49)	1,328 (60.89)		7,008 (66.59)	754 (59.56)		6,986 (65.44)	776 (65.65)		3.41 (3.37)	
Hospital Volumes (principal and secondary procedures)											
Hospital non-GB_C volume, n(%)/ mean (SD)			<0.0001			0.703			<0.0001		<0.0001
≤4,617 procs/yr	5,986 (61.86)	1,260 (57.77)		6,425 (61.05)	821 (61.59)		6,622 (62.03)	624 (52.79)		3.13 (2.98)	
>4,617 procs/yr	3,690 (38.14)	921 (42.23)		4,099 (38.95)	512 (38.41)		4,053 (37.97)	558 (47.21)		3.94 (4.13)	
Hospital non-GB_{NC} volume, n(%)/ mean (SD)			0.276			0.019			0.113		<0.0001
≤18,082 procs/yr	5,979 (61.79)	1,375 (63.04)		6,488 (61.65)	866 (64.97)		6,646 (62.26)	708 (59.90)		3.23 (3.17)	
>18,082 procs/yr	3,697 (38.21)	806 (36.96)		4,036 (38.35)	467 (35.03)		4,029 (37.74)	474 (40.10)		3.79 (3.68)	

TABLE 19 (continued)

	Composite Complications			Technical Complications			Systemic Complications			LOS	
	No (n=9,676)	Yes (n=2,181)	p-value	No (n=10,524)	Yes (n=1,333)	p-value	No (n=10,675)	Yes (n=1,182)	p-value	(n=11,857)	p-value
Hospital GB volume, n(%)/ mean (SD)			<0.0001			<0.0001			0.846		0.3830
≤125 procs/yr	3,104 (32.08)	818 (37.51)		3,369 (32.01)	553 (41.49)		3,534 (33.11)	388 (32.83)		3.41 (3.15)	
>125 procs/yr	6,572 (67.92)	1,363 (62.49)		7,155 (67.99)	780 (58.51)		7,141 (66.89)	794 (67.17)		3.47 (3.65)	
Bed size, mean (SD)	381.04 (205.13)	412.50 (234.07)	<0.0001	384.00 (205.20)	409.15 (6.90)	<0.0001	383.60 (211.09)	416.03 (209.46)	<0.0001	r**= 0.06	
Teaching hospital, n(%)/ mean (SD)			<0.0001			<0.0001			0.534		<0.0001
Teaching	472 (4.91)	171 (7.87)		509 (4.86)	134 (10.11)		574 (5.41)	69 (5.84)		4.76 (6.10)	
Non-teaching	9,147 (95.09)	2,002 (92.13)		9,957 (95.14)	1,192 (89.89)		10,037 (94.59)	1,112 (94.16)		3.37 (3.27)	
Major metropolitan area, n(%)/ mean (SD)			<0.0001			<0.0001			<0.0001		<0.0001
Hospital county population≥1 million	6,237 (64.46)	1,641 (75.24)		6,901 (65.57)	977 (73.29)		6,920 (65.20)	918 (77.66)		3.26 (3.84)	
Hospital county population<1 million	3,439 (35.54)	540 (24.76)		3,623 (34.43)	356 (26.71)		3,715 (34.80)	264 (22.34)		3.54 (3.30)	
Ownership, n(%)/ mean (SD)			<0.0001			0.110			<0.0001		<0.0001
For profit	5,578 (57.65)	1,122 (51.44)		5,974 (56.77)	726 (54.46)		6,139 (57.51)	561 (47.46)		3.32 (2.86)	
Not-for-profit or government	4,098 (42.35)	1,059 (48.56)		4,550 (43.23)	607 (45.54)		4,536 (42.49)	621 (52.54)		3.62 (4.16)	

*SD= standard deviation; total number of surgeons= 160; total number of hospitals= 81; **r= Pearson correlation coefficient; SE= Standard error- is reported for t-test results; Standard Deviation is reported for one-way ANOVA results

TABLE 20: Unadjusted association between each independent variable and composite complications among patients undergoing gastric bypass in Florida, 2003 – 2004 (for the surgeon volume study)

	Composite Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.03	1.02-1.03, <0.0001
Gender		
Female	1.00	referent
Male	1.09	0.91-1.32, 0.352
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.83	0.70-0.99, 0.041
Hispanic	0.94	0.49-1.79, 0.851
Other	1.21	0.77-1.91, 0.399
Payer Type		
Medicare	1.75	1.19-2.56, 0.004
Medicaid	0.78	0.50-1.24,0.297
Private	1.00	referent
Self pay/ underinsured	0.82	0.59-1.15, 0.253
Other	0.59	0.39-0.91, 0.017
Elixhauser Comorbidities		
No	1.00	referent
Yes	1.75	1.24-2.46, 0.001
Year		
2003	1.00	referent
2004	0.98	0.71-1.36, 0.912
Surgeon Characteristics		
Surgeon non-GB_C volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	1.19	0.74-1.91, 0.480
Surgeon non-GB_{NC} volume		
≤142 procs/yr (lower 66th percentile)	1.00	referent
>142 procs/yr (upper 33rd percentile)	1.72	1.14-2.60, 0.009
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.70	0.53-0.94, 0.017

TABLE 20 (continued)

	Composite Complications	
	Odds Ratio	**95% CI, p-value**
Hospital Characteristics		
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.78	0.53-1.16, 0.221
Hospital GB volume (based on principal and secondary procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.79	0.53-1.16, 0.225
Bed size	1.00	0.1.00-1.001, 0.036
Teaching status		
Non-teaching	1.00	referent
Teaching	1.56	1.11-2.20, 0.009
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.60	0.37-0.97, 0.036
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.30	0.86-1.98, 0.217

total number of surgeons=108; total number of hospitals=73; CI= confidence interval

TABLE 21: Unadjusted association between each independent variable and technical complications among patients undergoing gastric bypass in Florida, 2003 – 2004 (for the surgeon volume study)

	Technical Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.03	1.025-1.04, p<0.0001
Gender		
Female	1.00	referent
Male	0.87	0.71-1.07, 0.179
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	1.03	0.85-1.25, 0.757
Hispanic	0.75	0.50-1.14, 0.181
Other	1.04	0.66-1.64, 0.85
Payer Type		
Medicare	1.55	1.09-2.21, 0.015
Medicaid	0.76	0.43-1.32, 0.324
Private	1.00	referent
Self pay/ underinsured	0.84	0.59-1.21, 0.353
other	0.73	0.59-1.21, 0.353
Elixhauser Comorbidities		
No	1.00	referent
Yes	1.37	0.98-1.93, 0.068
Year		
2003	1.00	referent
2004	1.05	0.89-1.23, 0.559
Surgeon Characteristics		
Surgeon non-GB_C volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.94	0.64-1.37, 0.744
Surgeon non-GB_{NC} volume		
≤142 procs/yr (lower 66th percentile)	1.00	referent
>142 procs/yr (upper 33rd percentile)	1.26	0.85-1.86, 0.247
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.70	0.53-0.95, 0.019

TABLE 21 (continued)

	Technical Complications	
	Odds Ratio	**95% CI, p-value**
Hospital Characteristics		
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.67	0.46-0.97, 0.035
Hospital GB volume (based on principal and secondary procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.68	0.47-0.99, 0.045
Bed size	1.00	0.99-1.001, 0.167
Teaching status		
Non-teaching	1.00	referent
Teaching	2.03	1.51-2.81, <0.0001
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.72	0.45-1.16, 0.177
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.10	0.76-1.61, 0.611

total number of surgeons=108; total number of hospitals=73; CI= confidence interval

TABLE 22: Unadjusted association between each independent variable and systemic complications among patients undergoing gastric bypass in Florida, 2003 – 2004 (for the surgeon volume study)

	Systemic Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.02	1.01-1.03, 0.0003
Gender		
Female	1.00	referent
Male	1.45	1.18-1.80, 0.0006
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.62	0.49-0.77, <0.0001
Hispanic	1.12	0.50-2.49, 0.787
Other	1.24	0.78-1.96, 0.357
Payer Type		
Medicare	1.86	1.21-2.85, 0.005
Medicaid	0.76	0.49-1.18, 0.225
Private	1.00	referent
Self pay/ underinsured	0.77	0.49-1.19, 0.230
Other	0.57	0.25-1.27, 0.167
Elixhauser Comorbidities		
No	1.00	referent
Yes	2.09	1.40-3.10, 0.0003
Year		
2003	1.00	referent
2004	0.72	0.64-0.82, <0.0001
Surgeon Characteristics		
Surgeon non-GB_C volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	1.46	0.80-2.68, 0.221
Surgeon non-GB_{NC} volume		
≤142 procs/yr (lower 66th percentile)	1.00	referent
>142 procs/yr (upper 33rd percentile)	2.05	1.11-3.77, 0.021
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.70	0.48-1.03, 0.069

TABLE 22 (continued)

	Systemic Complications	
	Odds Ratio	**95% CI, p-value**
Hospital Characteristics		
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.96	0.57-1.63, 0.885
Hospital GB volume (based on principal and secondary procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.96	0.57-1.63, 0.892
Bed size	1.00	0.99-1.001, 0.172
Teaching status		
Non-teaching	1.00	referent
Teaching	1.10	0.72-1.68, 0.652
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.52	0.29-0.95, 0.032
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.52	0.79-2.93, 0.211

total number of surgeons=108; total number of hospitals=73; CI= confidence interval

TABLE 23: Unadjusted association between each independent variable and length of stay among patients undergoing gastric bypass in Florida, 2003 – 2004 (for the surgeon volume study)

	Length of Stay	
	Parameter Estimate[§]	**95% CI, p-value**
Patient Characteristics		
Age	1.01	1.007-1.011, <0.0001
Gender		
Female	1.00	referent
Male	1.09	1.04-1.14, 0.0004
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.96	0.90-1.02, 0.164
Hispanic	0.87	0.71-1.06, 0.171
Other	1.03	0.84-1.27
Payer Type		
Medicare	1.38	1.20-1.58, <0.0001
Medicaid	1.03	0.87-1.22, 0.729
Private	1.00	referent
Self pay/ underinsured	0.90	0.81-0.99, 0.031
Other	0.88	0.71-1.10, 0.268
Elixhauser Comorbidities		
No	1.00	referent
Yes	1.06	0.94-1.20, 0.342
Year		
2003	1.00	referent
2004	0.92	0.86-0.98, 0.007
Surgeon Characteristics		
Surgeon non-GB_C volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	1.13	0.94-1.37, 0.201
Surgeon non-GB_{NC} volume		
≤142 procs/yr (lower 66th percentile)	1.00	referent
>142 procs/yr (upper 33rd percentile)	1.18	0.99-1.42, 0.068
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.88	0.75-1.03, 0.115

TABLE 23 (continued)

	Length of Stay	
	Parameter Estimate[§]	**95% CI, p-value**
Hospital Characteristics		
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.99	0.82-1.18, 0.879
Hospital GB volume (based on principal and secondary procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	1.04	0.88-1.23, 0.644
Bed size	1.00	0.99-1.00, 0.086
Teaching status		
Non-teaching	1.00	referent
Teaching	1.46	1.19-1.79, 0.0002
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.93	0.70-1.23, 0.604
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.11	0.93-1.34, 0.253

total number of surgeons=108; total number of hospitals=73; CI= confidence interval;
[§]Parameter Estimate= incidence rate ratio

TABLE 24: Unadjusted association between each independent variable and composite complications among patients undergoing gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Composite Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.03	1.02-1.03,<0.0001
Gender		
Female	1.00	referent
Male	1.11	0.93-1.33, 0.256
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.87	0.73-1.04, 0.130
Hispanic	0.97	0.52-1.79, 0.912
Other	1.17	0.75-1.82, 0.5003
Payer Type		
Medicare	1.81	1.28-2.57,0.0007
Medicaid	0.96	0.66-1.41, 0.842
Private	1.00	referent
Self pay/ underinsured	0.79	0.57-1.09, 0.161
Other	0.59	0.38-0.92, 0.019
Elixhauser Comorbidities		
No	1.00	referent
Yes	1.76	1.26-2.45, 0.0009
Year		
2003	1.00	referent
2004	0.87	0.77-0.98, 0.020
Surgeon Characteristics		
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.71	0.54-0.93, 0.013
Hospital Characteristics		
Hospital Volumes - based on principal procedures		
Hospital non-GB_C volume		
≤2,743 procs/yr (lower 66th percentile)	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	1.11	0.71-1.74, 0.636
Hospital non-GB_{NC} volume		
≤6,478 procs/yr (lower 66th percentile)	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	0.89	0.56-1.40, 0.601
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.78	0.53-1.15, 0.217

TABLE 24 (continued)

	Composite Complications	
	Odds Ratio	**95% CI, p-value**
Hospital Volumes - based on principal and secondary procedures		
Hospital non-GB_C volume		
≤4,617 procs/yr (lower 66th percentile)	1.00	referent
>4,617 procs/yr (upper 33rd percentile)	1.19	0.75-1.86, 0.459
Hospital non-GB_{NC} volume		
≤18,082 procs/yr (lower 66th percentile)	1.00	referent
>18,082 procs/yr (upper 33rd percentile)	0.95	0.61-1.46, 0.809
Hospital GB volume		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.79	0.54-1.15, 0.218
Bed size	1.00	1.000-1.001, 0.028
Teaching status		
Non-teaching	1.00	referent
Teaching	1.66	1.17-2.36, 0.004
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
hospital county population<1 million	0.60	0.38-0.94, 0.029
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.28	0.85-1.93, 0.228

total number of surgeons=160; total number of hospitals=81; CI= confidence interval

TABLE 25: Unadjusted association between each independent variable and technical complications among patients undergoing gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Technical Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.03	1.02-1.04, <0.0001
Gender		
Female	1.00	referent
Male	0.88	0.73-1.07, 0.2001
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	1.09	0.91-1.30, 0.372
Hispanic	0.78	0.52-1.17, 0.230
Other	0.99	0.63-1.55, 0.965
Payer Type		
Medicare	1.61	1.16-2.24, 0.004
Medicaid	0.96	0.62-1.47, 0.839
Private	1.00	referent
Self pay/ underinsured	0.81	0.57-1.56, 0.248
other	0.72	0.49-1.06, 0.0969
Elixhauser Comorbidities		
no	1.00	referent
yes	1.38	0.98-1.93, 0.062
Year		
2003	1.00	referent
2004	1.06	0.908-1.24, 0.458
Surgeon Characteristics		
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.71	0.53-0.95, 0.023
Hospital Characteristics		
Hospital Volumes - based on principal procedures		
Hospital non-GB_C volume		
≤2,743 procs/yr (lower 66th percentile)	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	0.92	0.63-1.34, 0.650

TABLE 25 (continued)

	Technical Complications	
	Odds Ratio	**95% CI, p-value**
Hospital non-GB_{NC} volume		
≤6,478 procs/yr (lower 66th percentile)	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	0.82	0.54-1.22, 0.312
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.65	0.46-0.94, 0.026
Hospital Volumes - based on principal and secondary procedures		
Hospital non-GB_C volume		
≤4,617 procs/yr (lower 66th percentile)	1.00	referent
>4,617 procs/yr (upper 33rd percentile)	0.98	0.66-1.45, 0.910
Hospital non-GB_{NC} volume		
≤18,082 procs/yr (lower 66th percentile)	1.00	referent
>18,082 procs/yr (upper 33rd percentile)	0.87	0.59-1.27, 0.466
Hospital GB volume		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.66	0.46-0.95, 0.026
Bed size	1.00	0.99-1.001, 0.122
Teaching status		
non-teaching	1.00	referent
teaching	2.20	1.56-3.10, <0.0001
Major metropolitan area		
hospital county population≥1 million	1.00	referent
hospital county population<1 million	0.69	0.44-1.10, 0.121
Ownership		
for profit	1.00	referent
not-for-profit or government	1.10	0.76-1.58, 0.613

total number of surgeons=160; total number of hospitals=81; CI= confidence interval

