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ORIGINAL ARTICLE

# High-risk surgery among Medicare beneficiaries living in health professional shortage areas

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## Abstract

**Purpose:** Americans who reside in health professional shortage areas currently have less than half of the needed physician workforce. While the shortage designation has been associated with poor outcomes for chronic medical conditions, far less is known about outcomes after high-risk surgical procedures.

**Methods:** We performed a retrospective review of Medicare beneficiaries living in health professional shortage areas and nonshortage areas who underwent abdominal aortic aneurysm repair, coronary artery bypass graft, esophagectomy, liver resection, pancreatectomy, or rectal resection between 2014 and 2018. Risk-adjusted multivariable logistic regression was used to determine whether rates of postoperative complications and 30-day mortality differed between patient cohorts. Beneficiary and hospital ZIP codes were used to quantify travel time to obtain care.

**Findings:** Compared with patients living in nonshortage areas, patients living in health professional shortage areas traveled longer (median 60.0 vs 28.0 minutes, $P<.001$). There were no differences in risk-adjusted rates of complications (28.5% vs 28.6%, OR = 1.00, 95% CI 1.00-1.00, $P = .59$) and small differences in rates of 30-day mortality (4.2% vs 4.4%, OR = 0.95, 95% CI 0.95-0.95, $P<.001$) between beneficiaries living in shortage areas versus those not in shortage areas, respectively.

**Conclusions:** Patients living in health professional shortage area undergoing high-risk surgery traveled more than 2 times longer for their care to obtain similar outcomes. While reassuring for clinical outcomes, additional efforts may be needed to mitigate the travel burden experienced by shortage area patients.

KEYWORDS
health professional shortage area, rural surgery, surgical access, surgical outcomes, travel burden

## BACKGROUND

Americans living in health professional shortage areas have less than half of the necessary physician workforce to adequately service their population.[1] These shortage areas, predominately rural, are designated based on 3 key criteria: provider-to-patient ratio, percent of the population below the federal poverty level, and travel time to the nearest source of care outside of the shortage designation area.[2] Health professional shortage area designations have been used to guide federal resource allocation to these medically underserved areas and have also been used to inform policy aimed at improving access to surgical care.[3,4] Current evidence suggests that health professional shortage area hospitals have been responsive to federal incentives with appreciable increases in surgical volume.[5]

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While living in a health professional shortage area has been associated with worse medical conditions, far less is known about surgery.[6–9] For example, patients in health professional shortage areas have higher rates of common medical comorbidities and have worse overall health status.[6–8] However, recent findings suggest that patients living in health professional shortage area can obtain safe surgical care for common operations, but with a higher travel burden.[10] Less is known about high-risk surgery, which commonly requires the care of surgical subspecialists. In fact, many such high-risk operations have been restricted to higher-volume centers given their known volume-outcome relationships.[11] As such, patients residing in health professional shortage areas may be at risk for having worse quality and longer travel times.

In this context, this study sought to compare surgical quality and travel burden among Medicare beneficiaries residing in health professional shortage areas to those living in nonshortage areas who underwent high-risk surgery. We hypothesized that compared to their nonshortage area counterparts, beneficiaries living in health professional shortage areas undergoing high-risk surgery would be observed to have worse outcomes from high-risk operations and endure longer travel times to obtain this care.

## METHODS

### Data source

Patient-level data were obtained for fee-for-service eligible Medicare beneficiaries ages 65-99 years ffrom the Medicare Provider Analysis and Review (MEDPAR) file between the years of 2014 and 2018. The MEDPAR database captures claims on an annual basis, which are submitted to the Centers for Medicare and Medicaid Services (CMS) by hospitals where Medicare beneficiaries obtained care. Patient ZIP codes from MEDPAR were linked to the CMS list of ZIP codes that met the criteria for primary care health professional shortage area designation in order to identify beneficiaries living in health professional shortage areas. This list of health professional shortage area ZIP codes is released on an annual basis by CMS. Patients were considered to be living in a shortage area if their ZIP code in MEDPAR was designated as a health professional shortage area at the time they underwent their high-risk surgery.[12] No current health professional shortage area designation for surgical providers exists. The primary care health professional shortage area designation was used to identify these patients because it was also the basis for the creation of the Health Professional Shortage Area Surgical Incentive Payment Program.[3]

