Association of Insurance Type With Colorectal Surgery Outcomes and Costs at a Safety-Net Hospital

**A Retrospective Observational Study**

Jasmine C. Tetley, DO,* Michael A. Jacobs, MS,* Jeongsoo Kim, PhD,* Susanne Schmidt, PhD,† Bradley B. Brimhall, MD, MPH,‡§ Virginia Mika, PhD, MPH,§ Chen-Pin Wang, PhD,† Laura S. Manuel, BS,† Paul Damien, PhD,∥ and Paula K. Shireman, MD, MS, MBA*§¶

**Objective:** Association of insurance type with colorectal surgical complications, textbook outcomes (TO), and cost in a safety-net hospital (SNH).

**Background:** SNHs have higher surgical complications and costs compared to low-burden hospitals. How does presentation acuity and insurance type influence colorectal surgical outcomes?

**Methods:** Retrospective cohort study using single-site National Surgical Quality Improvement Program (2013–2019) with cost data and risk-adjusted by frailty, preoperative serious acute conditions (PASC), case status and open versus laparoscopic to evaluate 30-day reoperations, any complication, Clavien-Dindo IV (CDIV) complications, TO, and hospitalization variable costs.

**Results:** Cases (Private 252; Medicare 207; Medicaid/Uninsured 619) with patient mean age 55.2 years (SD = 13.4) and 53.1% male. Adjusting for frailty, open abdomen, and urgent/emergent cases, Medicaid/Uninsured patients had higher odds of presenting with PASC (adjusted odds ratio [aOR] = 2.02, 95% confidence interval [CI] = 1.22–3.52, \( P = 0.009 \)) versus Private. Medicaid/Uninsured (aOR = 1.80, 95% CI = 1.28–2.55, \( P < 0.001 \)) patients were more likely to undergo urgent/emergent surgeries compared to Private. Medicare patients had increased odds of any and CDIV complications while Medicaid/Uninsured had increased odds of any complication, emergency department or observations stays, and readmissions versus Private. Medicare (aOR = 0.51, 95% CI = 0.33–0.88, \( P = 0.003 \)) and Medicaid/Uninsured (aOR = 0.43, 95% CI = 0.30–0.60, \( P < 0.001 \)) patients had lower odds of achieving TO versus Private. Variable cost %change increased in Medicaid/Uninsured patients to 13.94% (\( P = 0.005 \)) versus Private but was similar after adjusting for case status. Urgent/emergent cases (43.23%, \( P < 0.001 \)) and any complication (78.34%, \( P < 0.001 \)) increased %change hospitalization costs.

**Conclusions:** Decreasing the incidence of urgent/emergent colorectal surgeries, possibly by improving access to care, could have a greater impact on improving clinical outcomes and decreasing costs, especially in Medicaid/Uninsured insurance type patients.

**Keywords:** colorectal surgery, insurance status, social risk factors, preoperative acute serious conditions, textbook outcomes, variable costs

---

**INTRODUCTION**

Frailty\(^1\) and social risk factors\(^2\) significantly impact colorectal surgical outcomes; however, value-based medicine risk adjustment models fail to account for these factors. Additionally, the impact of frailty on patient outcomes is not captured using standard Hierarchical Condition Category (HCC) risk adjustment.\(^3,4\) High Social Vulnerability Index scores in colorectal surgery patients were associated with higher risk of postoperative complications and index hospitalization expenditures,\(^2\) but

The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. The opinions expressed here are those of the authors and do not necessarily reflect the position of the United States government.

**SDC** Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site (www.annalsofsurgery.com).

Reprints: Paula K. Shireman, MD, MS, MBA, Office of the Dean, School of Medicine, Texas A&M Health, 8447 Riverside Parkway, Bryan, TX 77807. E-mail: Shireman@tamu.edu.

Copyright © 2022 The Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the Creative Commons Attribution License 4.0 (CCBY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Annals of Surgery Open (2022) 4:e215

Received: 18 May 2022; Accepted 2 September 2022

Published online 7 November 2022

DOI: 10.1097/AS9.000000000000215
are not included in risk adjustment. Safety-net hospitals (SNH) serve higher proportions of low socioeconomic status (SES) patients with higher severity of illness scores, higher rates of emergency surgeries, and longer hospital length of stay (LOS).\(^1\) Hospital Readmission Reduction Program and other pay for performance (P4P) programs unintentionally contribute to widening disparities in healthcare and outcomes, penalizing SNH, and further limiting resources to treat vulnerable populations.\(^5\) High-burden SNH have higher postoperative complications and costs compared to low-burden hospitals.\(^5,9,10\) Insurance status/type is a common proxy used for patient SES.\(^11,13\) Moreover, dual-eligibility for Medicare and Medicaid is indicative of poverty and plays a fundamental role in predicting surgical outcomes.\(^12,14\) along with urgent/emergent surgeries,\(^15\) frailty,\(^1,11,13,16-18\) and open compared to laparoscopic surgeries.\(^12\) Uninsured or Medicaid patients experience increased rates of emergency procedures, complications, and mortality.\(^14,19,20\) Additionally, the current NSQIP risk calculator understimates the risk of complications for emergency surgeries\(^11\) and does not provide risk prediction for urgent cases.\(^11\) Failure to account for factors beyond clinicians’ control (eg, increased presentation acuity and social risk factors) in value-based medicine when assessing outcomes of high-burden facilities may continue to widen disparities in access, care, and outcomes in vulnerable populations.\(^5,18\)

Textbook outcomes (TO) is a composite metric that has been increasingly used to assess surgical outcomes.\(^2,22\) Social risk factors may not consistently affect outcomes; therefore, including multiple outcomes of interest may more comprehensively assess the effects and costs of social risk factors, especially in underinsured/uninsured patients.