TABLE 26: Unadjusted association between each independent variable and systemic complications among patients undergoing gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Systemic Complications	
	Odds Ratio	**95% CI, p-value**
Patient Characteristics		
Age	1.02	1.01-1.03, <0.0001
Gender		
Female	1.00	referent
Male	1.49	1.21-1.82, 0.0001
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.63	0.51-0.79, <0.0001
Hispanic	1.13	0.52-2.45, 0.755
Other	1.21	0.77-1.91, 0.412
Payer Type		
Medicare	1.91	1.30-2.81, 0.0009
Medicaid	0.93	0.63-1.38, 0.718
Private	1.00	referent
Self pay/ underinsured	0.74	0.48-1.13, 0.164
Other	0.56	0.25-1.26, 0.164
Elixhauser Comorbidities		
No	1.00	referent
Yes	2.10	1.43-3.09, 0.0001
Year		
2003	1.00	referent
2004	0.72	0.64-0.82, <0.0001
Surgeon Characteristics		
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.71	0.50-1.10, 0.0614

TABLE 26 (continued)

	Systemic Complications	
	Odds Ratio	**95% CI, p-value**
Hospital Characteristics		
Hospital Volumes - based on principal procedures		
Hospital non-GB_C volume		
≤2,743 procs/yr (lower 66th percentile)	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	1.34	0.69-2.60, 0.383
Hospital non-GB_{NC} volume		
≤6,478 procs/yr (lower 66th percentile)	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	1.03	0.55-1.96, 0.917
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	1.01	0.60-1.69, 0.961
Hospital Volumes - based on principal and secondary procedures		
Hospital non-GB_C volume		
≤4,617 procs/yr (lower 66th percentile)	1.00	referent
>4,617 procs/yr (upper 33rd percentile)	1.46	0.75-2.84, 0.262
Hospital non-GB_{NC} volume		
≤18,082 procs/yr (lower 66th percentile)	1.00	referent
>18,082 procs/yr (upper 33rd percentile)	1.10	0.59-2.06, 0.756
Hospital GB volume		
≤125 procs/yr	1.00	referent
>125 procs/yr	1.01	0.60-1.70, 0.962

TABLE 26 (continued)

	Systemic Complications	
	Odds Ratio	**95% CI, p-value**
Bed size	1.00	0.99-1.001, 0.158
Teaching status		
Non-teaching	1.00	referent
Teaching	1.09	0.72-1.65, 0.680
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.54	0.30-0.96, 0.036
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.50	0.79-2.84, 0.215

total number of surgeons=160; total number of hospitals=81; CI= confidence interval

TABLE 27: Unadjusted association between each independent variable and length of stay among patients undergoing gastric bypass in Florida, 2003-2004 (for the hospital volume study)

	Length of Stay	
	Parameter Estimate[§]	**95% CI, p-value**
Patient Characteristics		
Age	1.01	1.007-1.011, <0.0001
Gender		
Female	1.00	referent
Male	1.09	1.04-1.14, 0.0003
Race/Ethnicity		
Non-Hispanic White	1.00	referent
Non-Hispanic Black	0.97	0.92-1.03, 0.325
Hispanic	0.88	0.73-1.07, 0.201
Other	1.03	0.85-1.25, 0.785
Payer Type		
Medicare	1.40	1.23-1.59, <0.0001
Medicaid	1.08	0.92-1.28, 0.342
Private	1.00	referent
Self pay/ underinsured	0.89	0.81-0.98, 0.017
Other	0.87	0.70-1.09, 0.229
Elixhauser Comorbidities		
No	1.00	referent
Yes	1.07	0.95-1.09, 0.229
Year		
2003	1.00	referent
2004	0.93	0.88-0.98, 0.006
Surgeon Characteristics		
Surgeon GB volume		
≤50 procs/yr (lower 66th percentile)	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.89	0.76-1.03, 0.115
Hospital Characteristics		
Hospital Volumes - based on principal procedures		
Hospital non-GB_C volume		
≤2,743 procs/yr (lower 66th percentile)	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	1.16	0.98-1.39, 0.089

TABLE 27 (continued)

	Length of Stay	
	Parameter Estimate[§]	**95% CI, p-value**
Hospital non-GB_{NC} volume		
≤6,478 procs/yr (lower 66th percentile)	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	1.12	0.91-1.37, 0.283
Hospital GB volume (based on principal procedures)		
≤125 procs/yr	1.00	referent
>125 procs/yr	0.97	0.81-1.16, 0.739
Hospital Volumes - based on principal and secondary procedures		
Hospital non-GB_C volume		
≤4,617 procs/yr (lower 66th percentile)	1.00	referent
>4,617 procs/yr (upper 33rd percentile)	1.26	1.06-1.49, 0.008
Hospital non-GB_{NC} volume	1.00	referent
≤18,082 procs/yr (lower 66th percentile)	1.00	referent
>18,082 procs/yr (upper 33rd percentile)	1.17	0.98-1.40, 0.082
Hospital GB volume		
≤125 procs/yr	1.00	referent
>125 procs/yr	1.02	0.86-1.20, 0.840
Bed size	1.00	0.99-1.00, 0.1005
Teaching status		
Non-teaching	1.00	referent
Teaching	1.41	1.15-1.73, 0.0008
Major metropolitan area		
Hospital county population≥1 million	1.00	referent
Hospital county population<1 million	0.92	0.70-1.21, 0.561
Ownership		
For profit	1.00	referent
Not-for-profit or government	1.09	0.92-1.30, 0.329

total number of surgeons=160; total number of hospitals=81; CI=confidence interval; [§]Parameter Estimate= incidence rate ratio

TABLE 28: Model fit assessment for the surgeon volume study

Outcomes	GEE model Link, Variance Function	Patients 'p' and no. of groups-hospitals 'h' used in the model	Working correlation structure	Cluster	QIC*
Composite Complications	logit, binomial	p=11,363, h=73	exchangeable	hospital	10,526.47
	logit, binomial	p=11,363, h=73	independent	hospital	10,510.64
Technical Complications	logit, binomial	p=11,363, h=73	exchangeable	hospital	7,752.22
	logit, binomial	p=11,363, h=73	independent	hospital	7,728.01
Systemic Complications	logit, binomial	p=11,363, h=73	exchangeable	hospital	7,224.07
	logit, binomial	p=11,363, h=73	independent	hospital	7,183.46
Length of Stay	log , negative binomial	p=11,363, h=73	exchangeable	hospital	2,652.26
	log , negative binomial	p=11,363, h=73	independent	hospital	2,597.10
	log , Poisson	p=11,363, h=73	independent	hospital	15,451.57
	log , Gaussian	p=11,363, h=73	independent	hospital	126,184.43
	identity , Gaussian	p=11,363, h=73	independent	hospital	126,169.44

*QIC= Quasi-likelihood under the independence model criterion, Lower QIC value better is the model fit; GEE Model - Surgeon non-GB_C volume + Surgeon non-GB_{NC} volume + Surgeon GB volume + Hospital GB volume (principal procedures) + age + male + Black + Hispanic + other race + Medicare + Medicaid + self/uninsured + other insurance + presence of comorbidities + year + teaching + not-for-profit or government + county population less than 1million + beds

TABLE 29: Model fit assessment for the hospital volume study

Outcomes	GEE model Link, Variance Function	Patients 'p' and no. of groups-hospitals 'h' used in the model	Working correlation structure	Cluster	QIC*
Composite Complications	logit, binomial	p=11,857, h=81	exchangeable	hospital	11083.11
	logit, binomial	p=11,857, h=81	independent	hospital	11,064.38
Technical Complications	logit, binomial	p=11,857, h=81	exchangeable	hospital	8,194.87
	logit, binomial	p=11,857, h=81	independent	hospital	8,147.64
Systemic Complications	logit, binomial	p=11,857, h=81	exchangeable	hospital	7,601.47
	logit, binomial	p=11,857, h=81	independent	hospital	7,577.59
Length of Stay	log , negative binomial	p=11,857, h=81	exchangeable	hospital	2,940.20
	log , negative binomial	p=11,857, h=81	independent	hospital	2,876.68
	log , Poisson	p=11,857, h=81	independent	hospital	17,161.30
	log , Gaussian	p=11,857, h=91	independent	hospital	140,242.04
	identity , Gaussian	p=11,857, h=91	independent	hospital	140,262.23

*QIC= Quasi-likelihood under the independence model criterion, Lower QIC value better is the model fit; GEE Model - Hospital non-GB_C volume (based on principal procedures) + Hospital non-GB_{NC} volume (based on principal procedures) + Surgeon GB volume + Hospital GB volume (based on principal procedures) + age + male + Black + Hispanic + other race + Medicare + Medicaid + self/uninsured + other insurance + presence of comorbidities + year + teaching + not-for-profit or government + county population less than 1million + beds

TABLE 30: Adjusted odds ratios for composite complications, by surgeon's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon non-GB_C Volume									
High	"Top-tertile" approach	0.79	0.54 - 1.15, 0.222	0.79	0.54 - 1.15, 0.224	0.91	0.66 - 1.27, 0.595	0.92	0.66 - 1.27, 0.605
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon non-GB_{NC} Volume									
High		**1.98**	**1.31 - 3.02, 0.001**	**1.97**	**1.29 - 2.99, 0.0015**	**1.70**	**1.16 - 2.51, 0.007**	**1.70**	**1.16 - 2.51, 0.007**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon GB volume									
High		-	-	**0.71**	**0.56 - 0.91, 0.006**	**0.73**	**0.57 - 0.95, 0.021**	**0.73**	**0.57 - 0.95, 0.017**
Low		-	-	1.00	referent	1.00	referent	1.00	referent
Hospital GB volume (based on principal procedures)	"Leapfrog group" approach								
High		-	-	-	-	0.88	0.64 - 1.22, 0.441	-	-
Low		-	-	-	-	1.00	referent	-	-

TABLE 30 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital GB volume (based on principal and secondary procedures)	"Leapfrog group" approach								
High		-	-	-	-	-	-	0.88	0.64 - 1.23, 0.457
Low		-	-	-	-	-	-	1.00	referent

[#]Surgeon non-GB_C Volume= surgeon's volume of non- gastric bypass complex procedures; [##]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [*]Surgeon's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 31: Adjusted odds ratios for technical complications, by surgeon's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon non-GB_C Volume									
High	"Top-tertile" approach	0.74	0.55 - 0.99, 0.042	0.74	0.57 - 0.95, 0.018	0.81	0.63-1.05, 0.106	0.82	0.64 -1.06, 0.134
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon non-GB_{NC} Volume									
High		**1.48**	**0.99 -2.21, 0.051**	**1.47**	**1.00 - 2.16, 0.049**	1.30	0.92-1.82, 0.134	1.29	0.92-1.81, 0.137
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon GB volume	"Leapfrog group" approach								
High		-	-	**0.74**	**0.55 - 0.98, 0.035**	0.88	0.67 -1.15, 0.339	0.87	0.67 -1.13, 0.293
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 31 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital GB volume (based on principal procedures)									
High	"Leapfrog group" approach		-	-	-	**0.72**	**0.52 - 0.98, 0.039**	-	-
Low		-	-	-	-	1.00	referent	-	-
Hospital GB volume (based on principal and secondary procedures)									
High			-	-	-	-	-	**0.71**	**0.51 - 0.98, 0.039**
Low		-	-	-	-	-	-	1.00	referent

[#]Surgeon non-GB_C Volume= surgeon's volume of non- gastric bypass complex procedures; [##]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [*]Surgeon's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 32: Adjusted odds ratios for systemic complications, by surgeon's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon non-GB_C Volume									
High	"Top-tertile" approach	0.92	0.56 -1.50, 0.737	0.93	0.56- 1.53, 0.759	1.12	0.70 - 1.80, 0.641	1.12	0.70 -1.80, 0.645
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon non-GB_{NC} Volume									
High		**2.20**	**1.22-3.96, 0.009**	**2.17**	**1.19 - 3.96, 0.012**	**1.88**	**1.13 - 3.13, 0.016**	**1.88**	**1.13 -3.13, 0.015**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon GB volume	"Leapfrog group" approach								
High		-	-	**0.68**	**0.47- 1.00, 0.050**	**0.59**	**0.36 -0.97, 0.036**	**0.58**	**0.36 -0.95, 0.029**
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 32 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital GB volume (based on principal procedures)									
High	"Leapfrog group" approach	-	-	-	-	1.16	0.66 - 2.03, 0.604	-	-
Low		-	-	-	-	1.00	referent	-	-
Hospital GB volume (based on principal and secondary procedures)									
High		-	-	-	-	-	-	1.19	0.69-2.04, 0.535
Low			-	-	-	-	-	-	1.00

[#]Surgeon non-GB_C Volume= surgeon's volume of non- gastric bypass complex procedures; [##]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [*]Surgeon's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 33: Adjusted parameter estimates for length of stay, by surgeon's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted Parameter Estimate[†]**	**(95% CI)‡, p-value**
Surgeon non-GB_C Volume									
High	"Top-tertile" approach	0.99	0.79 - 1.26, 0.984	0.99	0.79- 1.25, 0.959	1.05	0.86 - 1.28, 0.656	1.05	0.86 - 1.28, 0.664
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon non-GB_{NC} Volume									
High		1.21	0.97 - 1.50, 0.091	1.21	0.98 - 1.50, 0.081	1.19	0.99 - 1.42, 0.064	1.19	0.99 - 1.42, 0.060
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon GB volume	"Leapfrog group" approach								
High		-	-	0.89	0.77 -1.02, 0.092	0.88	0.77 -1.01, 0.070	0.88	0.77 -1.00, 0.051
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 33 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1 + Surgeon GB volume		Model 3[a]= Model 2+ Hospital characteristics (including hospital volume based on principal procedures)		**Additional Analysis** Model 4[b]= Model 2+ Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted Parameter Estimate[†]**	**(95% CI)‡, p-value**
Hospital GB volume (based on principal procedures)									
High	"Leapfrog group" approach	-	-	-	-	1.06	0.90 - 1.24, 0.477	-	-
Low		-	-	-	-	1.00	referent	-	-
Hospital GB volume (based on principal and secondary procedures)									
High		-	-	-	-	-	-	1.08	0.93 -1.25, 0.317
Low		-	-	-	-	-	-	1.00	referent

[#] Surgeon non-GB_C Volume= surgeon's volume of non- gastric bypass complex procedures; [##]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [*]Surgeon's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries; [†]Parameter Estimate= Incidence Rate Ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 34: Adjusted odds ratios for composite complications, by hospital's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital non-GB_C Volume[#]									
High	"Top-tertile" approach	1.61	**1.04-2.47, 0.031**	1.03	0.95-1.77, 0.094	1.29	0.95-1.76, 0.105	**1.55**	**1.09-2.20, 0.016**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital non-GB_{NC} Volume[##]									
High		0.58	**0.36-0.94, 0.026**	0.51	0.32-0.79, 0.003	**0.51**	**0.33-0.80, 0.003**	**0.51**	**0.34-0.77, 0.001**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital GB volume	"Leapfrog group" approach								
High		-	-	0.80	0.60-1.05, 0.111	0.86	0.64-1.14, 0.290	0.86	0.63 - 1.17, 0.348
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 34 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon GB volume									
High	"Leapfrog group" approach	-	-	-	-	**0.77**	**0.61-0.98, 0.032**	**0.76**	**0.60-0.96, 0.0215**
Low		-	-	-	-	1.00	referent	1.00	referent
Hospital volume based on principal procedure		-	-	Yes	Yes	Yes	Yes	N/A	N/A
Hospital volume based on principal procedure and secondary procedure		-	-	N/A	N/A	N/A	N/A	Yes	Yes

[#]Hospital non-GBc Volume= hospital's volume of non- gastric bypass complex procedures; Hospital GB volume= hospital's volume of gastric bypass surgeries; [##]Hospital's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 35: Adjusted odds ratios for technical complications, by hospital's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital non-GB_C Volume[#]									
High	"Top-tertile" approach	1.22	0.85-1.74, 0.272	0.99	0.75-1.30, 0.919	0.98	0.74-1.30, 0.899	1.13	0.82-1.57, 0.452
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital non-GB_{NC} Volume[##]									
High		0.68	0.46-1.01, 0.053	**0.60**	**0.41-0.87, 0.007**	**0.60**	**0.42-0.88, 0.008**	**0.62**	**0.45-0.85, 0.003**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital GB volume	"Leapfrog group" approach								
High		-	-	**0.68**	**0.52-0.90, 0.006**	**0.70**	**0.52-0.95, 0.022**	**0.69**	**0.50-0.96, 0.026**
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 35 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon GB volume	"Leapfrog group" approach								
High		-	-	-	-	0.91	0.69-1.19, 0.478	0.89	0.69-1.56, 0.397
Low		-	-	1.00	referent	1.00	referent	1.00	referent
Hospital volume based on principal procedure		-	-	Yes	Yes	Yes	Yes	N/A	N/A
Hospital volume based on principal procedure and secondary procedure		-	-	N/A	N/A	N/A	N/A	Yes	Yes

[#]Hospital non-GB_C Volume= hospital's volume of non- gastric bypass complex procedures; Hospital GB volume= hospital's volume of gastric bypass surgeries; [##]Hospital's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 36: Adjusted odds ratios for systemic complications, by hospital's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Hospital non-GB_C Volume[#]									
High	"Top-tertile" approach	1.83	0.89-3.76, 0.098	1.49	0.88-2.52, 0.137	1.47	0.87-2.48, 0.145	**1.90**	**1.09-3.30, 0.023**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital non-GB_{NC} Volume[##]									
High		0.60	0.29-1.26, 0.178	0.54	0.27-1.06, 0.070	0.56	0.28-1.07, 0.077	**0.52**	**0.28-0.98, 0.043**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital GB volume	"Leapfrog group" approach								
High		-	-	0.99	0.64-1.54, 0.979	1.13	0.70-1.83, 0.615	1.18	0.72-1.92, 0.515
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 36 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**
Surgeon GB volume	"Leapfrog group" approach								
High		-	-	-	-	**0.64**	**0.43-0.94, 0.024**	**0.63**	**0.43-0.92, 0.018**
Low		-	-	1.00	referent	1.00	referent	1.00	referent
Hospital volume based on principal procedure		-	-	Yes	Yes	Yes	Yes	N/A	N/A
Hospital volume based on principal procedure and secondary procedure		-	-	N/A	N/A	N/A	N/A	Yes	Yes

[#] Hospital non-GB_C Volume= hospital's volume of non- gastric bypass complex procedures; Hospital GB volume= hospital's volume of gastric bypass surgeries; [##]Hospital's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;[†]OR = Odds ratio; [‡]CI= Confidence interval

[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.

Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 37: Adjusted parameter estimates for length of stay, by hospital's non-gastric bypass volume and surgeon's- and hospital's-gastric bypass volume, among patients undergoing gastric bypass surgery in Florida, 2003-2004

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted Parameter Estimate[†]**	**(95% CI)‡, p-value**
Hospital non-GB_C Volume[#]									
High	"Top-tertile" approach	1.19	0.87-1.62, 0.268	1.18	0.87-1.60, 0.287	1.17	0.87-1.59, 0.301	**1.38**	**1.12-1.70, 0.002**
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital non-GB_{NC} Volume[##]									
High		0.97	0.69-1.36, 0.852	0.96	0.69-1.35, 0.836	0.97	0.70-1.35, 0.861	0.90	0.73-1.10, 0.288
Low		1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital GB volume	"Leapfrog group" approach								
High		-	-	0.97	0.84-1.13, 0.725	0.99	0.86-1.16, 0.984	1.02	0.88-1.17, 0.806
Low		-	-	1.00	referent	1.00	referent	1.00	referent

TABLE 37 (continued)

Volume Variables		Model 1 = Adjusted for patient characteristics + year		Model 2= Model 1+ Hospital characteristics (including hospital volume based on principal procedures)		Model 3[a]= Model 2 + Surgeon GB volume		**Additional Analysis** Model 4[b]= Model 1+Surgeon GB volume + Hospital characteristics (including hospital volume based on principal and secondary procedures)	
		Adjusted OR[†]	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted OR[†]**	**(95% CI)‡, p-value**	**Adjusted Parameter Estimate[†]**	**(95% CI)‡, p-value**
Surgeon GB volume									
High	"Leapfrog group" approach	-	-	-	-	0.90	0.80-1.02, 0.092	0.89	0.79-1.00, 0.063
Low		-	-	1.00	referent	1.00	referent	1.00	referent
Hospital volume based on principal procedure		-	-	Yes	Yes	Yes	Yes	N/A	N/A
Hospital volume based on principal procedure and secondary procedure		-	-	N/A	N/A	N/A	N/A	Yes	Yes

[#]Hospital non-GB_C Volume= hospital's volume of non- gastric bypass complex procedures; Hospital GB volume= hospital's volume of gastric bypass surgeries;
[##]Hospital's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [§]Hospital GB volume=hospital's volume of gastric bypass surgeries;
[†]Parameter Estimate= Incidence Rate Ratio; [‡]CI= Confidence interval;
[a]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.
[b]Estimates derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, surgeon GB volume, hospital GB volume (based on principal and secondary procedures), hospital teaching status, bed size, ownership status, major metropolitan area status, and year, and adjusting standard errors for the non-nested clustering structure.
Note: The hospital and surgeon GB volume results are shown in the table, although these volumes were covariates in the model.

TABLE 38: Unadjusted association between each independent variable and composite complications among patients undergoing gastric bypass in Florida, 2003-2004 (stratified by surgeon gastric bypass volume)

	Surgeon Gastric Bypass Volume			
	Low (≤50 procs/yr) n=1,699		**High (>50 procs/yr)** n=9,664	
Characteristics	**Odds Ratio**	**95% CI, p-value**	**Odds Ratio**	**95% CI, p-value**
Patient Characteristics				
Age	1.04	1.03-1.05, p<0.0001	1.025	1.02-1.03, p<0.0001
Gender				
Female	1.00	referent	1.00	referent
Male	1.09	1.61-1.93, 0.774	1.11	0.92-1.34, 0.280
Race/Ethnicity				
Non-Hispanic White	1.00	referent	1.00	referent
Non-Hispanic Black	0.93	0.63-1.97, 0.704	0.82	0.72-0.94, 0.004
Hispanic	0.84	0.43-1.63, 0.598	0.98	0.51-1.87, 0.945
Other	0.92	0.41-2.06, 0.847	1.28	0.88-1.87, 0.198
Payer Type				
Medicare	2.15	1.42-2.34, 0.0003	1.61	1.06-2.45, 0.027
Medicaid	0.40	0.18-0.97, 0.027	0.89	0.54-1.46, 0.641
Private	1.00	referent	1.00	referent
Self pay/ underinsured	1.01	0.61-1.69, 0.954	0.77	0.52-1.12, 0.170
Other	0.81	0.50-1.31, 0.395	0.59	0.27-1.28, 0.181
Elixhauser Comorbidities				
No	1.00	referent	1.00	referent
Yes	1.70	1.16-2.49, 0.007	1.76	1.26-2.45, 0.0008
Year				
2003	1.00	referent	1.00	referent
2004	0.98	0.71-1.36, 0.912	0.8	0.69-0.93, 0.004
Surgeon Characteristics				
Surgeon non-GB_C volume ≤50 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.78	0.53-1.15, 0.218	1.29	0.72-2.29, 0.390

TABLE 38 (continued)

	Surgeon Gastric Bypass Volume			
	Low (≤50 procs/yr) (n=1,699)		High (>50 procs/yr) (n=9,664)	
Characteristics	**Odds Ratio**	**95% CI, p-value**	**Odds Ratio**	**95% CI, p-value**
Surgeon non-GB_{NC} volume				
≤142 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>142 procs/yr (upper 33rd percentile)	1.12	0.78-1.60, 0.537	1.87	1.12-3.15, 0.018
Hospital Characteristics				
Hospital GB volume (based on principal procedures)				
≤125 procs/yr	1.00	referent	1.00	referent
>125 procs/yr	1.16	0.67-2.01, 0.588	0.79	0.54-1.17, 0.240
Hospital GB volume (based on principal and secondary procedures)				
≤125 procs/yr	1.00	referent	1.00	referent
>125 procs/yr	1.06	0.65-1.73, 0.810	0.80	0.54-1.19, 0.274
Bed size	1.00	0.99-1.001, 0.491	1.00	1.00-1.001, 0.001
Teaching status				
Non-teaching	1.00	referent	1.00	referent
Teaching	1.01	0.65-1.58, 0.958	1.77	1.29-2.43, 0.0004
Major metropolitan area				
Hospital county population≥1 million	1.00	referent	1.00	referent
Hospital county population<1 million	0.68	0.45-1.01, 0.058	0.57	0.34-0.95, 0.032
Ownership				
For profit	1.00	referent	1.00	referent
Not-for-profit or government	1.13	0.75-1.70, 0.548	1.33	0.81-2.17, 0.257

total number of surgeons=108; total number of hospitals=73; CI= confidence interval

TABLE 39: Unadjusted association between each independent variable and length of stay among patients undergoing gastric bypass in Florida, 2003 – 2004 (stratified by surgeon gastric bypass volume)

	Surgeon Gastric Bypass Volume			
	Low (≤50 procs/yr) (n=1,699)		High (>50 procs/yr) (n=9,664)	
Characteristics	**Parameter Estimate[§]**	**95% CI, p-value**	**Parameter Estimate[§]**	**95% CI, p-value**
Patient Characteristics				
Age	1.01	1.005-1.014, <0.0001	1.009	1.007-1.011, <0.0001
Gender				
Female	1.00	referent	1.00	referent
Male	1.08	0.923-1.25, 0.349	1.09	1.04-1.15, 0.0006
Race/Ethnicity				
Non-Hispanic White	1.00	referent	1.00	referent
Non-Hispanic Black	0.92	0.83-1.101, 0.088	0.97	0.92-1.03, 0.280
Hispanic	0.90	0.70-1.16, 0.420	0.87	0.71-1.06, 0.186
Other	1.03	0.70-1.52, 0.862	1.03	0.85-1.23, 0.790
Payer Type				
Medicare	1.44	1.17-1.77, 0.0005	1.35	1.17-1.56, <0.0001
Medicaid	1.17	0.81-1.69, 0.405	0.99	0.84-1.18, 0.950
Private	1.00	referent	1.00	referent
Self pay/ underinsured	0.79	0.70-0.9, 0.0004	0.92	0.83-1.02, 0.127
Other	1.14	0.72-1.78, 0.580	0.86	0.70-1.07, 0.189
Elixhauser Comorbidities				
No	1.00	referent	1.00	referent
Yes	1.08	0.88-1.33, 0.441	1.05	0.93-1.19, 0.403
Year				
2003	1.00	referent	1.00	referent
2004	0.88	0.76-1.02, 0.088	0.92	0.86-0.99, 0.020
Surgeon Characteristics				
Surgeon non-GB_C volume ≤50 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>50 procs/yr (upper 33rd percentile)	1.10	0.90-1.35, 0.336	1.13	0.90-1.44, 0.293

TABLE 39 (continued)

	Surgeon Gastric Bypass Volume			
	Low (≤50 procs/yr) (n=1,699)		High (>50 procs/yr) (n=9,664)	
Characteristics	**Parameter Estimate[§]**	**95% CI, p-value**	**Parameter Estimate[§]**	**95% CI, p-value**
Surgeon non-GB_{NC} volume				
≤142 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>142 procs/yr (upper 33rd percentile)	1.02	0.86-1.22, 0.800	1.22	0.97-1.52, 0.086
Hospital Characteristics				
Hospital GB volume (based on principal procedures)				
≤125 procs/yr	1.00	referent	1.00	referent
>125 procs/yr	1.18	0.96-1.46, 0.118	0.99	0.84-1.18, 0.957
Hospital GB volume (based on principal and secondary procedures)				
≤125 procs/yr	1.00	referent	1.00	referent
>125 procs/yr	1.13	1.09-1.58, 0.004	1.03	0.88-1.22, 0.709
Bed size	1.00	0.99-1.00, 0.110	1.00	0.99-1.00, 0.227
Teaching status				
Non-teaching	1.00	referent	1.00	referent
Teaching	1.29	1.01-1.65, 0.038	1.51	1.19-1.91, 0.0006
Major metropolitan area				
Hospital county population≥1 million	1.00	referent	1.00	referent
Hospital county population<1 million	1.19	0.95-1.50, 0.129	0.87	0.64-1.18, 0.371
Ownership				
For profit	1.00	referent	1.00	referent
Not-for-profit or government	1.15	0.90-1.46, 0.270	1.1	0.90-1.34, 0.339

total number of surgeons=108; total number of hospitals=73; CI= confidence interval; [§]Parameter Estimate= incidence rate ratio

TABLE 40: Unadjusted association between each independent variable and composite complications among patients undergoing gastric bypass in Florida, 2003 – 2004 (stratified by hospital gastric bypass volume)

	Hospital Gastric Bypass Volume			
	Low (≤125 procs/yr) n=4,095		High (>125 procs/yr) n=7,762	
Characteristics	**Odds Ratio**	**95% CI, p-value**	**Odds Ratio**	**95% CI, p-value**
Patient Characteristics				
Age	1.04	1.028-1.042, <0.0001	1.02	1.01-1.03, <0.0001
Gender				
Female	1.00	referent	1.00	referent
Male	0.94	0.74-1.18, 0.714	1.23	0.97-1.55, 0.085
Race/Ethnicity				
Non-Hispanic White	1.00	referent	1.00	referent
Non-Hispanic Black	0.95	0.70-1.28, 0.740	0.84	0.68-1.04, 0.104
Hispanic	1.04	0.67-1.62, 0.87	0.99	0.46-2.16, 0.982
Other	0.78	0.44-1.39, 0.407	1.45	0.88-2.40, 0.1445
Payer Type				
Medicare	2.21	1.72-2.84, <0.0001	1.63	0.97-2.73, 0.063
Medicaid	0.62	0.32-1.19, 0.152	1.19	0.80-1.77, 0.387
Private	1.00	referent	1.00	referent
Self pay/ underinsured	0.71	0.50-1.02, 0.061	0.84	0.52-1.36, 0.473
Other	0.96	0.58-1.59, 0.887	0.42	0.25-0.71, 0.001
Elixhauser Comorbidities				
No	1.00	referent	1.00	referent
Yes	1.82	1.29-2.58, 0.0007	1.69	1.07-2.66, 0.024
Year				
2003	1.00	referent	1.00	referent
2004	0.95	0.77-1.18, 0.667	0.75	0.62-0.91, 0.004
Surgeon Characteristics				
Surgeon GB volume				
≤50 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.90	0.69-1.17, 0.423	0.57	0.39-0.81, 0.002

TABLE 40 (continued)

Characteristics	Hospital Gastric Bypass Volume: Low (≤125 procs/yr) n=4,095 — Odds Ratio	95% CI, p-value	High (>125 procs/yr) n=7,762 — Odds Ratio	95% CI, p-value
Hospital Characteristics				
Hospital Volumes - based on principal procedures				
Hospital non-GB_C volume				
≤2,743 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	1.06	0.73-1.53, 0.760	1.15	0.60-2.22, 0.676
Hospital non-GB_{NC} volume				
≤6,478 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	0.88	0.62-1.25, 0.489	0.91	0.46-1.78, 0.780
Bed size	1.00	1.00-1.001, 0.033	1.001	0.99-1.002, 0.087
Teaching status				
Non-teaching	1.00	referent	1.00	referent
Teaching	1.37	0.84-2.22, 0.205	1.87	1.27-2.76, 0.002
Major metropolitan area				
Hospital county population≥1 million	1.00	referent	1.00	referent
Hospital county population<1 million	0.83	0.56-1.23, 0.354	0.44	0.25-0.76, 0.003
Ownership				
For profit	1.00	referent	1.00	referent
Not-for-profit or government	1.00	0.70-1.43, 0.999	1.44	0.78-2.66, 0.242

total number of surgeons=160; total number of hospitals=81; CI= confidence interval

TABLE 41: Unadjusted association between each independent variable and length of stay among patients undergoing gastric bypass in Florida, 2003 – 2004 (stratified by hospital gastric bypass volume)