Hospital-level characteristics where beneficiaries obtained care were assessed using the American Hospital Association (AHA) Annual Survey. AHA data were linked to individual Medicare beneficiaries based on each hospital's individual facility identification code.[13] This study was approved by the University of Michigan Investigational Review Board and deemed exempt due to the use of secondary data.

### Identification of procedures and analytic cohort

We identified beneficiaries aged 65-99 years who underwent 1 of 6 high-risk procedures. These procedures included abdominal aortic aneurysm repair, coronary artery bypass graft, esophagectomy, liver resection, pancreatectomy, and rectal resection. These procedures were identified using the International Classification of Diseases, Ninth (*ICD-9-CM*) and Tenth (*ICD-10-CM*) Revision, Clinical Modification codes (Table S1). These 6 procedures were selected based on their described volume-outcome relationships, which have prompted suggestions of subspecialist care and centralization for performing these procedures at higher-volume centers.[14–19]

### Outcome variables

The primary outcome in this study was 30-day mortality, which was defined as patients who died within 30 days of discharge from their index admission. This was determined using the Medicare beneficiary denominator file. Separately, patient vital signs at discharge were used to ascertain in-hospital mortality.

Secondary 30-day outcomes included postoperative complications, serious complications, reoperations, and readmissions. Complications were identified using *ICD-9-CM* and *ICD-10-CM* codes as previously validated using Medicare claims data.[20–22] These complications included pulmonary failure, pneumonia, myocardial infarction, deep venous thrombosis, acute kidney failure, postoperative hemorrhage, surgical site infection, and gastrointestinal bleed. Serious complications were defined as the development of a complication in a patient whose length of stay was higher than the 75th percentile for the index procedure, which is recognized to increase the outcome variable's specificity.[23] Reoperations were defined using *ICD-9-CM* and *ICD-10-CM* codes indicating secondary procedures during the index hospitalization as previously described in studies using the MEDPAR file.[24] Readmissions were defined as any inpatient admission within 30 days to any hospital after discharge from their index hospitalization.[24]

### Statistical analysis

The purpose of this study was to compare major outcomes after high-risk surgery between Medicare beneficiaries living in health professional shortage areas and nonshortage areas. Patient characteristics of interest included age, sex, race, comorbidities, Elixhauser comorbidity index,[25] discharge disposition, admission type, proportion of patients going to a hospital located in a shortage area, operation type, and travel time to obtain care. These were compared using chi-square tests for categorical variables and *t*-tests for continuous variables.

The number of minutes for travel time was determined using Google Maps and was based on the centroid of each patient's ZIP code and the corresponding hospital's ZIP code centroid where they underwent surgery. If a patient lived in the same ZIP code as the hospital where they obtained care, travel time was calculated as zero.

