Racial and Ethnic Disparities in the Surgical Management and Outcomes of Colorectal Cancer in the Non-Elective Setting

A thesis submitted by

Heather M. Grant, MD

in partial fulfillment of the requirements for the degree of

Master of Science

in

Clinical and Translational Science

Tufts University

Graduate School of Biomedical Sciences

May 2021

Advisor: Angie Mae Rodday, PhD, MS

Abstract

Background

There are racial and ethnic differences in the incidence and mortality of colorectal cancer, as well as in the postoperative outcomes of individuals undergoing elective, urgent, or emergent resections; however, there is limited data on the association of race/ethnicity with surgical approach and postoperative outcomes in the non-elective setting. The purpose of this study was to determine if there are racial and ethnic differences in surgical approach or postoperative outcomes in individuals undergoing urgent and emergent surgeries only.

Methods

We performed a retrospective cohort study using the American College of Surgeons National Surgical Quality Improvement Program database for 2005-2018. All patients with an ICD-10 code for colorectal cancer and a CPT code for colorectal surgery, who underwent a non-elective procedure were included. Patients were grouped as non-Hispanic white (NHW), non-Hispanic black (NHB), Hispanic, or other. We performed univariable and multivariable logistic regression to compare surgical approach and 30-day postoperative outcomes between racial and ethnic groups. All multivariable analyses adjusted for patient characteristics and urgent versus emergent presentation. Analyses of postoperative outcomes also adjusted for surgical approach (open or laparoscopic).

Results

A total of 12,572 patients met inclusion criteria: 8900 NHW (71%), 1828 NHB (15%), 1089 Hispanic (9%), and 755 other (6%). Nearly two-thirds of patients (n=7975) underwent an open surgery. Compared to NHW race, NHB race was associated with higher odds of an open approach (adjusted OR=1.11, 95% CI=1.00-1.25), while Hispanic ethnicity was associated with lower odds (adjusted OR=0.85, 95% CI=0.74-0.98). Postoperatively, NHB race was associated with higher odds of a 30-day morbidity, but lower 30-day mortality compared to NHW prior to adjustment, while Hispanic ethnicity was associated with lower odds of both in-hospital and 30-day mortality. After adjustment, however, there were no differences in the odds of a 30-day morbidity, in-hospital mortality, 30-day mortality, 30-day reoperation, or 30-day readmission among racial and ethnic groups.

Conclusions

We found that the odds of undergoing an open, non-elective colorectal resection for cancer were higher among NHB individuals but lower among Hispanic patients relative to NHW individuals. This implies that unidentified factors may contribute to the differential surgical management of patients with CRC based on race and ethnicity. Future studies should seek to identify these factors and to reduce or eliminate racial and ethnic differences in the surgical management and postoperative outcomes of CRC.

Table of Contents

Title Page i

Abstract ii

Table of Contents iv

List of Tables vi

List of Abbreviations vii

Chapter 1: Introduction 1
1.1 The Incidence and Mortality of Colorectal Cancer 1
1.2 The Surgical Management of Colorectal Cancer 3
1.3 Postoperative Outcomes after the Surgical Resection of Colorectal Cancer 5
1.4 Aims of the Study 5

Chapter 2: Racial and Ethnic Disparities in the Surgical Management and Outcomes of Colorectal Cancer in the Non-Elective Setting. 7
2.1 Introduction 8
2.2 Methods 9
2.2.1 Study Design and Setting 9
2.2.2 Inclusion and Exclusion Criteria 10
2.2.3 Exposure Variable 11
2.2.4 Primary and Secondary Outcomes 11
2.2.5 Covariates 12
2.2.6 Sample Size 13
2.2.7 Statistical Analysis 13
2.2.8 Sensitivity Analyses 14
2.3 Results 15
2.3.1 Patient Characteristics 15
2.3.2 Surgical Approach 18
2.3.3 Thirty-Day Morbidity 21
2.3.4 In-Hospital and 30-Day Mortality 23
2.3.5 Thirty-Day Reoperation 23
2.3.6 Thirty-Day Readmission 25
2.3.7 Sensitivity Analysis of Individuals with Missing Race and Ethnicity 25
2.3.8 Sensitivity Analysis of Results Stratified by the Urgency of the Operation 26
2.3.9 Sensitivity Analysis of Results Stratified by the Presence of Localized or Disseminated Cancer 27
2.3.10 Sensitivity Analysis Accounting for the Competing Risk of Death in the 30-Day Morbidity Outcome 27
2.4 Discussion 27
2.4.1 Conclusions 33

Chapter 3: Discussion 35
3.1 Surgical Approach and Postoperative Outcomes 36
3.2 Self-Reported Race/Ethnicity as an Explanatory Variable 40
3.3 Strengths and Limitations 41
3.4 Conclusions 42

Chapter 4: Appendix 44

Chapter 5: Bibliography 52

List of Tables

Table 2.1 Baseline Patient Characteristics by Race/Ethnicity 16
Table 2.2 Baseline Patient Characteristics by Surgical Approach 19
Table 2.3 Factors associated with an Open Surgical Approach 20
Table 2.4 Logistic Regression for Race/Ethnicity and 30-Day Morbidity 22
Table 2.5 Logistic Regression for Race/Ethnicity and In-Hospital Mortality, 30-Day Mortality, 30-Day Reoperation, and 30-Day Readmission 24
Table 4.1 ICD-10 Codes for Colorectal Cancer 44
Table 4.2 CPT Codes for Colorectal Surgery 45
Table 4.3 Sensitivity Analysis of Individuals with Missing Race and Ethnicity 47
Table 4.4 Sensitivity Analysis Results Stratified by the Urgency of the Operation 49
Table 4.5 Sensitivity Analysis Results Stratified by the Presence of Localized or Disseminated Cancer 50
Table 4.6 Sensitivity Analysis Accounting for the Competing Risks of 30-Day Morbidity and 30-Day Mortality 51

List of Abbreviations

ASA (American Society of Anesthesiologists)
CI (confidence interval)
CPT (Current Procedural Terminology)
CRC (colorectal cancer)
ICD (International Classification of Disease)
Iqr (interquartile range)
LOS (length of stay)
NHB (non-Hispanic black)
NHW (non-Hispanic white)
NSQIP (National Surgical Quality Improvement Program)
OR (odds ratio)
ROC (receiver operating characteristic)
Sd (standard deviation)
SES (socioeconomic status)
SIRS (systemic inflammatory response syndrome)

Chapter 1: Introduction

Colorectal cancer (CRC) is the third most common cancer diagnosis in the United States and the second leading cause of cancer-related mortality among cancers diagnosed in both men and women.[1,2] Data from the Centers for Disease Control and Prevention indicates that each year, there are approximately 37 new cases of CRC and 14 CRC-related deaths per 100,000 Americans after adjusting for age.[3] This represents a significant burden on the US healthcare system, with an estimated prevalence cost of $14.1 billion dollars annually.[4]

1.1 The Incidence and Mortality of Colorectal Cancer

Since the widespread adoption of screening colonoscopy in the mid-1980s, the annual overall incidence of CRC has decreased by approximately 30 cases per 100,000 Americans.[3,5] Modeling estimates indicate that the decline may be attributable to changes in risk factor distribution, such as a reduction in tobacco use,[6] while the later decline resulted from increased screening for CRC.[5] Despite this overall reduction in new CRC diagnoses, incidence rates vary significantly based on geographic location and patients' sociodemographic characteristics. For instance, in 2017 there were 36 new cases of CRC per 100,000 white individuals compared to 40 per 100,000 black individuals, 33 per 100,000 Hispanic individuals, 29 per 100,000 American Indians/Alaska Natives, and 29 per 100,000 Asians/Pacific Islanders.[3] These racial and ethnic differences are only partially explained by differences in the distribution of modifiable risk factors, including physical inactivity, tobacco use, obesity, and an

unhealthy diet,[7,8] suggesting that other factors, including genetic susceptibility and environmental risk factors, may play a role.

In recent decades, trends in the mortality of CRC have paralleled decreases in incidence. Throughout the 1940s, the survival rate for CRC was low: only 29% of men and 35% of women were still alive five-years after diagnosis. However, the nationwide implementation of early screening programs,[5,6,9] surgical advances, and new chemotherapy regimens[6] resulted in a dramatic increase in five-year survival to 63% and 64% among men and women, respectively, by 2017.[3] These improvements in survival have benefited individuals of all races and ethnicities, but differences in mortality outcomes between racial and ethnic groups persist. For example, in 1990, there were 24 deaths per 100,000 white Americans compared to 31 per 100,000 black Americans.[3] These numbers decreased by 2017 to 14 and 19 deaths per 100,000 white and black Americans, respectively, but white individuals have continued to experience a survival advantage compared to those who identify as black.[3] This enduring discrepancy in mortality outcomes could be the result of numerous factors, including structural barriers to CRC screening and aggressive tumor biology, resulting in tumor detection at an advanced stage. Additionally, certain sociodemographic characteristics, such as low socioeconomic status (SES), low education level, lack of health insurance, and public rather than private insurance type, may play a role in the differences in both screening and mortality rates.[2,10,11]

Although each of these factors likely contributes to the racial and ethnic differences in the incidence and mortality of CRC, they do not fully explain the disproportionate burden of CRC on black Americans. Recently, a growing body of

evidence has implicated racial residential segregation as an additional contributor.[12] Residential segregation, an example of institutional racism deeply rooted in American history, is likely upstream of racial differences in sociodemographic characteristics and has been linked to differences in various health outcomes.[12–15] Specifically, racial segregation has been associated with advanced stage at presentation, lower likelihood of undergoing surgical resection, and worse CRC-specific survival among black individuals.[12] This suggests that enduring structural racism plays an important role in the disparate impact of CRC on communities of different racial and ethnic backgrounds. However, to determine if there are disparities in CRC care, one must first establish if there are racial and ethnic differences in treatment. Differences in treatment that are associated with poor outcomes and cannot be explained by patient factors would constitute a racial or ethnic disparity in CRC-related health care.[16]

1.2 The Surgical Management of Colorectal Cancer

In terms of treatment for CRC, the cornerstone of management is surgical resection. This can be approached in an open or a minimally invasive manner. Minimally invasive methods can be further characterized as laparoscopic or robotic. When laparoscopy was first introduced, there were concerns that this approach would compromise survival by failing to achieve a complete oncologic resection, providing inadequate surgical margins and insufficient lymph nodes for staging purposes, and possibly resulting in tumor recurrence at trocar sites. Since then, however, several large trials have determined that elective laparoscopic colorectal resections are associated with similar or better outcomes compared to open surgery.[17–22] For instance, these trials found

that complication rates, recurrence, three-year overall survival, and 30-day mortality were similar between laparoscopic and open colorectal resections. Hospital length of stay (LOS), duration of narcotic use, and return of bowel function, however, were shorter in the laparoscopic group.[19–21] Additional studies have shown lower complication rates among individuals undergoing a laparoscopic procedure.[22] Similar results have been documented with a robotic approach.[23] Given this compelling evidence, the American Society of Colon and Rectal Surgeons and the Society of American Gastrointestinal Endoscopic Surgeons currently advocate for a laparoscopic approach in the management of CRC when feasible.[24,25]

Despite these recommendations, several studies have shown that certain patient, hospital, and procedure characteristics are associated with varying odds of a laparoscopic approach. For instance, an open approach is more common among patients with non-private insurance[26–28] and lower SES,[26,28] as well as those treated at rural and non-teaching hospitals.[27] Additionally, urgent and emergent procedures are much more likely to be performed through an open approach than elective cases.[28] Given that self-identified black individuals are more likely to have non-private insurance, lower SES,[29] and more emergent presentations,[30] it is surprising that no prior studies have shown a difference in the surgical approach based on race and ethnicity.[26–28] One possible explanation is that prior studies have not differentiated between elective, urgent, and emergent procedures and the majority of surgeries included were elective.[27,28] As a result, any racial or ethnic differences in surgical approach for non-elective surgeries may have been masked.

1.3 Postoperative Outcomes after the Surgical Resection of Colorectal Cancer

Among patients who undergo a colorectal resection for cancer, postoperative outcomes vary based on sociodemographic characteristics and procedure type. For instance, patients with non-private insurance,[26,28] lower SES,[28] or an emergent surgery[31–33] tend to have significantly higher morbidity and mortality rates and longer hospital LOS, compared to individuals with private insurance, higher SES, and an elective procedure. It is tempting to attribute these observations to the higher likelihood of an open approach among these individuals;[17–22] however, studies of pooled elective, urgent, and emergent cases have shown that black individuals are no more likely to undergo an open surgery than white patients, but have 8-23% increased odds of a postoperative complication,[26,28] 18% increased odds of mortality, and 33% longer hospital LOS.[28] One possible explanation for this phenomenon stems from the higher proportion of black individuals presenting emergently.[30] Since emergent procedures are more likely to be undertaken in an open fashion and to have worse postoperative outcomes,[34] it is possible that the inclusion of a heterogeneous population of elective and non-elective cases in prior studies precluded the possibility of showing a difference in surgical approach among non-elective procedures, which may be driving the higher morbidity and mortality rates in this population.

