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Failure to rescue after major abdominal surgery: The role of hospital safety net burden

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A B S T R A C T

Background: We aimed to examine whether safety-net burden is a significant predictor of failure-to-rescue (FTR) after major abdominal surgery controlling for patient and hospital characteristics, including surgical volume.

Methods: Data were extracted from the 2007–2011 Nationwide Inpatient Sample. FTR was defined as mortality among patients experiencing major postoperative complications. Differences in rates of complications, mortality, and FTR across quartiles of safety-net burden were assessed with univariate analyses. Multilevel regression models were constructed to estimate the association between FTR and safety-net burden.

Results: Among 238,645 patients, the incidence of perioperative complications, in-hospital mortality, and FTR were 33.7%, 4.4%, and 11.8%, respectively. All the outcomes significantly increased across the quartiles of safety-net burden. In the multilevel regression analyses, safety-net burden was a significant predictor of FTR after adjustment for patient and hospital characteristics, including hospital volume.

Conclusion: Increasing hospital safety-net burden is associated with higher odds of FTR for major abdominal surgery.

Introduction

Failure to rescue (FTR) has been defined as the occurrence of death after a severe, potentially preventable complication.[1] It is recognized as an important hospital quality care metric and an indicator of how effective the resources and processes of a hospital are coordinated to overcome postoperative adverse events.[2,3] Although patient demographics and clinical characteristics are strong predictors of complications and death, FTR has been more strongly associated with hospital factors than patient characteristics.[4] Multiple hospital factors have been linked to variation in FTR rates, including hospital surgical volume,[5,6] hospital technology [7], teaching status, bed size, intensive care unit availability, and hospital staffing models.[8] It is not surprising that the postoperative mortality varies widely across hospitals, without a direct correlation between hospital rate of complications and mortality, thus high-mortality hospitals do not necessarily have high rates of postoperative complications.[4]

According to the Institute of Medicine definition, a safety-net hospital is one that organizes and delivers a significant level of health care and other related services to uninsured, Medicaid, and other vulnerable patients.[9] Studies have found significantly worse mortality rates, prolonged length of hospital stay, and higher costs of care in hospitals with highest safety-net burden.[10–14] However, the association between hospital safety-net burden and FTR has not been investigated in depth.[8,15] Assessment of the effect of safety-net burden on FTR should account for patient-level and hospital-level factors, including patient socioeconomic status, based on the high proportion of disadvantaged patients, and known strong hospital predictors of outcomes, such as surgical volume and other hospital-level macro-system factors.

Major abdominal surgery carries a significant risk of postoperative morbidity and mortality. Rather than the rate of postoperative complications driving the mortality, Ghaferi et al.[4] found

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that FTR correlated more avidly with mortality rates after 6 major operations, including major abdominal surgery. The relationship between hospital characteristics and FTR after major abdominal surgery is not well understood, particularly in a safety-net hospital setting.[16] We aimed to study whether safety-net burden is a significant and independent predictor of in-hospital FTR after major abdominal surgery after controlling for the effects of patient demographics and comorbidities and hospital characteristics, including hospital surgical volume. We hypothesized that hospitals with highest safety-net burden will have higher adjusted FTR rates compared with hospitals with lowest safety-net burden.

Methods

Source of data

Because of the publicly available and de-identified nature of the data, the study was exempt from review by the Institutional Review Board of the University of Texas Southwestern Medical Center. Data were extracted from the 2007 to 2011 Nationwide Inpatient Sample (NIS) databases of the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). The NIS is an administrative, stratified, survey-weighted sample of 20% of all hospital discharges in the United States. Data on approximately 8 million hospital discharges from non-federal acute care hospitals located in the United States are available per year in the database. The main component of the NIS consist of a large core of annual data including patient demographics, insurance status, discharge status, length of hospital stay, direct hospital charges, up to 25 variables with diagnosis codes, and up to 25 variables containing procedure codes. HCUP also provides smaller annual databases containing hospital characteristics, which can be linked to the core NIS data sets. Up until 2011, the survey methodology allowed the inclusion of all the discharges from each of the hospitals that were randomly selected for inclusion in the NIS. In 2012, the sample design of the NIS (renamed National Inpatient Sample) was revised to create a sample of discharge records from each HCUP-participating hospital, rather than all discharge records from a sample of hospitals. This change restrains accurate calculation of variables including safety-net burden rate or annual hospital surgical volume, which require availability of all discharge records from a hospital to be included in the denominator. Because of this sampling strategy, we limited the study to the years 2007–2011. Complete documentation of the NIS can be found at http://www.hcup-us.ahrq.gov/nisoverview.jsp.

Selection of patients

Inclusion criteria included 5 major abdominal operations: colorectal resection, pancreatectomy, gastrectomy, liver resection, or esophagectomy. Patients undergoing these operations were identified using principal International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) procedure codes. Exclusion criteria included transfer to another acute care hospital (n = 2425), discharge against medical advice (n = 240), admission for trauma (1,546), or missing data on gender (n = 237), primary payer (n = 517), information on death during hospital stay (n = 199), or discharge status (n = 192).