	Hospital Gastric Bypass Volume			
	Low (≤125 procs/yr) (n=4,095)		High (>125 procs/yr) (n=7,762)	
Characteristics	**Parameter Estimate[§]**	**95% CI, p-value**	**Parameter Estimate[§]**	**95% CI, p-value**
Patient Characteristics				
Age	1.01	1.00-1.01, <0.0001	1.01	1.00-1.01, <0.0001
Gender				
Female	1.00	referent	1.00	referent
Male	1.17	1.04-1.20, 0.003	1.08	1.01-1.14, 0.018
Race/Ethnicity				
Non-Hispanic White	1.00	referent	1.00	referent
Non-Hispanic Black	0.92	0.85-1.00, 0.051	0.99	0.93-1.07, 0.936
Hispanic	1.01	0.84-1.22, 0.926	0.85	0.67-1.07, 0.936
Other	0.88	0.78-1.00, 0.050	1.12	0.88-1.43, 0.363
Payer Type				
Medicare	1.56	1.25-1.94, <0.0001	1.32	1.14-1.52, 0.0001
Medicaid	1.22	0.96-1.57, 0.118	1.06	0.86-1.20, 0.855
Private	1.00	referent	1.00	referent
Self pay/ underinsured	0.90	0.81-0.99, 0.037	0.89	0.77-1.03, 0.105
other	1.10	0.93-1.32, 0.267	0.77	0.60-0.97, 0.028
Elixhauser Comorbidities				
No	1.00	referent	1.00	referent
Yes	1.11	1.01-1.23, 0.038	1.05	0.89-1.24, 0.594
Year				
2003	1.00	referent	1.00	referent
2004	0.91	0.83-1.00, 0.055	0.92	0.83-1.03, 0.141
Surgeon Characteristics				
Surgeon GB volume				
≤50 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>50 procs/yr (upper 33rd percentile)	0.96	0.84-1.08, 0.464	1.22	0.97-1.54, 0.093

TABLE 41 (continued)

Characteristics	Hospital Gastric Bypass Volume: Low (≤125 procs/yr) (n=4,095) Parameter Estimate[§]	95% CI, p-value	High (>125 procs/yr) (n=7,762) Parameter Estimate[§]	95% CI, p-value
Hospital Characteristics				
Hospital Volumes - based on principal procedures				
Hospital non-GB_C volume				
≤2,743 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>2,743 procs/yr (upper 33rd percentile)	1.06	0.86-1.32, 0.564	1.22	0.97-1.54, 0.093
Hospital non-GB_{NC} volume				
≤6,478 procs/yr (lower 66th percentile)	1.00	referent	1.00	referent
>6,478 procs/yr (upper 33rd percentile)	1.17	0.89-1.53, 0.253	1.03	0.89-1.35, 0.405
Bed size	1.00	1.00-1.00, 0.047	1.00	0.99-1.00, 0.435
Teaching status				
Non-teaching	1.00	referent	1.00	referent
Teaching	1.46	1.09-1.95, 0.011	1.36	1.14-1.62, 0.0006
Major metropolitan area				
Hospital county population≥1 million	1.00	referent	1.00	referent
Hospital county population<1 million	1.05	0.85-1.30, 0.648	0.84	0.55-1.29, 0.433
Ownership				
For profit	1.00	referent	1.00	referent
Not-for-profit or government	1.09	0.91-1.31, 0.327	1.09	0.84-1.40, 0.520

total number of surgeons=160; total number of hospitals=81; CI= confidence interval; [§]Parameter Estimate= incidence rate ratio

TABLE 42: Adjusted parameter estimates for composite complications and length of stay, by surgeon volume of non-gastric bypass complex procedures, among patients undergoing gastric bypass surgery in Florida, 2003 – 2004 (stratified by surgeon's gastric bypass volume)

	Surgeon GB volume[†] ≤50procs/yr (n=1,699)					**Surgeon GB volume[†] >50procs/yr** (n=9,664)				
	Surgeon non-GB_C volume[#]					**Surgeon non-GB_C volume[#]**				
	Low (n=1,222)		**High** (n=477)			**Low** (n=7,169)		**High** (n=2,495)		
	Adjusted OR	**95% CI**	**Adjusted OR**	**95% CI**	p-value	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**	p-value
Clinical										
one or more complications	1.0	referent	0.90	0.64-1.25	0.515	1.0	referent	0.91	0.62-1.32	0.607
	Adjusted Parameter Estimate	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**		**Adjusted Parameter Estimate**	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**	
Resource use										
LOS[§]	1.0	referent	1.11	0.89-1.38	0.374	1.0	referent	1.03	0.80-1.31	0.837

[†]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [#]Surgeon non-GB_C volume = surgeon's volume of non-gastric bypass complex procedures; [§]LOS= total length of stay; *significant at α= 0.05

Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, surgeon non-GB_{NC} volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

TABLE 43: Adjusted parameter estimates for composite complications and length of stay, by surgeon volume of non-gastric bypass non-complex procedures, among patients undergoing gastric bypass surgery in Florida, 2003 – 2004 (stratified by surgeon's gastric bypass volume)

	Surgeon GB volume[†] ≤50procs/yr (n=1,699)					**Surgeon GB volume[†] >50procs/yr** (n=9,664)				
	Surgeon non-GB_{NC} volume[#]					**Surgeon non-GB_{NC} volume[#]**				
	Low (n=1,214)		**High** (n= 489)			**Low** (n=7,394)		**High** (n=2,270)		
	Adjusted OR	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**
Clinical										
one or more complications	1.0	referent	1.17	0.82-1.68	0.388	1.0	referent	**1.97***	1.30-2.99	0.001
	Adjusted Parameter Estimate	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**		**Adjusted Parameter Estimate**	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**	
Resource use										
LOS[§]	1.0	referent	0.99	0.78-1.24	0.900	1.0	referent	**1.26***	1.02-1.55	0.032

[†]Surgeon GB volume= surgeon's volume of gastric bypass surgeries; [#]Surgeon non-GB_{NC} volume = surgeon's volume of non-gastric bypass non-complex procedures; [§]LOS= total length of stay; *significant at α= 0.05

Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, surgeon non-GB_C volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

TABLE 44: Adjusted parameter estimates for composite complications and length of stay, by hospital volume of non-gastric bypass complex procedures, among patients undergoing gastric bypass surgery in Florida, 2003- 2004 (stratified by hospital's gastric bypass volume)

	Hospital GB volume[†] ≤125procs/yr (n=4,095)					**Hospital GB volume[†] >125procs/yr** (n=7,762)				
	Hospital non-GB_C volume[#]					**Hospital non-GB_C volume[#]**				
	Low (≤2,743 procs/yr) (n=2,526)		**High (>2,743 procs/yr)** (n=1,569)			**Low (≤2,743 procs/yr)** (n=4,746)		High (>2,743 procs/yr) (n=3,016)		
	Adjusted OR	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**
Clinical										
one or more complications	1.0	referent	1.18	0.83-1.68	0.356	1.0	referent	1.50	0.82-2.75	0.189
	Adjusted Parameter Estimate	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**		**Adjusted Parameter Estimate**	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**	
Resource use										
LOS[§]	1.0	referent	1.03	0.84-1.27	0.758	1.0	referent	1.36	0.78-2.35	0.275

[†]Hospital GB volume= hospitals volume of gastric bypass surgeries; [#]Hospital non-GB_C volume = hospital's volume of non-gastric bypass complex procedures; [§]LOS= total length of stay; *significant at α= 0.05

Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, hospital non-GB_{NC} volume (based on principal procedures) , hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

TABLE 45: Adjusted parameter estimates for composite complications and length of stay, by hospital volume of non-gastric bypass non-complex procedures, among patients undergoing gastric bypass surgery in Florida, 2003- 2004 (stratified by hospital's gastric bypass volume)

	Hospital GB volume† ≤125 procs/year (n=4,095)					**Hospital GB volume† >125 procs/year** (n=7,762)				
	Hospital non-GB_{NC} volume#					**Hospital non-GB_{NC} volume#**				
	Low (≤6,478 procs/yr) (n=2,626)		**High (> 6,478 procs/yr)** (n=1,469)			**Low (≤6,478 procs/yr)** (n=4,433)		**High (>6,478 procs/yr)** (n=3,329)		
	Adjusted OR	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**	**p-value**
Clinical										
one or more complications	1.0	referent	**0.56***	0.37-0.85	0.006	1.0	referent	**0.42***	0.20-0.91	0.027
	Adjusted Parameter Estimate	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**		**Adjusted Parameter Estimate**	**95% CI**	**Adjusted Parameter Estimate**	**95% CI**	
Resource use										
LOS§	1.0	referent	0.85	0.66-1.09	0.205	1.0	referent	0.96	0.58-1.62	0.888

†Hospital GB volume= hospitals volume of gastric bypass surgeries; #Hospital non-GB_{NC} volume = hospital's volume of non-gastric bypass non-complex procedures; §LOS= total length of stay; *significant at α= 0.05

Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, hospital non-GB_C volume (based on principal procedures) , hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

TABLE 46: Sensitivity analysis: Adjusted parameter estimates for composite, technical, systemic complications, and length of stay, according to surgeon volume of non-gastric bypass procedures in Florida, 2003-2004

Volume Variables	Composite Complications		Technical Complications		Systemic Complications		Length of Stay	
	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted Parameter Estimate	(95% CI)[‡], p-value
Surgeon non-GB_C Volume								
High	0.88	0.51-1.53, 0.655	0.80	0.45-1.43, 0.449	1.12	0.60-2.09, 0.717	1.11	0.77-1.59, 0.579
Medium	0.96	0.61-1.49, 0.840	0.95	0.57-1.59, 0.857	1.03	0.63-1.69, 0.910	1.08	0.81-1.42, 0.604
Low	1.00	referent	1.00	referent	1.00	referent	1.00	referent
Surgeon non-GB_{NC} Volume								
High	1.74	1.10-2.78, 0.018	1.27	0.84-1.91, 0.252	1.95	1.08-3.50, 0.025	1.15	0.81-1.61, 0.435
Medium	1.01	0.72-1.42, 0.937	0.94	0.65-1.37, 0.764	1.09	0.73-1.62, 0.687	0.98	0.79-1.22, 0.882
Low	1.00	referent	1.00	referent	1.00	referent	1.00	referent

[#]Surgeon non-GB_C Volume= surgeon's volume of non- gastric bypass complex procedures; [##]Surgeon's non-GB_{NC} volume= Surgeon's volume of non-gastric bypass non-complex procedures; [†]OR= Odds ratio; [‡]95% CI= 95% Confidence interval.
Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

TABLE 47: Sensitivity analysis: Adjusted parameter estimates for composite, technical, systemic complications, and length of stay, according to hospital volume of non-gastric bypass procedures in Florida, 2003-2004

Volume Variables	Composite Complications		Technical Complications		Systemic Complications		Length of Stay	
	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted OR[†]	(95% CI)[‡], p-value	Adjusted Parameter Estimate	(95% CI)[‡], p-value
Hospital non-GB_C Volume[#]								
High	1.23	0.80-1.91, 0.347	0.86	0.54-1.33, 0.489	1.81	0.93-3.54, 0.083	1.10	0.79-1.50, 0.585
Medium	0.91	0.61-1.35, 0.643	0.82	0.54-1.25, 0.354	1.25	0.80-1.94, 0.328	0.92	0.80-1.05, 0.222
Low	1.00	referent	1.00	referent	1.00	referent	1.00	referent
Hospital non-GB_{NC} Volume[##]								
High	0.46	0.20-1.05, 0.066	0.58	0.33-1.03, 0.062	0.46	0.13-1.64, 0.233	0.98	0.64-1.49, 0.910
Medium	0.87	0.45-1.69, 0.686	0.92	0.54-1.57, 0.773	0.83	0.31-2.28, 0.723	0.99	0.78-1.27, 0.965
Low	1.00	referent	1.00	referent	1.00	referent	1.00	referent

[#]Hospital non-GB_C Volume= hospital's volume of non-gastric bypass complex procedures; [##]Hospital's non-GB_{NC} volume= Hospital's volume of non-gastric bypass non-complex procedures; [†]OR= Odds ratio; [‡]95% CI= 95% Confidence interval.
Estimates are derived from GEE model adjusted for age, sex, race/ethnicity, insurance status, presence of comorbidities, year, surgeon GB volume, hospital GB volume (based on principal procedures), hospital teaching status, bed size, ownership status, and major metropolitan area status, and adjusting standard errors for the non-nested clustering structure.

CHAPTER 5: DISCUSSION

This population-based study investigated the effect of surgeon and hospital volume of non-gastric bypass surgeries (both complex and non-complex) on in-hospital complications and LOS outcomes after gastric bypass surgery using 2003-2004 Florida hospital discharge data.

Overall Findings

This study provides insight into the specificity aspect of procedure volume–outcome associations for gastric bypass procedures. The patients treated by general surgeons with high non-GB_{NC} volume had a higher likelihood of in-hospital composite (one or more) complications and systemic complications than those treated by general surgeons with low non-GB_{NC} volume. Although the effect of general surgeon's non-GB_{NC} volume was attenuated after accounting for general surgeon GB volume and hospital GB volume, the non-GB_{NC} volume effect remained significant for both composite and systemic complications. Overall, general surgeon's non-GB (both complex and non-complex procedures) volume did not show statistically significant effects for technical complications or LOS after gastric bypass surgery. However, the effect of general surgeon's non-GB_{NC} volume was more pronounced for composite complication and LOS when surgeons with high GB volume also performed high non-GB_{NC} procedures.

The current study demonstrated that patients treated by general surgeons with high GB volume had a notably lower likelihood of an in-hospital composite (one or more) complication and a systemic complication. This finding is consistent with previous studies examining effect of surgeon volume on gastric bypass complications.[117, 119, 121, 123] The apparent effect of general surgeon's gastric bypass volume for composite complications after gastric bypass was slightly pronounced when accounting for hospital GB volume. Although the effect of general surgeon's GB volume was attenuated after accounting for hospital GB volume, the surgeon's GB volume effect remained significant for systemic complications (Table 48).

The general surgeon's non-GB volume study results suggest that while general surgeon GB volume matters for in-hospital complications, the complexity of their overall surgical load also matters. The benefits of high volume of a procedure are restricted to that particular specific procedure performed by a general surgeon. In particular, the outcomes may improve if gastric bypass patients avoided surgeons with a high volume of non-complex procedures. As presented in the theoretical framework in Chapter 2 of this study, procedure-specific volume – a structural component of care- is an important determinant of short-term outcomes. It is possible that GB-specific volume is correlated with processes of care, for example, in the context of the theoretical framework: structure-process-outcomes, general surgeons performing large number of GB procedures could be more familiar with providing optimal treatment for in-hospital complications.[148, 195]

Alternatively, high GB volume general surgeons may work with well-experienced operating staff, for example, nurses play an important role in the early identification of

postoperative complications and previous studies have demonstrated that the patterns of nurse staffing might influence patient mortality from a surgery.[196, 197] Thus, the operating team might influence the effect of general surgeon's procedure specific volume-outcome association, especially for those general surgeons who perform large number of both GB and non-GB non-complex procedures. Most patients undergoing gastric bypass do not require very intensive postoperative management, and the length of stay is typically around 3 days. Thus, the role of surgeon procedure-specific volume in the outcome of this procedure is intuitively congruent.

The findings for the hospital's non-GB volume (based on principal procedures) study indicated that the patients treated at hospitals with high non-GB_{NC} volume had a lower likelihood of in-hospital composite (one or more) complications and technical complications than those treated at hospitals with low non-GB_{NC} volume. This protective effect of hospital's non-GB_{NC} volume did not change even after accounting for hospital GB volume and surgeon GB volume for both composite and technical complications. Although the protective effect for patients treated at hospitals with high non-GB_{NC} volume on composite complications remained significant when stratified by hospitals with high (vs. low) GB volume, the effect was more pronounced for composite complications when hospitals with high GB volume also performed high non-GB_{NC} procedures. However, the study did not find any significant association between hospital's non-GB_{C} volume and in-hospital complications or LOS. This result is consistent with earlier observations for other complex procedures shown in the study by Allareddy et al., where the researchers found that hospital volume levels for pancreatic resection or esophagectomy did not influence in-hospital mortality following CABG,

PCI, and AAA. Similarly, hospital volumes for CABG, PCI, and AAA did not influence the outcomes for pancreatic resection or esophagectomy. The intermediate outcomes such as in-hospital complications are correlated with in-hospital mortality, which is an ultimate outcome[126] Overall, hospital's non-GB (both complex and non-complex procedures) volume did not show statistically significant effect for systemic complications and LOS after gastric bypass surgery (Table 49).