1.4 Aims of the Study

The main objective of this study was to determine if race and ethnicity are associated with the surgical approach and postoperative outcomes of patients with CRC who are undergoing urgent or emergent colorectal resections. The selection of this

patient population allowed us to: 1) to determine if there are racial and ethnic differences in surgical approach among patients undergoing non-elective colorectal resections for cancer after accounting for various patient characteristics and clinical factors and 2) to determine if 30-day postoperative outcomes differ based on race and ethnicity after adjusting for patient characteristics, clinical factors, and surgical approach. We hypothesized that a higher proportion of non-Hispanic black patients would undergo open procedures and would experience worse postoperative outcomes, even after accounting for other variables. If this is the case, the next step would be to understand the clinical factors and the patient, provider, and hospital characteristics contributing to these differences in surgical approach and postoperative outcomes, with the goal of reducing or eliminating these disparities.

Chapter 2: Racial and Ethnic Disparities in the Surgical Management and Outcomes of Colorectal Cancer in the Non-Elective Setting.[1]

[1] Grant HM, Rodday AM, Breeze JL, Tirabassi MV, Stefan MS. To be submitted to *Journal of the American College of Surgeons*.

2.1 Introduction

Colorectal cancer (CRC) is the third most common cancer diagnosis and the second leading cause of cancer-related mortality among cancers diagnosed in both men and women, despite steady reductions in both incidence and mortality over the last few decades.[1,2] Prior studies have described differences in the incidence and mortality of CRC based on geographic location and sociodemographic characteristics.[2,3] For instance, there were 40 new cases of CRC per 100,000 black Americans compared to only 36 per 100,000 white Americans in 2017, and five-year survival was 6% lower for black individuals.[3] This trend could be the result of numerous factors, including structural barriers to CRC screening, tumor biology, management strategy, sociodemographic characteristics, and structural racism.

For patients with resectable disease, the cornerstone of management is surgical resection. Similar or better outcomes have been demonstrated among patients undergoing laparoscopic[20–22] or robotic[23] resections compared to open procedures, so laparoscopy is currently recommended when feasible.[24,25] However, studies have demonstrated that the odds of a laparoscopic approach vary based on patient, hospital, and procedure characteristics and that postoperative outcomes follow similar patterns.[26–28] One notable exception is race; no studies have demonstrated a difference in surgical approach based on race or ethnicity, yet black individuals have significantly higher postoperative morbidity and mortality rates compared to white patients undergoing the same procedures.[26–28] One possible explanation for this phenomenon stems from the higher proportion of black individuals presenting emergently.[30] Since emergent procedures are more likely to be undertaken in an open fashion and to have worse

postoperative outcomes,[34] it is possible that the inclusion of a heterogeneous population of elective and non-elective cases in prior studies precluded the possibility of showing a difference in surgical approach among non-elective procedures, which may be driving the higher morbidity and mortality rates among black individuals.

The purpose of the present study was two-fold: 1) to determine if there are racial and ethnic differences in surgical approach among patients undergoing non-elective colorectal resections for cancer after accounting for various patient characteristics and clinical factors and 2) to determine if 30-day postoperative outcomes differ based on race and ethnicity after adjusting for patient characteristics, clinical factors, and surgical approach. We hypothesized that a higher proportion of black patients would undergo open procedures and experience worse postoperative outcomes, even after accounting for patient and clinical factors. If this is the case, the next step would be to understand the clinical factors and the patient, provider, and hospital characteristics contributing to these differences in surgical approach and postoperative outcomes, with the goal of reducing or eliminating these disparities.

2.2 Methods

2.2.1 Study Design and Setting

We performed a retrospective cohort study using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database for 2015-2018.[35] The NSQIP is one of the largest surgical databases in the United States and has been used extensively for surgical outcomes research.[22,34,36] It contains prospectively collected information on adult patients (≥18-years old) undergoing major surgical

procedures in the inpatient and outpatient settings at over 700 participating community and university hospitals. Hospital participation is voluntary and fee-based, and cases are randomly assigned for data collection on an eight-day cycle to ensure that all cases have an equal chance of being selected from each day of the week over time. For each case, patient demographics and comorbidities, preoperative laboratory values, intraoperative variables, and 30-day postoperative morbidity and mortality outcomes are collected in the form of over 150 variables. To ensure the robustness of the dataset, data is abstracted from the medical record by trained clinical reviewers and patients are followed for the full 30 days, regardless of whether or not they remain in the hospital or have been discharged. Prior to allowing researchers access to the data, the information is deidentified and a Data Use Agreement must be signed by all team members who will have access to the data. The NSQIP and the centers participating in the NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.[35]

2.2.2 Inclusion and Exclusion Criteria

For the present study, all patients with an International Classification of Disease (ICD)-10 code for CRC (Table 4.1, Appendix) and a Current Procedural Terminology (CPT) code for a colorectal surgery (Table 4.2, Appendix) were eligible for inclusion. Patients who underwent an elective procedure and those with missing race and ethnicity were excluded.

2.2.3 Exposure Variable

Our exposure of interest was self-reported race and ethnicity. Consistent with prior literature, patients were categorized as non-Hispanic white (NHW), non-Hispanic black (NHB), Hispanic, or other.[26,28] Other included American Indian or Alaska natives, Asians, and Native Hawaiian or Pacific Islanders.

2.2.4 Primary and Secondary Outcomes

For aim 1, our primary outcome of interest was the surgical approach, which was classified by CPT codes as either open or laparoscopic (Table 4.2, Appendix). For aim 2, our primary outcome was 30-day morbidity, which was defined as a composite outcome that included any complication occurring within 30 days of surgery, other than death, readmission, or reoperation. Specific morbidities were superficial, deep, and organ space surgical site infections, wound disruptions, pneumonia, unplanned intubation, pulmonary embolism, ventilator requirement greater than 48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, cerebrovascular accident with neurological deficit, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, bleeding requiring transfusions, deep vein thrombosis or thrombophlebitis, sepsis, septic shock, and *Clostridium difficile* infection. Secondary outcomes included in-hospital and 30-day mortality, all-cause readmission within 30 days of surgery, and reoperation within 30 days of surgery.

2.2.5 Covariates

Based on prior literature[19,27,28] and subject matter expertise, covariates that could help explain the association between race/ethnicity and our primary and secondary outcomes were identified for inclusion in our multivariable models. These included age, sex, medical comorbidities, smoking status, functional status, the presence of localized versus disseminated cancer, transfusion of at least one unit of whole blood or packed red blood cells within 72-hours prior to surgery, the presence (within 48-hours prior to surgery) of preoperative systemic inflammatory response syndrome (SIRS), sepsis, or septic shock, American Society of Anesthesiologists (ASA) class, and urgent versus emergent presentation. Specific pre-existing comorbidities included were obesity, diabetes mellitus, dyspnea, ventilator-dependence, severe chronic obstructive pulmonary disease (COPD), ascites, congestive heart failure (CHF), hypertension requiring medication, acute renal failure, dialysis requirement, wound infection or open wound, steroid use for a chronic condition, greater than 10% weight loss in the prior 6-months, and bleeding disorders. Functional status was defined in the database as independent, partially dependent, totally dependent, or unknown. ASA classification describes an individual's physiologic status on a scale of 1-5 as follows: (1) healthy, (2) mild systemic disease, (3) severe systemic disease, (4) incapacitating disease that is a constant threat to life, and (5) moribund. This classification system has previously been shown to be a reliable predictor of postoperative morbidity and mortality.[37]

2.2.6 Sample Size

Given a sample size of 12,500 subjects with a ratio of approximately five NHW patients for each NHB individual, we determined that we would have over 80% power to detect an odds ratio (OR) of having an open procedure of at least 1.14 for NHB compared to NHW, assuming a baseline rate of 60% open procedures and a two-sided alpha of 0.05.[28] Additionally, we found that we would have over 80% power to detect an OR of 30-day postoperative morbidity of 1.23 for NHB compared to NHW, conservatively assuming a baseline morbidity rate of 16%.[28]

2.2.7 Statistical Analysis

We initially evaluated baseline patient characteristics overall, by race/ethnicity, and by surgical approach. Results for continuous variables are shown as mean and standard deviation (sd) or median and interquartile range (iqr), while categorical variables are shown as frequencies and percentages. For aim 1, we utilized univariable and multivariable logistic regression models to calculate unadjusted and adjusted OR and 95% confidence intervals (CI) for the association between race/ethnicity and surgical approach. The multivariable model was adjusted for the covariates listed above. We also calculated e-values to quantify the minimum strength of association that an unmeasured variables would need to have with both race/ethnicity and surgical approach to nullify any significant association between race/ethnicity and surgical approach.[38–40] Similar univariable and multivariable approaches were used for the 30-day morbidity, mortality, readmission, and reoperation outcomes in aim 2. Additional covariates included in the multivariable models for aim 2 were surgical approach and interaction terms between

race/ethnicity and surgical approach in order to evaluate if surgical approach modified the relationship between race/ethnicity and postoperative outcomes. In addition, we evaluated median time to surgery, as well as median hospital LOS overall and among individuals who survived their initial hospital admission. Linearity was assessed for all continuous variables and overall model fit was assessed using receiver operating characteristic (ROC) curves and c-statistics. Statistical significance was set at a two-sided alpha of 0.05. Statistical analysis was carried out with R Studio.[41]

2.2.8 Sensitivity Analyses

Although the NSQIP has relatively little missing data, a subset of patients was excluded from our study due to missing race and ethnicity. Prior studies have found that patients with and without a documented race or ethnicity differ in a number of ways, including sociodemographic characteristics and comorbid medical conditions.[42,43] To account for these individuals, we repeated the same analyses as described above, but categorized patients with missing race and ethnicity three different ways: (1) as a fifth exposure category, (2) as NHW, and (3) as NHB. In light of evidence that patients undergoing emergent procedures[28] and those with advanced cancer[26] are more likely to undergo an open surgical approach compared to individuals that present urgently and those with localized disease, we also repeated the aforementioned analyses after stratifying our sample by urgent or emergent procedure type and by the presence of localized versus disseminated cancer. Finally, to account for the competing risk of death within 30 days of surgery, we repeated the 30-day morbidity analysis using a composite outcome of 30-day morbidity and 30-day mortality.

2.3 Results

2.3.1 Patient Characteristics

A total of 12,572 patients met the inclusion criteria. Of these, 8900 (70.8%) were classified as NHW, 1828 (14.5%) as NHB, 1089 (8.7%) as Hispanic, and 755 (6.0%) as other (Table 2.1). Mean age was 68 years (sd=14) and one-half of patients were male. The most common comorbid conditions were hypertension (n=6890, 54.8%), obesity (n=3556, 28.6%), diabetes (n=2527, 20.1%), and smoking (n=2152, 17.1%), and nearly two-thirds of patients (n=7942) were classified as ASA class 3. Overall, one-fifth of patients presented with disseminated cancer (n=2751) and 17% with SIRS (n=669, 5.3%), sepsis (n=97, 0.8%), or septic shock (n=1382, 11.0%). Over 90% of individuals were functionally independent at the time of presentation. Surgical resection was designated as emergent in 20% of cases (n=2510) and nearly two-thirds of cases were undertaken via an open approach (n=7975).