Outcome variables

FTR was the primary outcome measure for the analyses and was calculated based on a numerator of the number of patients who had a major complication and died in the hospital and a denominator comprised by the total number of patients experiencing any of following eight major postoperative complications: respiratory failure, pneumonia, myocardial infarction, deep venous thrombosis or pulmonary embolism, acute renal failure, hemorrhage, surgical site infection, or gastrointestinal bleeding. The major postoperative complications were identified as described in previous studies [7,17] and defined using specific ICD-9-CM codes (Appendix A). We selected this subset of validated complications based on previous studies that have shown good agreement between ICD-9-CM coding and chart review.[18,19]

Hospital safety-net burden

Hospital safety-net burden was calculated annually for each hospital as the number of patients admitted to a hospital in a year and who were uninsured or insured by Medicaid, divided by the total number of patients admitted to the hospital in the respective year.

The numbers for the calculation of safety-net burden rate not only included admissions for major abdominal surgical procedures but all hospital admissions (medical and surgical). Hospitals were further categorized into quartiles of safety-net rate. The quartiles were calculated separately for each year based on the safety-net burden distribution of the hospitals included in the analysis. Variation on the thresholds to define the safety-net burden quartiles across the study years was minimal, and as a result, the quartiles were defined as follows: lowest quartile, 0–14%; low quartile, 14%–21%; medium quartile, 21%–30%, and highest quartile, > 30%.

Covariates

Patient demographics and comorbidities, and hospital characteristics were included in the analyses as covariates. Patient characteristics including gender, age, primary payer, race/ethnicity, and median household income for the patient's ZIP code (categorized in quartiles) were obtained directly from the NIS databases. The Deyo adaptation of the Charlson Comorbidity Index was used as a summary measure of a patient's global comorbidity burden [20] and 29 individual Elixhauser comorbidity measures were created from ICD-9-CM diagnosis codes using the HCUP Clinical Classification Software (CCS) definitions [Clinical Classifications Software for ICD-9-CM. Available at: http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp accessed March 14, 2019]. Hospital surgical volume was defined as the annual number of the five major abdominal surgical procedures performed by each hospital represented in the database. Hospitals were then categorized according to tertiles of procedure volume, which were calculated separately for each year. For example, for year 2011 the low, medium, and high tertiles of hospital volume were 1–15, 16–54, and >54 cases per year, respectively. Other hospital characteristics included teaching status of the hospital, bed size (small, medium, and large, as defined by Healthcare Cost and Utilization Project of the AHRQ), location of the hospital (urban or rural), and geographic region (Northeast, Midwest, South, and West).

Statistical analysis

Univariate analyses were used to describe baseline characteristics of the study cohort as a whole and stratified by quartiles of safety net burden. Differences among the groups were assessed with chi-square tests. Rates of major complications and FTR were compared across quartiles of safety-net burden using Cochran-Armitage trend tests. The unadjusted likelihood of complications and FTR between the lowest and highest quartiles of safety-net burden was compared using odds ratios with 95% confidence intervals (CI) derived from logistic regression analysis. Univariate

Table 1
Baseline characteristics of patients stratified by quartile of safety-net burden.