In addition, the study demonstrated that the patients treated at hospitals with high GB volume had a notably lower likelihood of an in-hospital technical complication (Table 49). This finding is consistent with previous studies examining effect of hospital GB volume on bariatric surgical complications including wound infection.[120, 121, 123] The apparent effect of hospital's gastric bypass volume on gastric bypass technical complications was slightly pronounced when accounting for surgeon's GB volume. Likewise, the patients treated by surgeons with high GB volume had a notably lower likelihood of an in-hospital composite and systemic complication. This result is consistent with the gastric bypass volume-outcome association studies in the literature.[121, 123]

When considering hospital's non-GB volume based on principal and secondary procedures, the findings of hospitals with high non-GB_{NC} volume showing a protective effect on composite and technical complications were consistent with the results using hospital's non-GB volume based on principal procedures only. In contrast to the results using hospital's non-GB volume based on principal procedures only, the patients operated at hospitals with high non-GB_C volume showed a higher likelihood of a

composite complication and increased LOS outcome when hospital's non-GB volume was based on principal and secondary procedures (Table 49).

Thus, the hospital's non-GB volume study results suggest that while complexity of hospital volume may not matter so much, the overall hospital procedural volume, i.e., hospital scale, matters. When considering the total hospital volume, the proportion of non-GB_C and GB volume is relatively small compared to the proportion of non-complex procedures performed at a hospital. This indicates that economies of scale achieved through overall larger volume could possibly be associated with better outcomes for gastric bypass. This could explain the protective effect of hospital's non-GB_{NC} volume on in-hospital complications for gastric bypass found in the study.

The focus of this study is limited to examining the overall hospital volume segregated into three components: GB volume, non-GB_C volume, and non-GB_{NC} volume. This absolute hospital volume is possibly a product of procedures performed by surgeons, surgical staff including anesthesiologists, and nursing staff. Therefore, for gastric bypass procedure, the absolute hospital volume measure may be limited in explaining the effect of non-GB_C volume on increased likelihood of composite complication and increased LOS outcomes, when hospital volume was computed based on principal and secondary procedures. For example, consider hospitals 'A' and 'B' performing the same total number of procedures (i.e., same total volume- say 1,000 procedures) and same proportion of complex procedures (say 300 procedures) and non-complex procedures (say 700 procedures). Only a small number of surgeons are performing those 300 complex procedures at hospital 'A' indicating larger volume per surgeon, while a large number of surgeons are performing those 300 complex procedures at hospital 'B'

indicating smaller volume per surgeon. Thus, it is possible that the hospitals with non-GB_C volume in this study reflect the group of those hospitals performing large number of complex procedures but having smaller non-GB_C volume per surgeon- similar to hospital 'B' described in the above example. The GB, non-GB_C, and non-GB_{NC} hospital volume per surgeon could possibly be a better measure that would capture the volume and complexity effect together. Another plausible explanation at patient-level could be that although comorbidities were accounted for in the model, the level of severity of the illness could not be adjusted in the model due to the non-availability of patient severity or acuity data. Accounting for this unmeasured patient acuity might attenuate the effect for patients operated at hospitals that perform high non-GB_C volume.

Limitations and Strengths

There were several limitations for the studies in this dissertation.

1) Non-differential Misclassification - Surgeon volume (GB as well as non-GB) and hospital volume (GB as well as non-GB) were abstracted from the Florida hospital discharge data. Although it does not appear that there would be any misclassification regarding the exposure (i.e. volume) status, coding errors could lead to possible misclassification. Thus, low volume surgeons might be coded as high volume surgeons and vice-a-versa. Likewise, low volume hospitals would be coded as high volume hospitals and vice-a-versa. These errors would most likely bias the results toward null. In-hospital complications were identified through secondary ICD-9-CM diagnosis codes, and LOS was identified through length of stay variable from the Florida hospital discharge data. Thus, it is possible that in-hospital complications after gastric bypass might be coded as the primary diagnoses instead of secondary. These misclassifications

of outcomes would most likely bias the results toward null. However, coding errors are unlikely for both volume and outcome in the study, as volume is computed based on hospital and surgeon identifier in the dataset and to address coding for outcomes, the hospital discharge data are abstracted from medical records with the help of experienced coders.[154]

2) Bias- This cross-sectional study provides a snap-shot of the exposure-outcome relationship at patient-level. Survivor bias may be unlikely, as this study considered both patients who died after the gastric bypass procedure and patients who survived with postoperative complications. Although exposure (surgeon non-GB_C volume and/or hospital non-GB_C volume) and adverse outcomes were assessed simultaneously, temporal bias may be unlikely because surgeon non-GB_C volume and/or hospital non-GB_C volume would remain steady over time and it would precede the outcomes. In addition, this study considered current volume (volume in a year) and controlled for year in the model to account for any possible variation in volume across two years.

Information bias, such as recall bias and interviewer's bias is unlikely, as the exposure and outcome data will be obtained through hospital discharge records and these are not collected through survey interviews. If exposure and adverse outcomes (for example- LOS and postoperative complications) data were collected through interviewing patients undergoing gastric bypass then, there could be a possible interviewer bias as well as recall bias. This could possibly under/ overestimate the true association. However, this bias appears to be quite unlikely in the present study. Finally, the Florida Inpatient Discharge Data does not allow identifying unique patients. Therefore, the unit of our analysis was inpatient-discharge, not patient. However, it is

extremely unlikely that the same patient would have had multiple discharges with GB during a given calendar year.

3) Confounding- A number of variables, suspected and known as potential confounders between the surgeon- and/or hospital- non-GB_C volume and adverse outcomes were controlled for in this study. However, there is the possibility of unmeasured potential confounding that could mask the true relationship between the surgeon- and/or hospital-non-GB_C volume and adverse outcomes. This could lead to biased estimates and would under/overestimate the effect (i.e., odds ratios or beta values).

Patient-level factors that are not available in the data and thus, were not controlled for included lifestyle or behavioral factors such as smoking, medications, dietary interventions or exercise, or other patient self-management techniques that occur in the community outside the influence of the health care system, or possibly as a result of interactions between the patient and the health care system. For example, patients who are likely to engage in unhealthy behaviors, such as smoking or improper diet, might be more likely to experience in-hospital mortality or in-hospital complications. Similarly, such patients might be less likely to get operated by high volume surgeons or at high volume hospitals. Thus, failure to control for these baseline behaviors could lead to bias, i.e., overestimate the true association between high volume surgeons and outcomes. However, this may not be a serious omitted variable bias due to two possible reasons: (1) prior to gastric bypass surgery it is important that patients quit smoking and engage in healthy diet, (2) there is no clear evidence that such patients are less likely to receive surgery from high volume surgeons.

Surgeon/ hospital- level unmeasured factors might also be possible confounders in the study. For example, surgeon's years from board certification might be positively correlated to surgeon's high volume, as increasing years from board certification is indicative of more experience and potentially high volume. Similarly, surgeon's years from board certification might be negatively correlated to in-hospital complications for their patients, i.e., surgeons with more experience will have fewer adverse outcomes for their patients. Thus, if the surgeon's number of years from board certification variable is not controlled, it could bias the coefficient on surgeon volume downward in the model of in-hospital complications. However, as indicated earlier, volume might be a proxy for years from board certification and was included in the analyses.

4) Generalizability- This population-based study used Florida-State hospital discharge data. Thus, the results could likely be generalized to patients ≥ 18 years of age undergoing gastric bypass in other areas of the U.S. that have surgeon- and/or hospital-non-GB_C and non-GB_{NC} volume mixes similar to that of Florida.

The studies in this dissertation also had number of strengths.

1) As previously mentioned, although very few studies on hospitals' non-specific procedural volume- outcome association have been conducted, there is no previous research related to the impact of provider's (surgeon and hospital) non-specific volume (both complex and non-complex procedures) on adverse outcomes after gastric bypass. This is a first study that provides insights into the associations between providers' total (non-specific and specific) volume and adverse in-hospital outcomes for gastric bypass patients.

2) The use of work RVU component, as a proxy for complexity, to segment provider's total practice load into complex and non-complex procedures aids in further understanding of the provider's procedural specificity aspect by incorporating complexity of procedures performed by the providers.

3) The studies in this dissertation used Florida hospital discharge data to generate population-based information on the provider total volume-outcome association. Both Urbach et al. and Allareddy et al. examined the specificity of only hospital volume–outcome associations for surgical procedures in Canada using secondary data (1994-1999) and in United States using National Inpatient Sample (2000-2003), respectively. Thus, the studies in this dissertation would strengthen the literature on hospital non-specific volume-outcome association by using relatively recent data (2003-2004). Unlike the National Inpatient Sample data where there are variations within states and hospitals with regards to reporting surgeon identifiers,[198] the Florida hospital discharge data contains uniformly reported information on all data variables including surgeon identifiers.[199, 200] This allows for the ability to study surgeons' non-specific volume-outcome association. Therefore, the studies in this dissertation would augment the surgeon's specific volume-outcome literature by providing surgeon's total volume dimension to it.

Significance

The studies in the dissertation enhance current understanding of the volume-outcome relationship by providing insights into the importance of procedure specificity and the composition of the total surgical practice in examining the volume-outcome relationship for general surgeons and hospitals. In particular, this dissertation work

developed a novel method of using work RVU, as a proxy measure for complexity, to segregate procedures into complex and non-complex for examining the volume-outcome association and further enhance the understanding of this association. In general, as the rates of morbid obesity continue to rise and so does the number of gastric bypass/bariatric surgeries performed in the United States, these studies provide a potential new dimension to aid policymakers, health insurers and healthcare providers in decision-making, especially, rethinking the volume-based regionalization policies adopted/debated for gastric bypass procedures. Thus, the development of population-based information on the relationship between "non-specific" volume and outcomes would be helpful to identify potential areas for quality improvement.

Summary, Conclusions and Implications

In summary, the analyses in this dissertation demonstrate that the likelihood of in-hospital composite and systemic complications from GB procedures is increased 70% and 88% respectively, for patients operated by general surgeons that have high non-gastric bypass non-complex surgical loads. Thus, in addition to confirming that general surgeons' GB volumes matter for in-hospital complications, the complexity of their overall procedural loads may also matter. When considering hospital non-gastric bypass volume, the likelihood of composite and technical complications from GB procedures is decreased by 49% and 40% for patients operated at hospitals that have high non-gastric bypass non-complex surgical loads. Thus, indicating that the overall scale may matter for hospitals to deliver better in-hospital outcomes for gastric bypass. Finally, if similar association for non-specific (both complex and non-complex) procedural volume and outcome is demonstrated across a wide range of relatively low volume but high risk

procedures, then researchers, purchasers, and policy makers might need to rethink the current volume-based quality improvement initiatives that are based only on the association demonstrated between the provider volume of a specific procedure alone and outcomes from that particular procedure. Therefore, the total provider practice volume in addition to the specific procedural volume may need to be considered in developing volume-based guidelines for selectively referring patients to high volume providers who typically perform such overall low volume high risk procedures.

Future Research

The studies in the dissertation provide a novel approach of using work RVU to identify complex and non-complex non-GB procedures. The validation of this approach using an expert panel is recommended. Based on the findings for general surgeon's and hospital's non-GB non-complex procedural volume on in-hospital outcomes, possible potential areas for future research could include: (1) profiling the provider (both hospital and surgeon) to characterize the complex and non-complex nature of the provider procedural case loads, and (2) examining the effect of hospital volume (both complex and non-complex) per surgeon on the outcomes for gastric bypass and/or other high-risk surgical procedures. The studies were focused on the total (GB, non-GB_C and non-GB_{NC}) procedural volume effect on short-term outcomes for gastric bypass. Future studies could investigate providers' total procedural volume complexity effect on short-term as well as long-term outcomes, such as readmission rates and long-term survival, for a range of certain other complex and high-risk surgical procedures. The analyses have only addressed the provider's total practice volume and GB outcome association, however,

examining disparities in the access to high GB and non-GB (both complex and non-complex procedures) volume providers would be of interest.

TABLE 48: Summary of findings for the effect of surgeon non-GB and GB volume, hospital GB volume on in-hospital adverse outcomes for gastric bypass in Florida, 2003-2004

Volume		In-hospital Outcomes			
		Composite	**Technical**	**Systemic**	**LOS**
Model with hospital GB volume based on principal procedures		**Odds Ratio**	**Odds Ratio**	**Odds Ratio**	**Parameter Estimate**
Surgeon Volumes-based on principal procedures	High Non-GB_C	0.91	0.81	1.12	1.05
	High Non-GB_{NC}	**1.70***	1.30	**1.88***	1.19
	High GB	**0.73***	0.88	**0.59***	0.88
Hospital GB volume	based on principal procedures	0.88	**0.72***	1.16	1.06
Model with hospital GB volume based on principal and secondary procedures		**Odds Ratio**	**Odds Ratio**	**Odds Ratio**	**Parameter Estimate**
	High Non-GB_C	0.92	0.82	1.12	1.05
	High Non-GB_{NC}	**1.70***	1.30	**1.88***	1.19
Surgeon Volumes-based on principal procedures	High GB	**0.73***	0.87	**0.58***	**0.88*** (borderline significance p=0.051)
Hospital GB volume	based on principal and secondary procedures	0.88	**0.71***	1.19	1.08

*significant at α=0.05, GB= gastric bypass, non-GB_C= non-gastric bypass complex procedures, non-GB_{NC}= non-gastric bypass non-complex procedures

TABLE 49: Summary of findings for the effect of hospital non-GB and GB volume, surgeon GB volume on in-hospital adverse outcomes for gastric bypass in Florida, 2003-2004

Volume		In-hospital Outcomes			
		Composite	**Technical**	**Systemic**	**LOS**
		Odds Ratio	**Odds Ratio**	**Odds Ratio**	**Parameter Estimate**
Hospital Volumes-based on principal procedures	High Non-GB_C	1.29	0.98	1.47	1.17
	High Non-GB_{NC}	**0.51***	**0.60***	0.56	0.97
	High GB	0.86	**0.70***	1.13	0.99
Hospital Volumes-based on all procedures-principal and secondary procedures	High Non-GB_C	**1.55***	1.13	1.90	**1.38***
	High Non-GB_{NC}	**0.51***	**0.62***	**0.52***	0.90
	High GB	0.86	**0.69***	1.18	1.02
Surgeon volume	Surgeon high GB volume in the model with hospital volume based on principal procedures	**0.77***	0.91	**0.64***	0.90
	Surgeon high GB volume in the model with hospital volume based on principal and secondary procedures	**0.76***	0.89	**0.63***	0.89

*significant at α=0.05, GB= gastric bypass, non-GB_C= non-gastric bypass complex procedures, non-GB_{NC}= non-gastric bypass non-complex procedures

REFERENCES

1. American Obesity Association. Obesity in the U.S: AOA fact sheet. http://obesity1.tempdomainname.com/subs/fastfacts/obesity_US.shtml. Accessed 26 February, 2009.

2. American Society for Metabolic and Bariatric Surgery. Rationale for the surgical treatment of morbid obesity http://www.asbs.org/Newsite07/patients/resources/asbs_rationale.htm. Accessed January 17, 2009.

3. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA.* 2006;295(13):1549-1555.

4. Santry H, Gillen D, Lauderdale D. Trends in bariatric surgical procedures. *JAMA.* 2005;294(15):1909-1917.

5. Sturm R. Increases in clinically severe obesity in the United States, 1986-2000. *JAMA.* 2003;163(18):2146-2148.

6. Sturm R. Increases in morbid obesity in the USA: 2000-2005. *Public Health.* 2007;121(7):492-496.

7. Bender R, Trautner C, Spraul M, Berger M. Assessment of excess mortality in obesity. *Am J Epidemiol.* 1998;147(1):42-48.

8. Calle E, Thun M, Petrelli J, Rodriguez C, Heath C. Body-mass index and mortality in a prospective cohort of US adults. *N Engl J Med.* 1999;341(15):1097-1105.

9. Drenick EJ, Bale GS, Seltzer F, Johnson DG. Excessive mortality and causes of death in morbidly obese men. *JAMA.* 1980;243(5):443-445.

10. Duflou J, Virmani R, Rabin I, Burke A, Farb A, Smialek J. Sudden death as a result of heart disease in morbid obesity. *American Heart Journal.* 1995;130(2):306.

11. Flegal KM, Graubard BI, Williamson DF, Gail MH. Excess deaths associated with underweight, overweight, and obesity. *JAMA.* 2005;293(15):1861-1867.

12. Flegal KM, Graubard BI, Williamson DF, Gail MH. Cause-specific excess deaths associated with underweight, overweight, and obesity. *JAMA.* 2007;298(17):2028-2037.

