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.

Published online March 12, 2014.

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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 = 423,474), 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 (eg, 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),
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Original Investigation Research

Table 1. Patient Characteristics by SES Quintile

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Quintiles of SES</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest</td>
<td>Low</td>
</tr>
<tr>
<td>Age, median, y</td>
<td>75.0</td>
<td>76.0</td>
</tr>
<tr>
<td>Female sex, %</td>
<td>54.6</td>
<td>54.5</td>
</tr>
<tr>
<td>Non-white race, %</td>
<td>24.6</td>
<td>10.9</td>
</tr>
<tr>
<td>≥3 Comorbidities</td>
<td>20.1</td>
<td>18.4</td>
</tr>
<tr>
<td>SES summary score, median (range)</td>
<td>~4 (~10 to ~2)</td>
<td>~1 (~2 to 0)</td>
</tr>
<tr>
<td>Wealth/income</td>
<td>Median household income, $</td>
<td>28 603</td>
</tr>
<tr>
<td></td>
<td>Median value of housing units, $</td>
<td>64 500</td>
</tr>
<tr>
<td></td>
<td>Households with interest, dividend, or rental income, %</td>
<td>21.5</td>
</tr>
<tr>
<td>Educational level, %</td>
<td>Adult residents who completed high school or more</td>
<td>67.8</td>
</tr>
<tr>
<td></td>
<td>Adult residents who completed college or more</td>
<td>14.5</td>
</tr>
<tr>
<td>Employment</td>
<td>Employed residents with management, professional, or related occupations</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Abbreviation: SES, socioeconomic status.

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-
tions were mildly different across socioeconomic levels (25.6% in the lowest quintile vs 23.8% in the highest quintile, \( P = .003 \)), greater disparities were seen in operative mortality across SES quintiles. Patients in the lowest SES quintile had 1.3-fold greater odds of experiencing perioperative mortality than patients in the highest (10.2% vs 7.7%, \( P = .0009 \)). Similar disparities in SES were observed for rates of FTR (26.7% in the lowest quintile vs 23.2% in the highest quintile, \( P = .007 \)).

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-
nificant for all operations combined (OR, 1.16; 95% CI, 1.12-
1.19), colectomy (OR, 1.17; 95% CI, 1.13-1.21), lung resection
(OR, 1.27; 95% CI, 1.16-1.40), and pancreatectomy (OR, 1.45;
95% CI, 1.21-1.73).

However, once adjusted for patient characteristics and hos-
pital effects, the odds of FTR decreased substantially for all op-
erations. As indicated in Table 2, the adjusted OR for all op-
erations decreased to 1.05 (95% CI, 1.01-1.09). The odds of FTR
also decreased considerably for each operation. For example,
the OR for FTR after pancreatectomy decreased to 1.22 (95%
CI, 0.95-1.57) and lost statistical significance. Only colectomy
retained statistical significance after adjustment for patient
characteristics and hospital effects (OR, 1.07; 95% CI, 1.02-
1.11). For both multivariable logistic regression and hierarchi-
cal regression models, results were similar when SES was evalu-
ated as a continuous variable.

Discussion

In our analysis, patients in the lowest quintiles of SES under-
going major oncologic operations have somewhat increased
rates of major complications but even higher rates of FTR. A
greater percentage of patients from the lowest quintile of SES
are treated at hospitals with higher FTR rates. Adjustments for
patient characteristics and hospital effects using fixed-effect
hierarchical modeling nearly eliminated disparities in FTR
across SES. Thus, this disparity appears to be driven in part by
the hospital at which the patient was treated because pa-
tients of all SES levels experience higher FTR rates at low-
quality hospitals.

These findings correlate with previous work that evalu-
ated the influence of SES on surgical outcomes. Birkmeyer and
colleagues, among others, have reported that SES is a sig-
nificant predictor of operative mortality in both cardiovascu-
lar and oncologic operations. Numerous theories have been of-
fered to explain these findings. Osborne and colleagues assert
that patient characteristics, such as the number and severity
of comorbidities, play the largest role in observed disparities.
However, they studied patients undergoing cardiovascular op-
erations, where perioperative processes may be different as a
result of long-standing quality improvement efforts. Multi-
ple studies have documented the importance of access to
care, reporting that those without insurance coverage have
worse mortality rates than those with coverage. Finally, Da-
ley and colleagues reported that patients of low SES most of-
ten receive care at lower-quality hospitals, as determined by
lack of available technology and decreased quality-of-care rat-
ings (assessing the technical competence of staff, monitoring
care quality, coordination of work, and surgical leadership,
among other factors).

The identification of hospital quality as an important con-
tributor to the disparities in surgical outcomes observed in dis-
advantaged populations is also supported by studies that
evaluated racial disparities, which report similar findings. A
systematic review of disparities in trauma care by Haider and
colleagues identified numerous potential mechanisms for these
variations, including hospital quality, within the do-
mains 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 litera-
ture 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. Previous, FTR was reported to play an im-
portant role in the outcomes of many different types of on-
cology patients, and it is likely one of the principal mecha-
nisms 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 percent-
age of all patients diagnosed as having cancer. The use of ad-
ministrative data could be considered a second limitation of
this study. Administrative data lack clinical details, such as can-
cer 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 administra-
tive data have been criticized for inaccuracy in coding comor-
bidities and complications, we used the best-performing co-
morbidities 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 geo-
graphic 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 conser-

dative, estimates of socioeconomic disparity. Fourth, al-
though we did not have access to individual-level data, the poten-
tial 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 improve-
ment efforts directed toward cancer surgery in disadvan-
taged populations. Many organizations, such as the CMS, fo-
cus their quality improvement efforts on the reduction of
complications. The Surgical Care Improvement Project, for ex-
ample, targets process adherence for surgical site infection,
venous thromboembolism, and myocardial infarction. Through
the Hospital Value-Based Purchasing Program, the CMS of-
fers incentive payments to hospitals based on these measures.

This work adds to expanding literature that asserts complica-
tions 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 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 found a 37% increased odds of death for patients undergoing oncologic surgery in hospitals with poor nursing environments. Multiple studies have illustrated decreased operative mortality in hospitals that have implemented daily intensive care unit rounds. Finally, Silber and colleagues 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. 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.