Title: Trends and Factors Impacting Healthcare Charges and Length of Stay for Cholecystectomies: A New York State Population-based Analysis

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Acknowledgment: We would like to thank the New York State Department of Health and SPARCS for allowing open access to the data used in this study. We would also like to thank Jason Crowley for assistance in data analysis.
Financing: None.
Conflict of interest statement by authors: None.
Compliance with ethical standards: This study was IRB exempt after review by the California University of Science and Medicine (CUSM), as data for the project came from a publicly available/open-source database: New York Statewide Planning and Research Cooperative System (SPARCS).

Authors Contribution Statement:

Conceptualization: 1,2. Data Curation: 1,2. Formal Analysis: 1. Investigation: 1. Methodology: 1. Project Administration: 1,2. Resources: 1,2. Software: 1. Supervision: 1,2. Validation: 1,2. Visualization: 1. Writing – Original Draft Preparation: 1. Writing – Review & Editing: 1,2

Manuscript word count: 2057
Abstract word count: 244
Number of Figures and Tables: 3 Figures, 5 Tables

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Discussion Points:

1. The aim of this study was to define and analyze the factors that influenced hospital costs and length of stay for patients undergoing cholecystectomies.
2. According to our results, race, insurance, procedure type, and patient presentation influenced hospital costs and length of stay, and further investigation into how to optimize these measures is required.
3. What methods can surgeons and hospital administrators take to minimize the current disparities in health outcomes among patients receiving cholecystectomies given the gap among race and insurance status?

ABSTRACT.

Background:
Gallbladder disease confers a significant economic toll on the United States healthcare system. The aim of this study is to characterize current trends and features of the cholecystectomy population and identify factors that influence the length of stay and total charges.

Methods:
Case information was extracted for laparoscopic and open cholecystectomies from 2013-2016 using the New York Statewide Planning and Research Cooperative System (SPARCS) database. Descriptive, comparative, and multivariable linear regression analysis was conducted on 58,141 cases assessing age group, race, gender, admission presentation, surgical technique, insurance status, year of operation and severity of illness by the length of stay and total charges.

Results:
Of all procedures, 91.6% were laparoscopic, and 79.4% were emergent on admission. Total procedures trended down, while laparoscopic and emergent cases steadily increased (p<.0001). Total charges increased during the study period, while the length of stay decreased (p<.0001). Open and emergent procedures were associated with a higher cost and longer inpatient stays (p<.0001). Open procedures were proportionally more common among elderly, male patients, and in elective cases (p<.0001). Emergent presentation was more common in females, non-whites, and younger patients (p<.0001). Regression model showed that male gender, open operation, Black race, and emergent presentation were independent predictors for a longer stay and greater total charges (p<.0001). Medicare insurance predicted lower total charges but longer length of stay (p<.0001).

Conclusion:
Race, insurance, procedure type, and patient presentation influence hospital charges and stays following cholecystectomy. Understanding these trends will allow policymakers and providers to limit the healthcare burden of cholecystectomy.

Key Words: Cholecystectomy, Length of Stay, Gallbladder Diseases, Healthcare Costs

INTRODUCTION.

Gallbladder disease is incredibly common in the United States and presents a significant burden to the country's healthcare system. In 2014, cholecystectomy was the 8th most frequent operating room procedure, accounting for 2.6% (372,600) of all operations.[1] Epidemiologists have gone to great lengths to identify and characterize factors contributing to the high prevalence of gallbladder disease in the United States. [2-5] Variables such as race, gender, and socio-economic class all contribute to the manifestation of this disease. [4,5]

While data on reductions in mortality or morbidity have been conflicting, laparoscopy has been shown to reduce patient hospital stays and total costs.[6-9] First performed in Germany in 1985, the less invasive laparoscopic cholecystectomy quickly became the gold standard operation in the 1990s, replacing the traditional open approach.[10] Despite its now widespread use, healthcare institutions still resort to the traditional open approach under certain circumstances including limited resources, lack of qualified surgeons, and predisposing patient risk factors.[11] Whether a procedure is emergent or elective may also determine surgical approach, as some surgeons argue the necrosis and inflammation in acute settings makes laparoscopy unfavorable.[12]

The aim of this study was to identify current trends in cholecystectomy procedures, describe differences in patient characteristics based on surgical approach and admission presentation, and identify factors that predict the patient length of stay and hospital charges. We targeted the New York State population, as characterization of cholecystectomy procedures in this specific area has not been recently reported.[13]

MATERIALS OR PATIENTS AND METHODS.