Safety-net Burden Quartiles						P Value
Characteristic	Total Patients in Cohort n(%)	Lowest quartile n(%)	Low quartile n(%)	Medium quartile n(%)	Highest quartile n(%)	
Sex						<.0001
Female	125,627 (47.4)	32,472 (52.9)	35,144 (53.4)	32,261 (52.8)	25,750 (51.2)	
Male	113,018 (52.6)	28,950 (47.1)	30,680 (46.6)	28,862 (47.2)	24,526 (48.8)	
Age, years						<.0001
18 to 39	16,462 (6.9)	3805 (6.19)	4276 (6.5)	4131 (6.8)	4250 (8.45)	
40 to 64	100,550 (42.1)	25,193 (41.0)	27,054 (41.1)	25,441 (41.6)	22,862 (45.5)	
65 to 74	57,427 (24.1)	14,849 (24.2)	15,794 (24.0)	15,039 (24.6)	11,745 (23.4)	
75+	64,206 (26.9)	17,575 (28.6)	18,700 (28.4)	16,512 (27.0)	11,419 (22.7)	
Primary Payer						<.0001
Private Insurance	91,092 (38.2)	26,767 (43.6)	25,636 (39.0)	22,442 (36.7)	16,247 (32.3)	
Medicare	118,691 (49.7)	30,835 (50.2)	33,861 (51.4)	31,255 (51.1)	22,740 (45.2)	
Medicaid	13,945 (5.8)	1705 (2.8)	2970 (4.5)	3604 (5.9)	5666 (11.3)	
No insurance/other	14,917 (6.2)	2115 (3.4)	3357 (5.1)	3822 (6.3)	5623 (11.2)	
Race/ethnicity						<.0001
Non-Hispanic White	153,856 (64.5)	42,042 (68.5)	44,982 (68.3)	3,9859 (65.2)	26,973 (53.6)	
Black	19,368 (8.1)	3340 (5.4)	3807 (5.8)	5551 (9.1)	6670 (13.3)	
Hispanic	14,168 (5.9)	2803 (4.6)	2644 (4.0)	2961 (4.8)	5760 (11.5)	
Other/unknown	51,253 (21.5)	13,237 (21.5)	14,391 (21.9)	12,752 (20.9)	10,873 (21.6)	
Quartile median income for ZIP code						<.0001
Lowest quartile	57,010 (24.4)	7765 (12.9)	13,386 (20.7)	17,853 (29.83)	18,006 (36.9)	
Low quartile	61,238 (26.2)	12,206 (20.2)	18,161 (28.1)	17,601 (29.41)	13,270 (27.2)	
Medium quartile	59,171 (25.3)	15,993 (26.5)	18,175 (28.1)	14,300 (23.9)	10,703 (21.9)	
Highest quartile	56,244 (24.1)	24,435 (40.4)	14,867 (23.1)	10,087 (16.86)	6855 (14.0)	
Categories of Charlson index						<.0001
0 - 1	73,898 (31.0)	18,933 (30.8)	21,447 (32.6)	19,036 (31.1)	14,482 (28.8)	
2 - 3	81,258 (34.0)	20,141 (32.8)	22,588 (34.3)	21,230 (34.7)	17,299 (34.4)	
4+	83,489 (35.0)	223,48 (36.4)	21,789 (33.1)	20,857 (34.2)	18,495 (36.8)	
Hospital surgical volume						<.0001
Lowest tertile	8505 (3.6)	2198 (3.6)	1953 (2.9)	1954 (3.2)	2400 (4.8)	
Medium tertile	43,528 (18.2)	8458 (13.8)	10,705 (16.3)	13,208 (21.6)	11,157 (22.2)	
Highest tertile	186,612 (78.2)	50,766 (82.6)	53,166 (80.8)	45,961 (75.2)	36,719 (73.0)	
Geographic region of hospital						<.0001
Northeast	46,212 (19.4)	16,772 (27.3)	13,838 (21.0)	10,131 (16.6)	5471 (10.9)	
Midwest	57,712 (24.2)	16,368 (26.7)	19,326 (29.4)	14,099 (23.1)	7919 (15.8)	
South	87,887 (36.8)	13,270 (21.6)	24,540 (37.3)	25,476 (41.7)	24,601 (48.9)	
West	46,834 (19.6)	15,012 (24.4)	8120 (12.3)	11,417 (18.6)	12,285 (24.4)	
Hospital bed size						<.0001
Small	26,732 (11.1)	11,159 (18.1)	7022 (10.6)	4835 (7.9)	3784 (7.4)	
Medium	52,895 (22.1)	13,413 (21.8)	15,452 (23.4)	13,012 (21.2)	11,287 (22.1)	
Large	157,112 (65.8)	36,942 (60.0)	43,187 (65.5)	42,721 (69.5)	35,447 (69.4)	
Urban location of hospital	210,207 (88.1)	58,756 (95.7)	56,808 (86.3)	50,928 (83.3)	43,715 (87.0)	<.0001
Teaching status of hospital	119,420 (50.1)	32,078 (52.2)	30,406 (46.2)	26,156 (42.8)	30,780 (61.2)	<.0001
Elective vs. non-elective admission	135,200 (56.3)	37,958 (61.8)	36,884 (56.0)	33,239 (54.4)	27,052 (53.8)	<.0001
Admission on a weekend	25,148 (10.5)	5899 (9.6)	7263 (11.0)	6785 (11.1)	5201 (10.3)	<.0001
Type of surgery						<.0001
Colorectal	194,432 (81.5)	48,892 (79.6)	56,663 (86.1)	51,487 (84.2)	37,390 (74.3)	
Pancreatectomy	15,391 (6.5)	4213 (6.9)	2975 (4.5)	3181 (5.2)	5022 (10.0)	
Gastrectomy	14,493 (6.1)	3729 (6.1)	3426 (5.2)	3486 (5.7)	3852 (7.7)	
Liver resection	10,313 (4.3)	3165 (5.2)	1953 (3.0)	2174 (3.6)	3021 (6.0)	
Esophagectomy	4016 (1.7)	1423 (2.3)	807 (1.2)	795 (1.3)	991 (2.0)	

logistic regression analyses were used to examine patient and hospital characteristics associated with FTR. Multilevel generalized regression models with fixed and random effects were constructed to estimate the association between FTR and safety-net burden taking into account the correlated nature of the data, where patients were clustered into hospitals. Random intercepts for hospitals were fit using the GLIMMIX procedure of the SAS software, where the HCUP hospital identification number was used as the "subject" on the random statement. A binary distribution was specified for the models. FTR was the dependent variable and safety-net burden was considered the independent variable of interest in the models. Patient and hospital characteristics were incrementally entered in the models as fixed effects. The first regression model assessed the univariate association between FTR and quartiles of safety-net burden. A second model assessed the association of FTR and safety-net burden after adjusting for patient characteristics (demographics, comorbidities summarized as categories of Charlson Comorbidity Index, median household income for the patient's ZIP code, type of surgical procedure, and type of admission (elective vs. non-elective, weekend vs. weekday). A final model was constructed to adjust for all the variables present in the second model plus several hospital characteristics, including tertiles of hospital surgical volume, teaching status, hospital location (urban vs. rural), bed size, and hospital geographic region. Sensitivity analyses were performed adjusting for patient comorbidities using all the Elixhauser comorbidities as fixed effects in the models instead of the Charlson Index. As the results were basically identical, we reported the more parsimonious models using the Charlson comorbidity scores. Using similar generalized regression models, further sensitivity analyses were performed by subgroup of major abdominal surgical procedures. All the analyses were conducted using SAS 9.4 statistical software (Cary, NC). P values of < 0.05 were considered statistically significant.