As we assessed the association of Private, Medicare, and Medicaid/Uninsured (ie, Medicaid, dual-eligible Medicare/Medicaid, self-pay, indigent programs) health insurance type with complications and cost after colorectal surgeries in an SNH with a large range of SES patients. We hypothesize that after adjusting for frailty and open versus laparoscopic procedure type, increased presentation acuity, measured by presenting with acute serious conditions and urgent or emergent cases in patients with Medicaid/Uninsured insurance type will be associated with higher complications and index hospitalization costs compared to patients with Private insurance.

MATERIALS AND METHODS

Study Population and Data

This retrospective cohort study followed STROBE Reporting Guidelines\(^2\) and used local, identified data on all patients undergoing colorectal procedures present in the 2013-2019 American College of Surgeons National Surgical Quality Improvement Program (NSQIP) at a single facility, serving as an academic medical center and SNH. NSQIP registry was used for cohort identification. NSQIP provides standardized definitions of preoperative risk factors and complications.\(^25\) The Institutional Review Board of the University of Texas Health San Antonio approved this study.

Patient Preoperative and Operative Variables

Frailty was measured using the recalibrated Risk Analysis Index (RAI)\(^26\) using preoperative variables from NSQIP as previously described.\(^16\) The RAI has been validated using both Veterans Affairs Quality Improvement Program and NSQIP datasets\(^26\) and exhibits collinearity with the Charlson Comorbidity Index.\(^1\) RAI has been used for risk adjustment for medical comorbidities in multiple studies.\(^16,17,27\) RAI scores were grouped into robust (≤20), normal (21–29), frail (30–39), and very frail (≥40).

Patients presenting with preoperative acute serious conditions (PASC) were defined using 6 NSQIP present at the time of surgery (PATOS) variables and NSQIP variables defining acute renal failure (with or without dialysis required) within 2 weeks before surgery, as previously described (Supplemental Table 1, http://links.lww.com/AOSO/A177 lists the NSQIP variable names).\(^16\) Case status was determined from NSQIP variables with urgent cases being defined as neither elective nor emergency, as determined by “no” responses to the ELECTSURG and EMERGNCY variables.\(^11\) Procedures were categorized as open or laparoscopic surgeries using NSQIP principal Current Procedural Terminology Codes (Supplemental Table 2, http://links.lww.com/AOSO/A177).

Any and Clavien-Dindo IV 30-Day Complications

Clavien-Dindo classifies complications based on their treatments.\(^29\) We approximated Clavien-Dindo IV (CDIV) complications using the NSQIP variables of postoperative septic shock, postoperative dialysis, pulmonary embolus, myocardial infarction, cardiac arrest, prolonged ventilation, reintubation, or stroke as previously reported.\(^16\) Unplanned reoperations were defined using the NSQIP variable REOPERATION\(^1\) as present or absent. Any complication was defined using the CDIV and reoperation NSQIP variables plus an additional 11 NSQIP variables defining postoperative complications.

TO Composite Variable

TOs were defined as surgeries with the absence of 30-day CDIV complications, unplanned reoperations, 30-day mortality after the date of surgery, and 30-day after the date of discharge from the index hospitalization readmissions and emergency department or observations stays (EDOS).

Mortality

Mortality was defined as death within 30 days of the index colorectal surgical procedure. Dates of death were obtained from ACS NSQIP and cross referenced from our data warehouse using the electronic health records of the local health system as well as the Social Security Death Master File.

Insurance Type and Cost Data

The identified, local NSQIP data were merged with electronic health records and managerial accounting data to determine insurance type and the variable cost of the index hospitalization. Insurance type was categorized based upon billing data for the encounter supplemented by EHR data and defined as (1) Private including TRICARE and workers compensation; (2) Medicare; and (3) Medicaid/Uninsured including Medicaid, dual enrollment in Medicare/Medicaid, charity care, self-pay with ≤1% of charges paid, or county indigent care programs (Supplemental Table 3, http://links.lww.com/AOSO/A177). “Other” included encounters billed to the Veterans Administration, Department of Corrections, or self-pay with >1% of charges collected and were excluded (n = 13).

We defined variable costs as related directly to patient care occurring during the encounter, such as supplies/salaries and include direct variable costs that vary directly with the quantity of resources provided for patient care.\(^30,31\) Direct variable costs are accounted primarily using direct measurements from a bottom-up approach rather than calculated estimates derived from charges. Hospital fixed costs, outpatient and professional fees were not included. We used variable costs, as fixed costs are not directly related to patient care and vary between hospitals.\(^31\) The natural logarithm of variable costs was used, as previously described\(^30\) after adjusting costs to 2019 dollars using the Personal Health Care Index.\(^22\)
Management of Missing Variables
Cases were excluded due to (1) perineal and transsacral only procedures; (2) missing or inaccurate cost variables; and (3) “Other” insurance type.

Study Outcomes
Clinical outcomes of interest were 30-day unplanned reoperations, any complication, severe/life-threatening CDIV complications, readmissions, EDOS, TO composite variable, and variable costs for the index surgery hospitalization adjusted for RAI, case status, open versus laparoscopic procedure, and insurance type.

