Original Investigation  | SURGICAL CARE OF THE AGING POPULATION

Socioeconomic Disparities in Mortality After Cancer Surgery Failure to Rescue

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IMPORTANCE Disparities in operative mortality due to socioeconomic status (SES) have been consistently demonstrated, but the mechanisms underlying this disparity are not well understood.

OBJECTIVE To determine whether variations in failure to rescue (FTR) contribute to socioeconomic disparities in mortality after major cancer surgery.

DESIGN, SETTING, AND PARTICIPANTS We performed a retrospective cohort study using the Medicare Provider Analysis and Review File and the Medicare Denominator File. A summary measure of SES was created for each zip code using 2000 US Census data linked to residence. Multivariable logistic regression was used to examine the influence of SES on rates of FTR, and fixed-effects hierarchical regression was used to evaluate the extent to which disparities could be attributed to differences among hospitals. A total of 596,222 patients undergoing esophagectomy, pancreatectomy, partial or total gastrectomy, colectomy, lung resection, and cystectomy for cancer from 2003 through 2007 were studied.

MAIN OUTCOMES AND MEASURES Operative mortality, postoperative complications, and FTR (case fatality after ≥1 major complication).

RESULTS Patients in the lowest quintile of SES had mildly increased rates of complications (25.6% in the lowest quintile vs 23.8% in the highest quintile, \( P = .003 \)), a larger increase in mortality (10.2% vs 7.7%, \( P = .0009 \)), and the greatest increase in rates of FTR (26.7% vs 23.2%, \( P = .007 \)). Analysis of hospitals revealed a higher FTR rate for all patients (regardless of SES) at centers treating the largest proportion of patients with low SES. The adjusted odds ratios (95% CIs) of FTR according to SES ranged from 1.04 (0.95–1.14) for gastrectomy to 1.45 (1.21–1.73) for pancreatectomy. Additional adjustment for hospital effect nearly eliminated the disparity observed in FTR across levels of SES.

CONCLUSIONS AND RELEVANCE Patients in the lowest quintile of SES have significantly increased rates of FTR. This finding appears to be in part a function of the hospital where patients with low SES are treated. Future efforts to improve socioeconomic disparities should concentrate on hospital processes and characteristics that contribute to successful rescue.

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Disparities in postoperative mortality based on socioeconomic status (SES) have been consistently demonstrated after major cancer surgery. Patients with low SES undergoing gastrectomy are 55% more likely to die after surgery compared with those with higher SES, and operative mortality after lung resection is 37% higher in low-income patients. Although some authors have concluded that patient characteristics account for a portion of these differences, other evidence suggests that hospital quality plays an important role in the socioeconomic variations observed in mortality.

The hospital mechanisms that contribute to increased mortality rates at centers that disproportionately treat patients of low SES remain poorly understood. Although it has long been assumed that increased rates of mortality are a consequence of higher rates of complications, recent studies of mortality variations after major surgery have challenged this notion, asserting that the timely recognition and treatment of complications once they occur may be a larger concern. Failure to rescue (FTR), first described by Silber and colleagues, signifies the inability to rescue a patient from death after a major complication. This notion has become an increasingly important concept in the current understanding of mortality variation because it explains a large portion of the variation in mortality rates among hospitals.

The objective of this study is to determine whether variation in FTR helps explain socioeconomic disparities in mortality rates after cancer surgery in Medicare patients who underwent 1 of 6 major cancer operations. For this analysis, a summary measure of SES was created that links 2000 US Census data (income, educational level, and employment) to zip code of residence, and multivariable logistic regression was used to examine its influence on rates of FTR. Insight into hospital-level mechanisms, such as FTR, that contribute to the inequalities seen in this subset of surgery patients could have significant implications for future health policy aimed at reducing variations in mortality after major cancer surgery.