Table 2
Major complications and failure to rescue stratified by quartiles of safety-net burden.

Outcomes	Total Cohort of Patients	Safety-net Burden Quartiles				Odds Ratio (95% CI), highest vs. lowest quartile	P value
		Lowest quartile	Low quartile	Medium quartile	Highest quartile		
Major Complications, n(%)							
Any Complication	80,349 (33.7)	19,588 (31.9)	22,283 (33.9)	21,034 (34.4)	17,444 (34.7)	1.14 (1.11–1.16)	<.0001
Respiratory failure	30,623 (12.8)	6904 (11.2)	8594 (13.1)	8335 (13.6)	6790 (13.5)	1.23 (1.20–1.30)	<.0001
Pneumonia	18,386 (7.8)	4317 (7.0)	5064 (7.7)	4990 (8.2)	4015 (8.0)	1.15 (1.10–1.20)	<.0001
Acute myocardial infarction	3408 (1.4)	739 (1.2)	1013 (1.5)	916 (1.5)	740 (1.5)	1.23 (1.11–1.36)	0.0007
Deep vein thrombosis or pulmonary embolism	3880 (1.6)	1035 (1.7)	1004 (1.5)	979 (1.6)	862 (1.7)	1.04 (0.95–1.14)	0.5708
Acute renal failure	22,673 (9.5)	5307 (8.6)	6403 (9.7)	6116 (10.0)	4847 (9.6)	1.13 (1.08–1.17)	<.0001
Gastrointestinal bleeding	8489 (3.6)	1920 (3.1)	2238 (3.4)	2282 (3.7)	2049 (4.1)	1.32 (1.24–1.40)	<.0001
Postoperative hemorrhage	29,795 (12.5)	7527 (12.3)	8313 (12.6)	7715 (12.6)	6240 (12.4)	1.02 (0.99–1.06)	0.3882
Surgical site infection	13,076 (5.5)	3495 (5.7)	3396 (5.2)	3162 (5.2)	3023 (6.0)	1.06 (1.01–1.12)	0.0686
Unadjusted Mortality rate, n(%)	10,524 (4.4)	2249 (3.7)	2904 (4.4)	2903 (4.8)	2468 (4.9)	1.36 (1.28–1.44)	<.0001
Failure-to-Rescue, n(%)							
Any Complication	9453 (11.8)	2048 (10.5)	2620 (11.8)	2615 (12.4)	2170 (12.4)	1.22 (1.14–1.30)	<.0001
Respiratory failure	7318 (23.9)	1593 (23.1)	2044 (23.8)	2020 (24.2)	1661 (24.5)	1.08 (1.00–1.17)	0.0427
Pneumonia	3264 (17.7)	719 (16.7)	885 (17.5)	916 (18.4)	744 (18.5)	1.13 (1.02–1.27)	0.012
Acute myocardial infarction	988 (29.0)	204 (27.6)	287 (28.3)	278 (30.4)	219 (29.6)	1.10 (0.88–1.38)	0.2588
Deep vein thrombosis or pulmonary embolism	562 (14.5)	116 (11.2)	152 (15.1)	153 (15.6)	141 (16.4)	1.55 (1.19–2.02)	0.0014
Acute renal failure	5457 (24.1)	1221 (23.0)	1516 (23.7)	1482 (24.2)	1238 (25.5)	1.15 (1.05–1.26)	0.0024
Gastrointestinal bleeding	820 (9.7)	171 (8.9)	205 (9.2)	245 (10.7)	199 (9.7)	1.10 (0.88–1.36)	0.1644
Postoperative hemorrhage	2088 (7.0)	456 (6.1)	576 (6.9)	574 (7.4)	482 (7.7)	1.30 (1.14–1.48)	<.0001
Surgical site infection	892 (6.8)	207 (5.9)	224 (6.6)	226 (7.2)	235 (7.8)	1.34 (1.10–1.63)	0.002

Results

A total of 238,645 major abdominal surgical procedures performed at 2551 hospitals in the United States were identified in the 2007 to 2011 NIS datasets. The majority of the procedures were colorectal resections. Baseline characteristics of the study cohort stratified by quartile of safety-net rate are displayed in Table 1. Most patients were men, of non-Hispanic white race/ethnicity, insured by Medicare, and with a median (IQR) age of 65 (53–75) years. Compared to the lowest quartile, patients treated at hospitals in the highest quartile of safety-net burden were significantly younger, more likely to be black or Hispanic, more likely to live in ZIP code areas within the lowest quartile of median household income, and less likely to have had their operations performed in high surgical volume hospitals. Most patients in the highest quartile of safety-net burden had the procedures done in teaching hospitals and in institutions located in the South region of the United States.