Statistical Analysis
Categorical data were summarized using count and percentage and continuous data using mean and standard deviation (SD). Chi-square tests and F-tests were used to test for difference between groups for categorical and continuous variable. Logistic regression analyses were performed for (1) PASC and case status adjusting for RAI, open abdominal procedures, and insurance type; (2) open abdominal procedures adjusting for RAI, insurance type, PASC and case status; (3) complications, EDOS, readmissions and TO adjusting for RAI, open abdominal procedures, insurance type, and case status; and (4) TO subgroup analyses for elective and urgent/emergent cases. Natural logarithms were used to normalize the skewed LOS and variable costs for the index hospitalization, which reduces the impact of extreme values, as previously described.30,33 Percent change/relative difference was calculated using the exponential function; % change = \left(\frac{\text{estimated coefficients} - 1}\right) \times 100. Analyses were performed using R version 4.1.0 (2021-05-18).

RESULTS
Population Characteristics
Our cohort consisted of 1,078 cases of inpatient procedures at a major urban SNH (Fig. 1). Cases (Table 1) were more commonly performed on males (53.1%) and White patients (90.4%) with the majority identifying as Hispanic ethnicity (64.7%). Most cases were performed on patients with Medicaid/Uninsured insurance type (57.4%), followed by Private (23.4%) and Medicare (19.2%). Most cases were performed on robust (60.3%) and normal (27.5%) patients based on RAI scores. Only 9.7% and 2.5% of patients were frail and very frail, respectively, with Medicare patients exhibiting higher rates of frailty. Complication rates were higher in Medicare and Medicaid/Uninsured patients compared to Private.

Increased PASC in Medicaid/Uninsured Patients and Increased Urgent/Emergent Cases in Medicaid/Uninsured and Medicare Patients
Rates of patients presenting with PASC (13.8%) were highest in Medicaid/Uninsured (15.8%) and Medicare (15.5%) patients versus Private (7.5%, \( P = 0.004 \), Table 1). Medicaid/Uninsured patients had higher odds of presenting with PASC (adjusted odds ratio \( \text{aOR} = 2.02, 95\% \text{CI} = 1.22–3.52, P = 0.009 \); Table 2) compared to Private after adjusting for frailty and open procedures. Odds of undergoing an urgent/emergent case were lowest in robust compared to normal patients and higher for patients undergoing open abdomen surgeries compared to laparoscopic (\( \text{aOR} = 2.26, 95\% \text{CI} = 1.70–3.03, P < 0.001 \)) and Medicaid/Uninsured patients (\( \text{aOR} = 1.8, 95\% \text{CI} = 1.28–2.55, P < 0.001 \)) compared to Private. Patients presenting with PASC had higher odds of undergoing urgent/emergent surgeries (\( \text{aOR} = 26.65, 95\% \text{CI} = 13.61–60.28, P < 0.001 \)). All 3 insurance types had similar odds of undergoing open abdominal surgeries after adjusting for frailty, PASC, and urgent/emergent procedures.

Distribution of CDIV Complications and Increased Odds of 30 Days From Date of Surgery Complications in Medicare and Medicaid/Uninsured Patients
Rates of CDIV complications were 10.5% overall and were higher in Medicare and Medicaid/Uninsured patients (17.4% and 10.3%, respectively, \( P < 0.001 \); Table 1) compared to Private (5.2%). Any complication (43.6%) was also higher in Medicare and Medicaid/Uninsured patients (49.8% and 45.7%, respectively, \( P = 0.001 \)). The distribution of CDIV complications (Supplemental Table 1, http://links.lww.com/AOSO/A177) was similar between insurance types except myocardial infarction was highest in Medicare patients (25.0%) and Private (23.1%) compared to Medicaid/Uninsured (7.8%, \( P = 0.048 \)).

Medicare patients had higher odds of any complication (\( \text{aOR} = 1.57, 95\% \text{CI} = 1.02–2.42, P = 0.042 \); Table 3) and CDIV complications (\( \text{aOR} = 2.56, 95\% \text{CI} = 1.26–5.46, P = 0.011 \)), while Medicaid/Uninsured patients had higher odds of any complication (\( \text{aOR} = 1.41, 95\% \text{CI} = 1.02–1.96, P = 0.040 \)) versus Private.

Urgent/emergent surgeries greatly increased 30-day mortality odds (\( \text{aOR} = 6.91, 95\% \text{CI} = 2.30–29.87, P = 0.002 \)) compared to elective cases.

Subgroup analysis including only elective (Supplemental Table 4, http://links.lww.com/AOSO/A177) or urgent/emergent (Supplemental Table 5, http://links.lww.com/AOSO/A177) cases demonstrated that Medicare patients had higher \( \text{aOR} \) for CDIV complications for elective cases and any complication for the urgent/emergent subgroup compared to Private insurance patients. Medicaid/Uninsured patients had higher \( \text{aOR} \) only for any complication in the urgent/emergent subgroup compared to the Private insurance group.
Increased Odds of 30 Days From Date of Discharge EDOS and Readmissions in Medicaid/Uninsured Patients

Medicaid/Uninsured patients had higher odds of EDOS occurring (aOR = 4.64, 95% CI = 2.54–9.34, P = 0.001; Table 3) compared to Private. Medicaid/Uninsured patients also had higher odds of hospital readmissions (aOR = 1.69, 95% CI = 1.14–2.35, P = 0.011). Subgroup analysis including only elective (Supplemental Table 4, http://links.lww.com/AOSO/A177) or urgent/emergent (Supplemental Table 5, http://links.lww.com/AOSO/A177) cases showed EDOS had a higher aOR for...
Medicaid/Uninsured versus Private insurance group in the elective and urgent/emergent subgroups.