13. Dorn JM, Schisterman EF, Winkelstein W, Jr., Trevisan M. Body mass index and mortality in a general population sample of men and women. The Buffalo Health Study. *Am J Epidemiol.* 1997;146(11):919-931.

14. Health implications of obesity. National Institutes of Health Consensus Development Conference Statement. *Ann Intern Med.* 1985;103(6 (Pt 2)):1073-1077.

15. Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *Arch Intern Med.* 1998;158(17):1855-1867.

16. Despres JP. Intra-abdominal obesity: an untreated risk factor for Type 2 diabetes and cardiovascular disease. *J Endocrinol Invest.* 2006;29(3 Suppl):77-82.

17. Philipson EH, Kalhan SC, Edelberg SC, Williams TG. Maternal obesity as a risk factor in gestational diabetes. *Am J Perinatol.* 1985;2(4):268-270.

18. Ben-Haroush A, Hadar E, Chen R, Hod M, Yogev Y. Maternal obesity is a major risk factor for large-for-gestational-infants in pregnancies complicated by gestational diabetes. *Arch Gynecol Obstet.* 2009;279(4):539-543.

19. Chan J, Rimm E, Colditz G, Stampfer M, Willett W. Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care.* 1994;17(9):961-969.

20. Mokdad A, Ford E, Bowman B, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA.* 2003;289(1):76-79.

21. Colditz G, Willett W, Rotnitzky A, Manson J. Weight gain as a risk factor for clinical diabetes mellitus in women. *Annals of Internal Medicine.* 1995;122(7):481-486.

22. Rashid MN, Fuentes F, Touchon RC, Wehner PS. Obesity and the risk for cardiovascular disease. *Prev Cardiol.* 2003;6(1):42-47.

23. Eckel R, Krauss R. American Heart Association call to action: obesity as a major risk factor for coronary heart disease. *Circulation.* 1998;97(21):2099-2100.

24. Hubert H, Feinleib M, McNamara P, Castelli W. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation.* 1983;67(5):968-977.

25. Sowers J. Obesity as a cardiovascular risk factor. *The American Journal of Medicine.* 2003;115(8S1):37-41.

26. Cooper R, McFarlane-Anderson N, Bennett F, et al. ACE, angiotensinogen and obesity: a potential pathway leading to hypertension. *Journal of Human Hypertension.* 1997;11(2):107-111.

27. Gus M, Fuchs S, Moreira L, et al. Association between different measurements of obesity and the incidence of hypertension. *American Journal of Hypertension.* 2004;17(1):50-53.

28. Wang Y, Wang Q. The Prevalence of Prehypertension and Hypertension Among US Adults According to the New Joint National Committee Guidelines New Challenges of the Old Problem. *Arch Intern Med.* 2004;164(19):2126-2134.

29. Fang CX, Dong F, Thomas DP, Ma H, He L, Ren J. Hypertrophic cardiomyopathy in high-fat diet-induced obesity: role of suppression of forkhead transcription factor and atrophy gene transcription. *Am J Physiol Heart Circ Physiol.* 2008;295(3):H1206-H1215.

30. Carr MC, Brunzell JD. Abdominal obesity and dyslipidemia in the metabolic syndrome: importance of type 2 diabetes and familial combined hyperlipidemia in coronary artery disease risk. *J Clin Endocrinol Metab.* 2004;89(6):2601-2607.

31. Rexrode K, Hennekens C, Willett W, et al. A prospective study of body mass index, weight change, and risk of stroke in women. *JAMA.* 1997;277(19):1539-1545.

32. Suk SH, Sacco RL, Boden-Albala B, et al. Abdominal obesity and risk of ischemic stroke: the Northern Manhattan Stroke Study. *Stroke.* 2003;34(7):1586-1592.

33. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res.* 1998;6 Suppl 2:51S-209S.

34. Busetto L, Enzi G, Inelmen EM, et al. Obstructive sleep apnea syndrome in morbid obesity: effects of intragastric balloon. *Chest.* 2005;128(2):618-623.

35. Stohl KP SR, Parisi RA. *Obesity and pulmonary function*. Bary GA ed. New York, NY: Marcel Dekker Inc.; 1998.

36. Vgontzas A, Tan T, Bixler E, Martin L, Shubert D, Kales A. Sleep apnea and sleep disruption in obese patients. *Arch Intern Med.* 1994;154(15):1705-1711.

37. Bernstein R, Werner L, Rimm A. Relationship of gallbladder disease to parity, obesity, and age. *Health Services Reports.* 1973;88(10):925.

38. Layde P, Vessey M, Yeates D. Risk factors for gall-bladder disease: a cohort study of young women attending family planning clinics. *British Medical Journal.* 1982;36(4):274-278.

39. Pacchioni M, Nicoletti C, Caminiti M, et al. Association of obesity and type II diabetes mellitus as a risk factor for gallstones. *Digestive Diseases and Sciences.* 2000;45(10):2002-2006.

40. Stampfer M, Maclure K, Colditz G, Manson J, Willett W. Risk of symptomatic gallstones in women with severe obesity. *American Journal of Clinical Nutrition.* 1992;55(3):652-658.

41. Nair S, Mason A, Eason J, Loss G, Perrillo R. Is obesity an independent risk factor for hepatocellular carcinoma in cirrhosis? *Hepatology.* 2002;36(1).

42. Naveau S, Giraud V, Borotto E, Aubert A, Capron F, Chaput J. Excess weight risk factor for alcoholic liver disease. *Hepatology.* 1997;25(1).

43. Regimbeau JM, Colombat M, Mognol P, et al. Obesity and diabetes as a risk factor for hepatocellular carcinoma. *Liver Transpl.* 2004;10(2 Suppl 1):S69-73.

44. Scheen A, Luyckx F. Obesity and liver disease. *Best Practice & Research Clinical Endocrinology & Metabolism.* 2002;16(4):703-716.

45. Carman W, Sowers M, Hawthorne V, Weissfeld L. Obesity as a risk factor for osteoarthritis of the hand and wrist: a prospective study. *Am J Epidemiol.* 1994;139(2):119-129.

46. Cooper C, Inskip H, Croft P, et al. Individual risk factors for hip osteoarthritis: obesity, hip injury and physical activity. *Am J Epidemiol.* 1998;147(6):516-522.

47. Felson D. Weight and osteoarthritis. *Am J Clin Nutr.* 1996;63(3):430-432.

48. Rose D, Gilhooly E, Nixon D. Adverse effects of obesity on breast cancer prognosis, and the biological actions of leptin. *International Journal of Oncology.* 2002;21(6):1285-1292.

49. Schapira D, Clark R, Wolff P, Jarrett A, Kumar N, Aziz N. Visceral obesity and breast cancer risk. *Cancer.* 1994;74(2).

50. MacMahon B. Risk factors for endometrial cancer. *Gynecol Oncol.* 1974;2(2-3):122-129.

51. Swanson C, Potischman N, Wilbanks G, et al. Relation of endometrial cancer risk to past and contemporary body size and body fat distribution. *Cancer Epidemiology Biomarkers & Prevention.* 1993;2(4):321-327.

52. Thun M, Calle E, Namboodiri M, et al. Risk factors for fatal colon cancer in a large prospective study. *Journal of National Cancer Institute.* 1992;84(19):1491-1500.

53. Stattin P, Lukanova A, Biessy C, et al. Obesity and colon cancer: does leptin provide a link? *International Journal of Cancer.* 2004;109(1).

54. Giovannucci E, Ascherio A, Rimm E, Colditz G, Stampfer M, Willett W. Physical activity, obesity, and risk for colon cancer and adenoma in men. *Ann Intern Med.* 1995;122(5):327-334.

55. Nowbar S, Burkart K, Gonzales R, et al. Obesity-associated hypoventilation in hospitalized patients: prevalence, effects, and outcome. *The American Journal of Medicine.* 2004;116(1):1-7.

56. Mond JM, Rodgers B, Hay PJ, et al. Obesity and impairment in psychosocial functioning in women: the mediating role of eating disorder features. *Obesity.* 2007;15(11):2769-2779.

57. Onyike C, Crum R, Lee H, Lyketsos C, Eaton W. Is obesity associated with major depression? Results from the Third National Health and Nutrition Examination Survey. *Am J Epidemiol.* 2003;158(12):1139-1147.

58. Roberts R, Kaplan G, Shema S, Strawbridge W. Are the obese at greater risk for depression? *Am J Epidemiol.* 2000;152(2):163-170.

59. Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: how much, and who's paying? *Health Aff (Millwood).* 2003;Suppl Web Exclusives:W3-219-226.

60. Thorpe KE, Florence CS, Howard DH, Joski P. The impact of obesity on rising medical spending. *Health Aff (Millwood).* 2004;Suppl Web Exclusives:W4-480-486.

61. Gastrointestinal surgery for severe obesity: National Institutes of Health Consensus Development Conference Statement. *Am J Clin Nutr.* 1992;55(2 Suppl):615S-619S.

62. North American Association for the Study of Obesity (NAASO) and the National Heart L, and Blood Institute (NHLBI). The Practical Guide: Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: NIH Publication Number 00-4084; Oct 2000: http://www.nhlbi.nih.gov/guidelines/obesity/prctgd_c.pdf. Accessed August 17, 2008.

63. Benotti PN, Bistrain B, Benotti JR, Blackburn G, Forse RA. Heart disease and hypertension in severe obesity: the benefits of weight reduction. *Am J Clin Nutr.* 1992;55(2 Suppl):586S-590S.

64. Brolin RE, Kenler HA, Wilson AC, Kuo PT, Cody RP. Serum lipids after gastric bypass surgery for morbid obesity. *Int J Obes.* 1990;14(11):939-950.

65. Brolin RL, Robertson LB, Kenler HA, Cody RP. Weight loss and dietary intake after vertical banded gastroplasty and Roux-en-Y gastric bypass. *Ann Surg.* 1994;220(6):782-790.

66. Charuzi I, Lavie P, Peiser J, Peled R. Bariatric surgery in morbidly obese sleep-apnea patients: short- and long-term follow-up. *Am J Clin Nutr.* 1992;55(2 Suppl):594S-596S.

67. Foley EF, Benotti PN, Borlase BC, Hollingshead J, Blackburn GL. Impact of gastric restrictive surgery on hypertension in the morbidly obese. *Am J Surg.* 1992;163(3):294-297.

68. Gleysteen JJ, Barboriak JJ, Sasse EA. Sustained coronary-risk-factor reduction after gastric bypass for morbid obesity. *Am J Clin Nutr.* 1990;51(5):774-778.

69. Buchwald H. Overview of bariatric surgery. *Journal of the American College of Surgeons.* 2002;194(3):367-376.

70. Buchwald H, Rucker R. The rise and fall of jejunoileal bypass. In: Nelson RL NL, ed. *Surgery of the Small Intestine*. Norwalk, CT: Appleton Century Crofts; 1987:529–541.

71. Buchwald H, Buchwald JN. Evolution of operative procedures for the management of morbid obesity 1950-2000. *Obes Surg.* 2002;12(5):705-717.

72. Mason EE, Ito C. Gastric bypass in obesity. *Surg Clin North Am.* 1967;47(6):1345-1351.

73. Mason EE, Printen KJ, Hartford CE, Boyd WC. Optimizing results of gastric bypass. *Ann Surg.* 1975;182(4):405-414.

74. Alden JF. Gastric and jejunoileal bypass. A comparison in the treatment of morbid obesity. *Arch Surg.* 1977;112(7):799-806.

75. Brolin R, LaMarca L, Kenler H, Cody R. Malabsorptive gastric bypass in patients with superobesity. *Journal of Gastrointestinal Surgery.* 2002;6(2):195-205.

76. Fobi M, Lee H, Holness R, Cabinda D. Gastric bypass operation for obesity. *World Journal of Surgery.* 1998;22(9):925-935.

77. Griffen W, Bivins B, Bell R, Jackson K. Gastric bypass for morbid obesity. *World Journal of Surgery.* 1981;5(6):817-822.

78. Salmon PA. Gastroplasty with distal gastric bypass: a new and more successful weight loss operation for the morbidly obese. *Can J Surg.* 1988;31(2):111-113.

79. Torres JC, Oca CF, Garrison RN. Gastric bypass: Roux-en-Y gastrojejunostomy from the lesser curvature. *South Med J.* 1983;76(10):1217-1221.

80. Vassallo C, Negri L, Della Valle A, et al. Biliopancreatic diversion with transitory gastroplasty preserving duodenal bulb: 3 years experience. *Obes Surg.* 1997;7(1):30-33.

81. Madan AK, Harper JL, Tichansky DS. Techniques of laparoscopic gastric bypass: on-line survey of American Society for Bariatric Surgery practicing surgeons. *Surg Obes Relat Dis.* 2008;4(2):166-172; discussion 172-163.

82. Monteforte MJ, Turkelson CM. Bariatric surgery for morbid obesity. *Obes Surg.* 2000;10(5):391-401.

83. Encinosa WE, Bernard DM, Du D, Steiner CA. Recent improvements in bariatric surgery outcomes. *Med Care.* 2009;47(5):531-535.

84. American Society of Metabolic and Bariatric Surgery. Brief history and summary of bariatric surgery. May 2005; http://www.asbs.org/html/patients/bypass.html. Accessed November 9, 2008.

85. Encinosa W, Bernard D, Steiner C, Chen C. Use and costs of bariatric surgery and prescription weight-loss medications. *Health Affairs.* 2005;24(4):1039-1046.

86. Encinosa WE, Bernard DM, Chen CC, Steiner CA. Healthcare utilization and outcomes after bariatric surgery. *Med Care.* 2006;44(8):706-712.

87. Birkmeyer JD, Dudley AR, Phibbs C. *Evidence-based hospital referral (EBHR) factsheet*: The Leapfrog Group;2007.

88. Birkmeyer JD, Dudley AR, Phibbs C. *Evidence-based hospital referral (EBHR) factsheet*: The Leapfrog Group;2008.

89. Begg CB, Cramer LD, Hoskin WJ, al. e. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA.* 1998;280:1747–1751.

90. Begg CB, Riedel ER, Bach PB, et al. Variations in morbidity after radical prostatectomy *N Engl J Med.* 2002;346:1138–1144.

91. Birkmeyer JD, Finlayson SRG, Tosteson ANA, Sham SM, Warshaw AL, Fisher ES. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy *Surgery.* 1999;125:250–256.

92. Birkmeyer JD, Siewers AE, Finlayson EV, et al. Hospital volume and surgical mortality in the United States. *N Engl J Med.* 2002;346:1128–1137.

93. Dimick JB, Pronovost PJ, Cowan JA, Lipsett PA. Surgical volume and quality of care for esophageal resection: do high-volume hospitals have fewer complications? *Ann Thorac Surg.* 2003;75:337-341.

94. Gordon TA, Burleyson GP, Tielsch JM, Cameron JL. The effects of regionalization on cost and outcome for one general high-risk surgical procedure. *Ann Surg.* 1995;221(1):43-49.

95. Gouma DJ, van Geenen RC, van Gulik TM, et al. Rates of complications and death after pancreaticoduodenectomy: risk factors and the impact of hospital volume *Ann Surg.* 2000;232:786–795.

96. Hannan EL, Radzyner M, Rubin D, Dougherty J, Brennan MF. The influence of hospital and surgeon volume on in-hospital mortality for colectomy, gastrectomy, and lung lobectomy in patients with cancer. *Surgery.* 2002;131:6–15.

97. Lieberman M, Kilburn H, Lindsey M, Brennan M. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. *Ann Surg.* 1995;222(5):638.

98. Schrag D, Panageas KS, Riedel E, al. e. Hospital and surgeon procedure volume as predictors of outcome following rectal cancer resection. *Ann Surg.* 2002;236:583–592.

99. Sosa JA, Bowman HM, Tielsch JM, Powe NR, Gordon TA, Udelsman R. The importance of surgeon experience for clinical and economic outcomes from thyroidectomy. *Ann Surg.* 1998;228:320–330.

100. Birkmeyer J, Stukel T, Siewers A, Goodney P, Wennberg D, Lucas F. Surgeon volume and operative mortality in the United States. *New England Journal of Medicine.* 2003;349(22):2117-2127.

101. Moscucci M, Share D, Smith D, et al. Relationship between operator volume and adverse outcome in contemporary percutaneous coronary intervention practice. *J Am Coll Cardiol.* 2005;46:625-632.