The overall incidence of perioperative complications and in-hospital mortality were 33.7% (80,349/238,645) and 4.4% (10,524/238,645), respectively. The mortality rate among the patients who experienced one or more complications (FTR rate) was 11.8% (9453 deaths in 80,349 patients with major complications). The overall rate of complications, mortality, and FTR significantly increased across the quartiles of safety-net burden (Table 2). Analysis of individual complications revealed no significant incidence differences across the quartiles of safety-net burden for deep venous thrombosis/pulmonary embolism, postoperative hemorrhage, or surgical site infection. However, these individual complications had the strongest impact (highest odds ratios) on the differences of FTR rates between patients treated in hospitals with highest vs. lowest safety-net burden (Table 2).

Our univariate analysis revealed a significant association between safety-net burden and FTR. Compared to the reference (lowest) quartile, the odds ratios for FTR steadily increased across quartiles of safety-net burden (Table 3). Other hospital characteristics, including hospital surgical volume, and several patient variables were also significantly associated with FTR. Table 4 summarizes the results of our multilevel generalized regression models. The unadjusted model reveals that after accounting for the clustered nature of the data, safety-net burden was significantly associated with FTR, with patients in the highest quartiles of safety-net burden having increased odds of FTR. The significant association between increasing safety-net burden and FTR persisted after adjustment for patient characteristics, type of surgical procedure, and type of hospital admission (model 2). Of note, the statistical significance of household income for patient's ZIP code lost significance after adjustment for the other factors (Appendix B). Finally, safety-net burden was still a significant predictor of FTR after adjustment for patient and hospital characteristics (model 3). In this final model, hospital surgical volume was a predictor of FTR with borderline statistical significance ($P = 0.044$) after adjustment for safety-net burden and the other variables (Appendix B). Our sensitivity analyses by type of major surgery procedure revealed that after adjustment for patient and hospital characteristics, safety-net burden was significantly associated with FTR for colon resection procedures [OR (95% CI) for highest vs. lowest quartile of safety-net, 1.17 (1.05–1.29), $P = 0.007$], liver resection [OR (95% CI), 1.14 (1.10–2.44), $P = 0.025$], and esophagectomy [2.25 (1.28–3.96), $P = 0.002$]. A statistically non-significant association between FTR and increasing quartiles of safety-net burden was observed for gastrectomy [OR (95% CI), 1.30 (0.98–1.72), $P = 0.238$] and for pancreatectomy [OR (95% CI) 1.13 (0.85–1.52), $P = 0.212$].

Discussion

Our analysis of a large sample of national hospital discharges revealed that high safety-net burden is an independent predictor of FTR after major abdominal surgical procedures. The association between safety-net burden and FTR persisted even after adjustment for patient factors and important hospital characteristics such as hospital volume of surgical procedures. To our knowledge, this is the first study to assess the association between FTR and safety-net burden, accounting for the potential confounding effects of hospital surgical volume, median household income in the patient's zip

Table 3
Univariate analysis of factors associated with failure to rescue.

Characteristic	Number (%)	Odds ratio (95% CI)	P Value
Safety-net quartiles			<.0001
Lowest quartile	2048 (10.5)	ref	
Low quartile	2620 (11.8)	1.14 (1.07–1.21)	
Medium quartile	2615 (12.4)	1.22 (1.14–1.29)	
Highest quartile	2170 (12.4)	1.22 (1.14–1.30)	
Hospital surgical volume, tertiles			<.0001
Highest tertile	7236 (11.4)	ref	
Medium tertile	1913 (12.9)	1.15 (1.09–1.22)	
Lowest tertile	304 (13.5)	1.21 (1.07–1.37)	
Patient's Sex			0.0617
Female	4802 (11.6)	ref	
Male	4651 (12.0)	1.04 (0.99–1.08)	
Age, yrs			<.0001
18 to 39	129 (3.9)	ref	
40 to 64	2035 (7.5)	1.96 (1.64–2.36)	
65 to 74	2366 (11.5)	3.17 (2.64–3.80)	
75+	4923 (16.9)	4.95 (4.14–5.92)	
Primary Payer			<.0001
Private Insurance	1471 (6.7)	ref	
Medicare	7081 (14.4)	2.34 (2.21–2.48)	
Medicaid	517 (10.4)	1.61 (1.45–1.79)	
No insurance/other	384 (8.9)	1.37 (1.21–1.54)	
Race/ethnicity			<.0001
Non-Hispanic White	6287 (12.2)	ref	
Black	806 (10.8)	0.87 (0.81–0.94)	
Hispanic	520 (11.5)	0.94 (0.85–1.03)	
Other/unknown	1840 (11.0)	0.90 (0.85–0.94)	
Quartile income for ZIP code			0.0056
Highest quartile	1924 (11.1)	ref	
Medium quartile	2308 (11.7)	1.06 (0.99–1.13)	
Low quartile	2488 (12.1)	1.10 (1.03–1.17)	
Lowest quartile	2528 (12.1)	1.11 (1.04–1.18)	
Categories of Charlson index			<.0001
0 - 1	1528 (8.8)	ref	
2 - 3	3719 (12.6)	1.50 (1.41–1.60)	
4+	4206 (12.6)	1.49 (1.40–1.59)	
Geographic region of hospital			<.0001
Northeast	1892 (12.9)	ref	
Midwest	2101 (10.5)	0.79 (0.74–0.84)	
South	3616 (12.0)	0.91 (0.86–0.97)	
West	1844 (12.0)	0.92 (0.86–0.98)	
Hospital bed size			0.1108
Small	937 (11.4)	ref	
Medium	2213 (12.2)	1.08 (0.99–1.17)	
Large	6307 (11.7)	1.03 (0.95–1.10)	
Location of hospital			0.2871
Rural	970 (12.1)	ref	
Urban	8403 (11.7)	0.96 (0.89–1.03)	
Teaching status of hospital			<.0001
Teaching	4437 (11.1)	ref	
Non-teaching	4936 (12.5)	1.14 (1.09–1.19)	
Type of admission			<.0001
Elective	1932 (6.1)	ref	
Non-elective	7494 (15.5)	2.83 (2.69–2.99)	
Admission day			<.0001
Weekday	7497 (11.0)	ref	
Weekend	1956 (16.1)	1.53 (1.45–1.61)	
Type of surgery			<.0001
Colorectal	7824 (12.3)	ref	
Pancreatectomy	472 (8.8)	0.69 (0.63–0.76)	
Gastrectomy	769 (10.9)	0.87 (0.80–0.94)	
Liver resection	226 (8.7)	0.68 (0.62–0.78)	
Esophagectomy	162 (8.5)	0.66 (0.57–0.78)	