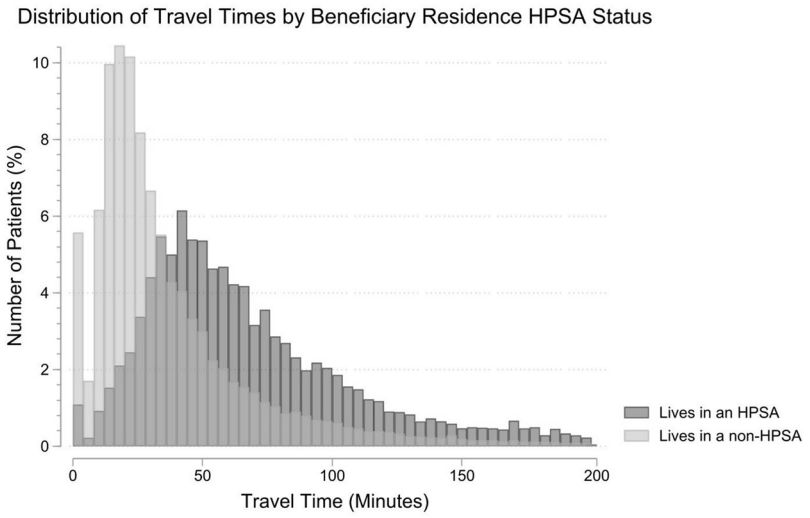



**FIGURE 1** Distribution of travel times by beneficiary based on health professional shortage area residency status. Abbreviation: HPSA, health professional shortage area.

Next, hospital characteristics were assessed to uncover any differences between the facilities where health professional shortage area patients obtained care, compared to their nonshortage area counterparts. Bed capacity, hospital geographic region, teaching hospital status, patient-to-nurse ratio, and Medicare hospital procedure volumes were all compared using chi-square and *t*-tests where appropriate.

Multivariable logistic regression was used to compare major outcomes between patient cohorts. Models were risk-adjusted for patient age, sex, comorbidities, procedure type, and admission type at the patient level. At the hospital level, models were risk-adjusted for teaching hospital status and patient-to-nurse ratio. Finally, models were adjusted for the year patients underwent their operations to account for potential secular trends in the data. Statistical analyses were performed using STATA, version 16 (STATA Corp). All statistical tests were 2-tailed, and a *P* value of $< .05$ was used as the threshold for significance.

## RESULTS

A total of 788,380 beneficiaries underwent 1 of 6 high-risk surgical procedures (Table 1). Among these patients, 60,494 (7.7%) lived in a health professional shortage area. The average overall patient age was 75.1 years (standard deviation = 7.0), and 283,480 (36.0%) of patients in the overall cohort were female. Comorbidity burdens, discharge disposition, admission type, proportion of patients who went to a hospital located in a shortage area for their care, and operative procedure distribution comparing the health professional shortage area beneficiaries and the nonshortage area cohort are summarized in Table 1.

Compared to patients living in nonshortage areas, patients living in health professional shortage areas traveled longer (median 60.0 vs 28.0 minutes, $P < .001$) (Table 1). The comparative distributions of travel times among beneficiaries residing in shortage areas versus those not living in shortage areas are demonstrated in Figure 1.

Hospital characteristics where health professional shortage area beneficiaries and nonshortage area beneficiaries received care for high-risk surgery are summarized in Table 2. Health professional shortage area beneficiaries were less likely to obtain care at a facility with a capacity of ≥ 500 beds (24,405 [40.5%] vs 316,758 [43.5%], $P < .001$). Similarly, shortage area beneficiaries were less likely to obtain care at a teaching hospital compared to the nonshortage area cohort (50,244 [83.1%] vs 626,830 [86.1%], $P < .001$).

Risk-adjusted clinical outcomes are summarized in Table 3. For clinical outcomes comparing health professional shortage area and nonshortage area beneficiaries combining all 6 high-risk operations, 30-day mortality was 4.2% and 4.4%, respectively (OR = 0.95, CI 0.95-0.95, $P < .001$). Rates of serious complications were 13.6% for shortage area beneficiaries and 13.8% for nonshortage area beneficiaries (OR = 0.98, CI 0.98-0.98, $P < .001$). Rates of reoperation were 2.7% and 2.8% for shortage and nonshortage area beneficiaries, respectively (OR = 0.95, CI 0.95-0.95, $P < .001$). Finally, readmission rates were 15.4% for shortage area beneficiaries and 15.7% for their nonshortage area counterparts (OR = 0.98, CI 0.97-0.98, $P < .001$). Readmissions to index versus nonindex hospitals are demonstrated in Table S1. Risk-adjusted outcomes for each of the 6 individual high-risk operations are also summarized in Table 3. Table S2 includes a sensitivity analysis for patients with disproportionately long travel time burdens. Table S3 demonstrates an additional sensitivity comparing travel time in minutes across Rural-Urban Commuting Area codes among shortage area and nonshortage area beneficiaries in this analysis.