102. Hannan EL, Siu AL, Kumar D, Kilburn H, Jr., Chassin MR. The decline in coronary artery bypass graft surgery mortality in New York State. The role of surgeon volume. *JAMA.* 1995;273(3):209-213.

103. Hannan E, Wu C, Walford G, et al. Volume outcome relationships for percutaneous coronary interventions in the stent era *Circulation.* 2005;112:1171-1179.

104. Hughes RG, Hunt SS, Luft HS. Effects of surgeon volume and hospital volume on quality of care in hospitals. *Med Care.* 1987;25(6):489-503.

105. Weller WE, Hannan EL. Relationship between provider volume and postoperative complications for bariatric procedures in New York State. *J Am Coll Surg.* 2006;202:753-761.

106. Karanicolas PJ, Dubois L, Colquhoun PH, Swallow CJ, Walter SD, Guyatt GH. The more the better?: the impact of surgeon and hospital volume on in-hospital mortality following colorectal resection. *Ann Surg.* 2009;249(6):954-959.

107. Dudley RA, Johansen KL, Brand R, Rennie DJ, Milstein A. Selective referral to high-volume hospitals: estimating potentially avoidable deaths. *JAMA.* 2000;283(9):1159-1166.

108. Halm E, Lee C, Chassin M. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Annals of Internal Medicine.* 2002;137(6):511-520.

109. Hewitt M. *Interpreting the Volume-outcome Relationship in the Context of Health Care Quality Workshop Summary*: Institute of Medicine Washington; 2000.

110. Rosen L, Stasik J, Reed J, Olenwine J, Aronoff J, Sherman D. Variations in colon and rectal surgical mortality. *Diseases of the Colon & Rectum.* 1996;39(2):129-135.

111. Flood AB, W. R. Scott, and W. Ewy. Does practice make perfect? I: The relation between hospital volume and outcomes for selected diagnostic categories. *Medical Care.* 1984;22(2):98-114.

112. Flood AB, W. R. Scott, and W. Ewy Does practice make perfect? II: The relation between volume and outcomes and other hospital characteristics. *Medical Care.* 1984; 22(2):115-125.

113. Luft HS, Hunt SS, Maerki SC. The volume-outcome relationship: practice-makes-perfect or selective-referral patterns? *Health Serv Res.* 1987;22(2):157-182.

114. Birkmeyer JD NB. Factsheet-Surgeon volume. The Leapfrog Group. 2007.

115. Dimick JB, Pronovost PJ, Cowan JA, Jr., Lipsett PA, Stanley JC, Upchurch GR, Jr. Variation in postoperative complication rates after high-risk surgery in the United States. *Surgery.* 2003;134(4):534-540; discussion 540-531.

116. Ritchie WP RR, Biester TW Workloads and practice patterns of general surgeons in the United States 1995-1997. *Ann Surg.* 1999;230:533-543.

117. Courcoulas A, Schuchert M, Gatti G, Luketich J. The relationship of surgeon and hospital volume to outcome after gastric bypass surgery in Pennsylvania: a 3-year summary. *Surgery.* 2003;134(4):613-621; discussion 621-613.

118. Flum DR, Dellinger EP. Impact of gastric bypass operation on survival: a population-based analysis. *J Am Coll Surg.* 2004;199(4):543-551.

119. Liu JH, Zingmond D, Etzioni DA, et al. Characterizing the performance and outcomes of obesity surgery in California. *Am Surg.* 2003;69(10):823-828.

120. Nguyen N, Paya M, Stevens C, Mavandadi S, Zainabadi K, Wilson S. The relationship between hospital volume and outcome in bariatric surgery at academic medical centers. *Ann Surg.* 2004;240(4):586.

121. Weller WE, Hannan EL. Relationship between provider volume and postoperative complications for bariatric procedures in New York State. *J Am Coll Surg.* 2006;202(5):753-761.

122. Zingmond DS, McGory ML, Ko CY. Hospitalization before and after gastric bypass surgery. *JAMA.* 2005;294(15):1918-1924.

123. Weller W, Rosati C, Hannan E. Predictors of in-hospital postoperative complications among adults undergoing bariatric procedures in New York state, 2003. *Obesity Surgery.* 2006;16(6):702-708.

124. Urbach D, Baxter N. Does it matter what a hospital is" high volume" for? Specificity of hospital volume-outcome associations for surgical procedures: analysis of administrative data. *BMJ.* 2004;328(7442):737.

125. Southern DA, Quan H, Ghali WA. Comparison of the Elixhauser and Charlson/Deyo methods of comorbidity measurement in administrative data. *Med Care.* 2004;42(4):355-360.

126. Allareddy V, Konety BR. Specificity of procedure volume and in-hospital mortality association. *Ann Surg.* 2007;246(1):135-139.

127. Gaynor M, Seider H, Vogt W. The volume-outcome effect, scale economies, and learning-by-doing. *American Economic Review.* 2005;95(2):243-247.

128. Schilling M, Vidal P, Ployhart R, Marangoni A. Learning by doing something else: Variation, relatedness, and the learning curve. *Management Science.* 2003;49(1):39-56.

129. Huesch M, Sakakibara M. Forgetting the learning curve for a moment: how much performance is un related to own experience? *Health Economics.* 2008;18(7):855-862.

130. Sfekas A. Learning, forgetting, and hospital quality: an empirical analysis of cardiac procedures in Maryland and Arizona. *Health Economics.* 2008;18(6):697-711.

131. Davenport D, Henderson W, Khuri S, Mentzer Jr R. Preoperative risk factors and surgical complexity are more predictive of costs than postoperative complications: a case study using the National Surgical Quality Improvement Program (NSQIP) database. *Ann Surg.* 2005;242(4):463.

132. Centers for Medicare and Medicaid Services. Available at: http://www.cms.hhs.gov/physicianfeesched/pfsrvf/list.asp Accessed September 27, 2007 for 2003, 2004, and 2005 data.

133. Elixhauser A, Steiner C, Harris D, Coffey R. Comorbidity measures for use with administrative data. *Medical Care.* 1998:8-27.

134. Khan NA, Quan H, Bugar JM, Lemaire JB, Brant R, Ghali WA. Association of postoperative complications with hospital costs and length of stay in a tertiary care center. *J Gen Intern Med.* 2006;21(2):177-180.

135. Byrne T. Complications of surgery for obesity. *Surgical Clinics of North America.* 2001;81(5):1181-1193.

136. Rabkin RA. Distal gastric bypass/duodenal switch procedure, Roux-en-Y gastric bypass and biliopancreatic diversion in a community practice. *Obes Surg.* 1998;8(1):53-59.

137. Livingston E. Obesity and its surgical management. *Am J Surg.* 2002;184(2):103-113.

138. Livingston E, Liu C, Glantz G, Li Z. Characteristics of bariatric surgery in an integrated VA Health Care System: follow-up and outcomes. *Journal of Surgical Research.* 2003;109(2):138-143.

139. Livingston E. Procedure incidence and in-hospital complication rates of bariatric surgery in the United States. *Am J Surg.* 2004;188(2):105-110.

140. Perugini RA, Mason R, Czerniach DR, et al. Predictors of complication and suboptimal weight loss after laparoscopic Roux-en-Y gastric bypass: a series of 188 patients. *Arch Surg.* 2003;138(5):541-545; discussion 545-546.

141. Schauer P, Ikramuddin S, Gourash W, Ramanathan R, Luketich J. Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Ann Surg.* 2000;232(4):515.

142. Schauer PR, Ikramuddin S. Laparoscopic surgery for morbid obesity. *Surg Clin North Am.* 2001;81(5):1145-1179.

143. Podnos Y, Jimenez J, Wilson S, Stevens C, Nguyen N. Complications after laparoscopic gastric bypass a review of 3464 cases. *Archives of Surgery.* 2003;138(9):957-961.

144. Ren CJ, Patterson E, Gagner M. Early results of laparoscopic biliopancreatic diversion with duodenal switch: a case series of 40 consecutive patients. *Obes Surg.* 2000;10(6):514-523; discussion 524.

145. Safadi BY, Kieran JA, Hall RG, et al. Introducing laparoscopic Roux-en-Y gastric bypass at a Veterans Affairs medical facility. *Am J Surg.* 2004;188(5):606-610.

146. Murr MM, Martin T, Haines K, et al. A state-wide review of contemporary outcomes of gastric bypass in Florida: does provider volume impact outcomes? *Ann Surg.* 2007;245(5):699-706.

147. AHRQ Quality indicators: A guide to patient safety indicators. 2006. http://www.qualityindicators.ahrq.gov/downloads/psi/psi_guide_v30a.pdf. Accessed August 15, 2007.

148. Donabedian A. The quality of care. How can it be assessed? *JAMA.* 1988;260(12):1743-1748.

149. Peterson E, Coombs L, DeLong E, Haan C, Ferguson T. Procedural volume as a marker of quality for CABG surgery. *JAMA.* 2004;291(2):195-201.

150. Shahian DM, Edwards FH, Ferraris VA, et al. Quality measurement in adult cardiac surgery: part 1--Conceptual framework and measure selection. *Ann Thorac Surg.* 2007;83(4 Suppl):S3-12.

151. Shahian D. Improving cardiac surgery quality-volume, outcome, process? *JAMA.* 2004;291(2):246-248.

152. Shahian D, Normand S. The volume-outcome relationship: from Luft to Leapfrog. *Ann Thorac Surg* 2003;75(3):1048-1058.

153. Shroyer A, Marshall G, Warner B, et al. No continuous relationship between Veterans Affairs hospital coronary artery bypass grafting surgical volume and operative mortality. *Ann Thorac Surg* 1996;61(1):17-20.

154. Hospital inpatient data file- File description form and public data file layout. Florida Agency for Healthcare Administration Available at http://ahca.myflorida.com/SCHS/hpdunit.shtml. Accessed August 17, 2008.

155. Florida Department of Health- Licensee Data Center. Practitioner profile data. Available at: https://ww2.doh.state.fl.us/downloadnet/Profile.aspx. Accessed August 17, 2008.

156. Florida Department of Health. A guide to the Florida practitioner profile. Available at: http://www.doh.state.fl.us/MQA/profiling/profile_about.html and http://www.doh.state.fl.us/MQA/profiling/guide.pdf. Accessed August 18, 2008.

157. Florida Hospital Association. Available at http://www.fha.org/hospdir.html

158. Florida Agency for Health Care Administration. Hospitals and ambulatory surgery centers http://www.floridahealthfinder.gov/CompareCare/ListFacilities.aspx. Accessed November 8, 2008.

159. U.S. Department of Health and Human Services, Health Resources and Services Administration. Area resource file - National county-level health resource information database. Available at: http://www.arfsys.com/overview.htm. Accessed September 27, 2008.

160. Centers for Medicare and Medicaid Services. Physician fee schedule. Available at: http://www.cms.hhs.gov/PhysicianFeeSched/PFSRVF/list.asp#TopOfPage, September 27, 2007.

161. EMC Captiva software- 2004 and 2005 ICD9-to-CPT procedure crosswalk. Available at: http://www.wisent.com/codelink.htm.

162. Centers for Medicare and Medicaid Services. Physician/Supplier Procedure Summary Master File. Available at: http://www.cms.hhs.gov/NonIdentifiableDataFiles/06_PhysicianSupplierProcedureSummaryMasterFile.asp#TopOfPage. Accessed September 25 2008.

163. Ansari MZ, Collopy BT, Hart WG, Carson NJ, Chandraraj EJ. In-hospital mortality and associated complications after bowel surgery in Victorian public hospitals. *Aust N Z J Surg.* 2000;70(1):6-10.

164. *Evidence-based Hospital Referral (EBHR) Coding Specifications for Volume*: The Leapfrog Group;2007.

165. Miller ME, Welch WP, Welch HG. The impact of practicing in multiple hospitals on physician profiles. *Medical Care.* 1996;34(5):455-462.

166. Florida Department of Health. Practitioner profile information. Available at: http://ww2.doh.state.fl.us/IRM00profiling/searchform.asp.

167. American Board of Medical Specialties. Avaialble at: http://www.abms.org/login.asp. Accessed February 26, 2008.

168. American Board of Medical Specialties (ABMS). About ABMS. http://www.abms.org/About_ABMS/. Accessed February 26, 2008.

169. Hsiao WC. The resource-based relative value scale: an option for physician payment. *Inquiry.* 1987;24(4):360-361.

170. Hsiao WC, Braun P, Dunn D, Becker ER, DeNicola M, Ketcham TR. Results and policy implications of the resource-based relative-value study. *N Engl J Med.* 1988;319(13):881-888.

171. Hsiao WC, Braun P, Yntema D, Becker ER. Estimating physicians' work for a resource-based relative-value scale. *N Engl J Med.* 1988;319(13):835-841.

172. Hariri S, Bozic KJ, Lavernia C, Prestipino A, Rubash HE. Medicare physician reimbursement: past, present, and future. *J Bone Joint Surg Am.* 2007;89(11):2536-2546.

173. Glass KP, Anderson JR. Relative value units: from A to Z (Part I of IV). *J Med Pract Manage.* 2002;17(5):225-228.

174. Becker ER, Dunn D, Braun P, Hsiao WC. Refinement and expansion of the Harvard Resource-Based Relative Value Scale: the second phase. *Am J Public Health.* 1990;80(7):799-803.

175. Jenkins KJ, Gauvreau K, Newburger JW, Kyn LB, Iezzoni LI, Mayer JE. Validation of relative value scale for congenital heart operations. *Ann Thorac Surg.* 1998;66(3):860-869.

176. Moore KJ. A productivity primer. *Fam Pract Manag.* 2002;9(5):72-73.

177. Medicare program: Revisions to payment policies and adjustments to the relative value units under the physician fee schedule for calendar year 1996--HCFA. Final rule with comment period. *Federal Register.* 1995;60(236):63124-63357.

178. Capella RF, Iannace VA, Capella JF. Bowel obstruction after open and laparoscopic gastric bypass surgery for morbid obesity. *J Am Coll Surg.* 2006;203(3):328-335.

179. Paxton JH, Matthews JB. The cost effectiveness of laparoscopic versus open gastric bypass surgery. *Obes Surg.* 2005;15(1):24-34.

180. Podnos YD, Jimenez JC, Wilson SE, Stevens CM, Nguyen NT. Complications after laparoscopic gastric bypass: a review of 3464 cases. *Arch Surg.* 2003;138(9):957-961.

181. Stellato TA, Hallowell PT, Crouse C, Schuster M, Petrozzi MC. Two-day length of stay following open Roux-En-Y gastric bypass: is it feasible, safe and reasonable? *Obes Surg.* 2004;14(1):27-34.

182. Iezzoni L. Assessing quality using administrative data. *Ann Intern Med.* 1997;127(8 Part 2):666-674.

183. Jollis J, Ancukiewicz M, DeLong E, Pryor D, Muhlbaier L, Mark D. Discordance of databases designed for claims payment versus clinical information systems: implications for outcomes research. *Ann Intern Med.* 1993;119(8):844-850.

184. Roos L, Sharp S, Cohen M. Comparing clinical information with claims data: some similarities and differences. *Journal of Clinical Epidemiology.* 1991;44(9):881.

185. Iezzoni LI. *Risk adjustment for measuring health care outcomes*. 3rd ed. Chicago, IL: Health Administration Press; 2003.

186. Liang K, Zeger S. Longitudinal data analysis using generalized linear models. *Biometrika.* 1986;73(1):13-22.

187. McCullagh P NJ. *Generalized Linear Models*. 2nd ed. London: Chapman and Hall; 1989.

188. Miglioretti D, Heagerty P. Marginal modeling of nonnested multilevel data using standard software. *Am J Epidemiol.* 2007;165(4):453.

189. Neuhaus J. Estimation efficiency and tests of covariate effects with clustered binary data. *Biometrics.* 1993:989-996.

190. Zeger S, Liang K. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics.* 1986:121-130.

191. Greenberg R, Kleinbawm D. Mathematical modeling strategies for the analysis of epidemiologic research. *Annual Review of Public Health.* 1985;6(1):223-245.

192. Hardin JW HJ. *Generalized Estimating Equations*: Chapman & Hall/CRC; 2003.

193. Cui J. QIC program and model selection in GEE analyses. *Stata Journal.* 2007;7(2):209-220.

194. Birkmeyer JD DA, Phibbs C *Evidence-based hospital referral (EBHR) factsheet. The Leapfrog Group*2008.

195. Donabedian A. Volume, quality, and the regionalization of health care services. *Medical Care.* 1984:95-97.

196. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA.* 2002;288(16):1987-1993.