code, and other patient and hospital characteristics.

Previous studies have reported that high-safety-net burden hospitals have inferior outcomes, including higher postoperative mortality and readmission rates.[10,11,13] However, very few studies have investigated the association between safety-net burden and FTR, a quality metric more closely linked to hospital performance than to patient characteristics.[8,21,22] Wakeam et al.[8] found that high safety-net burden was an independent predictor of FTR after high-risk abdominal, thoracic, and vascular operations. However, the study did not examine the impact of hospital surgical volume or patient socioeconomic status on outcomes. In contrast, in a cohort of inpatients who underwent emergency appendectomy, cholecystectomy, or herniorrhaphy, Shahan et al.[22] found that safety net hospitals had higher complication rates but no differences in FTR or mortality. Similarly, Bell et al.[21] found no association between safety-net burden and FTR in a cohort of trauma patients. Disparities in the findings of those studies may be explained by differences in the type of procedures and patient populations analyzed.

Our univariate analysis demonstrated that the likelihood of FTR steadily increased across the quartiles of safety-net burden, suggesting that the odds of FTR after major abdominal surgery is higher at hospitals that treat a large proportion of Medicaid or uninsured patients. Similar to other studies,[8,21–23] in our study cohort, patients within the highest quartile of safety-net burden were more likely to be of low income or of minority race or ethnicity; to have more non-elective admissions; and less likely to be treated in high-volume urban hospitals. All these factors are known to increase the risk of mortality and FTR. In contrast, patients in the highest quartile of safety-net burden were also younger and more likely to be treated in large teaching hospitals, factors that have been linked to decreased likelihood of FTR.[12,22,23] Defining the association between safety-net burden and FTR safety-net burden is, therefore, challenging given the large number of confounders that may affect this relationship. Nonetheless, the current study confirmed a significant association between higher hospital safety-net burden and higher odds of FTR after adjustment for all the patient and hospital characteristics available in the database using multivariable analyses.

Patient socioeconomic status is a strong predictor of postoperative adverse events. However, in the context of a safety-net burden analysis, it is difficult to separate the impact of patient socioeconomic status and hospital safety-net burden on outcomes. Low socioeconomic status has been linked to higher rates FTR,[24] readmissions,[25] and mortality.[26] In our study, a greater percentage of patients from the lowest quartile of household income were treated at hospitals within the highest quartile of safety-net burden. Although the NIS data do not provide variables for a complete measurement of patient socioeconomic status, we found that the unadjusted likelihood of FTR was significantly higher for patients living in ZIP code areas with lowest income. Furthermore, patients treated at highest safety-net burden hospitals experienced increased FTR rates, regardless of their level of household income. It is important to note that the effect of household income on FTR lost statistical significance after adjustment for safety-net burden, suggesting that in-hospital mortality after postoperative complications may be more strongly linked to the hospital environment of high safety-net burden hospitals than to the socioeconomic factors of the individual patient.

Surgical volume is a hospital characteristic that has been found strongly associated with postoperative outcomes, including FTR.[5,6,16,27,28] In our study, patients treated at hospitals in the lowest tertile of hospital volume had increased odds of FTR, confirming the findings of previous reports. When safety-net burden and hospital volume were both included in our multivariable models, safety-net burden remained an independent and strong predictor of FTR, while the statistical significance of hospital volume was decreased. This finding may indicate that the beneficial impact of a high surgical volume on outcomes may be attenuated by some intrinsic characteristics of high safety net hospitals that become barriers to the rescue of patients who undergo serious postoperative complications.

Table 4
Multivariable analysis of the association between failure to rescue and safety net burden.