Patient Population

Patient records were taken from the New York State Department of Health Statewide Planning and Research Cooperative System (SPARCS), a publicly available prospective database that captures all admissions and discharge records from New York State hospitals. All New York State hospitals are required to submit admissions and discharge data, including patient characteristics, treatments, insurance status, and All Patient Refined Diagnosis-related Groups (APR DRG) and International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) codes. The SPARCS database has been used for a variety of clinical and epidemiological studies.[14,15] Due to the open-source nature of the data used for this study, IRB clearance was deemed unnecessary by the research team's affiliated institutional review board.

Admissions and discharge data for 66,647 hospitalizations undergoing non-laparoscopic or laparoscopic cholecystectomies from 2013-2016 were identified using Clinical Classifications Software (CCS) codes for the principal diagnosis of biliary tract disease (149) and the principal procedure of cholecystectomy and common duct exploration (84) **(Table 1)**. CCS codes are clustered ICD-9-CM codes that fit into more cohesive and uniform categories, allowing for more effective data analytics. These codes have been used in a variety of clinical studies.[16-18] The data excluded admissions on non-biliary CCS diagnostic codes such as pancreatic disorder (152) and secondary malignancy (42). This focused our study population to patients with biliary tract disease, whose primary purpose for hospital admissions was a cholecystectomy. Patients under the age of 18 were also excluded. APR DRG codes were then used to create cohorts of patients undergoing laparoscopic (263) and non-laparoscopic (262) procedures.

Primary outcome variables were total hospital charges and length of stay (LOS). Total charges are defined as all hospital expenses accrued from admissions to discharge. LOS is defined as the number of days the patient spends as an inpatient from admission to discharge, rounded to the nearest day. Co-variables used in this study were gender, race, age, presentation, surgical technique, insurance, year of discharge, and APR DRG severity of illness (SOI) score. Patient age was divided into four groups: 18-29, 30-49, 50-69, and above 70. SOI subclasses ranks patients as either minor, moderate, major, or extreme based on the amount of physiologic or organ system function loss. This score was used in our multivariable analysis and considers the severity of secondary diagnosis and comorbidities, accounting for interactions with patient characteristics and requirements for additional resources for care.[19] The insurance category "other" included self-pay, worker compensation, and unreported data. The racial category "other" encompassed multiracial and undisclosed race. Presentation referred to whether the patient was admitted to the emergency department upon admission.

Statistical Analysis

Univariable analysis was conducted to summarize total admissions, procedure type (laparoscopic or open), patient presentation (elective or emergency), year of discharge, age group, gender, race, and insurance status. Number of cases and procedure type were described by year of discharge, along with a separate chart outlining yearly changes in LOS and total charges. Comparative analysis was carried out to assess differences between procedure type and patient presentation. Two-sample t-tests were used to compare differences in LOS and total

charges among differences in patient presentation and procedure type. Chi-squared tests and two-proportion z-tests were used to compare proportions of the categorical variables of gender, race, age group, insurance status, admissions presentation, and procedure type.

Multivariate linear regression models with selection were used to assess the predictability of outcome variables LOS and total charges. The model included age group, gender, presentation, procedure type, race, insurance status, year of discharge, and SOI score. These factors were chosen because they had significant associations in the bivariate analysis. A two-tailed p-value <0.05 was set for statistical significance for all analyses. All data analysis was conducted using IBM SPSS Statistics 26.0 (Armonk, New York).

RESULTS.

After this initial screening, 58,141 patient records were included in this study **(Figure 1)**. The characteristics of the study cohort are outlined in **Table 2**. Admissions for cholecystectomies declined annually, with an overall decrease of 15.3% (15,691 cases in 2013 to 13,602 cases in 2016). The percentage of laparoscopic surgeries increased (91.0% to 92.5%, p<0.0001) **(Figure 2)**. LOS decreased (3.94 to 3.74, p<.0001) and total charges increased ($34,260 to $42232, p<.0001) over the course of the study **(Figure 3)**.