197. Aiken LH, Clarke SP, Cheung RB, Sloane DM, Silber JH. Educational levels of hospital nurses and surgical patient mortality. *JAMA.* 2003;290(12):1617-1623.

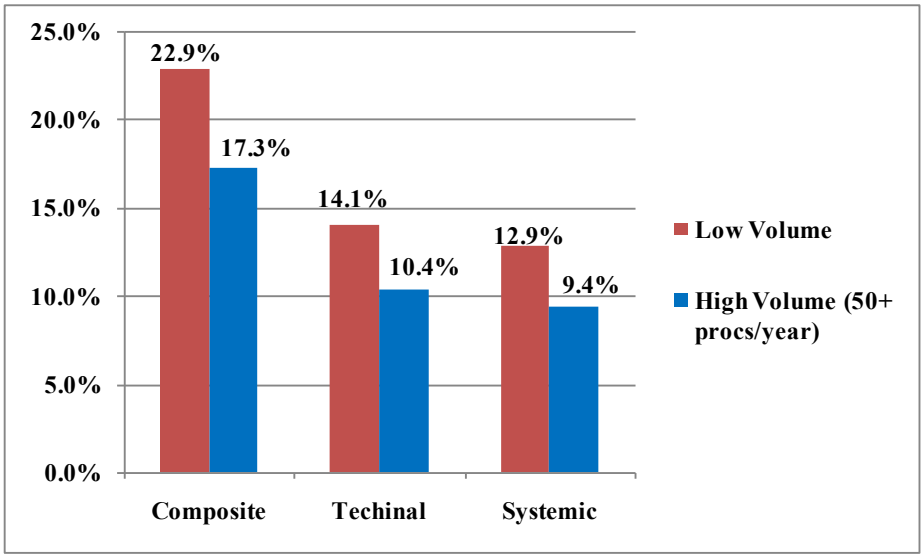
198. HCUP Databases. Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/databases.jsp. Accessed June 26, 2009.

199. ACHA: Florida hospital uniform reporting system. http://ahca.myflorida.com/MCHQ/CON_FA/fa_data/index.shtml. Accessed October 25, 2008.

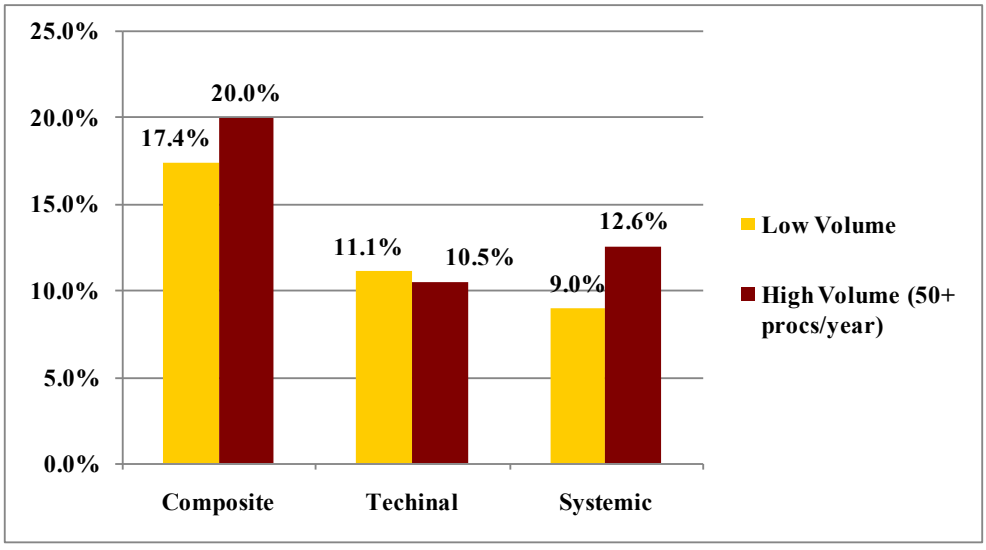
200. ACHA. Chapter 59E-7 data collection. http://ahca.myflorida.com/SCHS/pdf/59E7.pdf. Accessed June 26, 2009.

APPENDIX A: DESCRIPTIVES - PROVIDER VOLUMES AND GASTRIC BYPASS OUTCOMES: A GRAPHICAL REPRESENTATION

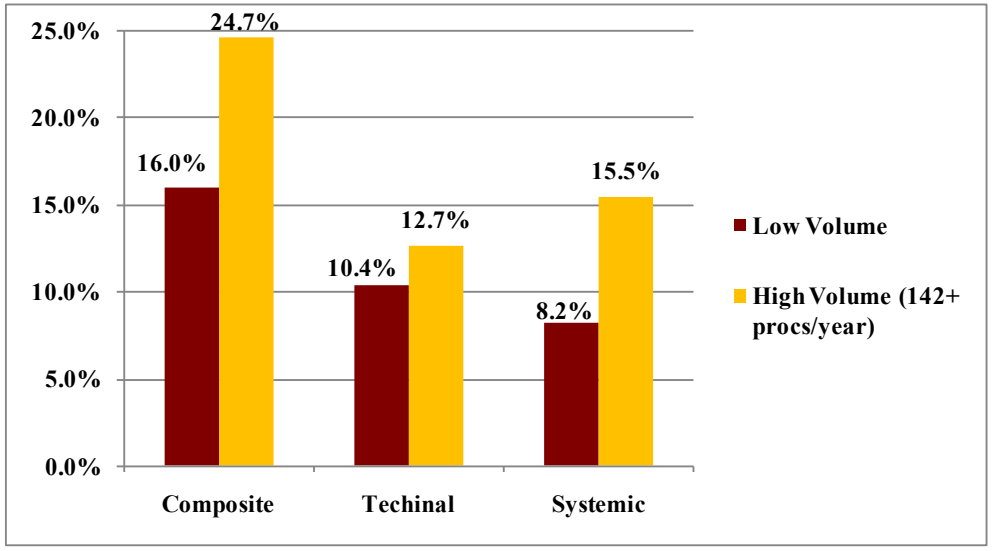
1. GB Complication Rates by High (vs. Low) Gastric Bypass Volume General Surgeons



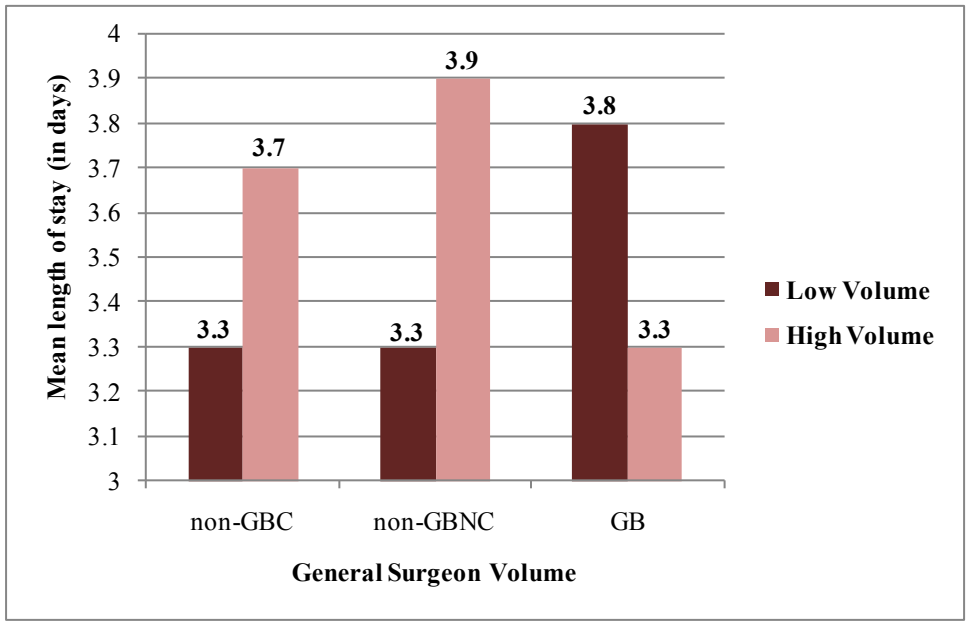
2. GB Complication Rates by High (vs. Low) Non-GB_C Volume General Surgeons



3. GB Complication Rates by High (vs. Low) Non-GB_{NC} Volume General Surgeons

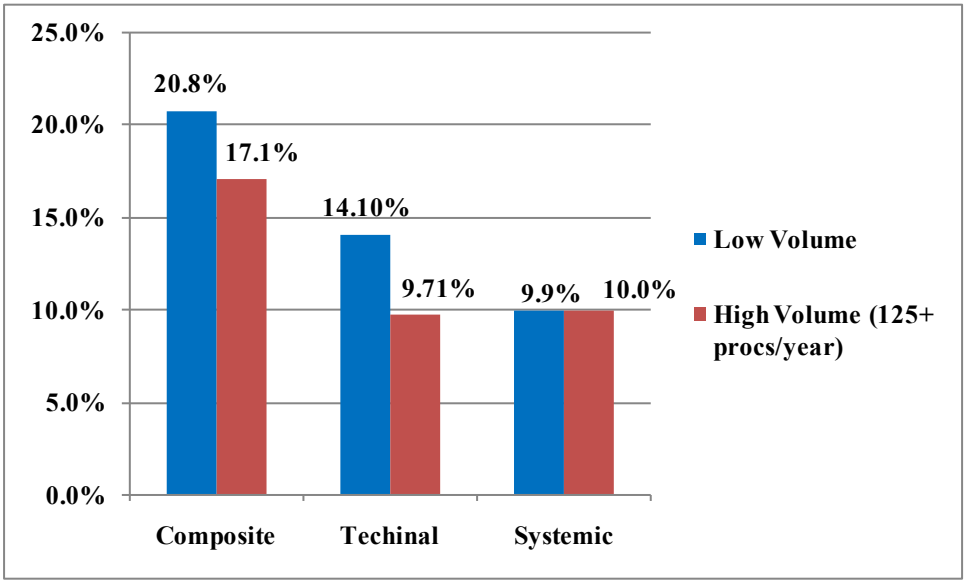


4. GB Length of Stay by high (vs. low) General Surgeon Volumes

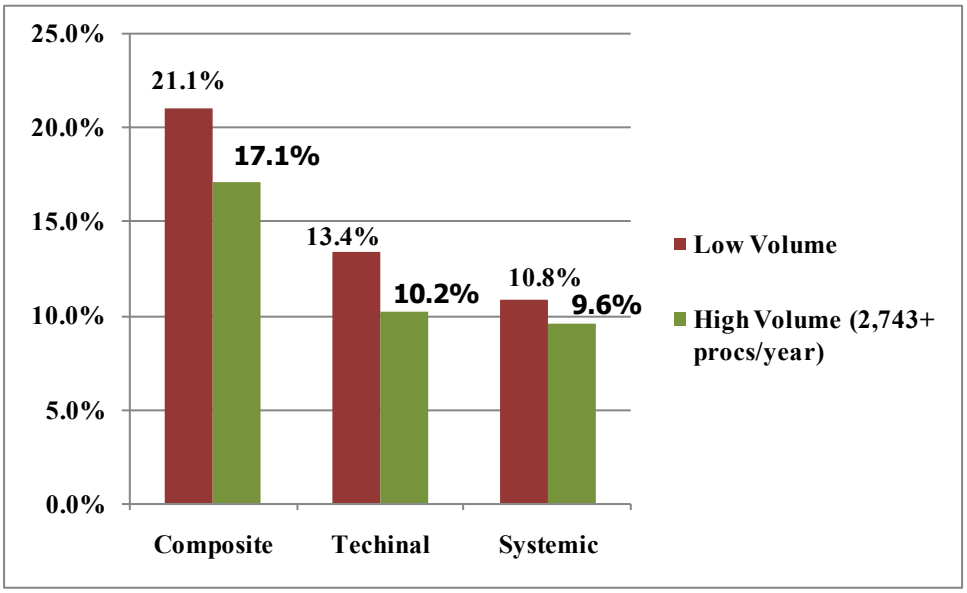


non-GB_C = non-gastric bypass complex procedures
non-GB_{NC} = non-gastric bypass non-complex procedures
GB = gastric bypass

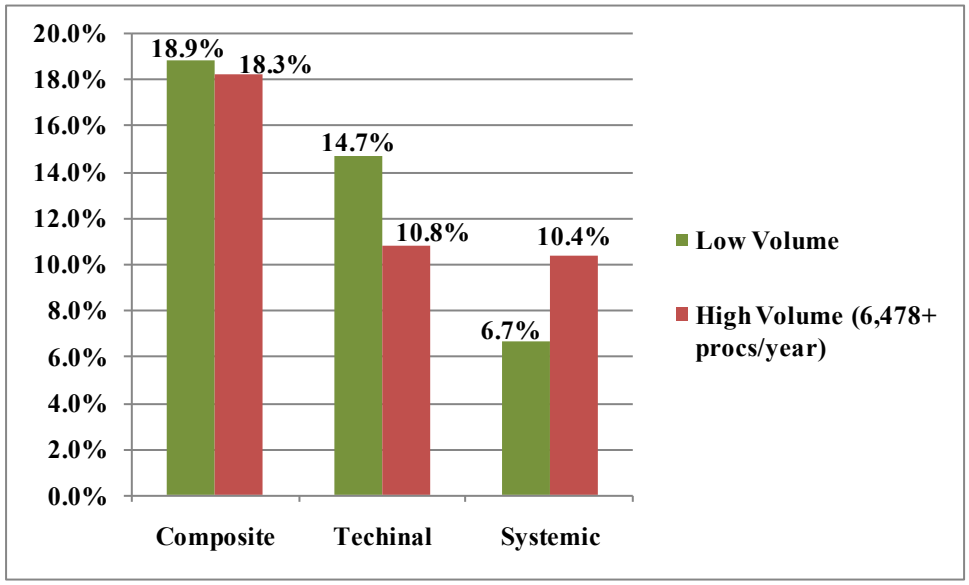
5. GB Complication Rates by High (vs. Low) Gastric Bypass Volume Hospitals



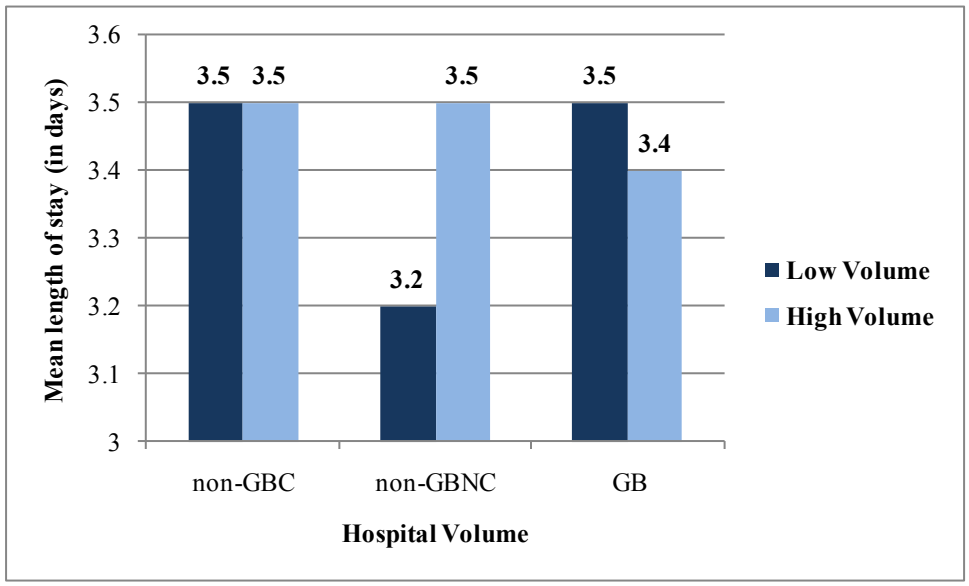
6. GB Complication Rates by High (vs. Low) Non-GB_C Volume Hospitals



7. GB Complication Rates by High (vs. Low) Non-GB_{NC} Volume Hospitals



8. GB Length of Stay by High (vs. Low) Hospital Volumes



non-GB_C = non-gastric bypass complex procedures
non-GB_{NC} = non-gastric bypass non-complex procedures
GB = gastric bypass