**Decreased Odds of TO in Medicare and Medicaid/Uninsured Patients**

Both Medicare (aOR = 0.51, 95% CI = 0.33–0.80, P = 0.003; Table 4) and Medicaid/Uninsured (aOR = 0.43, 95% CI = 0.30–0.60, P < 0.001) patients had decreased odds of achieving TO compared to Private. Subgroup analyses of elective and urgent/emergent case status also demonstrated that Medicare and Medicaid/Uninsured patients exhibited decreased odds of TO compared to Private. Rates of TO for Private, Medicare and Medicaid/Uninsured patients were 79.4%, 74.9%, and 62.0% for elective cases (P < 0.001) and 72.7%, 46.2%, and 51.2% for urgent/emergent cases (P = 0.001), respectively.

**Medicaid/Uninsured Patients Have Longer Index Hospitalizations but Not After Adjusting for Urgent/Emergent Cases**

Medicaid/Uninsured (17.51%, P < 0.001, Supplemental Table 6, http://links.lww.com/AOSO/A177) patients had longer %change LOS compared to Private. However, after adjusting for urgent/emergent case status, LOS of Medicaid/Uninsured patients were similar to Private. Urgent/emergent cases resulted in a 70.42% change in LOS compared to elective cases (P < 0.001).

### Table 3. Any Complication and Outcome Variables Used in Textbook Outcomes Adjusted for Frailty, Open Abdomen Procedures, Insurance Type and Urgent/Emergent Case Status

| Any Complication | CDIV Complications | Reoperations |
|------------------|--------------------|--------------|
|                  | aOR CI P           | aOR CI P     | aOR CI P         |
| RAI (Ref = Normal 21–29) |                    |              |                |
| Robust (≤20)     | 0.75 0.55–1.03 0.074 | 0.45 0.27–0.75 0.002 | 1.15 0.67–2.04 0.610 |
| Frail (30–39)    | 1.57 0.98–2.56 0.065 | 1.05 0.56–1.91 0.878 | 1.31 0.61–2.72 0.472 |
| Very frail (≥40) | 3.18 1.23–9.88 0.026 | 1.93 0.77–4.67 0.151 | 0.74 0.11–2.73 0.692 |
| Open abdomen     |                    |              |                |
| (Ref = Laparoscopic) | 3.43 2.59–4.55 <0.001 | 3.03 1.76–5.54 <0.001 | 2.02 1.22–3.45 0.008 |
| Insurance (Ref = Private) |                |              |                |
| Medicare         | 1.57 1.02–2.42 0.042 | 2.56 1.26–5.46 0.011 | 1.60 0.76–3.39 0.215 |
| Medicaid/Uninsured | 1.41 1.02–1.96 0.040 | 1.53 0.83–3.02 0.197 | 1.24 0.71–2.31 0.467 |
| Urgent/emergent  | (Ref = Elective)   | 1.41 1.08–1.85 0.013 | 4.22 2.63–6.99 <0.001 | 1.17 0.74–1.86 0.498 |

30-day EDOS and Readmissions defined as 30 days from date of discharge from the index hospitalization. 30-day Mortality defined as 30 days from date of index surgery. Bolded P-values are significant at the <0.05 level.

### Table 4. TOs Adjusted for RAI, Open Abdomen, and Insurance Type With Cases Status Subgroup Analyses

| TO All Cases | TO Elective | TO Urgent/Emergent |
|--------------|-------------|-------------------|
| aOR CI P     | aOR CI P    | aOR CI P          |
| RAI (Ref = Normal 21–29) |            |                   |
| Robust (≤20) | 1.22 0.89–1.67 0.210 | 0.91 0.58–1.42 0.683 | 1.72 1.09–2.72 0.020 |
| Frail (30–39) | 0.89 0.56–1.42 0.628 | 0.83 0.41–1.71 0.611 | 1.02 0.54–1.91 0.950 |
| Very Frail (≥40) | 0.16 0.04–0.43 <0.001 | 0.09 0.00–0.57 0.031 | 0.22 0.05–0.72 0.023 |
| Open abdomen | 0.44 0.33–0.59 <0.001 | 0.45 0.31–0.64 <0.001 | 0.42 0.26–0.67 <0.001 |
| (Ref = Laparoscopic) |            |                   |
| Medicare     | 0.51 0.33–0.80 0.003 | 0.54 0.30–0.96 0.037 | 0.41 0.20–0.83 0.015 |
| Medicaid/Uninsured | 0.43 0.30–0.60 <0.001 | 0.44 0.28–0.68 <0.001 | 0.37 0.20–0.64 <0.001 |
| Urgent/emergent (Ref = Elective) | 0.78 0.60–1.02 0.074 |                   |                   |

Bolded P-values are significant at the <0.05 level.
TABLE 5.
Variable Costs Adjusted for RAI, Open Abdomen, and Insurance Type: Medicaid/Uninsured Similar to Private Insurance Type After Adjusting for Urgent/Emergent Case Status

|                      | % change | Estimates | CI       | P       | % change | Estimates | CI       | P       |
|----------------------|----------|-----------|----------|---------|----------|-----------|----------|---------|
| Interception         | 9.12     | 9.01–9.24 | <0.001   |         | 9.03     | 8.92–9.14 | <0.001   |         |
| RAI (Ref = Normal 21–29) |          |           |          |         |          |           |          |         |
| Robust (≤20)          | −15.66   | −0.17     | −0.26 to −0.08 | <0.001  | −12.42   | −0.13     | −0.22 to −0.05 | 0.003   |
| Frail (30–39)         | 21.39    | 0.19      | 0.06–0.33 | 0.006   | 18.14    | 0.17      | 0.03–0.30 | 0.014   |
| Very frail (≥40)      | 39.52    | 0.33      | 0.09–0.58 | 0.007   | 29.99    | 0.26      | 0.03–0.50 | 0.028   |
| Open abdomen          | 51.04    | 0.41      | 0.34–0.49 | <0.001  | 38.57    | 0.33      | 0.25–0.40 | <0.001  |
| Medicare              | 11.27    | 0.11      | −0.01 to 0.23 | 0.085   | 11.72    | 0.11      | −0.01 to 0.23 | 0.063   |
| Medicaid/Uninsured    | 13.94    | 0.13      | 0.04–0.22 | 0.005   | 8.13     | 0.08      | −0.01 to 0.17 | 0.081   |
| Urgent/emergent (Ref = Elective) | 43.23     | 0.36      | 0.28–0.44 | <0.001  | 38.57    | 0.33      | 0.25–0.40 | <0.001  |