Differences in baseline patient characteristics between racial and ethnic groups are presented in Table 2.1. Self-identified NHW individuals were the oldest (mean=69 years, sd=14) and had the highest prevalence of both dyspnea (n=1065, 12.0%) and severe COPD (n=736, 8.3%). Among both NHW (n=5629) and NHB (n=1197) patients, nearly two-thirds of individuals were designed ASA class 3. NHB individuals had the highest proportion of smokers (n=412, 22.5%) and individuals with obesity (n=586, 32.5%), hypertension (n=1116, 61.1%), renal failure (n=25, 1.4%), dialysis-dependence (n=56, 3.1%), and preoperative blood transfusion requirements (n=282, 15.4%). With the exception of diabetes, which was most prevalent among Hispanic individuals (n=277,

Table 2.1 Baseline Patient Characteristics by Race/Ethnicity					
	Overall n=12,572	NHW[a] n=8900	Hispanic n=1089	NHB[b] n=1828	Other n=755
Age (years), mean (sd)	67.79 (14.13)	69.42 (13.76)	61.62 (15.12)	64.40 (13.32)	66.23 (14.78)
Male, n (%)	6317 (50.2)	4444 (49.9)	564 (51.8)	940 (51.4)	369 (48.9)
Comorbidities, n (%)					
Obesity	3556 (28.6)	2568 (29.2)	315 (29.3)	586 (32.5)	87 (11.8)
Diabetes	2527 (20.1)	1667 (18.7)	277 (25.4)	430 (23.5)	153 (20.3)
Current Smoker	2152 (17.1)	1483 (16.7)	149 (13.7)	412 (22.5)	108 (14.3)
Dyspnea	1377 (11.0)	1065 (12.0)	66 (6.1)	175 (9.6)	71 (9.4)
Ventilator-Dependence	46 (0.4)	33 (0.4)	3 (0.3)	7 (0.4)	3 (0.4)
Severe COPD[c]	869 (6.9)	736 (8.3)	26 (2.4)	86 (4.7)	21 (2.8)
Ascites	269 (2.1)	190 (2.1)	24 (2.2)	33 (1.8)	22 (2.9)
CHF[d]	453 (3.6)	353 (4.0)	15 (1.4)	71 (3.9)	14 (1.9)
Hypertension	6890 (54.8)	4926 (55.3)	475 (43.6)	1116 (61.1)	373 (49.4)
Acute Renal Failure	73 (0.6)	34 (0.4)	6 (0.6)	25 (1.4)	8 (1.1)
Dialysis-Dependence	166 (1.3)	86 (1.0)	15 (1.4)	56 (3.1)	9 (1.2)
Open Wound	313 (2.5)	234 (2.6)	20 (1.8)	48 (2.6)	11 (1.5)
Steroid Use	424 (3.4)	310 (3.5)	34 (3.1)	59 (3.2)	21 (2.8)
>10% Weight Loss	1658 (13.2)	1129 (12.7)	166 (15.2)	282 (15.4)	81 (10.7)
Bleeding Disorder	1056 (8.4)	808 (9.1)	78 (7.2)	123 (6.7)	47 (6.2)
Preoperative Transfusion	1610 (12.8)	1123 (12.6)	118 (10.8)	282 (15.4)	87 (11.5)
Preoperative Sepsis, n (%)					
None	10424 (82.9)	7368 (82.8)	920 (84.5)	1522 (83.3)	614 (81.3)
SIRS[e]	669 (5.3)	996 (11.2)	109 (10.0)	187 (10.2)	90 (11.9)
Sepsis	97 (0.8)	467 (5.2)	56 (5.1)	104 (5.7)	42 (5.6)
Septic Shock	1382 (11.0)	69 (0.8)	4 (0.4)	15 (0.8)	9 (1.2)
Disseminated Cancer, n (%)	2751 (21.9)	1933 (21.7)	242 (22.2)	427 (23.4)	149 (19.7)
Functional Status, n (%)					
Independent	11557 (91.9)	8198 (92.1)	1014 (93.1)	1661 (90.9)	684 (90.6)
Partially Dependent	828 (6.6)	575 (6.5)	57 (5.2)	134 (7.3)	62 (8.2)
Totally Dependent	140 (1.1)	95 (1.1)	11 (1.0)	25 (1.4)	9 (1.2)
Unknown	47 (0.4)	32 (0.4)	7 (0.6)	8 (0.4)	0 (0.0)

ASA[f] Classification, n (%)					
1 - No Disturbance	96 (0.8)	60 (0.7)	14 (1.3)	12 (0.7)	10 (1.3)
2 - Mild Disturbance	2562 (20.4)	1749 (19.7)	281 (25.8)	313 (17.1)	219 (29.0)
3 - Severe Disturbance	7942 (63.2)	5629 (63.2)	673 (61.8)	1197 (65.5)	443 (58.7)
4 - Life Threat	1926 (15.3)	1428 (16.0)	115 (10.6)	302 (16.5)	81 (10.7)
5 - Moribund	38 (0.3)	29 (0.3)	4 (0.4)	3 (0.2)	2 (0.3)
None Assigned	8 (0.1)	5 (0.1)	2 (0.2)	1 (0.1)	0 (0.0)
Open Approach, n (%)	7975 (63.4)	5656 (63.6)	646 (59.3)	1203 (65.8)	470 (62.3)
Emergent, n (%)	2510 (20.0)	1737 (19.5)	212 (19.5)	327 (17.9)	234 (31.0)

[a] NHW = Non-Hispanic White
[b] NHB = Non-Hispanic Black
[c] COPD = chronic obstructive pulmonary disease
[d] CHF = congestive heart failure
[e] SIRS = systemic inflammatory response syndrome
[f] ASA = American Society of Anesthesiologists

25.4%), those in the Hispanic and other groups had the fewest comorbidities and the lowest ASA classes.

2.3.2 Surgical Approach

Nearly two-thirds of patients (n=7975) underwent an open colorectal resection for cancer, including 64% (n=5656) of NHW individuals, 66% (n=1203) of NHB individuals, 62% (n=470) of individuals characterized as other, and 59% (n=646) of Hispanic individuals (Table 2.2). From 2015 to 2018, the proportion of laparoscopic procedures steadily increased from 32.5% to 39.6%, with a corresponding decrease in the proportion of open surgeries. Overall, an open approach was more common among smokers and among individuals with disseminated cancer, greater than 10% weight loss in the six months prior to admission, SIRS, sepsis, or septic shock within 48 hours prior to admission, higher ASA class, and an emergent presentation. Overall, 20% (n=2510) of cases were described as emergent. Emergent procedures were the least common among NHB individuals (n=327, 17.9%) and most common among patients grouped as other (n=234, 31.0%).

Overall, median time from admission to surgery was 2 days (iqr=1-5); however, NHB and Hispanic individuals had a median of 3 days (NHB iqr=1-6, Hispanic iqr=1-5) to surgery. Unadjusted logistic regression revealed that Hispanic ethnicity was associated with 16% lower odds of undergoing an open procedure (OR=0.84, 95% CI=0.74-0.95) compared to NHW race (Table 2.3). This association persisted after adjustment for patient characteristics and other factors (OR=0.85, 95% CI=0.74-0.98). For individuals identifying as NHB, the unadjusted association was not significant, but the adjusted

Table 2.2 Baseline Patient Characteristics by Surgical Approach		
	Laparoscopic n=4597	Open n=7975
Race/Ethnicity, n (%)		
NHW[a]	3244 (70.6)	5656 (70.9)
Hispanic	625 (13.6)	1203 (15.1)
NHB[d]	443 (9.6)	646 (8.1)
Other	285 (6.2)	470 (5.9)
Age (years), mean (sd)	68.14 (14.07)	67.59 (14.17)
Male, n (%)	2270 (49.4)	4047 (50.7)
Comorbidities, n (%)		
Obesity	1336 (29.3)	2220 (28.2)
Diabetes	973 (21.2)	1554 (19.5)
Current Smoker	679 (14.8)	1473 (18.5)
Dyspnea	566 (12.3)	811 (10.2)
Ventilator-Dependence	4 (0.1)	42 (0.5)
Severe COPD[c]	300 (6.5)	569 (7.1)
Ascites	55 (1.2)	214 (2.7)
CHF[d]	196 (4.3)	257 (3.2)
Hypertension	2587 (56.3)	4303 (54.0)
Acute Renal Failure	19 (0.4)	54 (0.7)
Dialysis-Dependence	69 (1.5)	97 (1.2)
Open Wound	111 (2.4)	202 (2.5)
Steroid Use	151 (3.3)	273 (3.4)
>10% Weight Loss	526 (11.4)	1132 (14.2)
Bleeding Disorder	401 (8.7)	655 (8.2)
Preoperative Transfusion, n (%)	644 (14.0)	966 (12.1)
Preoperative Sepsis, n (%)		
None	4176 (90.8)	6248 (78.3)
SIRS[e]	348 (7.6)	1034 (13.0)
Sepsis	67 (1.5)	602 (7.5)
Septic Shock	6 (0.1)	91 (1.1)
Disseminated Cancer, n (%)	793 (17.3)	1958 (24.6)
Functional Status, n (%)		
Independent	4274 (93.0)	7283 (91.3)
Partially Dependent	265 (5.8)	563 (7.1)
Totally Dependent	51 (1.1)	89 (1.1)
Unknown	7 (0.2)	40 (0.5)
ASA[f] Classification, n (%)		
1 - No Disturbance	33 (0.7)	63 (0.8)
2 - Mild Disturbance	1051 (22.9)	1511 (18.9)
3 - Severe Disturbance	2915 (63.4)	5027 (63.0)
4 - Life Threat	591 (12.9)	1335 (16.7)
5 - Moribund	4 (0.1)	34 (0.4)
None Assigned	3 (0.1)	5 (0.1)
Emergent, n (%)	478 (10.4)	2032 (25.5)

[a] NHW = Non-Hispanic White
[b] NHB = Non-Hispanic Black
[c] COPD = chronic obstructive pulmonary disease
[d] CHF = congestive heart failure
[e] SIRS = systemic inflammatory response syndrome
[f] ASA = American Society of Anesthesiologists

Table 2.3 Logistic Regression for Race/Ethnicity and an Open Surgical Approach		
	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)
Race/Ethnicity (referent = NHW[c])		
Hispanic	**0.84 (0.74-0.95)**	**0.85 (0.74-0.98)**
NHB[d]	1.10 (0.99-1.23)	**1.11 (1.00-1.25)**
Other	0.95 (0.81-1.10)	0.89 (0.75-1.04)
Age		1.00 (1.00-1.00)
Male		1.04 (0.96-1.12)
Comorbidities		
Obesity		1.01 (0.92-1.10)
Diabetes		0.97 (0.88-1.08)
Current Smoker		**1.22 (1.09-1.36)**
Dyspnea		**0.81 (0.72-0.93)**
Ventilator-Dependence		2.55 (0.96-8.80)
Severe COPD[e]		1.11 (0.94-1.31)
Ascites		**1.62 (1.18-2.24)**
CHF[f]		**0.76 (0.62-0.95)**
Hypertension		0.95 (0.87-1.04)
Acute Renal Failure		1.22 (0.69-2.22)
Dialysis-Dependence		0.74 (0.53-1.04)
Open Wound		0.90 (0.70-1.17)
Steroid Use		0.98 (0.79-1.22)
>10% Weight Loss		**1.15 (1.03-1.30)**
Bleeding Disorder		0.91 (0.79-1.05)
Preoperative Transfusion		**0.87 (0.78-0.98)**
Disseminated Cancer		**1.35 (1.22-1.49)**
Preoperative Sepsis (referent = none)		
SIRS[g]		**1.67 (1.46-1.91)**
Sepsis		**4.26 (3.30-5.59)**
Septic Shock		**4.31 (1.89-12.45)**
Functional Status (referent = independent)		
Partially Dependent		**1.26 (1.07-1.49)**
Totally Dependent		0.91 (0.63-1.33)
Unknown		**3.12 (1.45-7.75)**
ASA[h] Classification (referent = ASA class 1)		
2 - Mild Disturbance		0.90 (0.57-1.40)
3 - Severe Disturbance		1.12 (0.71-1.74)
4 - Life Threat		1.38 (0.86-2.17)
5 - Moribund		2.78 (0.83-12.86)
None Assigned		0.72 (0.13-4.17)
Emergent (referent = urgent)		**2.37 (2.12-2.67)**

[a] OR = odds ratio
[b] 95% CI = 95% confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black
[e] COPD = chronic obstructive pulmonary disease
[f] CHF = congestive heart failure
[g] SIRS = systemic inflammatory response syndrome
[h] ASA = American Society of Anesthesiologists

analysis revealed 11% higher odds of an open procedure (OR=1.11, 95% CI=1.00-1.25) compared to NHW patients. There was no difference in surgical approach for individuals grouped as other compared to NHW before or after adjustment. In addition to NHB race, emergent status was associated with increased odds of an open approach after adjustment. Patient characteristics associated with a significant difference in surgical approach can be found in Table 2.3. The e-values for the associations between race/ethnicity and surgical approach were 1.29 and 1.39 for NHB race and Hispanic ethnicity, respectively. The assumption of linearity was met for our continuous variable (age) and the c-statistic for the adjusted model was 0.649 (95% CI=0.635-0.659).