Methods

Patients and Databases
We used data from the Medicare Provider Analysis and Review (MEDPAR) File, which includes inpatient claims data from the national Medicare database for the years 2003 to 2007. The claims data contain hospital discharge records for fee-for-service, acute care hospitalizations of all Medicare recipients. We used the Medicare Denominator File to determine the vital status of patients 30 days after surgery. Medicare patients enrolled in managed care plans were not included in this analysis because they do not appear in the MEDPAR File. We excluded Medicare patients younger than 65 years and older than 99 years. The institutional review board of the University of Michigan and the Centers for Medicare & Medicaid Services (CMS) approved this protocol and waived the requirement for informed consent.

Using appropriate International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes, we identified all patients with a corresponding cancer diagnosis undergoing 1 of 6 operations during the study period: esophagectomy (procedure codes 42.40, 42.41, 42.42, and 43.99; diagnosis codes 150-150.9; n = 14,562), pancreatectomy (procedure codes 52.51, 52.53, 52.6, and 52.7; diagnosis codes 152-152.9 and 156-157.9; n = 15,239), partial or total gastrectomy (procedure codes 43.5-43.99; diagnosis codes 151-151.9; n = 39,584), colectomy (procedure codes 45.73-45.76; diagnosis codes 153-153.9, 154; n = 42,474), lung resection (procedure codes 32.4 and 32.5; diagnosis codes 162-165.9; n = 80,395), and cystectomy (procedure codes 57.7-57.79; diagnosis codes 188-189.9; n = 22,968). These particular procedures were selected because they are complex high-risk operations and represent a broad range of cancer diagnoses and specialties. In addition, each operation has a risk of mortality high enough to ensure the necessary power to evaluate potential causative factors that influence variations in surgical mortality by SES. Patient demographic data, as well as admission acuity (emergency, urgent, or elective), were determined from the MEDPAR File. Other types of admissions (e.g., trauma and newborn) were excluded. Comorbid conditions were defined by the Elixhauser comorbidity measure, which uses ICD-9-CM codes to classify secondary diagnoses on the MEDPAR File into 30 different comorbid conditions.

Socioeconomic Status
We constructed a summary measure of SES for each zip code, using data on income, educational level, and occupation from the 2000 US Census linked to the patient’s residence in the Medicare files. The individual variables chosen and methods for calculating the summary measure were based on previously developed methods. In brief, for each zip code, a z score was estimated for each variable by subtracting the overall mean and dividing by the SD. The median SES summary score was created by summing the z scores of all 6 variables within the categories of Income, Education, and Employment (Table 1). These scores ranged from −20 to 20; larger scores indicate greater socioeconomic disparity. Patients were sorted according to SES summary score and grouped into quintiles. Quintiles were used to evaluate SES because they allow for accurate modeling of a dose-response relationship, regardless of the shape of that relationship. Hospitals were also sorted according to the mean summary SES score of their patient populations to form quintiles that would identify hospitals that predominantly treat patients of either low or high SES. To confirm the significance of the relationship between SES and FTR, similar models incorporating SES as a continuous variable were evaluated separately.

Primary Outcomes and Statistical Analysis
Primary outcomes for this study included operative mortality, postoperative complications, and FTR. Operative mortality was defined as death within 30 days of the index procedure or before hospital discharge. Postoperative complications were classified as medical or surgical and were identified by ICD-9-CM codes using previously validated methods. Medical postoperative complications included the following: myocardial infarction (procedure codes 410.00-410.91), pulmonary failure (procedure codes 518.4, 518.5, 518.8, 518.81),...
pneumonia (procedure codes 481, 482.0-482.9, 483, 484, 485, and 507.0), acute renal failure (procedure code 584), and venous thromboembolism (procedure codes 415.1, 451.11, 451.19, 451.2, 451.81, and 453.8). Surgical complications included the following: postoperative hemorrhage (diagnosis code 998.1), surgical site infection (diagnosis codes 958.3, 998.3, 998.5, 998.59, and 998.51), and gastrointestinal hemorrhage (diagnosis codes 530.82, 531.00-531.21, 531.40, 531.41, 531.60, 531.61, 532.00-532.21, 532.40, 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, and 578.9).