## DISCUSSION

This study evaluating surgical outcomes and travel times for high-risk surgery among health professional shortage area Medicare beneficiaries and nonshortage area beneficiaries had 2 principal findings. First, the findings here revealed no evidence of worse clinical outcomes from high-risk surgery among health professional shortage area beneficiaries compared to their nonshortage area counterparts. However,

**TABLE 1** Patient characteristics

| | Total | Lives in HPSA | Does not live in HPSA | *P* value |
|---|---|---|---|---|
| No. of patients | 788,380 | 60,494 | 727,886 | |
| Demographic characteristics | | | | |
| Age, mean (SD) | 75.1 (7.0) | 74.4 (6.6) | 75.2 (7.0) | <.001 |
| Men | 504,900 (64.0%) | 39,425 (65.2%) | 465,475 (63.9%) | <.001 |
| Race | | | | |
| White | 699,652 (88.7%) | 53,931 (89.2%) | 645,721 (88.7%) | .001 |
| Black | 47,971 (6.1%) | 4,246 (7.0%) | 43,725 (6.0%) | <.001 |
| Asian | 11,977 (1.5%) | 165 (0.3%) | 11,812 (1.6%) | <.001 |
| Hispanic | 11,176 (1.4%) | 976 (1.6%) | 10,200 (1.4%) | <.001 |
| Native American | 3,370 (0.4%) | 617 (1.0%) | 2,753 (0.4%) | <.001 |
| Other | 14,234 (1.8%) | 559 (0.9%) | 13,675 (1.9%) | <.001 |
| Comorbidities | | | | |
| Hypertension | 535,224 (67.9%) | 41,834 (69.2%) | 493,390 (67.8%) | <.001 |
| Diabetes | 300,782 (38.2%) | 24,219 (40.0%) | 276,563 (38.0%) | <.001 |
| Fluid and electrolyte disorders | 240,231 (30.5%) | 18,027 (29.8%) | 222,204 (30.5%) | <.001 |
| Chronic pulmonary disease | 191,609 (24.3%) | 15,945 (26.4%) | 175,664 (24.1%) | <.001 |
| Renal failure | 165,207 (21.0%) | 12,126 (20.0%) | 153,081 (21.0%) | <.001 |
| Peripheral vascular disease | 157,513 (20.0%) | 12,358 (20.4%) | 145,155 (19.9%) | .004 |
| Obesity | 151,148 (19.2%) | 12,480 (20.6%) | 138,668 (19.1%) | <.001 |
| Deficiency anemias | 135,726 (17.2%) | 10,037 (16.6%) | 125,689 (17.3%) | <.001 |
| Coagulopathy | 132,253 (16.8%) | 9,513 (15.7%) | 122,740 (16.9%) | <.001 |
| Hypothyroidism | 117,573 (14.9%) | 8,488 (14.0%) | 109,085 (15.0%) | <.001 |
| Depression | 63,396 (8.0%) | 4,609 (7.6%) | 58,787 (8.1%) | <.001 |
| Weight loss | 50,982 (6.5%) | 3,814 (6.3%) | 47,168 (6.5%) | .092 |
| Other neurological disorders | 47,950 (6.1%) | 3,639 (6.0%) | 44,311 (6.1%) | .48 |
| Metastatic cancer | 31,239 (4.0%) | 1,954 (3.2%) | 29,285 (4.0%) | <.001 |
| Rheumatoid arthritis | 24,094 (3.1%) | 1,734 (2.9%) | 22,360 (3.1%) | .005 |
| Liver disease | 20,972 (2.7%) | 1,378 (2.3%) | 19,594 (2.7%) | <.001 |
| Solid tumor | 20,713 (2.6%) | 1,409 (2.3%) | 19,304 (2.7%) | <.001 |
| Congestive heart failure | 18,994 (2.4%) | 1,403 (2.3%) | 17,591 (2.4%) | .13 |
| Valvular disease | 11,586 (1.5%) | 674 (1.1%) | 10,912 (1.5%) | <.001 |
| Psychoses | 10,167 (1.3%) | 642 (1.1%) | 9,525 (1.3%) | <.001 |
| Elixhauser comorbidities | | | | |
| 0 | 32,515 (4.1%) | 2,376 (3.9%) | 30,139 (4.1%) | .011 |
| 1 | 107,493 (13.6%) | 8,101 (13.4%) | 99,392 (13.7%) | .070 |
| ≥2 | 648,372 (82.2%) | 50,017 (82.7%) | 598,355 (82.2%) | .003 |
| Discharge location | | | | |
| Home | 570,631 (72.4%) | 44,361 (73.3%) | 526,270 (72.3%) | <.001 |
| Skilled nursing facility, rehabilitation | 185,533 (23.5%) | 12,967 (21.4%) | 172,566 (23.7%) | <.001 |
| Transferred | 4,063 (0.5%) | 339 (0.6%) | 3,724 (0.5%) | .11 |
| Hospice | 2,678 (0.3%) | 182 (0.3%) | 2,496 (0.3%) | .088 |