2.3.3 Thirty-Day Morbidity

Over one-third of patients had the composite 30-day morbidity outcome. Individuals identifying as NHB had the highest complication rate (n=729/1828, 40%), followed by other (n=293/755, 39%), NHW (n=3287/8900, 37%), and Hispanic (n=376/1089, 35%) individuals. In the unadjusted model, these morbidity rates corresponded to 13% increased odds of sustaining any complication among individuals with NHB race (OR=1.13, 95% CI=1.02-1.26) compared to NHW (Table 2.4); however, this association became non-significant after adjusting for patient factors. Additionally, there was no difference in the odds of a 30-day morbidity between Hispanic ethnicity or other race compared to NHW. After adjustment, numerous covariates were associated with higher odds of any complication within 30 days of surgery, but the strongest predictors were the presence of sepsis or septic shock. The only covariate associated with a lower complication rate was an ASA class of 2. The interactions between

Table 2.4 Logistic Regression for Race/Ethnicity and 30-Day Morbidity		
	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)
Race/Ethnicity (referent = NHW[c])		
Hispanic	0.90 (0.79-1.03)	0.88 (0.68-1.12)
NHB[d]	**1.13 (1.02-1.26)**	1.07 (0.87-1.31)
Other	1.08 (0.93-1.26)	1.04 (0.77-1.39)
Age		**1.01 (1.00-1.01)**
Male		1.07 (0.99-1.16)
Comorbidities		
Obesity		**1.14 (1.04-1.25)**
Diabetes		**1.19 (1.07-1.32)**
Current Smoker		0.98 (0.88-1.09)
Dyspnea		**1.23 (1.08-1.40)**
Ventilator-Dependence		1.64 (0.76-3.71)
Severe COPD[e]		**1.18 (1.00-1.38)**
Ascites		**1.51 (1.15-1.99)**
CHF[f]		**1.29 (1.04-1.61)**
Hypertension		1.05 (0.96-1.15)
Acute Renal Failure		1.75 (0.99-3.18)
Dialysis-Dependence		**1.63 (1.16-2.30)**
Open Wound		1.16 (0.90-1.49)
Steroid Use		**1.24 (1.00-1.53)**
>10% Weight Loss		**1.22 (1.09-1.37)**
Bleeding Disorder		**1.34 (1.17-1.54)**
Preoperative Transfusion		**1.55 (1.38-1.75)**
Disseminated Cancer		**1.14 (1.03-1.25)**
Preoperative Sepsis (referent = none)		
SIRS[g]		**1.41 (1.25-1.60)**
Sepsis		**4.63 (3.84-5.61)**
Septic Shock		**14.76 (6.83-38.64)**
Functional Status (referent = independent)		
Partially Dependent		**1.34 (1.14-1.58)**
Totally Dependent		1.33 (0.91-1.94)
Unknown		**1.55 (0.82-2.92)**
ASA[h] Classification (referent = ASA class 1)		
2 - Mild Disturbance		**0.59 (0.38-0.94)**
3 - Severe Disturbance		0.85 (0.55-1.35)
4 - Life Threat		1.09 (0.69-1.75)
5 - Moribund		0.89 (0.33-2.51)
None Assigned		0.22 (0.01-1.52)
Emergent (referent = urgent)		1.08 (0.97-1.19)
Open Approach		**1.90 (1.72-2.11)**

[a] OR = odds ratio
[b] 95% CI = 95% confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black
[e] COPD = chronic obstructive pulmonary disease
[f] CHF = congestive heart failure
[g] SIRS = systemic inflammatory response syndrome
[h] ASA = American Society of Anesthesiologists

race/ethnicity and surgical approach were not significant. The linearity assumption was met for age and the c-statistic for the adjusted model was 0.686 (95% CI=0.679-0.702).

2.3.4 In-Hospital and 30-Day Mortality

The in-hospital and 30-day mortality rates were approximately 3% and 5%, respectively. Both in-hospital and 30-day mortality were the lowest among Hispanic individuals, followed by NHB, while in-hospital and 30-day mortality were highest among individuals classified as other and NHW, respectively (Table 2.5). In the unadjusted analysis, Hispanic ethnicity was associated with 45% lower odds of in-hospital mortality (OR=0.55, 95% CI=0.33-0.85) and 50% lower odds of 30-day mortality (OR=0.53, 95% CI=0.36-0.75) compared to NHW race, while those identifying as NHB had 27% lower odds of 30-day mortality (OR=0.73, 95% CI=0.56-0.93) (Table 2.5). After adjustment for patient and perioperative factors, however, these relationships were no longer significant. An open surgical approach and several patient characteristics were also associated with increased odds of both in-hospital and 30-day mortality after adjustment. The interactions between race/ethnicity and surgical approach were not significant. For the adjusted models, the c-statistics for in-hospital and 30-day mortality were 0.818 (95% CI=0.791-0.835) and 0.796 (95% CI=0.779-0.814), respectively.

2.3.5 Thirty-Day Reoperation

A total of 733 patients (5.8%) required at least one reoperation within 30-days of surgery. Of these, 639 (87.2%) returned to the operating room once, 71 (9.7%) twice, and 23 (3.1%) three times. This included 7% of individuals identifying as NHB

(n=134/1828), 6% of NHW (n=540/8900), and 5% each of Hispanic (n=58/1089) and other (n=41/755). On unadjusted analysis, NHB race was associated with 22% higher odds of reoperation (OR=1.22, 95% CI=1.00-1.49) compared to NHW race, but this association was no longer significant after adjustment (Table 2.5). There was no

Table 2.5 Logistic Regression for Race/Ethnicity and In-Hospital Mortality, 30-Day Mortality, 30-Day Reoperation, and 30-Day Readmission

	N (%)	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)
In-Hospital Mortality			
NHW[c]	280 (3.1)	1.00 (referent)	1.00 (referent)
Hispanic	19 (1.7)	**0.55 (0.33-0.85)**	1.08 (0.32-2.72)
NHB[d]	44 (2.4)	0.76 (0.54-1.04)	1.21 (0.54-2.43)
Other	24 (3.2)	1.01 (0.64-1.51)	1.03 (0.25-2.89)
30-Day Mortality			
NHW	493 (5.5)	1.00 (referent)	1.00 (referent)
Hispanic	32 (2.8)	**0.53 (0.36-0.75)**	0.68 (0.26-1.46)
NHB	74 (4.0)	**0.73 (0.56-0.93)**	1.07 (0.61-1.78)
Other	33 (4.4)	0.89 (0.61-1.27)	0.84 (0.29-1.96)
30-Day Reoperation			
NHW	540 (6.1)	1.00 (referent)	1.00 (referent)
Hispanic	58 (5.3)	0.87 (0.65-1.14)	0.74 (0.41-1.24)
NHB	134 (7.3)	**1.22 (1.00-1.49)**	1.38 (0.94-1.97)
Other	41 (5.4)	0.89 (0.63-1.22)	1.00 (0.52-1.76)
30-Day Readmission			
NHW	1125 (13.1)	1.00 (referent)	1.00 (referent)
Hispanic	146 (13.6)	1.11 (0.92-1.35)	0.95 (0.67-1.34)
NHB	229 (12.8)	0.99 (0.85-1.16)	0.99 (0.74-1.30)
Other	77 (10.5)	0.90 (0.70-1.15)	0.96 (0.60-1.47)

[a] OR = odds ratio
[b] 95% CI = 95% confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black

association between Hispanic ethnicity or other race and the odds of reoperation either before or after adjustment. Covariates associated with the need for reoperation included male sex, COPD, preoperative SIRS, and an open surgical approach. The interactions between race/ethnicity and surgical approach were not significant. The c-statistic was 0.619 (95% CI=0.609-0.654) for the adjusted model.

2.3.6 Thirty-Day Readmission

Among the 12,205 patients who survived their initial hospitalization, time from admission to discharge was missing for 66 patients. For each of these patients, days from operation to discharge, operation to death, and total hospital length of stay were all missing. For the remaining individuals, median hospital LOS was 10-days (iqr=7-14); however, NHB individuals were hospitalized for a median of 2 days longer (iqr=7-16) than those identifying as NHW, Hispanic, or other. Overall, 13% of patients who survived their initial hospital course were readmitted to the hospital within 30-days of surgery. The readmission rate was slightly lower for individuals classified as other (n=77/731, 10.5%) compared to NHW (n=1125/8620, 13.1%), NHB (n=229/1784, 12.8%), or Hispanic (n=146/1070, 13.6%) individuals; however, there was no significant difference in the unadjusted or adjusted odds of readmission between racial and ethnic groups (Table 2.5). The covariates associated with increased odds of readmission after adjustment were diabetes, chronic steroid use, bleeding disorder, disseminated cancer, partially dependent functional status, and an ASA class of 4 or 5. The interactions between race/ethnicity and surgical approach were not significant. For the adjusted model, the c-statistic was 0.592 (95% CI=0.582-0.629).

2.3.7 Sensitivity Analysis of Individuals with Missing Race and Ethnicity

Among individuals meeting initial inclusion criteria, a total of 2297 (15.4%) had no documented race or ethnicity. These individuals had higher ASA classifications and were more likely to present emergently (n=1221, 53.2%) than patients identifying as NHW, NHB, Hispanic, or other. Additionally, they had 30% lower odds of undergoing

an open surgery, but 35% higher odds of a 30-day morbidity compared to NHW individuals after adjustment (Table 4.3, Appendix). The inclusion of this group as NHW increased the likelihood of an open procedure among NHB individuals from 11% (OR=1.11, 95% CI=1.00-1.25) to 17% (OR=1.17, 95% CI=1.05-1.31), while the odds of a morbidity, mortality, readmission, or reoperation remained non-significant after adjustment. When the individuals missing race/ethnicity were included as NHB, on the other hand, the associations for surgical approach and 30-day morbidity changed direction: NHB individuals were 10% less likely to have an open surgery (OR=0.90, 95% CI=0.82-0.98) and 21% more likely to sustain a complication (OR=1.21, 95% CI=1.04-1.41).

2.3.8 Sensitivity Analysis of Results Stratified by the Urgency of the Operation

Patients in our sample underwent 10,062 urgent (80.0%) and 2510 (20.0%) emergent colorectal resections for cancer. Among patients undergoing an urgent procedure, other race and Hispanic ethnicity were associated with 17% (adjusted OR=0.83, 95% CI=0.69-1.00) and 14% (adjusted OR=0.86, 95% CI=0.74-1.00) lower odds of an open approach compared to NHW race but were similar for NHB race after adjustment (Table 4.4, Appendix). In terms of postoperative outcomes, NHB individuals had 56% higher odds of a reoperation within 30-days of surgery (OR=1.56, 95% CI=1.05-2.27), but the remaining outcomes were not significantly different for any group after adjustment. Among emergent cases, there were no significant differences in surgical approach or postoperative outcomes between racial and ethnic groups.

2.3.9 Sensitivity Analysis of Results Stratified by the Presence of Localized or Disseminated Cancer

Nearly 80% of individuals in our sample had localized CRC (n=9821), while the remaining patients had disseminated disease (n=2751). Among individuals with localized disease, Hispanic ethnicity and other race were associated with 20% (OR=0.80, 95% CI=0.69-0.94) and 16% (OR=0.84, 95% CI=0.70-1.00) lower odds, respectively, of an open approach compared to NHW patients, but there were no differences in postoperative outcomes between racial and ethnic groups (Table 4.5, Appendix). Among individuals with disseminated disease, there were no significant differences in surgical approach or 30-day postoperative outcomes.

2.3.10 Sensitivity Analysis Accounting for the Competing Risk of Death in the 30-Day Morbidity Outcome

In total, 4817 patients suffered a morbidity, a mortality, or both within 30 days of surgery. There were only 132 mortalities (1.0%) that did not also sustain a complication within 30 days of surgery. Prior to adjustment, Hispanic ethnicity was associated with 13% lower odds of a 30-day morbidity (OR=0.87, 95% CI=0.77-1.00) compared to NHW race, but this association was no longer significant after adjustment (Table 4.6). There was no significant difference in the odds of a complication for NHB or other race.

2.4 Discussion

In this large, observation study of 12,572 patients with CRC who underwent a non-elective colorectal resection, we found that Hispanic ethnicity and NHB race were

associated with decreased and increased odds, respectively, of an open surgical approach compared to NHW race; however, these racial and ethnic differences did not lead to differences in postoperative outcomes after adjusting for patient and clinical factors. The identification of factors contributing to these racial and ethnic differences in surgical approach could help reduce or eliminate disparities in care in the urgent and emergent settings.

From the mid- to late-2000s, numerous studies established the benefits of a laparoscopic, rather than an open, approach in the surgical management of CRC.[17–22] For this reason, laparoscopy is recommended when possible and has become increasingly accepted over the last two decades.[24,25] More recently, evidence has emerged that a robotic approach can achieve similar outcomes to laparoscopy, but this approach remains confined to the elective setting.[23] To date, no other studies to our knowledge have documented racial or ethnic differences in surgical approach for these patients.[26–28] For instance, a study of 100,515 combined elective and non-elective hospitalizations for a primary diagnosis of CRC in the National Inpatient Sample between 2009-2015 found no difference in surgical approach based on race and ethnicity.[28] Our results, however, demonstrated that in the non-elective setting, NHB individuals were more likely than NHW patients to undergo an open surgery, even after adjusting for patient characteristics and clinical factors, while Hispanic individuals were more likely to have a laparoscopic procedure. These findings are notable because they contradict prior studies showing no racial or ethnic difference in surgical approach and they show that minorities groups with similar sociodemographic characteristics may undergo different treatment courses.