Failure to rescue was classified as a case fatality among patients with 1 or more of the defined major complications. Crude rates of the primary outcome measures were determined for each SES quintile. We first used multivariable logistic regression to determine risk-adjusted rates of our 3 primary outcome measures. We then used unique hospital identifiers in fixed-effects hierarchical regression models to assess the association between SES and FTR after cancer surgery, adjusting for patient characteristics and the hospital at which patients received their care. Given that the data sets include all Medicare patients treated during the study period, a fixed-effects model was chosen to determine population estimates. This modeling adjusts for the hospital-level effects that influence FTR of all patients to isolate the socioeconomic differences in FTR within hospitals.11 If the socioeconomic disparity in FTR is no longer significant after accounting for hospital-level variation, the differences in mortality can be assumed to arise from differences among hospitals. Patients with missing data were excluded because the total amount of missing data was small (<0.019%) and assumed to be missing at random. Final risk-adjustment models had C statistics that ranged from 0.75 (pancreatectomy) to 0.83 (colectomy). All analyses were performed using STATA statistical software (release 11; StataCorp LP), with 2-sided tests and a set at .05.

Results

A total of 596,222 patients underwent 1 of the 6 cancer operations during the 5-year study period. The demographic and socioeconomic characteristics of included patients are given in Table 1. The median age of the patients in the study population was 76 years, and there were slightly more females than males. The percentage of minority patients in each quintile decreased as the SES score increased. The lowest quintile of SES included 24.6% nonwhite patients, whereas the highest quintile included only 7.2% nonwhite patients.

Rates of major complications, mortality, and FTR for all operations combined across patient quintiles of SES are shown in Figure 1. Although major complications from all opera-
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Figure 2. Adjusted Failure to Rescue (FTR) Among the Lowest and Highest Patient Quintiles of Socioeconomic Status (SES) Within the Lowest and Highest Hospital Quintiles of SES

Figure 2 illustrates the extent to which disparities in FTR are attributable to the effect of the hospital at which patients were treated. For each operation, there is a higher rate of FTR at hospitals treating more patients with a low SES. However, all patients treated at those hospitals, regardless of the patient’s SES, experience this effect. For each operation, patients in the highest quintile of SES treated at low-quality hospitals experienced a higher rate of FTR than patients from the lowest quintile of SES being treated at high-quality hospitals. For some operations, such as cystectomy and pancreatectomy, this disparity was marked.

The crude and adjusted odds ratios (ORs) of FTR for each operation are listed in Table 2. These ORs were determined after adjusting for patient characteristics and then for patient characteristics and fixed-hospital effects in the lowest quintile of SES compared with the highest. The crude OR for FTR for all operations was 1.20 (95% CI, 1.16-1.25), and these disparities were significant for all individual operations except cystectomy. The highest crude odds of death after a complication were seen after pancreatectomy, with an OR of 1.43 (95% CI, 1.21-1.70). When adjusted for patient characteristics alone, the ORs for FTR decreased slightly but remained sig-
Several studies have documented the importance of access to care as a result of long-standing quality improvement efforts. Multiple studies, where perioperative processes may be different as a consequence of SES, have identified numerous potential mechanisms for these variations, including hospital quality, within the domains of “host factors,” “prehospital factors,” “hospital/provider factors,” and “posthospital care/rehabilitation factors.” Dimick and colleagues investigated mechanisms of racial disparities and found that residential segregation and race-related differences in referral patterns likely contribute to use of low-quality hospitals. This study adds to the literature by highlighting specific mechanisms within low-quality hospitals, such as FTR, that likely play a significant role in the socioeconomic disparities of operative mortality seen among patients undergoing major inpatient cancer surgery within the United States.5,21 Previously, FTR was reported to play an important role in the outcomes of many different types of oncology patients, and it is likely one of the principal mechanisms through which available technology, staff technical competence, and work coordination influence the mortality variations that result in socioeconomic disparities.