Characteristic	Model 1: Unadjusted		Model 2: Patient characteristics		Model 3: Patient And Hospital characteristics	
	Odds ratio (95% CI)	P Value	Odds ratio (95% CI)	P Value	Odds ratio (95% CI)	P Value
Safety-net quartiles		<.0001		0.0005		0.0031
Lowest quartile	Reference		Reference		Reference	
Low quartile	1.10 (1.01–1.19)		1.08 (1.00–1.18)		1.09 (1.01–1.19)	
Medium quartile	1.17 (1.08–1.27)		1.16 (1.06–1.26)		1.16 (1.06–1.27)	
Highest quartile	1.21 (1.11–1.32)		1.20 (1.10–1.31)		1.18 (1.08–1.30)	

Model 1 is the unadjusted model. Model 2 is adjusted for patient demographics, comorbidities, median household income for the patient's ZIP code, type of surgical procedure, and type of admission (elective vs. non-elective, weekend vs. weekday). Model 3 is adjusted for all the variables present in model 2 plus tertiles of hospital surgical volume, teaching status, hospital location (urban vs. rural), bed size, and hospital geographic region.

This study reveals that patient characteristics and hospital macrosystem factors (teaching status, hospital bed size, etc.) do not fully explain why FTR is increased in high safety-net burden hospitals. Therefore, hospital microsystem variables (i.e., staff [medical and/or nursing] attitudes and behaviors and institutional safety culture) may be important determinants of differences in outcomes between high- and low-safety-net burden hospitals.[29] Microsystem factors may act as barriers to initiate appropriate escalation of care needed to rescue the patient when a complication occurs. Escalation of care includes the identification of clinical deterioration followed by an effective team communication and response to deterioration.[30] In various studies, clinical inexperience,[31] high workload,[31–34] and overconfidence [32] have been associated with failure to identify clinical deterioration. Similarly, hierarchical barriers within the team, fear of intimidation or criticism, a desire for independence, and frequent interruptions or distractions during clinical work have been linked to failures in effective team communication.[31,34–36] Institutional safety culture is an additional microsystem factor that may affect FTR in high safety-net burden hospitals. As described by Ghaferi et al.,[37] culture can be seen as the forces in an organization that operate in the background and are modeled by the values, beliefs, norms, and traditions of the organization. The institutional safety culture may interact with the human factors cited above to facilitate or obstruct escalation of care processes. However, data on how human factors and institutional safety culture affect FTR in safety net hospitals are scant.

Our study has several limitations, primarily related to the nature of the administrative dataset, that need to be acknowledged. First, the coding used to define comorbidities may be inaccurate or incomplete, leading to imprecisions regarding risk adjustment for patient clinical characteristics. Important variability may exist among hospitals regarding their accuracy to assign appropriate codes to diagnosis and procedures generated during an inpatient visit. In addition, the severity or chronicity of comorbid conditions cannot be clearly determined from the diagnosis codes. The definition of postoperative complications based on ICD-9CM codes available in the database may suffer from potential coding inaccuracies. However, we attempted to overcome this shortcoming by using validated codes as described above. Although we used median income of patient's ZIP code in the analysis, a more accurate measure of patient's socio-economic status, such as level of education, employment, and household income was lacking in the database. We used overall hospital surgical volume of all the procedures included in the study as one of our predictor variables of FTR. However, for some hospitals, the volume classification by specific procedure may have been different to that assigned to the hospital based on the overall volume of the combined procedures. This limitation may have confounded the association between FTR and hospital volume. As described in the methods section, we were unable to include data after 2011 in our analysis due to the change in the sampling methodology of the NIS. In order to make the study sample more homogeneous, we excluded laparoscopic colon resection cases. Therefore, our findings may not apply to laparoscopic colectomy, where the FTR rate may be lower and the interaction with safety-net burden may be different to what we found in the open procedures. Most cases in our study consisted of colorectal procedures. This may limit the generalizability of our findings. However, a similar tendency to increasing FTR rates with increasing safety-net burden was observed for most of the other major abdominal procedures despite a smaller sample size of the subgroups. Finally, we were unable to measure any of the hospital microsystem factors that may explain the differences in outcomes between highest and lowest safety-net burden hospitals.

Conclusions

Increasing hospital safety-net burden resulted in a higher rate of FTR after major abdominal surgery. This association persisted after adjusting for surgical volume and patient- and hospital-level variables. Our analyses further indicate that safety-net burden is more important than socioeconomic status in influencing FTR after major abdominal surgery. We surmise that there may be hospital microsystem variables that underpin the role of safety-net burden in FTR. Further research is needed to understand the effect of microsystem variables on FTR in hospitals with different levels of safety-net burden.

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Declarations of competing interest

None.