There are a number of possible explanations for the discrepancy between our results and those of prior studies. Firstly, we limited our study to patients undergoing non-elective procedures, while prior studies included more heterogeneous populations of individuals being treated on elective, urgent, and emergent bases. In these studies, the majority of procedures were elective, so our analysis may have unmasked a difference in surgical approach among non-elective cases. Secondly, a number of variables that were included in prior studies and could have affected surgical approach, including tumor stage, SES, insurance, residential region, and hospital characteristics, were not available in the NSQIP database. The inability to account for these variables and to cluster at the hospital level may have been influenced our results away from the null and likely contributed to the low to moderate discrimination of our model. Racial differences in these variables likely represent the downstream effects of structural racism, which would suggest that racism plays a role in surgical approach. Thirdly, prior studies have shown that NHB and Hispanic individuals with CRC are more likely to undergo nonoperative management than NHW patients.[26] Since the NSQIP database only includes patients who underwent a surgical procedure, our results may have biased by the exclusion of individuals unfit for surgery. Additionally, we did not account for any changes in surgical approach by race and ethnicity over time. The use of laparoscopy increased over the study time period, but this increase may not have been equally distributed across all racial and ethnic groups. Lastly, we were unable to evaluate for implicit bias among physicians, which may influence treatment decisions and outcomes.[44]

The difference in surgical approach that we noted between NHB and Hispanic individuals compared to NHW patients is interesting for several reasons. Although it

parallels the higher incidence of CRC among NHB individuals and the lower incidence among Hispanic patients relative to NHW individuals seen in prior studies,[2] it is surprising in light of the sociodemographic similarities between individuals of NHB race and Hispanic ethnicity.[45,46] Additionally, adherence to CRC screening guidelines is lower among Hispanic individuals than NHW and NHB patients.[2] Since screening for CRC can result in the removal of precancerous polyps and the early detection of cancerous lesions, the low screening rate among Hispanic individuals might suggest more presentations with late-stage disease, requiring an open approach. This was not the case in our study, potentially as a result of the selecting out of Hispanic individuals who presented with terminal disease and thus, were not surgical candidates. Other factors, such as genetic diversity among Hispanic individuals,[47,48] as well as differences in healthcare utilization,[49] CRC risk factors,[50] and structural racism targeted at NHB individuals, may also play a role.

Results from both our study and prior studies have shown that an open surgical approach is associated with higher morbidity and mortality rates among patients with CRC undergoing elective or non-elective resections.[26,28] Prior studies also showed 7-23% increased odds of a postoperative complication among NHB individuals undergoing colorectal resections for cancer compared to NHW patients.[26,28] These results were consistent, even after adjustment for patient characteristics, surgical approach, and hospital characteristics. In our study, on the other hand, NHB race was associated with higher 30-day morbidity before adjustment, but this was not significant after adjusting for patient characteristics, clinical factors, and surgical approach. The attenuation of this association suggests that poor access to medical care and worse overall health, which

may be due to structural racism, could contribute to worse postoperative outcomes among NHB individuals. Additionally, surgical approach did not modify the relationship between race/ethnicity and postoperative outcomes. This implies that, among individuals undergoing non-elective colorectal resections for cancer, the use of an open approach may help explain the higher burden of postoperative morbidities associated with NHB race. Better understanding the reasons behind the predilection for an open approach could help determine if this represents a disparity in care.

One possible explanation for the difference in postoperative outcomes between our results and prior studies relates to individuals in the database with missing racial and ethnic data. On sensitivity analysis, these individuals had considerably higher ASA scores and more emergent presentations than those with a documented race or ethnicity, suggesting that there are important differences between the groups. Prior studies have corroborated this finding. For instance, Sholle et al. noted that black and Hispanic individuals with no documented race/ethnicity differed significantly from those who were identified as black or Hispanic in the electronic medical record.[42] These patients were older, more likely to be male and to have non-private insurance, and had more medical comorbidities. If patients with and without documented racial and ethnic data in the NSQIP differ in similar ways, this would lend credence to the hypothesis that racial and ethnic information is missing from the database not at random. We attempted to account for this unique subset of individuals by including them as a fifth racial/ethnic group or as all NHW or all NHB with mixed results, suggesting that this may constitute a relatively heterogeneous population. A more effective method to account for these individuals would have been multiple imputation. For instance, prior studies have imputed missing

race and ethnicity using various combinations of surname, zip code, family race, SES, and insurance type.[51,52] Given that sociodemographic characteristics, such as insurance type, have been associated with missing race and ethnicity in prior studies[42] and the NSQIP provides very limited sociodemographic information, the use of multiple imputation would likely have been ineffective in our study.

Our study had a number of strengths, including the use of a large database that is dedicated to surgical outcomes research, has strict oversight and auditing processes resulting in accurate data, and is diligent about collecting all postoperative outcomes within the 30-day follow-up period. Despite these strengths, our study has several limitations. Firstly, we were restricted to variables collected by the NSQIP and thus, we were unable to incorporate a number of sociodemographic, hospital, geographic, and disease characteristics into our analysis. Many of these variables are often included in studies of racial and ethnic differences in health outcomes. Given the modest e-values for the associations between NHB race and Hispanic ethnicity with surgical approach, it would not be surprising if these unmeasured variables were able to negate the significance of these racial and ethnic differences in approach.[38,39] The inability to account for these variables may help explain the low to moderate discrimination of our models. Additionally, we were unable to cluster patients at the hospital- or regional-level, which has been shown to impact surgical approach and postoperative outcomes in prior studies.[26,27] Secondly, the NSQIP only includes patients who underwent a major surgical procedure and not those who were admitted but did not have an operation. This introduces the possibility of selection bias. Since Hispanic and NHB individuals are more likely to be treated non-operatively,[26] it is possible that Hispanic patients who were

not candidates for laparoscopy and NHB patients at high risk for poor postoperative outcomes may have been selected out. This could have artificially decreased the odds of an open approach among Hispanic individuals and the odds of a postoperative complication among NHB patients. Thirdly, participation in the NSQIP is voluntary and fee-based; as a result, smaller institutions and those without a dedicated quality improvement department may not participate. Studies have shown that these hospitals are comparable to participating institutions in most ways, but there is still a possibility that our results may not be generalizable to non-participant institutions.[53] Finally, our results may have been biased by the patients with missing race and ethnicity and by individuals in the database with racial or ethnic misclassification.

2.4.1 Conclusions

In our study, the odds of undergoing an open, non-elective colorectal resection for cancer were increased among NHB individuals but decreased among Hispanic patients. Although we adjusted for a number of patient characteristics and clinical factors, this finding implies that there may be unidentified factors contributing to the differential surgical management of patients with CRC based on race and ethnicity. Additionally, our results suggest that structural racism, leading to poor access to high-quality medical care and a higher burden of comorbid medical conditions, may have influenced surgical approach, leading to worse postoperative outcomes among NHB individuals. Future studies should seek to identify these factors in order to reduce or eliminate racial and ethnic differences in the surgical management and postoperative outcomes of CRC in the non-elective setting.

All of the data and tables presented herein are based on the author's own experimental analysis and results.

Chapter 3: Discussion

A growing body of literature has documented racial and ethnic differences in health outcomes in the United States. Within surgery, studies on CRC have shown that black individuals have higher incidence and mortality rates than white patients,[2,3] and are less likely to be managed surgically.[26] In addition, black patients who undergo surgery tend to have more complications than their white counterparts. As we strive to improve health care quality and delivery, it is important to interpret these findings within a theoretical framework.

One such framework has been proposed by Rathore and Krumholz.[16] They suggest that racial and ethnic differences should be assessed based on clinical need rather than health care utilization rates, in order to allow for the incorporation of both patient preference and opportunity to receive appropriate treatment. Using this framework, they differentiate between racial and ethnic differences, disparities, and biases. They define a difference as any observed variation in health care based on race or ethnicity, while a disparity reflects a shortfall in appropriate care that is associated with comparatively poor outcomes and cannot be explained by patient factors. These disparities can be described as a bias if they do not result from barriers to care, low-quality providers, or other health system factors. Using this framework, the purpose of our study was to identify racial and ethnic differences in the surgical care and postoperative outcomes of patients with CRC undergoing non-elective procedures, and to characterize those variations as differences, disparities, or biases.

3.1 Surgical Approach and Postoperative Outcomes

In this large, observation study of 12,572 patients with CRC who underwent a non-elective colorectal resection, we found that Hispanic ethnicity and NHB race were associated with decreased and increased odds, respectively, of an open surgical approach compared to NHW race; however, these racial and ethnic differences did not lead to differences in postoperative outcomes after adjusting for patient and clinical factors. The identification of factors contributing to these racial and ethnic differences in surgical approach could improve the quality of care for patients of all racial and ethnic backgrounds in the urgent and emergent settings.

From the mid- to late-2000s, numerous have established the benefits of a laparoscopic, rather than an open, approach in the surgical management of CRC.[17–23] For this reason, laparoscopy is recommended when possible and has become increasingly accepted over the last two decades.[24,25] More recently, evidence has emerged that a robotic approach can achieve similar outcomes to laparoscopy, but this approach remains confined to the elective setting.[23] To date, no other studies to our knowledge have documented racial or ethnic differences in surgical approach for these patients.[26–28] For instance, a study of 100,515 combined elective and non-elective hospitalizations for a primary diagnosis of CRC in the National Inpatient Sample between 2009-2015 found no difference in surgical approach based on race and ethnicity.[28] Our results, however, demonstrated that in the non-elective setting, NHB individuals were more likely than NHW patients to undergo an open surgery, even after adjusting for patient characteristics and clinical factors, while Hispanic individuals were more likely to have a laparoscopic procedure. These findings are notable because they contradict prior studies showing no

racial or ethnic difference in surgical approach and they show that minorities groups with similar sociodemographic characteristics may undergo different treatment courses.

There are a number of possible explanations for the discrepancy between our results and those of prior studies. Firstly, we limited our study to patients undergoing non-elective procedures, while prior studies included more heterogeneous populations of individuals being treated on elective, urgent, and emergent bases. In these studies, the majority of procedures were elective, so our analysis may have unmasked a difference in surgical approach among non-elective cases. Secondly, a number of variables that were included in prior studies and could have affected surgical approach, including tumor stage, SES, insurance, residential region, and hospital characteristics, were not available in the NSQIP database. The inability to account for these variables and to cluster at the hospital level may have been influenced our results away from the null and likely contributed to the low to moderate discrimination of our model. Racial differences in these variables likely represent the downstream effects of structural racism, which would suggest that racism plays a role in surgical approach. Thirdly, prior studies have shown that NHB and Hispanic individuals with CRC are more likely to undergo nonoperative management than NHW patients.[26] Since the NSQIP database only includes patients who underwent a surgical procedure, our results may have biased by the exclusion of individuals unfit for surgery. Additionally, we did not account for any changes in surgical approach by race and ethnicity over time. The use of laparoscopy increased over the study time period, but this increase may not have been equally distributed across all racial and ethnic groups. Lastly, we were unable to evaluate for implicit bias among physicians, which may influence treatment decisions and outcomes.[44]

The difference in surgical approach that we noted between NHB and Hispanic individuals compared to NHW patients is interesting for several reasons. Although it parallels the higher incidence of CRC among NHB individuals and the lower incidence among Hispanic patients relative to NHW individuals seen in prior studies,[2] it is surprising in light of the sociodemographic similarities between individuals of NHB race and Hispanic ethnicity.[45,46] Additionally, adherence to CRC screening guidelines is lower among Hispanic individuals than NHW and NHB patients.[2] Since screening for CRC can result in the removal of precancerous polyps and the early detection of cancerous lesions, the low screening rate among Hispanic individuals might suggest more presentations with late-stage disease, requiring an open approach. This was not the case in our study, potentially as a result of the selecting out of Hispanic individuals who presented with terminal disease and thus, were not surgical candidates. Other factors, such as genetic diversity among Hispanic individuals,[47,48] as well as differences in healthcare utilization,[49] CRC risk factors,[50] and structural racism targeted at NHB individuals, may also play a role.