This study has several important limitations. First, the use of Medicare data limits our analyses to patients 65 years and older and could threaten the generalizability of our results. However, this subset of patients accounts for a large percentage of all patients diagnosed as having cancer.26 The use of administrative data could be considered a second limitation of this study. Administrative data lack clinical details, such as cancer stage and disease location, which influence the outcome and prognosis of oncology patients. This is less of a concern when evaluating rates of 30-day mortality; however, it limits adjustment for operative complexity. Although administrative data have been criticized for inaccuracy in coding comorbidities and complications, we used the best-performing morbidity index currently available.

A third potential limitation of this study is reliance on SES measured at the level of zip code, as opposed to US Census tracts. Although studies that have compared different geographic units of measurement have generally found that US Census-based units produce the greatest gradients in health according to SES, those and other studies have also found that zip code-level measures provide similar, but more conservative, estimates of socioeconomic disparity. Fourth, although we did not have access to individual-level data, the potential misclassification of SES according to zip code has been reported to be random, and as a result, the bias that results is a conservative estimate of the true influence of SES on health. Consequently, the significant differences identified in this study are likely just a portion of the true disparities that exist among patients of varying SES.

This work has important implications for quality improvement efforts directed toward cancer surgery in disadvantaged populations. Many organizations, such as the CMS, focus on their quality improvement efforts on the reduction of complications. The Surgical Care Improvement Project, for example, targets process adherence for surgical site infection, venous thromboembolism, and myocardial infarction. Through the Hospital Value-Based Purchasing Program, the CMS offers incentive payments to hospitals based on these measures. This work adds to expanding literature that asserts complications and mortality are not causally related at the hospital level and, as such, advocates a different approach. Moreover, these findings highlight the possibility that value-
based purchasing could actually have a paradoxical effect on socioeconomically disadvantaged populations. By financially rewarding only high-performing hospitals, which care for fewer patients in the lowest SES quintile, this program could instead have the unintended consequence of widening the disparities observed in these populations. With this in mind, organizations wishing to reduce socioeconomic disparities and improve mortality rates after major cancer surgery could instead direct their efforts and resources toward processes and systems aimed at the timely recognition and management of complications once they occur.

Multiple hospital characteristics, such as nursing environments, intensive care unit staffing, and teaching status, have been proposed to explain differences in FTR rates among hospitals. Aiken and colleagues\(^4\) reported that, after adjusting for other hospital factors, each additional patient per nurse beyond a 4:1 ratio resulted in a 7% increase in the likelihood of dying and a similar increase in the rate of FTR. Similarly, Friese and colleagues\(^4\) found a 37% increased odds of death for patients undergoing oncologic surgery in hospitals with poor nursing environments. Multiple studies\(^39\) have illustrated decreased operative mortality in hospitals with daily intensive care unit rounds. Finally, Silber and colleagues\(^4\) established that patients undergoing surgery at hospitals with high teaching intensity had a 15% lower odds of death.

**Conclusions**

Although various hospital characteristics have been identified as potential contributors to successful rescue from complications, it is likely that some combination of hospital resources, attitudes, and behaviors is what yields an environment most conducive to the timely recognition and effective management of complications.\(^4\) Future work to rectify the origins of socioeconomic disparities in perioperative care should also concentrate on these factors, not just on adherence measures directed toward complications and their prevention. Future national hospital quality improvement initiatives can use these findings as evidence to support efforts to improve rescue rates in poorly performing hospitals, as part of a broad strategy directed toward effectively reducing socioeconomic disparities in cancer surgery mortality.

**ARTICLE INFORMATION**

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