% change is calculated with marginal change of \( \log(\text{direct costs}) \) for one unit of each variable change below:

\[
\frac{\text{exp(estimated coefficients) − exp(intercept)}}{\text{exp(intercept)}} \times 100, \text{ which is equal to } \frac{\text{exp(estimated coefficients) − 1}}{\text{exp(intercept)}} \times 100.
\]

Ref indicates reference value.

Bolded \( p \)-values are significant at the <0.05 level.

Increased Hospitalization Variable Costs in Medicaid/Uninsured Patients Were Similar to Private After Adjusting for Urgent/Emergent Cases

Medicaid/Uninsured patients (13.94%, \( p = 0.005 \)) had higher \% changes in variable costs compared to Private (Table 5). However, after adjusting for urgent/emergent cases, Medicaid/Uninsured patients had similar variable costs compared to Private patients. Urgent/emergent case status resulted in a 43.23 \% change compared to elective case status (\( p < 0.001 \)). Adjusting for any complication or CDIV complications increased the \% change by 78.34 % and 153.07 %, respectively (Table 6). After adjusting for either any complication or CDIV complications, both Medicare and Medicaid/Uninsured patients exhibited similar \% change of variable costs compared to Private.

Subgroup analysis for patients without any postoperative complications showed that Medicaid/Uninsured patients had 8.84 \% higher variable costs compared to Private insurance patients but had similar costs after adjusting for urgent/emergent cases (Supplemental Table 7, http://links.lww.com/AOSO/A177). For the TO patient subgroup, Medicaid/Uninsured patients had 13.48 \% higher variable costs versus Private and 8.84 \% higher variable costs after adjusting for urgent/emergent cases (Supplemental Table 8, http://links.lww.com/AOSO/A177).

DISCUSSION

Medicare and Medicaid/Uninsured patients had higher odds of 30-day complications with decreased odds of achieving TO compared to the Private group. Contributing to the worse outcomes in Medicaid/Uninsured patients were the increased odds of presenting with PASC (\( aOR = 2.02 \)) and undergoing urgent/emergent surgeries (\( aOR = 1.80 \)) versus Private. Presenting with PASC was associated with 94.6 \% rate and \( aOR = 26.65 \) of undergoing an urgent/emergent surgery. Consistent with our data, uninsured patients were 3.54 times more likely to undergo emergent colorectal surgeries.\(^{19}\) Urgent/emergent surgeries had higher odds of complications in this study and in prior publications for urgent\(^{19}\) and emergent\(^{19,34,35}\) procedures, suggesting that Medicaid/Uninsured patients present under worse condition than privately insured patients. Urgent cases usually occur after a failed trial of medical management in unplanned hospitalizations. Numerous studies stratify cases into elective and emergent without categorizing urgent case status\(^{19,34,35}\) or stating how urgent cases were classified.\(^{19,34,35}\) Urgent cases were more common than emergent cases in all three insurance groups and highest (37.0\%) in the Medicaid/Uninsured group (Table 1). Combining urgent and elective cases may disproportionately increase complication rates of vulnerable patients that have higher rates of urgent surgeries.

TABLE 6.
Variable Costs Adjusted for RAI, Open Abdomen, Insurance Type, Urgent/Emergent Case Status, and Complications

|                      | % change | Estimates | CI       | P       | % change | Estimates | CI       | P       |
|----------------------|----------|-----------|----------|---------|----------|-----------|----------|---------|
| Interception         | 8.92     | 8.82–9.02 | <0.001   |         | 9.01     | 8.92–9.11 | <0.001   |         |
| RAI (Ref = Normal 21–29) |          |           |          |         |          |           |          |         |
| Robust (≤20)          | −9.19    | −0.10     | −0.17 to −0.02 | 0.015   | −7.43    | −0.08     | −0.15 to 0.00 | 0.051   |
| Frail (30–39)         | 11.16    | 0.11      | −0.01 to 0.22 | 0.080   | 15.86    | 0.15      | 0.03–0.27 | 0.015   |
| Very frail (≥40)      | 13.73    | 0.13      | −0.08 to 0.34 | 0.229   | 11.61    | 0.11      | −0.10 to 0.32 | 0.304   |
| Open abdomen          | 18.21    | 0.17      | 0.10–0.24 | <0.001  | 30.10    | 0.26      | 0.20–0.33 | <0.001  |
| Medicare              | 5.89     | 0.06      | −0.05 to 0.16 | 0.282   | 4.66     | 0.05      | −0.06 to 0.15 | 0.391   |
| Medicaid/Uninsured    | 3.80     | 0.04      | −0.04 to 0.12 | 0.350   | 6.64     | 0.06      | −0.01 to 0.14 | 0.107   |
| Urgent/emergent (Ref = Elective) | 37.07     | 0.22      | 0.25–0.38 | <0.001  | 28.19    | 0.29      | 0.18–0.32 | <0.001  |
| Any complication      | 78.34    | 0.58      | 0.51–0.65 | <0.001  | 153.07   | 0.93      | 0.82–1.04 | <0.001  |

% change is calculated with marginal change of \( \log(\text{direct costs}) \) for one unit of each variable change below:

\[
\frac{\text{exp(estimated coefficients) − exp(intercept)}}{\text{exp(intercept)}} \times 100, \text{ which is equal to } \frac{\text{exp(estimated coefficients) − 1}}{\text{exp(intercept)}} \times 100.
\]

Ref indicates reference value.