(Continues)

**TABLE 1** (Continued)

| | Total | Lives in HPSA | Does not live in HPSA | *P* value |
|---|---|---|---|---|
| Other | 25,475 (3.2%) | 2,645 (4.4%) | 22,830 (3.1%) | <.001 |
| Admission type | | | | |
| Elective | 514,254 (65.2%) | 39,681 (65.6%) | 474,573 (65.2%) | .049 |
| Unplanned | 274,126 (34.8%) | 20,813 (34.4%) | 253,313 (34.8%) | .049 |
| Went to a hospital in an HPSA | 5,822 (0.7%) | 2,435 (4.0%) | 3,387 (0.5%) | <.001 |
| Type of operation | | | | |
| AAAR | 222,804 (28.3%) | 15,780 (26.1%) | 207,024 (28.4%) | <.001 |
| CABG | 401,623 (50.9%) | 33,773 (55.8%) | 367,850 (50.5%) | <.001 |
| Esophagectomy | 14,922 (1.9%) | 986 (1.6%) | 13,936 (1.9%) | <.001 |
| Liver resection | 25,266 (3.2%) | 1,511 (2.5%) | 23,755 (3.3%) | <.001 |
| Pancreatectomy | 33,542 (4.3%) | 2,011 (3.3%) | 31,531 (4.3%) | <.001 |
| Rectal resection | 90,223 (11.4%) | 6,433 (10.6%) | 83,790 (11.5%) | <.001 |
| Travel time in minutes, mean (SD) | 70.2 (180.6) | 96.1 (173.9) | 68.1 (181.0) | <.001 |
| Travel time in minutes, median (IQR) | 29.0 (17.0-56.0) | 60.0 (40.0-95.0) | 28.0 (17.0-51.0) | <.001 |
| Travel time in minutes | | | | |
| <30 | 394,867 (50.1%) | 7,945 (13.1%) | 386,922 (53.2%) | <.001 |
| 30-60 | 216,335 (27.4%) | 22,731 (37.6%) | 193,604 (26.6%) | <.001 |
| >60 | 177,178 (22.5%) | 29,818 (49.3%) | 147,360 (20.2%) | <.001 |

Abbreviations: AAAR, abdominal aortic aneurysm repair; CABG, coronary artery bypass graft; HPSA, health professional shortage area; SD, standard deviation.