Open procedures were more likely to be elective in nature (42.2% vs. 18.6%, p<.0001) **(Table 3)**. Open procedures were, on average, more expensive and resulted in longer hospital stays (6.88 vs. 3.58 days, $56,415 vs. $36,607, p<.0001) **(Table 4).** The percentage of emergent presentations increased during the study (78.6% to 81.2%, p<.0001). Emergent surgeries had longer hospital stays and greater total charges on average (3.97 vs. 3.4 days, $39,324 vs. $34,202, p<.0001).

Females were more likely to require emergent procedures (80.1% vs. 78.0%, p<.0001) and underwent laparoscopic procedures more often (93.7% vs. 87.8%, p<.0001). Black patients were more likely to undergo an emergent procedure than White patients (81.2% vs. 78.5%, p<.0001). White patients underwent laparoscopic surgeries less often than Black patients (90.9% vs. 91.4%, p=0.10). As the age group increased, the likelihood of emergent presentations decreased (age 18-29: 86.1% vs. 70+: 73.4%, p<0.0001). Proportions of laparoscopic surgeries decreased as age increased (Ages 18-29: 97.3% vs. Above 70:85.5%, p<.0001). Medicare patients were the least likely to have emergent operations (73.8% vs. Medicaid: 83.2%, p <.0001). Medicare patients were also the least likely to undergo a laparoscopic procedure (86.3% vs. Medicaid: 93.8%, p <.0001).

Multivariable analysis showed that male gender, open procedures, emergent presentation, and Black race predicted significant increases in LOS and total charges (p<.0001) **(Table 5).** Medicare predicted decreased hospital charges but longer LOS (p<.0001).

DISCUSSION.

The findings of this study offer several noteworthy observations. Univariable analysis confirmed the known nature of gallbladder disease. This disease disproportionately affects females, Black people and middle age, generally presents in emergent settings, and is overwhelmingly treated laparoscopically in modern medical practice.[4, 5] Interestingly, we found that total admissions have been incrementally decreasing every year in the adult population of New York State, dropping 15.3% from 2013 to 2016. In a New York State study from 1995 to 2013, Alli et al. found that cholecystectomy procedures did not match the increase in population (1.23% procedural increase a populational increase of 6.32%).[13] While the nationwide incidence is rising, we suggest there may be a population-specific fall of all biliary-type diseases in New York State.[4,5,13] Our data did, however, show a rise in emergent admissions, which could be attributed to the specific rise of acute cholecystitis.[2,20] Multi-regional analysis is warranted to better characterize these trends. One possible explanation for this fall in total cholecystectomy procedures is the shifting indications for elective laparoscopic procedures and more thoughtful decision-making by both surgeons and patients, who are better informed about the substantial risks of surgery. We believe this trend will continue in the years moving forward.

In accordance with the literature, we observed a rise in mean total charges and a decrease in LOS over the course of our study.[20] As hospital expenses continue to rise, monitoring ways to limit the economic burden of cholecystectomy becomes more important. We attribute the fall in hospital stays to enhanced patient fast-tracking and the use of multidisciplinary and multimodal teams to expedite rehabilitation.

Comparative analysis between laparoscopic and open procedures suggests that laparoscopy limits hospital costs and patient stay.[3,6,7] Interestingly, open procedures were disproportionately elective in nature. This was noteworthy because there is no indication to prefer the open technique in an elective setting, and some surgeons prefer open procedures in emergent cases due to the associated excess inflammation and necrosis.[12] A 2013 study by To et. al found that conversion rates to open procedures increased nearly two-fold in emergent settings.[21] While the evidence is limited to support using open procedures more frequently in emergent settings, our findings indicate that open procedures are more often used in elective situations.[22] Future research should evaluate the factors that may be influencing this interesting finding.