Bolded \( p \)-values are significant at the <0.05 level.
Open procedures in our study and others had higher odds of complications, reoperations, costs, and lower odds of achieving TO compared to laparoscopic surgeries. Medicaid/Uninsured patients displayed similar odds of undergoing open procedures as Private after adjusting for PASC and urgent/emergent cases (Table 2). This suggests that the higher rates of open procedures in Medicaid/Uninsured patients were due to increased presentation acuity and need for urgent/emergent surgeries, as opposed to not providing the alternative of laparoscopic surgery.

Medicaid/Uninsured patients had higher odds of 30-day EDOS (aOR = 4.64) and readmissions (aOR = 1.69). Emergency departments often serve as the primary healthcare source for low-SES patients with limited access to care. The strongest predictor for preventable readmissions was patients undergoing urgent/emergent colorectal procedures. Higher odds of readmission were observed in our Medicaid/Uninsured group with longer LOS given their higher rates of emergent cases, consistent with previous studies. Adjusting for patient SES showed similar readmission odds after major surgery between SNH and non-SNH, leading the authors to conclude that differences in patient case mix of low-SES patients, not quality of care, were responsible for higher readmission rates at SNH.

Medicare and Medicaid/Uninsured patients had decreased odds of achieving the composite TO measure, regardless of case status. We chose TO as our primary outcome because composite measures often provide more comprehensive assessments of surgical outcomes than single variables. Our data demonstrate the utility of this approach. While all component variables had increased aOR for Medicare and Medicaid/Uninsured patients compared to the Private insurance group (Table 3), only CDIV complications were significant for Medicare and 30-day EDOS and readmissions for Medicaid/Uninsured patients. Thus, identification of healthcare disparities may be improved by composite variables secondary to the additive effects of each component. Prior studies using TO in colorectal surgery have been limited to oncological procedures. Insurance type has consistently been identified as an independent risk factor for worse surgical outcomes with vastly different patient populations. The National Academy of Medicine recommends studying the effect of social needs, by decreasing the incidence of urgent/emergent colorectal surgeries, particularly in low-SES, vulnerable patients.

The patients with Private insurance treated in our SNH had a similar complication rate (33.3%) to the previously reported complication rate (32.8%) of privately insured cohorts treated in low-burden hospitals. This suggests that poor outcomes are not a result of lower quality of care in SNH but due to patient-level differences. While some groups have established SNH provide equitable care, high-burden SNH have been associated with increased risk of complications and costs. Many colorectal surgery studies assess surgical outcomes across multiple healthcare systems based on safety-net burden rather than within a healthcare system, which ultimately compares institutions with vastly different patient populations. The National Academy of Medicine recommends studying the effect of social risk factors within a hospital system, especially one that cares for a range of SES patients, to target factors that distinguish between high and low quality of care. This study is one of the first to assess colorectal surgery outcomes following these recommendations and includes factors influencing the cost of care for patients in these insurance groups.

The Medicaid/Uninsured group was associated with increased adjusted odds of longer index hospitalization LOS and higher variable costs, but both were similar to Private after adjusting for urgent/emergent cases. Major factors impacting the %change in variable costs (Table 6) were urgent/emergent cases (28.19%), open abdominal surgeries (30.10%), and CDIV complications (153.07%). Our findings suggest insurance type plays a significant role in outcomes and costs after colorectal surgery. Worse outcomes in Medicaid/Uninsured, low-SES patients were driven by increased presentation acuity, measured by increased odds of presenting with PASC and undergoing urgent/emergent surgeries, driving the increased complications and costs, consistent with a previous publication. Healthcare providers are increasingly being held accountable for quality, outcomes, and cost of care. Decreasing rates of nonelective surgeries is a potential target for policy change. Medicaid expansion was associated with a 1.8-percentage point increase in the probability of an early, uncomplicated presentation for several surgical conditions compared to states that did not expand Medicaid. Improving access to health care to decrease the incidence of PASC and urgent/emergent operations may be a better approach to improving surgical outcomes and reducing costs than P4P programs. A Cochrane review concluded that hospital P4P programs have an uncertain impact and effects on patient outcomes were at most small on quality of care, equity, or resource use. Further studies should assess the impact of improved healthcare access for vulnerable patients on reducing urgent/emergent surgeries, complications, and costs. Numerous studies indicate that SNH and academic medical centers are disproportionately penalized in current value-based medicine programs. Integration of socioeconomic risk factors into evaluation of high- and low-burden hospitals could improve the distribution/allocation of resources, improving resources to SNH and mitigating disparities potentially propagated by P4P programs.

**Limitations**

This study is a retrospective review and cannot establish causal relationships. NSQIP provides a representative sample of surgeries but does not include all procedures performed at our institution. High complication and mortality rates may occur in cases performed for palliation, rather than for the purpose of extending life, but these data do not clearly define procedures that were performed specifically for palliation. While we included frailty, laparoscopic procedures and case status variables, multiple other variables could have been included.