**TABLE 2** Hospital characteristics

| | Total | Lives in HPSA | Does not live in HPSA | *P* value |
|---|---|---|---|---|
| No. of patients | 788,380 | 60,494 | 727,886 | |
| Hospital size | | | | |
| Has fewer than 250 beds | 143,503 (18.2%) | 12,904 (21.3%) | 130,599 (17.9%) | <.001 |
| Has between 250 and 499 beds | 303,714 (38.5%) | 23,185 (38.3%) | 280,529 (38.5%) | .30 |
| Has 500 or more beds | 341,163 (43.3%) | 24,405 (40.3%) | 316,758 (43.5%) | <.001 |
| Hospital region | | | | |
| Northeast | 141,644 (18.0%) | 2,366 (3.9%) | 139,278 (19.1%) | <.001 |
| Midwest | 187,406 (23.8%) | 14,968 (24.7%) | 172,438 (23.7%) | <.001 |
| South | 321,434 (40.8%) | 32,314 (53.4%) | 289,120 (39.7%) | <.001 |
| West | 137,896 (17.5%) | 10,846 (17.9%) | 127,050 (17.5%) | .003 |
| Teaching hospital | 677,074 (85.9%) | 50,244 (83.1%) | 626,830 (86.1%) | <.001 |
| Patient-to-nurse ratio | 9.0 (2.8) | 8.9 (2.9) | 9.0 (2.8) | <.001 |
| Hospital Medicare procedure volume | | | | |
| AAAR | 80.9 (91.1) | 66.4 (75.3) | 82.1 (92.2) | <.001 |
| CABG | 114.6 (82.8) | 107.1 (74.3) | 115.2 (83.5) | <.001 |
| Esophagectomy | 4.8 (7.9) | 3.9 (7.2) | 4.9 (8.0) | <.001 |
| Liver resection | 9.1 (15.3) | 6.9 (12.9) | 9.3 (15.5) | <.001 |
| Pancreatectomy | 12.3 (20.2) | 9.3 (16.8) | 12.5 (20.5) | <.001 |
| Rectal resection | 21.7 (22.4) | 18.0 (19.2) | 22.0 (22.6) | <.001 |

Abbreviations: AAAR, abdominal aortic aneurysm repair; CABG, coronary artery bypass graft; HPSA, health professional shortage area; IQR, interquartile range.

**TABLE 3** Comparison of clinical outcomes after undergoing high-risk surgery procedures at health professional shortage area hospitals and nonshortage hospitals