Appendix A. International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) Diagnosis Codes for Major Complications

Major Complication	Diagnosis ICD-9-CM Codes
Respiratory failure	518.81, 518.82, 518.84, 518.4, 518.5, 518.8, 967.2
Pneumonia	481, 482.0–482.9, 483, 484, 485, 486, 507.0
Myocardial infarction	410.00–410.91
Deep venous thrombosis or pulmonary embolism	415.1, 415.19, 451.11, 451.19, 451.2, 451.81, 453.40, 453.41, 453.42, 453.8
Acute renal failure	584, 584.5, 584.6, 584.7, 584.8, 584.9
Hemorrhage	285.1, 459.0, 568.81, 958.2, 998.11
Surgical site infection	958.3, 998.3, 998.5, 998.51, 998.59
Gastrointestinal bleeding	530.82, 531.00–531.21, 531.40, 531.41, 531.60, 531.61, 532.00–532.21, 532.40, 532.41, 532.60, 532.61, 533.00–533.21, 533.40, 533.41, 533.60, 533.61, 534.00–534.21, 534.40, 534.41, 534.60, 534.61, 535.01, 535.11, 535.21, 535.31, 535.41, 535.51, 535.61, 578.9

Appendix B. Multivariable regression models of predictors of failure to rescue

Characteristic	Model 1: Unadjusted			Model 2: Patient characteristics			Model 3: Patient and Hospital characteristics		
	Odds ratio	95% CI	P Value	Odds ratio	95% CI	P Value	Odds ratio	95% CI	P Value
Safety-net quartiles			<.0001			0.0005			0.0031
Lowest quartile	ref			ref			ref		
Low quartile	1.10	(1.01–1.19)		1.08	(1.00–1.18)		1.09	(1.01–1.19)	
Medium quartile	1.17	(1.08–1.27)		1.16	(1.06–1.26)		1.16	(1.06–1.27)	
Highest quartile	1.21	(1.11–1.32)		1.20	(1.10–1.31)		1.18	(1.08–1.30)	
Patient's Sex						<.0001			<.0001
Female				ref			ref		
Male				1.14	(1.09–1.20)		1.14	(1.09–1.20)	
Age, yrs						<.0001			<.0001
18 to 39				ref			ref		
40 to 64				2.00	(1.64–2.45)		1.99	(1.62–2.43)	
65 to 74				2.78	(2.26–3.43)		2.75	(2.23–3.39)	
75+				4.03	(3.28–4.97)		3.99	(3.24–4.92)	
Categories of Charlson index						<.0001			<.0001
0 - 1				ref			ref		
2 - 3				1.35	(1.26–1.45)		1.35	(1.26–1.45)	
4+				1.38	(1.29–1.48)		1.37	(1.27–1.49)	
Primary Payer						<.0001			<.0001
Private Insurance				ref			ref		
Medicare				1.37	(1.27–1.49)		1.37	(1.27–1.49)	
Medicaid				1.41	(1.25–1.56)		1.40	(1.24–1.58)	
No insurance/other				1.23	(1.08–1.40)		1.24	(1.08–1.41)	
Race/ethnicity						0.0003			<.0001
Non-Hispanic White				ref			ref		
Black				0.83	(0.77–0.91)		0.82	(0.75–0.89)	
Hispanic				0.91	(0.82–1.01)		0.90	(0.80–0.99)	
Other/unknown				0.97	(0.90–1.06)		0.98	(0.90–1.07)	
Quartile income for ZIP code						0.2573			0.0529
Highest quartile				ref			ref		
Medium quartile				1.05	(0.97–1.13)		1.08	(0.99–1.16)	
Low quartile				1.08	(1.00–1.16)		1.11	(1.03–1.20)	
Lowest quartile				1.05	(0.97–1.12)		1.06	(0.98–1.14)	
Type of admission						<.0001			<.0001
Elective				ref			ref		
Non-elective				2.79	(2.62–2.97)		2.78	(2.61–2.96)	
Admission day						<.0001			0.0001
Weekday				ref			ref		
Weekend				1.13	(1.06–1.20)		1.13	(1.06–1.20)	
Type of surgery						<.0001			0.0002
Colorectal				ref			ref		
Pancreatectomy				1.21	(1.08–1.35)		1.19	(1.07–1.34)	
Gastrectomy				1.05	(0.96–1.15)		1.05	(0.96–1.15)	
Liver resection				1.37	(1.17–1.61)		1.36	(1.16–1.60)	
Esophagectomy				1.22	(1.01–1.47)		1.20	(1.00–1.45)	
Hospital surgical volume, tertiles									0.0436
Highest tertile							ref		
Medium tertile							1.07	(0.99–1.17)	
Lowest tertile							1.23	(1.04–1.45)	

(continued on next page)

(*continued*)

Characteristic	Model 1: Unadjusted			Model 2: Patient characteristics			Model 3: Patient and Hospital characteristics		
	Odds ratio	95% CI	P Value	Odds ratio	95% CI	P Value	Odds ratio	95% CI	P Value
Geographic region of hospital									0.0002
Northeas							ref		
Midwest							0.81	(0.73–0.89)	
South							0.91	(0.84–1.00)	
West							0.96	(0.88–1.06)	
Hospital bed size									0.0646
Small							ref		
Medium							1.08	(0.97–1.20)	
Large							1.13	(1.02–1.26)	
Location of hospital									0.0152
Urban							ref		
Rural							0.88	(0.79–0.97)	
Teaching status of hospital									0.0960
Teaching							ref		
Non-teaching							0.94	(0.88–1.01)	

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