**CONCLUSIONS**

Medicaid/Uninsured insurance type was associated with decreased odds of achieving TO and increased odds of presenting with PASC and urgent/emergent cases, driving higher odds of complications, and index hospitalization costs. This suggests that factors beyond the surgeons’ control, such as increased presentation acuity and insurance type, impact surgical outcomes. Socioeconomic factors profoundly affect patient outcomes, which can account for the higher complication rates and costs of SNH serving a higher proportion of low-SES patients. Improving access to health care could provide a more significant impact on patient outcomes and decrease index hospitalization costs, by decreasing the incidence of urgent/emergent colorectal surgeries, particularly in low-SES, vulnerable patients.

**Acknowledgments**

J.C.T. and M.A.J. are co-first authors and contributed equally to the contents of this study. P.K.S., J.K., M.A.J., and L.S.M. had full access to the data and take responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: P.K.S., S.S., M.A.J., J.K., B.B.B., and P.D. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: J.C.T., M.A.J., and P.K.S. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: M.A.J., J.K., C.-F.W., and P.D. Obtained funding: P.K.S., B.B.B., S.S., P.D., and C.-P.W. Administrative, technical, or material support: All authors. Supervision: P.K.S.
REFERENCES

1. Chirimould FM, Schmidt S, Simon RC, et al. Association of socioeconomic area deprivation index with hospital readmissions after colon and rectal surgery. J Gastrointest Surg. 2021;25:795–808.

2. Diaz A, Hyer JM, Barmash E, et al. County-level social vulnerability is associated with worse surgical outcomes especially among minority patients. Ann Surg. 2021;274:881–891.

3. Johnston KJ, Bynum JPW, Joynt Maddox KE. The need to incorporate additional patient information into risk adjustment for medicare beneficiaries. JAMA. 2020;323:925–926.

4. Johnston KJ, Wen H, Joynt Maddox KE. Relationship of a claims-based frailty index to annualized medicare costs: a cohort study. Ann Intern Med. 2020;173:53–54.

5. Hoehn RS, Wima K, Vestal MA, et al. Effect of hospital safety-net burden on cost and outcomes after surgery. JAMA Surg. 2016;151:1758–1580.

6. Glance LG, Kellermann AL, Osler TM, et al. Impact of risk adjustment for socioeconomic status on risk-adjusted surgical readmission rates. Ann Surg. 2016;263:698–704.

7. Zogg CK, Thamma JR, Ryan AM, et al. Medicare’s hospital acquired condition reduction program disproportionately affects minority-serving hospitals; by race, socioeconomic status, and disproportionate share hospital payment receipt. JAMA Surg. 2020;271:985–993.

8. Wang W, Hoyler MM, White RS, et al. Hospital safety-net burden is associated with increased inpatient mortality and perioperative complications after colectomy. J Surg Res. 2022;125:24–33.

9. Rosero EB, Modrall JG, Joshi GP. Failure to rescue after major abdominal surgery: the role of hospital safety net burden. Ann Surg. 2020;220:1023–1030.

10. Tang VL, Jing B, Boscardin J, et al. Association of functional, cognitive, and psychological measures with 1-year mortality in patients undergoing major surgery. JAMA Surg. 2020;155:412–418.

11. Sastrow DL, White RS, Mauer E, et al. The disparity of care and outcomes for medicare patients undergoing colectomy. J Surg Res. 2019;235:190–201.

12. Irinson Z, Tang VL, Finlayson E. Postoperative functional outcomes in older adults. Curr Surg Rep. 2016;4:21.

13. LaPar DJ, Bhamidipati CM, Mery CM, et al. Primary payer status affects mortality for major surgical operations. Ann Surg. 2010;252:544–550; discussion 550.

14. Mullen MG, Michaels AD, Mchaffey JH, et al. Risk associated with complications and mortality after urgent surgery vs elective and emergency surgery: implications for defining “Quality” and reporting outcomes for urgent surgery. JAMA Surg. 2017;152:768–774.

15. Yan Q, Kim J, Hall DE, et al. Association of frailty and the expanded operative stress score with preoperative acute serious conditions, complications and mortality in males compared to females: a retrospective observational study. Ann Surg. Online Ahead of print Jun 25, 2021. doi:10.1097/sla.0000000000005027

16. Shih T, Ryan AM, Gonzalez AA, et al. Medicare’s hospital readmissions reduction program in surgery may disproportionately affect minority-serving hospitals. Ann Surg. 2015;261:1027–1031.

17. Schwartz DA, Hui X, Schneider EB, et al. Worse outcomes among uninsured general surgery patients: does the need for an emergency operation explain these disparities? Surgery. 2014;156:345–351.

18. Mills AM, Holena DN, Kallan MJ, et al. Effect of insurance status on patients admitted for acute diverticulitis. Colorectal Dis. 2013;15:613–620.

19. Lubitz AL, Chan E, Zarif D, et al. Effect of insurance status on patients admitted for acute diverticulitis. Colorectal Dis. 2013;15:613–620.

20. van Roessel S, Mackay TM, van Dieren S, et al.; Dutch Pancreatic Cancer Group. Textbook outcome: nationwide analysis of a novel quality measure in pancreatic surgery. Ann Surg. 2020;271:1155–1162.

21. Ghaferi AA, Schwartz TA, Pawlik TM. STROBE reporting guidelines for observational studies. JAMA Surg. 2021;156:577–578.

22. Lawson EH, Zingmond DS, Hall BL, et al. Comparison between clinical registry and medicare claims data on the classification of hospital quality of surgical care. Ann Surg. 2015;261:290–296.

23. Arya S, Varley P, Youk S, et al. Recalibration and external validation of the risk analysis index: a surgical frailty assessment tool. Ann Surg. 2020;272:996–1005.

24. Reitz KM, Varley PR, Liang NL, et al. The correlation between case total work relative value unit, operative stress, and patient frailty: retrospective cohort study. Ann Surg. 2021;274:637–645.