Results from both our study and prior studies have shown that an open surgical approach is associated with higher morbidity and mortality rates among patients with CRC undergoing elective or non-elective resections.[26,28] However, prior studies also showed 7-23% increased odds of a postoperative complication among NHB individuals undergoing colorectal resections for cancer compared to NHW patients.[26,28] These results were consistent, even after adjustment for patient characteristics, surgical approach, and hospital characteristics. In our study, on the other hand, NHB race was associated with higher 30-day morbidity before adjustment, but this was not significant after adjusting for

patient characteristics, clinical factors, and surgical approach. The attenuation of this association suggests that poor access to medical care and worse overall health, which may be due to structural racism, could contribute to worse postoperative outcomes among NHB individuals. Additionally, surgical approach did not modify the relationship between race/ethnicity and postoperative outcomes. This implies that, among individuals undergoing non-elective colorectal resections for cancer, the use of an open approach may help explain the higher burden of postoperative morbidities associated with NHB race. Better understanding the reasons behind the predilection for an open approach could help determine if this represents a disparity in care.

One possible explanation for the difference in postoperative outcomes between our results and prior studies relates to individuals in the database with missing racial and ethnic data. On sensitivity analysis, these individuals had considerably higher ASA scores and more emergent presentations than those with a documented race or ethnicity, suggesting that there are important differences between the groups. Prior studies have corroborated this finding. For instance, Sholle et al. noted that black and Hispanic individuals with no documented race/ethnicity differed significantly from those who were identified as black or Hispanic in the electronic medical record.[42] These patients were older, more likely to be male and to have non-private insurance, and had more medical comorbidities. If patients with and without documented racial and ethnic data in the NSQIP differ in similar ways, this would lend credence to the hypothesis that racial and ethnic information is missing from the database not at random. We attempted to account for this unique subset of individuals by including them as a fifth racial/ethnic group or as all NHW or all NHB with mixed results, suggesting that this may constitute a relatively

heterogeneous population. A more effective method to account for these individuals would have been multiple imputation. For instance, prior studies have imputed missing race and ethnicity using various combinations of surname, zip code, family race, SES, and insurance type.[51,52] Given that sociodemographic characteristics, such as insurance type, have been associated with missing race and ethnicity in prior studies[42] and the NSQIP provides very limited sociodemographic information, the use of multiple imputation would likely have been ineffective in our study.

3.2 Self-Reported Race/Ethnicity as an Explanatory Variable

In light of the significant proportion of patients in the NSQIP database with no documented race or ethnicity, it is important to consider the reliability of this variable and its import for scientific research. Originally, the inclusion of race/ethnicity in research arose from the idea that these categories might reflect underlying population genetics and thus, could be clinically useful; however, a growing body of evidence has shown that race does not reliably correspond to genetic differences. Rather, current researchers view race and ethnicity as social constructs that can be used to explore disparities in health care and health outcomes, as we have done in this study. Although health disparities research is critical to identifying populations at risk for poor outcomes, it is important to recognize the limitations of self-reported race and ethnicity as an explanatory variable. Specifically, there is considerable variability in the completeness of racial and ethnic data.[54] One method to account for this information is multiple imputation, but this typically requires United States Census information, including sociodemographic characteristics. Additionally, among individuals with a documented race or ethnicity,

there is a risk of misclassification, particularly among Hispanics, American Indians, and Alaska Natives.[55,56] Consequently, the results of studies using race/ethnicity as an explanatory variable should be interpreted with caution.

3.3 Strengths and Limitations

Our study had a number of strengths, including the use of a large database that is dedicated to surgical outcomes research, has strict oversight and auditing processes resulting in accurate data, and is diligent about collecting all postoperative outcomes within the 30-day follow-up period. Despite these strengths, our study has several limitations. Firstly, we were restricted to variables collected by the NSQIP and thus, we were unable to incorporate a number of sociodemographic, hospital, geographic, and disease characteristics into our analysis. Many of these variables are often included in studies of racial and ethnic differences in health outcomes. Given the modest e-values for the associations between NHB race and Hispanic ethnicity with surgical approach, it would not be surprising if these unmeasured variables were able to negate the significance of these racial and ethnic differences in approach.[38,39] The inability to account for these variables may help explain the low to moderate discrimination of our models. Additionally, we were unable to cluster patients at the hospital- or regional-level, which has been shown to impact surgical approach and postoperative outcomes in prior studies.[26,27] Secondly, the NSQIP only includes patients who underwent a major surgical procedure and not those who were admitted but did not have an operation. This introduces the possibility of selection bias. Since Hispanic and NHB individuals are more likely to be treated non-operatively,[26] it is possible that Hispanic patients who were not candidates for laparoscopy and NHB patients at high risk for poor postoperative

outcomes may have been selected out. This could have artificially decreased the odds of an open approach among Hispanic individuals and the odds of a postoperative complication among NHB patients. Thirdly, participation in the NSQIP is voluntary and fee-based; as a result, smaller institutions and those without a dedicated quality improvement department may not participate. Studies have shown that these hospitals are comparable to participating institutions in most ways, but there is still a possibility that our results may not be generalizable to non-participant institutions.[53] Finally, mortality may have been a competing risk in our analysis of 30-day postoperative morbidity; however, our results did not change significantly when we studied the composite 30-day morbidity and 30-day mortality outcome, suggesting that the effect of death as a competing risk was limited.

3.4 Conclusions

In our study, the odds of undergoing an open, non-elective colorectal resection for cancer were increased among NHB individuals but decreased among Hispanic patients. Although we adjusted for a number of patient characteristics and clinical factors, this finding implies that there may be unidentified factors contributing to the differential surgical management of patients with CRC based on race and ethnicity. Additionally, our results suggest that structural racism, leading to poor access to high-quality medical care and a higher burden of comorbid medical conditions, may have influenced surgical approach, leading to worse postoperative outcomes among NHB individuals. Future studies should seek to identify these factors in order to reduce or eliminate racial and

ethnic differences in the surgical management and postoperative outcomes of CRC in the non-elective setting.

Chapter 4: Appendix

Table 4.1 ICD-10 Codes for Colorectal Cancer	
C18.0	Malignant neoplasm of cecum
C18.2	Malignant neoplasm of ascending colon
C18.3	Malignant neoplasm of hepatic flexure
C18.4	Malignant neoplasm of transverse colon
C18.5	Malignant neoplasm of splenic flexure
C18.6	Malignant neoplasm of descending colon
C18.7	Malignant neoplasm of sigmoid colon
C18.8	Malignant neoplasm of overlapping sites of colon
C18.9	Malignant neoplasm of colon, unspecified
C19	Malignant neoplasm of rectosigmoid junction
C20	Malignant neoplasm of rectum
C21.8	Malignant neoplasm of overlapping sites of rectum, rectosigmoid junction, anus and anal canal

Table 4.2 CPT Codes for Colorectal Surgery	
Open Procedures	
44140	Colectomy, partial; with anastomosis
44141	Colectomy, partial; with skin level cecostomy or colostomy
44143	Colectomy, partial; with end colostomy and closure of distal segment (Hartmann type procedure)
44144	Colectomy, partial; with resection, with colostomy or ileostomy and creation of mucous fistula
44145	Colectomy, partial; with coloproctostomy (low pelvic anastomosis)
44146	Colectomy, partial; with coloproctostomy (low pelvic anastomosis), with colostomy
44147	Colectomy, partial; abdominal and transanal approach
44150	Colectomy, total, abdominal, without proctectomy; with ileostomy or ileoproctostomy
44151	Colectomy, total, abdominal, without proctectomy; with continent ileostomy
44155	Colectomy, total, abdominal, with proctectomy; with ileostomy
44156	Colectomy, total, abdominal, with proctectomy; with continent ileostomy
44157	Colectomy, total, abdominal, with proctectomy; with ileoanal anastomosis, includes loop ileostomy, and rectal mucosectomy, when performed
44160	Colectomy, partial, with removal of terminal ileum with ileocolostomy
44320	Colostomy or skin level cecostomy
50810	Ureterosigmoidostomy, with creation of sigmoid bladder and establishment of abdominal or perineal colostomy, including intestine s
57307	Closure of rectovaginal fistula; abdominal approach, with concomitant colostomy
45110	Proctectomy; complete, combined abdominoperineal, with colostomy
45111	Proctectomy; partial resection of rectum, transabdominal approach
45112	Proctectomy, combined abdominoperineal, pull-through procedure (eg, colo-anal anastomosis)
45113	Proctectomy, partial, with rectal mucosectomy, ileoanal anastomosis, creation of ileal reservoir (S or J), with or without loop ileostomy
45114	Proctectomy, partial, with anastomosis; abdominal and transsacral approach
45116	Proctectomy, partial, with anastomosis; transsacral approach only (Kraske type)
45119	Proctectomy, combined abdominoperineal pull-through procedure (eg, colo-anal anastomosis), with creation of colonic reservoir (eg, J-pouch), with diverting enterostomy when performed
45120	Proctectomy, complete (for congenital megacolon), abdominal and perineal approach; with pull-through procedure and anastomosis (eg, Swenson, Duhamel, or Soave type operation)
45121	Proctectomy, complete (for congenital megacolon), abdominal and perineal approach; with subtotal or total colectomy, with multiple biopsies
45123	Proctectomy, partial, without anastomosis, perineal approach
45126	Pelvic exenteration for colorectal malignancy, with proctectomy (with or without colostomy), with removal of bladder and ureteral transplantations, and/or hysterectomy, or cervicectomy, with or without removal of tube(s), with or without removal of ovary(s), or any combination thereof
45136	Excision of ileoanal reservoir with ileostomy
45150	Division of stricture of rectum
45160	Excision of rectal tumor by proctotomy, transsacral or transcoccygeal approach
45171	Excision of rectal tumor, transanal approach; not including muscularis propria (ie, partial thickness)

45172	Excision of rectal tumor, transanal approach; including muscularis propria (ie, full thickness)
45190	Destruction of rectal tumor (eg, electrodesiccation, electrosurgery, laser ablation, laser resection, cryosurgery) transanal approach
Laparoscopic Procedures	
44204	Laparoscopy, surgical; colectomy, partial, with anastomosis
44205	Laparoscopy, surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy
44206	Laparoscopy, surgical; colectomy, partial, with end colostomy and closure of distal segment (Hartmann type procedure)
44207	Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis)
44208	Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis) with colostomy
44210	Laparoscopy, surgical; colectomy, total, abdominal, without proctectomy, with ileostomy or ileoproctostomy
44211	Laparoscopy, surgical; colectomy, total, abdominal, with proctectomy, with ileoanal anastomosis, creation of ileal reservoir (S or J), with loop ileostomy, includes rectal mucosectomy, when performed
44212	Laparoscopy, surgical; colectomy, total, abdominal, with proctectomy, with ileostomy
44213	Laparoscopy, surgical, mobilization (take-down) of splenic flexure performed in conjunction with partial colectomy (List separately in addition to primary procedure)
44188	Laparoscopy, surgical, colostomy or skin level cecostomy
44206	Laparoscopy, surgical; colectomy, partial, with end colostomy and closure of distal segment (Hartmann type procedure)
44208	Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis) with colostomy
45395	Laparoscopy, surgical; proctectomy, complete, combined abdominoperineal, with colostomy
45397	Laparoscopy, surgical; proctectomy, combined abdominoperineal pull-through procedure (eg, colo-anal anastomosis), with creation of colonic reservoir (eg, J-pouch), with diverting enterostomy, when performed