| | Risk-adjusted rates (95% CI), % | | | |
|---|---|---|---|---|
| | Beneficiaries living in an HPSA | Beneficiaries not living in an HPSA | Odds ratio | *P* value |
| **All cohorts** | | | | |
| Mortality, 30 days | 4.20 (4.16 -4.24) | 4.36 (4.32-4.41) | 0.95 (0.95-0.95) | <.001 |
| Mortality, in-hospital | 2.62 (2.59-2.66) | 2.72 (2.69-2.76) | 0.95 (0.95-0.95) | <.001 |
| Any complications | 28.53 (28.44-28.62) | 28.61 (28.52-28.70) | 1.00 (1.00-1.00) | .59 |
| Serious complications | 13.58 (13.51-13.65) | 13.78 (13.71-13.85) | 0.98 (0.98-0.98) | <.001 |
| Reoperations | 2.70 (2.67-2.74) | 2.83 (2.80-2.87) | 0.95 (0.95-0.95) | <.001 |
| Readmissions | 15.39 (15.31-15.47) | 15.70 (15.62-15.78) | 0.98 (0.97-0.98) | <.001 |
| **AAAR** | | | | |
| Mortality, 30 days | 4.61 (4.52-4.69) | 4.59 (4.50-4.67) | 1.00 (0.99-1.00) | .10 |
| Mortality, in-hospital | 2.98 (2.91-3.05) | 2.92 (2.86-2.99) | 1.02 (1.01-1.02) | <.001 |
| Any complications | 21.59 (21.44-21.74) | 21.66 (21.51-21.8) | 1.00 (0.99-1.00) | <.001 |
| Serious complications | 12.77 (12.65-12.89) | 12.68 (12.56-12.8) | 1.00 (1.00-1.00) | .31 |
| Reoperations | 1.93 (1.87-1.99) | 1.78 (1.73-1.83) | 1.09 (1.08-1.10) | <.001 |
| Readmissions | 13.98 (13.83-14.12) | 14.24 (14.1-14.39) | 0.98 (0.97-0.98) | <.001 |
| **CABG** | | | | |
| Mortality, 30 days | 3.69 (3.63-3.74) | 3.86 (3.80-3.92) | 0.96 (0.96-0.96) | <.001 |
| Mortality, in-hospital | 2.32 (2.28-2.37) | 2.45 (2.40-2.49) | 0.96 (0.95-0.96) | <.001 |
| Any complications | 32.84 (32.71-32.97) | 33.78 (33.65-33.91) | 0.95 (0.95-0.95) | <.001 |
| Serious complications | 13.77 (13.67-13.86) | 14.29 (14.19-14.38) | 0.95 (0.95-0.95) | <.001 |
| Reoperations | 1.61 (1.57-1.65) | 1.69 (1.65-1.73) | 0.96 (0.95-0.96) | <.001 |
| Readmissions | 14.84 (14.73-14.95) | 15.00 (14.89-15.11) | 0.99 (0.99-0.99) | <.001 |
| **Esophagectomy** | | | | |
| Mortality, 30 days | 9.86 (9.39-10.34) | 9.26 (8.83-9.70) | 1.04 (1.03-1.06) | <.001 |
| Mortality, in-hospital | 6.45 (6.05-6.85) | 6.10 (5.74-6.47) | 1.03 (1.02-1.05) | <.001 |
| Any complications | 38.67 (37.97-39.37) | 37.43 (36.75-38.11) | 1.07 (1.06-1.08) | <.001 |
| Serious complications | 19.71 (19.11-20.31) | 18.10 (17.55-18.66) | 1.10 (1.08-1.11) | <.001 |
| Reoperations | 5.75 (5.36-6.14) | 5.48 (5.12-5.84) | 1.04 (1.02-1.05) | <.001 |
| Readmissions | 22.00 (21.30-22.70) | 21.83 (21.16-22.51) | 1.01 (1.00-1.02) | .09 |
| **Liver resection** | | | | |
| Mortality, 30 days | 4.26 (4.03-4.49) | 4.73 (4.49-4.98) | 0.91 (0.90-0.92) | <.001 |
| Mortality, in-hospital | 2.61 (2.43-2.80) | 2.92 (2.73-3.12) | 0.92 (0.90-0.93) | <.001 |
| Any complications | 22.94 (22.48-23.39) | 23.73 (23.27-24.18) | 0.95 (0.95-0.96) | <.001 |
| Serious complications | 13.19 (12.82-13.55) | 13.87 (13.51-14.24) | 0.94 (0.94-0.95) | <.001 |
| Reoperations | 5.82 (5.53-6.11) | 5.90 (5.62-6.19) | 1.00 (0.99-1.01) | .90 |
| Readmissions | 15.65 (15.20-16.10) | 15.90 (15.45-16.35) | 0.98 (0.98-0.99) | <.001 |
| **Pancreatectomy** | | | | |
| Mortality, 30 days | 6.30 (6.04-6.57) | 6.12 (5.88-6.37) | 1.05 (1.04-1.06) | <.001 |

(Continues)