25. Lawson EH, Zingmond DS, Hall BL, et al. Comparison between clinical registry and medicare claims data on the classification of hospital quality of surgical care. Ann Surg. 2015;261:290–296.

26. Reitz KM, Varley PR, Liang NL, et al. The correlation between case total work relative value unit, operative stress, and patient frailty: retrospective cohort study. Ann Surg. 2021;274:637–645.

27. Ara IH, Youk S, Varley P, et al. Association of preoperative patient frailty and operative stress with postoperative mortality. JAMA Surg. 2020;155:e194620.

28. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;239:225–232.

29. Craven D, Varley P, Youk S, et al. Association of preoperative frailty and operative stress with mortality after elective vs emergency surgery: implications for defining “Quality” and reporting outcomes for urgent surgery. JAMA Surg. 2017;152:768–774.

30. Hyer JM, Tsilimigras DI, Diaz A, et al. High social vulnerability and “Textbook Outcomes” after cancer operation. J Am Coll Surg. 2020;231:351–359.

31. Delaney CP, Kipin RP, Senagore AJ, et al. Case-matched comparison of clinical and financial outcome after laparoscopic or open colorectal surgery. Ann Surg. 2003;238:67–72.

32. Schurr JD, Venkatesh AK. The growing role of emergency departments in hospital admissions. N Engl J Med. 2012;367:391–393.

33. Hyde LZ, Al-Marzouk AM, Kuntzkes BA, et al. Readmissions after colorectal surgery: not all are equal. Int J Colorectal Dis. 2018;33:1667–1674.

34. Diaz A, Dalmary D, Herbert C, et al. Association of county-level racial diversity and likelihood of a textbook outcome following pancreas surgery. Ann Surg Oncol. 2021;28:8076–8084.

35. Bolger JC, Al Azzawi M, Whoseley J, et al. Surgery by a minimally invasive approach is associated with improved textbook outcomes in oesophageal and gastric cancer. Eur J Surg Oncol. 2021;47:2332–2339.

36. Hyer JM, Tsilimigras DI, Diaz A, et al. High social vulnerability and “Textbook Outcomes” after cancer operation. J Am Coll Surg. 2022;231:351–359.

37. Arora P, Dhar A, Mohanty S, et al. The impact of surgical care. Ann Surg. 2015;261:290–296.

38. Schor JD, Venkatesh AK. The growing role of emergency departments in hospital admissions. N Engl J Med. 2012;367:391–393.

39. Hyde LZ, Al-Marzouk AM, Kuntzkes BA, et al. Readmissions after colorectal surgery: not all are equal. Int J Colorectal Dis. 2018;33:1667–1674.

40. Diaz A, Dalmary D, Herbert C, et al. Association of county-level racial diversity and likelihood of a textbook outcome following pancreas surgery. Ann Surg Oncol. 2021;28:8076–8084.

41. Bolger JC, Al Azzawi M, Whoseley J, et al. Surgery by a minimally invasive approach is associated with improved textbook outcomes in oesophageal and gastric cancer. Eur J Surg Oncol. 2021;47:2332–2339.

42. Hyer JM, Tsilimigras DI, Diaz A, et al. High social vulnerability and “Textbook Outcomes” after cancer operation. J Am Coll Surg. 2022;231:351–359.

43. Arora P, Dhar A, Mohanty S, et al. The impact of surgical care. Ann Surg. 2015;261:290–296.

44. Schor JD, Venkatesh AK. The growing role of emergency departments in hospital admissions. N Engl J Med. 2012;367:391–393.

45. Hyde LZ, Al-Marzouk AM, Kuntzkes BA, et al. Readmissions after colorectal surgery: not all are equal. Int J Colorectal Dis. 2018;33:1667–1674.

46. Diaz A, Dalmary D, Herbert C, et al. Association of county-level racial diversity and likelihood of a textbook outcome following pancreas surgery. Ann Surg Oncol. 2021;28:8076–8084.

47. Bolger JC, Al Azzawi M, Whoseley J, et al. Surgery by a minimally invasive approach is associated with improved textbook outcomes in oesophageal and gastric cancer. Eur J Surg Oncol. 2021;47:2332–2339.

48. Hyer JM, Tsilimigras DI, Diaz A, et al. High social vulnerability and “Textbook Outcomes” after cancer operation. J Am Coll Surg. 2022;231:351–359.

49. Arora P, Dhar A, Mohanty S, et al. The impact of surgical care. Ann Surg. 2015;261:290–296.

50. Schor JD, Venkatesh AK. The growing role of emergency departments in hospital admissions. N Engl J Med. 2012;367:391–393.
51. Kwan LY, Stratton K, Steinwachs DM; National Academies of Sciences E, Medicine. eds. Accounting for Social Risk Factors in Medicare Payment. The National Academies Press; 2017:580. https://www.nap.edu/catalog/23635/accounting-for-social-risk-factors-in-medicare-payment. Accessed January 31, 2022.

52. Chen LM, Epstein AM, Orav EJ, et al. Association of practice-level social and medical risk with performance in the medicare physician value-based payment modifier program. JAMA. 2017;318:453–461.

53. Khullar D, Schpero WL, Bond AM, et al. Association between patient social risk and physician performance scores in the first year of the merit-based incentive payment system. JAMA. 2020;324:975–983.

54. Loehrer AP, Chang DC, Scott JW, et al. Association of the affordable care act medicaid expansion with access to and quality of care for surgical conditions. JAMA Surg. 2018;153:e175568.

55. Mathes T, Pieper D, Morche J, et al. Pay for performance for hospitals. Cochrane Database Syst Rev. 2019;7:CD011156.