Geriatric procedures were more often elective in nature and used the open approach. This trend may be explained by concerns that laparoscopy poses increased risk through high physiologic demand, especially considering these patients often present with other comorbidities.[11] For example, insufflating carbon dioxide during laparoscopy may cause acid-base disturbances and changes in cardiopulmonary physiology that are otherwise avoided in the open approach.[23-25] Despite these concerns, systematic studies indicate that laparoscopic procedures in elderly patients offer many advantages, such as lower pain and convalescence, and clinicians still tend to prefer laparoscopy in the elderly in both emergent or elective settings.[11,26,27]

Our multivariable linear regression model illustrated that elective admissions, laparoscopic operations, and younger patients were associated with lower hospital stays and total costs.[3] This model also showed that women had lower total costs and shorter hospital stays than men. Women are more often candidates for

cholecystectomies, but men tend to have more complex and longer procedures which may explain their less favorable outcomes.[28,29] In agreement with our findings, Carbonell et al. found in a US-nationwide study in 2000 that male gender was linked to higher charges, longer LOS, and increased morbidity and mortality after cholecystectomy.[3]

Black race was an independent predictor for increased LOS and total cost. Gahagan et al. conducted a 2009-2012 study using nationwide data that had similar findings. Namely, they found that white patients had shorter hospital stays and lower total charges, despite higher morbidity odds.[30] These findings are concerning and warrant further investigation, as they demonstrate a racial disparity in care beyond disease state and presentation. Likewise, compared to Medicaid patients, private insurance predicted a shorter hospital stay, yet a higher total cost. This suggests wealth disparities that could be attributable to several factors including overbilling, or additional treatments and testing. Overall, our data reinforces evidence of racial and insurance-based disparities in healthcare, specifically among cholecystectomy patients.

There are several limitations to this study. The SPARCS database receives administrative coding, which may not be standardized. This could result in variations in coding that alter the assumed specificity of the inclusion criteria used in this study. Additionally, we attempted to limit confounding factors that would influence outcomes by excluding patients with non-biliary primary diagnoses, which means our data does not reflect absolute values of admissions. Comorbidities were also addressed in our multivariable regression model by including APR severity of illness score. While this scoring system is believed to be valid, its efficiency in studies such ours needs to be further assessed.[19] Furthermore, the SPARCS database accounts for admissions and discharges, meaning an individual patient could account for multiple data entries. Although the SPARCS database has its flaws, it has been used in a variety of epidemiological and outcomes studies and offers great value in assessing trends in the New York State area. [14,15] We suggest caution when inferring these results to nationwide trends. Future studies should include assessing morbidity and mortality, investigating potential causes for disparities seen among specific ethnic groups and insurance types, and examining trends in the pediatric population.

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FIGURES AND TABLES.