Table 4.3 Sensitivity Analysis of Individuals with Missing Race and Ethnicity						
	Missing Race/Ethnicity as a Fifth Category		Missing Race/Ethnicity as NHW		Missing Race/Ethnicity as NHB	
	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Open Surgical Approach (NHW[c] = referent)						
Hispanic	**0.84 (0.74-0.95)**	**0.85 (0.74-0.98)**	**0.85 (0.75-0.96)**	0.90 (0.79-1.03)	**0.84 (0.74-0.95)**	**0.85 (0.74-0.97)**
NHB[d]	1.10 (0.99-1.23)	1.11 (0.99-1.25)	**1.12 (1.01-1.24)**	**1.17 (1.05-1.31)**	1.01 (0.93-1.09)	**0.90 (0.82-0.98)**
Other	0.95 (0.81-1.10)	0.89 (0.76-1.05)	0.96 (0.82-1.12)	0.95 (0.81-1.12)	0.95 (0.81-1.10)	0.90 (0.76-1.06)
Missing	0.94 (0.85-1.03)	**0.70 (0.63-0.79)**	-	-	-	-
30-Day Morbidity (NHW = referent)						
Hispanic	0.90 (0.79-1.03)	0.88 (0.68-1.13)	**0.87 (0.77-1.00)**	0.83 (0.65-1.07)	0.90 (0.79-1.03)	0.88 (0.68-1.13)
NHB	**1.13 (1.02-1.26)**	1.08 (0.88-1.31)	1.10 (0.99-1.22)	1.02 (0.84-1.24)	**1.14 (1.06-1.23)**	**1.21 (1.04-1.41)**
Other	1.08 (0.93-1.26)	1.05 (0.78-1.41)	1.05 (0.90-1.22)	1.00 (0.74-1.33)	1.08 (0.93-1.26)	1.05 (0.78-1.41)
Missing	**1.15 (1.05-1.26)**	**1.35 (1.11-1.63)**	-	-	-	-
In-Hospital Mortality (NHW = referent)						
Hispanic	**0.55 (0.33-0.85)**	1.09 (0.32-2.74)	**0.49 (0.30-0.76)**	1.02 (0.30-2.53)	**0.55 (0.33-0.85)**	1.09 (0.32-2.75)
NHB	0.76 (0.54-1.04)	1.23 (0.55-2.46	**0.68 (0.49-0.93)**	1.16 (0.52-2.27)	1.19 (0.98-1.46)	1.32 (0.77-2.19)
Other	1.01 (0.64-1.51)	1.05 (0.25-2.95)	0.91 (0.58-1.35)	0.98 (0.24-2.72)	1.01 (0.64-1.51)	1.05 (0.25-2.96)
Missing	**1.55 (1.23-1.93)**	1.39 (0.72-2.55)	-	-	-	-
30-Day Mortality (NHW = referent)						
Hispanic	**0.53 (0.36-0.75)**	0.67 (0.26-1.44)	**0.52 (0.35-0.73)**	0.67 (0.26-1.44)	**0.53 (0.36-0.75)**	0.67 (0.26-1.44)
NHB	**0.73 (0.56-0.93)**	1.07 (0.61-1.77)	**0.71 (0.55-0.91)**	1.07 (0.62-1.76)	0.95 (0.80-1.12)	1.01 (0.67-1.50)
Other	0.89 (0.61-1.27)	0.85 (0.29-1.97)	0.87 (0.60-1.23)	0.85 (0.29-1.97)	0.89 (0.61-1.27)	0.85 (0.29-1.97)
Missing	1.13 (0.93-1.38)	0.97 (0.56-1.60)	-	-	-	-
30-Day Reoperation (NHW = referent)						
Hispanic	0.87 (0.65-1.14)	0.75 (0.42-1.25)	0.87 (0.66-1.14)	0.73 (0.41-1.20)	0.87 (0.65-1.14)	0.75 (0.42-1.25)
NHB	**1.22 (1.00-1.49)**	1.38 (0.94-1.97)	**1.23 (1.01-1.48)**	1.34 (0.92-1.89)	1.09 (0.94-1.27)	1.27 (0.95-1.69)
Other	0.89 (0.63-1.22)	0.99 (0.51-1.73)	0.89 (0.63-1.22)	0.96 (0.50-1.67)	0.89 (0.63-1.22)	0.99 (0.51-1.73)
Missing	0.99 (0.81-1.20)	1.17 (0.80-1.69)	-	-	-	-

30-Day Readmission (NHW = referent)						
Hispanic	1.11 (0.92-1.35)	0.96 (0.67-1.34)	1.17 (0.96-1.41)	0.96 (0.67-1.34)	1.11 (0.92-1.35)	0.96 (0.67-1.34)
NHB	0.99 (0.85-1.16)	0.99 (0.74-1.30)	1.04 (0.89-1.21)	0.99 (0.74-1.30)	**0.86 (0.77-0.97)**	0.99 (0.79-1.23)
Other	0.90 (0.70-1.15)	0.96 (0.60-1.47)	0.95 (0.73-1.21)	0.96 (0.60-1.47)	0.90 (0.70-1.15)	0.96 (0.60-1.47)
Missing	**0.76 (0.64-0.89)**	0.99 (0.73-1.32)	-	-	-	-

[a] OR = odds ratio
[b] CI = confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black

Table 4.4 Sensitivity Analysis Results Stratified by the Urgency of the Operation				
	Urgent Procedures (n=10,062)		Emergent Procedures (n=2510)	
	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Open Surgical Approach (NHW[c] = referent)				
Hispanic	**0.84 (0.73-0.97)**	**0.86 (0.74-1.00)**	0.78 (0.56-1.11)	0.81 (0.56-1.18)
NHB[d]	**1.12 (1.00-1.26)**	1.10 (0.98-1.24)	1.16 (0.85-1.60)	1.13 (0.81-1.61)
Other	**0.80 (0.67-0.95)**	**0.83 (0.69-1.00)**	1.01 (0.72-1.45)	1.17 (0.81-1.72)
30-Day Morbidity (NHW = referent)				
Hispanic	0.92 (0.79-1.07)	0.90 (0.69-1.17)	0.83 (0.62-1.11)	0.75 (0.33-1.58)
NHB	**1.16 (1.03-1.30)**	1.05 (0.85-1.29)	1.09 (0.86-1.38)	1.28 (0.64-2.49)
Other	1.00 (0.83-1.21)	1.02 (0.73-1.40)	1.08 (0.82-1.42)	1.15 (0.52-2.40)
In-Hospital Mortality (NHW = referent)				
Hispanic	**0.55 (0.29-0.95)**	0.97 (0.23-2.75)	0.54 (0.22-1.09)	1.73 (0.08-12.70)
NHB	0.95 (0.65-1.35)	1.30 (0.55-2.69)	**0.44 (0.21-0.84)**	1.29 (0.06-9.27)
Other	1.26 (0.72-2.05)	1.23 (0.29-3.52)	0.56 (0.25-1.09)	0.00 (0.00-554.67)
30-Day Mortality (NHW = referent)				
Hispanic	**0.47 (0.28-0.73)**	0.68 (0.24-1.57)	0.68 (0.35-1.20)	0.62 (0.03-3.68)
NHB	0.85 (0.64-1.12)	1.21 (0.68-2.05)	**0.47 (0.25-0.79)**	0.33 (0.02-2.14)
Other	1.18 (0.76-1.75)	1.00 (0.34-2.35)	**0.39 (0.16-0.78)**	0.00 (0.00-0.00)
30-Day Reoperation (NHW = referent)				
Hispanic	0.99 (0.72-1.3)	0.93 (0.51-1.57)	**0.52 (0.24-0.98)**	0.00 (0.00-0.00)
NHB	**1.29 (1.03-1.60)**	**1.56 (1.05-2.27)**	1.05 (0.67-1.59)	0.45 (0.07-1.62)
Other	1.10 (0.74-1.57)	1.20 (0.60-2.18)	**0.47 (0.22-0.88)**	0.32 (0.02-1.61)
30-Day Readmission (NHW = referent)				
Hispanic	1.18 (0.96-1.46)	1.05 (0.72-1.49)	0.85 (0.52-1.33)	0.30 (0.05-1.09)
NHB	1.02 (0.86-1.21)	0.99 (0.73-1.33)	0.86 (0.58-1.24)	1.03 (0.36-2.60)
Other	0.90 (0.66-1.20)	0.90 (0.54-1.44)	0.90 (0.55-1.42)	1.25 (0.34-3.64)

[a] OR = odds ratio
[b] CI = confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black

Table 4.5 Sensitivity Analysis Results Stratified by the Presence of Localized or Disseminated Cancer				
	Localized Cancer (n=9821)		Disseminated Cancer (n=2751)	
	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Open Surgical Approach (NHW[c] = referent)				
Hispanic	**0.78 (0.68-0.91)**	**0.80 (0.69-0.94)**	1.07 (0.80-1.45)	1.07 (0.78-1.48)
NHB[d]	1.09 (0.97-1.23)	1.10 (0.97-1.25)	1.13 (0.90-1.44)	1.11 (0.87-1.43)
Other	0.92 (0.78-1.09)	0.84 (0.70-1.00)	1.14 (0.79-1.68)	1.18 (0.79-1.78)
30-Day Morbidity (NHW = referent)				
Hispanic	0.88 (0.75-1.02)	0.90 (0.68-1.18)	0.97 (0.74-1.28)	0.78 (0.39-1.45)
NHB	1.06 (0.94-1.20)	1.04 (0.83-1.31)	**1.37 (1.11-1.69)**	1.14 (0.71-1.80)
Other	0.98 (0.82-1.16)	0.98 (0.70-1.35)	**1.61 (1.15-2.25)**	1.36 (0.61-2.83)
In-Hospital Mortality (NHW = referent)				
Hispanic	**0.37 (0.17-0.68)**	1.15 (0.27-3.30)	0.96 (0.46-1.79)	1.14 (0.06-6.16)
NHB	0.85 (0.58-1.22)	1.46 (0.58-3.20)	**0.53 (0.26-0.99)**	0.71 (0.10-2.89)
Other	0.87 (0.49-1.43)	0.43 (0.02-2.08)	1.43 (0.66-2.76)	3.33 (0.47-14.31)
30-Day Mortality (NHW = referent)				
Hispanic	**0.44 (0.26-0.72)**	0.80 (0.24-2.20)	0.66 (0.36-1.10)	0.63 (0.10-2.29)
NHB	**0.70 (0.50-0.96)**	1.04 (0.49-2.02)	0.74 (0.49-1.09)	1.22 (0.50-2.72)
Other	0.90 (0.56-1.39)	0.46 (0.07-1.56)	0.91 (0.47-1.64)	2.15 (0.45-7.48)
30-Day Reoperation (NHW = referent)				
Hispanic	0.76 (0.53-1.04)	0.65 (0.31-1.19)	1.26 (0.74-2.04)	1.08 (0.36-2.67)
NHB	1.04 (0.81-1.31)	1.43 (0.92-2.15)	**1.84 (1.28-2.60)**	1.31 (0.57-2.72)
Other	0.82 (0.55-1.17)	1.12 (0.54-2.08)	1.18 (0.59-2.15)	0.72 (0.11-2.53)
30-Day Readmission (NHW = referent)				
Hispanic	1.02 (0.81-1.27)	0.90 (0.59-1.32)	1.45 (0.99-2.09)	1.32 (0.60-2.69)
NHB	0.89 (0.74-1.07)	1.02 (0.73-1.40)	1.30 (0.97-1.74)	0.84 (0.44-1.51)
Other	0.80 (0.59-1.07)	0.91 (0.54-1.46)	1.30 (0.79-2.09)	1.29 (0.40-3.47)

[a] OR = odds ratio
[b] CI = confidence interval
[c] NHW = Non-Hispanic White
[d] NHB = Non-Hispanic Black

Table 4.6 Sensitivity Analysis Accounting for the Competing Risks of 30-Day Morbidity and 30-Day Mortality			
	N (%)	Unadjusted OR[a] (95% CI[b])	Adjusted OR (95% CI)
NHW[c]	2308 (37.8)	1.00 (referent)	1.00 (referent)
Hispanic	248 (34.7)	**0.87 (0.77-1.00)**	0.86 (0.66-1.10)
NHB[d]	506 (40.5)	1.10 (0.99-1.21)	1.09 (0.89-1.32)
Other	180 (39.2)	1.06 (0.91-1.23)	1.01 (0.75-1.36)
[a] OR = odds ratio		[c] NHW = Non-Hispanic White	
[b] CI = confidence interval		[d] NHB = Non-Hispanic Black	