Figure 1. *Patient Flow Chart*

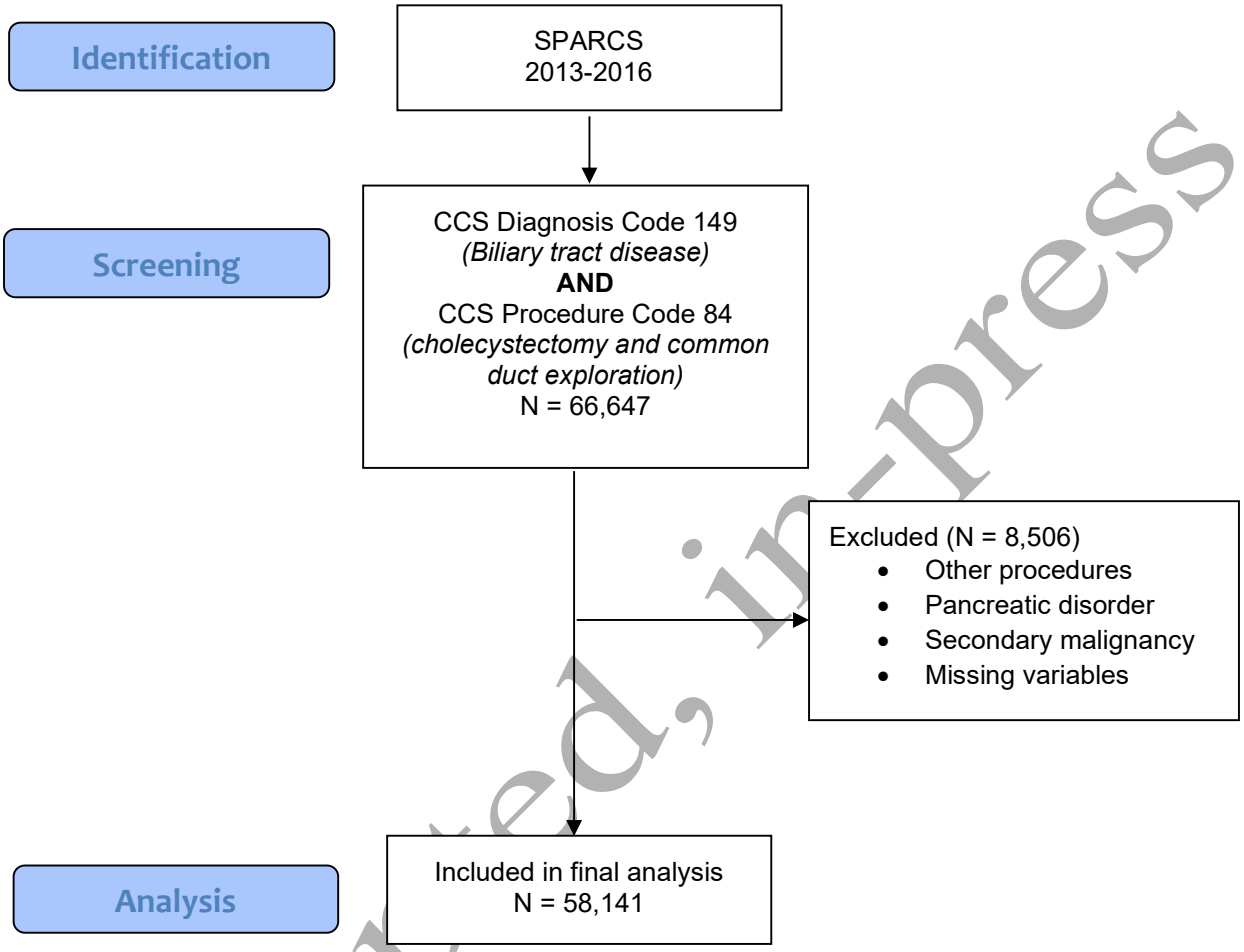


Figure 2. *Trends in Laparoscopic and Emergent Cholecystectomies*

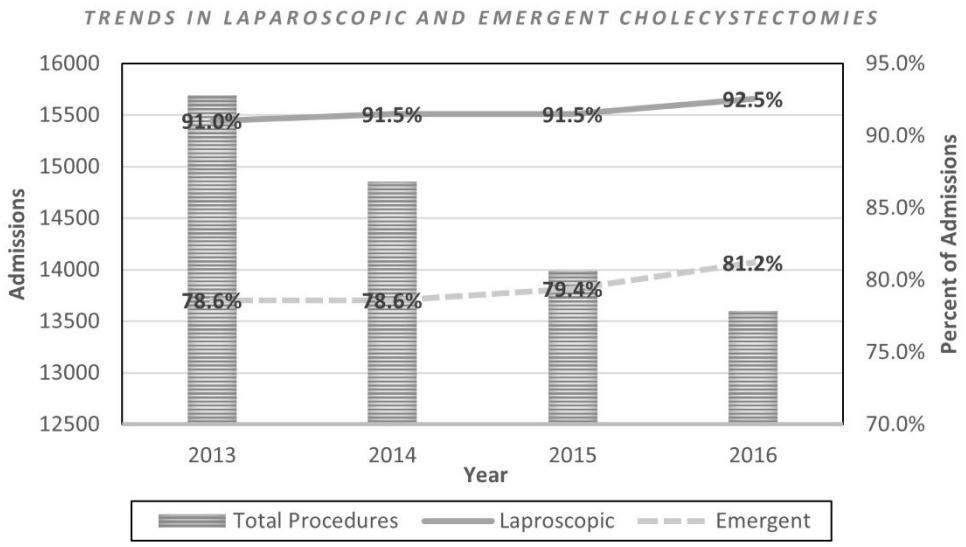
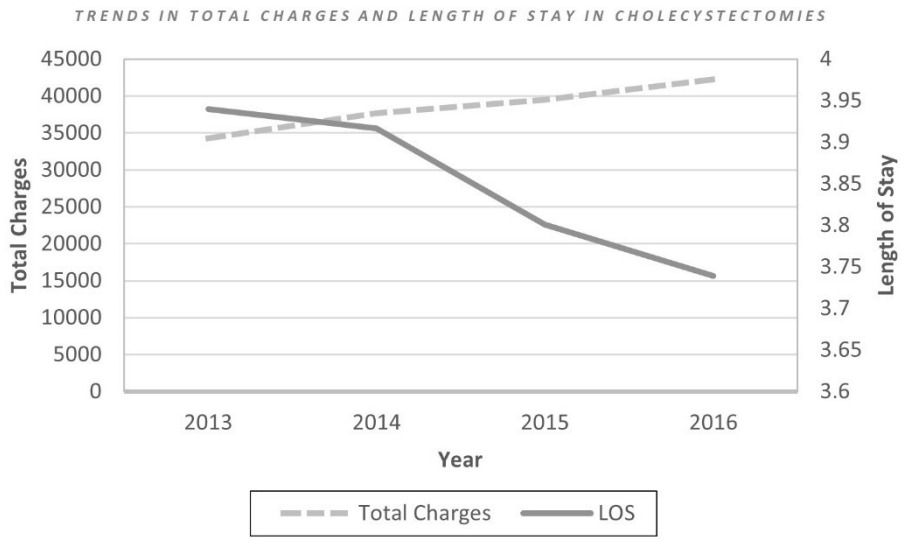


Figure 3. *Trends in Total Charges and Length of Stay in Cholecystectomies*



1 **Table 1**. *Procedural and Diagnostic Codes Included in Study*
2

Code Type	Code	Description
APR DRG	262	Cholecystectomy except laparoscopic
	263	Laparoscopic cholecystectomy
CCS ICD-9-CM Procedural	84	Cholecystectomy and common duct exploration
CCS ICD-9-CM Diagnostic	149	Biliary tract disease

APR all patient refined diagnosis-related groups*; CCS* clinical classifications software

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4
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6

1 **Table 2**. *Cholecystectomy Patient Demographic and Clinical Characteristics (2013-2016)*

2

Variable	Value
Admissions	58,141 14,532/year
Gender	
Female	37,804 (65%)
Male	30,337 (35%)
Age Group	
18-29	8,333 (14.3%)
30-49	19,251 (33.1%)
50-69	19,731 (33.9%)
70+	10,826 (18.6%)
Race	
White	33,369 (57.4%)
Black	7,407 (12.7%)
Unknown	17,365 (29.9%)
Presentation	
Elective	11,897 (20.6%)
Emergency	46,154 (79.4%)
Operation	
Laparoscopic	53,266 (91.6%)
Open	4,875 (8.4%)
Insurance	
Medicaid	14,977 (25.8%)
Medicare	15,586 (26.8%)
Private	23,248 (40%)
Other	4,330 (7.4%)

1

2 **Table 3**. *Cholecystectomy Patient Characteristics By Clinical Presentation (2013-2016)*

Variable	Emergency	Elective	p value
Mean LOS	3.97 ± 3.97	3.4 ± 3.94	<.0001
Mean Charges	$39,324 ± $33,621	$34,202 ±$38,503	<.0001
Gender			
Female	30,291 (80.1%)	7,513 (19.9%)	<.0001
Male	15,863 (78.0%)	4,474 (22.0%)	-
Operation			
Laparoscopic	43,338 (81.4%)	9,928 (18.6%)	<.0001
Open	2,816 (57.8%)	2,059 (42.2%)	-
Age Group			<.0001
18-29	7,175 (86.1%)	1,158 (13.9%)	<.0001
30-49	15,943 (82.8%)	3,308 (17.2%)	<.0001
50-69	15,092 (76.5%)	4,639 (23.5%)	<.0001
70+	7,944 (73.4%)	2,882 (26.6%)	-
Race			<.0001
White	26,209 (78.5%)	7,160 (21.5%)	-
Black	6,011 (81.2%)	1,396 (18.8%)	<.0001
Other	13,934 (80.2%)	3,431 (19.8%)	<.0001
Insurance			<.0001
Medicaid	12,461 (83.2%)	2,516 (16.8%)	-
Medicare	11,505 (73.8%)	4,081 (26.2%)	<.0001
Private	18,502 (79.6%)	4,746 (20.4%)	<.0001
Other	3,686 (85.1%)	644 (14.9%)	<.005