Chapter 5: Bibliography

1. Cancer Statistics Center: Colorectum. American Cancer Society. 2019. https://cancerstatisticscenter.cancer.org/?_ga=2.208914386.1721688692.1563471194-1341317515.1512942150#!/cancer-site/Colorectum. Accessed December 1, 2020.
2. Siegel RL, Miller KD, Fedewa SA, et al. Colorectal Cancer Statistics, 2017. *Ca Cancer J Clin*. 2017;67(3):177-193. doi:10.3322/caac.21395
3. U.S. Cancer Statistics Working Group. U.S. Cancer Statistics Data Visualizations Tool, based on 2019 submission data (1999-2017): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; www.cdc.gov/cancer/dataviz, released in June 2020. Accessed December 1, 2020.
4. Yabroff KR, Lund J, Kepka D, Mariotto A. Economic burden of cancer in the United States: Estimates, projections, and future research. *Cancer Epidemiol Biomarkers Prev*. 2011;20(10):2006-2014. doi:10.1158/1055-9965.EPI-11-0650
5. Zauber AG. The Impact of Screening on Colorectal Cancer Mortality and Incidence: Has It Really Made a Difference? *Dig Dis Sci*. 2015;60(3):681-691. doi:10.1007/s10620-015-3600-5
6. Edwards BK, Ward E, Kohler BA, et al. Annual report to the nation on the status of cancer, 1975-2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. *Cancer*. 2010;116(3):544-573. doi:10.1002/cncr.24760
7. Doubeni CA, Major JM, Laiyemo AO, et al. Contribution of behavioral risk factors and obesity to socioeconomic differences in colorectal cancer incidence. *J Natl Cancer Inst*. 2012;104(18):1353-1362. doi:10.1093/jnci/djs346
8. Ollberding NJ, Nomura AMY, Wilkens LR, Henderson BE, Kolonel LN. Racial/Ethnic Differences in Colorectal Cancer Risk: The Multiethnic Cohort Study. *Int J Cancer*. 2011;129(8):1899-1906. doi:10.1002/ijc.25822
9. Shaukat A, Mongin SJ, Geisser MS, et al. Long-Term Mortality after Screening for Colorectal Cancer. *N Engl J Med*. 2013;369(12):1106-1114. doi:10.1056/NEJMoa1300720
10. Breen N, Lewis DR, Gibson JT, Yu M, Harper S. Assessing disparities in colorectal cancer mortality by socioeconomic status using new tools: health disparities calculator and socioeconomic quintiles. *Cancer Causes Control*. 2017;28(2):117-125. doi:10.1007/s10552-016-0842-2
11. Shokar NK, Carlson CA, Weller SC. Factors associated with racial/ethnic differences in colorectal cancer screening. *J Am Board Fam Med*. 2008;21(5):414-426. doi:10.3122/jabfm.2008.05.07026
12. Poulson M, Cornell E, Madiedo A, et al. The Impact of Racial Residential Segregation on Colorectal Cancer Outcomes and Treatment. *Ann Surg*. 2020;Publish Ah. doi:10.1097/sla.0000000000004653
13. Williams DR, Priest N, Anderson N. Understanding Associations between Race, Socioeconomic Status and Health: Patterns and Prospects. *Heal Psychol*. 2016;35(4):407-411. doi:doi:10.1037/hea0000242
14. Landrine H, Corral I, Lee JGL, Efird JT, Hall MB, Bess JJ. Residential Segregation and Racial Cancer Disparities: A Systematic Review. *J Racial Ethn Heal Disparities*.

2017;4(6):1195-1205. doi:10.1007/s40615-016-0326-9
15. Poulson MR, Helrich SA, Kenzik KM, Dechert TA, Sachs TE, Katz MH. The impact of racial residential segregation on prostate cancer diagnosis and treatment. *BJU Int*. 2020:1-9. doi:10.1111/bju.15293
16. Rathore SS, Krumholz HM. Differences, Disparities, and Biases: Clarifying Racial Variations in Health Care Use. *Ann Intern Med*. 2004;141:635-638. doi:10.7326/0003-4819-141-8-200410190-00011
17. Braga M, Vignali A, Gianotti L, et al. Laparoscopic versus open colorectal surgery: A randomized trial on short-term outcome. *Ann Surg*. 2002;236(6):759-767. doi:10.1097/01.SLA.0000036269.60340.AE
18. Fujii S, Tsukamoto M, Fukushima Y, et al. Systematic review of laparoscopic vs open surgery for colorectal cancer in elderly patients. *World J Gastrointest Oncol*. 2016;8(7):573-582. doi:10.4251/wjgo.v8.i7.573
19. The Clinical Outcomes of Surgical Therapy Group. A Comparison of Laparoscopically Assisted and Open Colectomy for Colon Cancer. *N Engl J Med*. 2004;350(20):2050-2059. doi:10.1056/NEJMoa032651
20. Veldkamp R, Kuhry E, Hop W, et al. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol*. 2005;6(7):477-484. doi:10.1016/S1470-2045(05)70221-7
21. Hewett PJ, Allardyce RA, Bagshaw PF, et al. Short-term outcomes of the australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: The ALCCaS trial. *Ann Surg*. 2008;248(5):728-738. doi:10.1097/SLA.0b013e31818b7595
22. van Dalen A, Ali U, Murray A, Kiran R. Optimizing Patient Selection for Laparoscopic and Open Colorectal Cancer Resections: A National Surgical Quality Improvement Program-Matched Analysis. *Am Surg*. 2019;85(2):206-213.
23. Jayne D, Pigazzi A, Marshall H, et al. Effect of Robotic-Assisted vs Conventional Laparoscopic Surgery on Risk of Conversion to Open Laparotomy Among Patients Undergoing Resection for Rectal Cancer: The ROLARR Randomized Clinical Trial. *JAMA - J Am Med Assoc*. 2017;318(16):1569-1580. doi:10.1001/jama.2017.7219
24. Vogel JD, Eskicioglu C, Weiser MR, Feingold DL, Steele SR. The American Society of Colon and Rectal Surgeons Clinical Practice Guidelines for the Treatment of Colon Cancer. Dis Colon Rectum. 2017;60(10):999-1017. doi:10.1097/DCR.000000000000092
25. Guidelines for Laparoscopic Resection of Curable Colon and Rectal Cancer. Society of American Gastrointestinal and Endoscopic Surgeons. February 2012. https://www.sages.org/publications/guidelines/guidelines-for-laparoscopic-resection-of-curable-colon-and-rectal-cancer/. Published 2012. Accessed February 13, 2020.
26. Akinyemiju T, Meng Q, Vin-Raviv N. Race/ethnicity and socio-economic differences in colorectal cancer surgery outcomes: analysis of the nationwide inpatient sample. *BMC Cancer*. 2016;16(1):715-724. doi:1186/s12885-016-2738-7
27. AlNasser M, Schneider EB, Gearhart SL, et al. National disparities in laparoscopic colorectal procedures for colon cancer. *Surg Endosc*. 2014;28(1):49-57. doi:10.1007/s00464-013-3160-8
28. Cairns AL, Schlottmann F, Strassle PD, Di Corpo M, Patti MG. Racial and Socioeconomic Disparities in the Surgical Management and Outcomes of Patients with

Colorectal Carcinoma. *World J Surg*. 2019;43(5):1342-1350. doi:10.1007/s00268-018-04898-5
29. Semega J, Kollar M, Shrider EA, Creamer J. *Income and Poverty in the United States: 2019*. Last revised September 2020. https://www.census.gov/library/publications/2020/demo/p60-270.html. Accessed January 12, 2020.
30. Pruitt S, Davidson N, Gupta S, Yan Y, Schootman M. Missed opportunities: racial and neighborhood socioeconomic disparities in emergency presentation of colorectal cancer diagnosis and surgery. *BMC Cancer*. 2014;14:927. doi:10.1186/1471-2407-14-927
31. Diggs JC, Xu F, Diaz M, Cooper GS, Koroukian SM. Failure to screen: predictors and burden of emergency colorectal cancer resection. *Am J Manag Care*. 2007;13(3):157-164.
32. Littlechild J, Junejo M, Simons A-M, Curran F, Subar D. Emergency resection surgery for colorectal cancer: Patterns of recurrent disease and survival. *World J Gastrointest Pathophysiol*. 2018;9(1):8-17. doi:10.4291/wjgp.v9.i1.8
33. Okuda Y, Shimura T, Yamada T, et al. Colorectal obstruction is a potential prognostic factor for stage II colorectal cancer. *Int J Clin Oncol*. 2018;23(6):1101-1111. doi:10.1007/s10147-018-1307-2
34. Ingraham AM, Cohen ME, Bilimoria KY, et al. Comparison of Hospital Performance in Nonemergency Versus Emergency Colorectal Operations at 142 Hospitals. *J Am Coll Surg*. 2010;210(2):155-165. doi:10.1016/j.jamcollsurg.2009.10.016
35. User Guide for the 2016 ACS NSQIP Participant Use Data File (PUF). American College of Surgeons National Surgical Improvement Program. October 2017. https://www.facs.org/-/media/files/quality-programs/nsqip/nsqip_puf_userguide_2016.ashx. Accessed January 1, 2020.
36. Eisenstein S, Stringfield S, Holubar SD. Using the National Surgical Quality Improvement Project (NSQIP) to Perform Clinical Research in Colon and Rectal Surgery. *Clin Colon Rectal Surg*. 2019;32(1):41-53. doi:10.1055/s-0038-1673353
37. Hackett NJ, De Oliveira GS, Jain UK, Kim JYS. ASA class is a reliable independent predictor of medical complications and mortality following surgery. *Int J Surg*. 2015;18:184-190. doi:10.1016/j.ijsu.2015.04.079
38. VanderWeele TJ, Ding P. Sensitivity Analysis in Observational Research: Introducing the E-Value. *Ann Intern Med*. 2017;167(4):268-274. doi:10.7326/M16-2607
39. Mathur MB, Ding P, Riddell CA, VanderWeele TJ. Website and R Package for Computing E-values. *Epidemiology*. 2018;29(5):e45-e47. doi:10.1097/EDE.0000000000000864
40. Mathur M, Ding P, Riddell C, Smith L, VanderWeele T. E-value Calculator. https://www.evalue-calculator.com/. Accessed February 15, 2021.
41. RStudio Team (2018). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/.
42. Sholle ET, Pinheiro LC, Adekkanattu P, et al. Underserved populations with missing race ethnicity data differ significantly from those with structured race/ethnicity documentation. *J Am Med Informatics Assoc*. 2019;26(8-9):722-729. doi:10.1093/jamia/ocz040
43. Dembosky JW, Haviland AM, Haas A, et al. Indirect Estimation of Race/Ethnicity for

Survey Respondents Who Do Not Report Race/Ethnicity. *Med Care*. 2019;57(5):E28-E33. doi:10.1097/MLR.0000000000001011
44. Santry HP, Wren SM. The role of unconscious bias in surgical safety and outcomes. *Surg Clin North Am*. 2012;92(1):137-151. doi:10.1016/j.suc.2011.11.006
45. Ryan CL, Bauman K. *Educational Attainment in the United States: 2015*. Published March 29, 2016.
46. Fontenot KR, Semega JL, Kollar MA. *Income and Poverty in the United States: 2017*. Published September 12, 2018.
47. Conomos MP, Laurie CA, Stilp AM, et al. Genetic Diversity and Association Studies in US Hispanic/Latino Populations: Applications in the Hispanic Community Health Study/Study of Latinos. *Am J Hum Genet*. 2016;98(1):165-184. doi:10.1016/j.ajhg.2015.12.001
48. Jackson CS, Oman M, Patel AM, Vega KJ. Health disparities in colorectal cancer among racial and ethnic minorities in the United States. *J Gastrointest Oncol*. 2016;7(Suppl 1):S32-S43. doi:10.3978/j.issn.2078-6891.2015.039
49. Laiyemo AO, Doubeni C, Pinsky PF, et al. Race and Colorectal Cancer Disparities: Health-Care Utilization vs Different Cancer Susceptibilities. *J Natl Cancer Inst*. 2010;102(8):538-546. doi:10.1093/jnci/djq068
50. Cokkinides VE, Bandi P, Siegel RL, Jemal A. Cancer-related risk factors and preventive measures in US Hispanics/Latinos. *Ca Cancer J Clin*. 2012;62(6):353-363. doi:10.3322/caac.21155
51. Grundmeier RW, Song L, Ramos MJ, et al. Imputing missing race/ethnicity in pediatric electronic health records: Reducing bias with use of U.S. census location and surname data. *Health Serv Res*. 2015;50(4):946-960. doi:10.1111/1475-6773.12295
52. Silva GC, Trivedi AN, Gutman R. Developing and evaluating methods to impute race/ethnicity in an incomplete dataset. *Heal Serv Outcomes Res Methodol*. 2019;19(2-3):175-195. doi:10.1007/s10742-019-00200-9
53. Dahlke AR, Chung JW, Holl JL, et al. Evaluation of initial participation in public reporting of American College of surgeons NSQIP surgical outcomes on Medicare's hospital compare website. *J Am Coll Surg*. 2014;218(3):374-380.e1-5. doi:10.1016/j.jamcollsurg.2013.11.022
54. Long JA, Bamba MI, Ling B, Shea JA. Missing race/ethnicity data in Veterans Health Administration based disparities research: A systematic review. *J Health Care Poor Underserved*. 2006;17(1):128-140. doi:10.1353/hpu.2006.0029
55. Magaña López M, Bevans M, Wehrlen L, Yang L, Wallen GR. Discrepancies in Race and Ethnicity Documentation: a Potential Barrier in Identifying Racial and Ethnic Disparities. *J Racial Ethn Heal Disparities*. 2017;4(5):812-818. doi:10.1007/s40615-016-0283-3
56. Dougherty TM, Janitz AE, Williams MB, et al. Racial Misclassification in Mortality Records Among American Indians/Alaska Natives in Oklahoma From 1991 to 2015. *J Public Health Manag Pract*. 2019;25, Tribal Epidemiology Centers: Advancing Public Health in Indian Country for Over 20 Years(5):S36-S43. doi:10.1097/PHH.0000000000001019