LOS length of stay

3

Table 4. *Cholecystectomy Patient Characteristics By Procedure (2013-2016)*

Variable	Laparo.	Open	p value
Mean LOS	3.58 ± 3.25	6.88 ± 6.21	<.0001
Mean Charges	$36,607 ± $31,051	$56,415 ± $59,197	<.0001
Gender			
Female	35,414 (93.7%)	2,390 (6.3%)	<.0001
Male	17,852 (87.8%)	2,485 (12.2%)	-
Presentation			
Emergent	43,338 (93.9%)	2,816 (6.1%)	<.0001
Elective	9,928 (82.8%)	2,059 (17.2%)	-
Age Group			<.0001
18-29	8,112 (97.3%)	221 (2.7%)	<.0001
30-49	18,285 (95.0%)	966 (5.0%)	<.0001
50-69	17,615 (89.3%)	2116 (10.7%)	<.0001
70+	9,254 (85.5%)	1,572 (14.5%)	-
Race			<.0001
White	30,343 (90.9%)	3,026 (9.1%)	-
Black	6,770 (91.4%)	637 (8.6%)	.10
Other	16,153 (93.0%)	1,212 (7.0%)	<.0001
Insurance			<.0001
Medicaid	14,053 (93.8%)	924 (6.2%)	-
Medicare	13,446 (86.3%)	2,140 (13.7%)	<.0001
Private	21,736 (93.5%)	1,512 (6.5%)	.0951
Other	4,031 (93.1%)	299 (6.9%)	.04

Laparo. laparoscopic; *LOS* length of stay

1 **Table 5**. *Multivariable Predictor for Length of Stay (Days) and Hospital Charges (USD)*

2

Variables	Length of Stay				Hospital Charges			
	B Coefficient	95% CI		*p* value	B Coefficient	95% CI		*p* value
		Lower	*Upper*			*Lower*	*Upper*	
Age								
18-29	-1.04	-1.15	-.93	<.0001	-$7,316	-$8,426	-$6,208	<.0001
30-49	-.93	-1.03	-.84	<.0001	-$6,114	-$7,078	-$5,149	<.0001
50-69	-.70	-.78	-.61	<.0001	-$4,393	-$5,244	-$3,542	<.0001
Over 70	-	-	-	-				
Race								
White	-	-	-	-	-	-	-	-
Black	.65	.57	.72	<.0001	$7,010	$6,238	$7,781	<.0001
Other	.30	.24	.36	<.0001	$5,700	$5,119	$6,280	<.0001
Female Gender	-.08	-.13	-.02	.005	-$1,605	-$2,134	-$1,076	<.0001
Elect. Pres.	-1.04	-1.10	-.98	<.0001	-$7,960	-$8,153	-$6,748	<.0001
Laparo. Tech.	-2.35	-2.44	-2.26	<.0001	-12,766	-$13,678	-$11,854	<.0001
Year								
2013	.34	.27	.40	<.0001	-$7,450	-$8,153	-$6,748	<.0001
2014	.19	.12	.26	<.0001	-$4,379	-$5,080	-$3,678	<.0001
2015	.05	-.2	.12	.186	-$2,720	-$3,432	-$2,010	<.0001
2016	-	-	-	-	-	-	-	-
Insurance								
Medicaid	.37	.30	.43	<.0001	-$1,248	-$1,908	-$587	<.0001
Medicare	.52	.44	.60	<.0001	$1,119	-$317	-$1,921	.006
Private	-	-	-	-	-	-	-	-
Other	.15	.06	.25	.002	-$4,106	-$5,087	-$3,123	<.0001
SOI Score								
Mild	-1.10	-1.15	-1.04	<.0001	-$7,650	-$8,185	-$7,114	<.0001
Moderate	-	-	-	-	-	-	-	-
Major	3.05	2.97	3.14	<.0001	$21,203	$20,327	$22,079	<.0001
Extreme	11.15	10.95	11.34	<.0001	97,660	$95,630	$99,690	<.0001

Laparo tech. laparoscopic technique; *elect. pres* elective presentation; *LOS* length of stay

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4