**TABLE 3** (Continued)

| | Risk-adjusted rates (95% CI), % | | Odds ratio | *P* value |
|---|---|---|---|---|
| | Beneficiaries living in an HPSA | Beneficiaries not living in an HPSA | | |
| Mortality, in-hospital | 3.93 (3.72-4.14) | 3.85 (3.65-4.04) | 1.05 (1.04-1.06) | <.001 |
| Any complications | 31.10 (30.64-31.56) | 29.90 (29.47-30.34) | 1.07 (1.06-1.07) | <.001 |
| Serious complications | 16.00 (15.63-16.37) | 15.08 (14.74-15.42) | 1.08 (1.07-1.09) | <.001 |
| Reoperations | 6.63 (6.36-6.91) | 6.36 (6.10-6.61) | 1.04 (1.03-1.05) | <.001 |
| Readmissions | 24.71 (24.23-25.19) | 24.24 (23.77-24.70) | 1.03 (1.02-1.03) | <.001 |
| **Rectal resection** | | | | |
| Mortality, 30 days | 4.44 (4.32-4.57) | 4.44 (4.32-4.57) | 0.99 (0.98-1.00) | .001 |
| Mortality, in-hospital | 2.43 (2.33-2.52) | 2.40 (2.30-2.49) | 1.00 (0.99-1.01) | .51 |
| Any complications | 23.01 (22.76-23.25) | 22.41 (22.18-22.65) | 1.04 (1.03-1.04) | <.001 |
| Serious complications | 13.47 (13.27-13.67) | 13.00 (12.81-13.19) | 1.03 (1.02-1.03) | <.001 |
| Reoperations | 7.97 (7.79-8.14) | 7.80 (7.63-7.97) | 1.02 (1.02-1.03) | <.001 |
| Readmissions | 18.28 (18.02-18.54) | 18.12 (17.87-18.37) | 1.01 (1.01-1.01) | <.001 |

Abbreviations: AAAR, abdominal aortic aneurysm repair; CABG, coronary artery bypass graft; CI, confidence interval; HPSA, health professional shortage area.

health professional shortage area beneficiaries were found to sustain an average travel time more than twice as long as nonshortage area beneficiaries. Taken together, these findings underscore that health professional shortage area patients take on a disproportionate travel burden to obtain a similar quality of care for high-risk operations.

Prior work has raised concerns about the quality of medical and surgical care for patients living in health professional shortage areas. Multiple studies have identified the population's poor health status, disproportionate rates of medical comorbidities, and delays in diagnosis of medical conditions.[6,8,26,27] In contrast, health professional shortage area patients have been found to receive similar quality of care for common general surgery operations, such as cholecystectomy and appendectomy.[10] Hospitals located within health professional shortage areas have also been found to provide similar quality of surgical care at non-different costs compared to non-shortage area hospitals for these common operations.[28] This study extends the existing literature by assessing clinical outcomes in this population for high-risk surgery, which often is subject to centralization of care at higher-volume centers.

While our study could not identify the mechanism by which patients in health professional shortage areas obtain safe surgical care for complex operations, our data suggest 2 possibilities. First, it is clear that patients in health professional shortage areas traveled farther for care. In doing so, they likely obtained their procedures at relatively similar centers as those not living in shortage areas. Second, the travel burden associated with these high-risk procedures may be self-selecting for patients with more means or social support to obtain and undergo specialized care, both of which have been associated with better outcomes.[29,30] In other words, more socially vulnerable patients, who are potentially sicker and have less means to travel to obtain high-risk surgery, may have been selected out and not included in this study.

Our findings also add important information to the ongoing debates of centralizing high-risk surgical procedures. As volume-outcome relationships have become better understood for high-quality high-risk surgery, centralization for surgical care has become increasingly studied and adopted in the past 2 decades.[17,31,32] However, whether or not the relatively small improvement in clinical outcomes is worth the associated increased travel burden has been called into question.[31] Our present study underscores the significant travel burden for these high-risk procedures, and at a minimum, raises interest in how that burden can be mitigated.

This study should be interpreted within the context of its limitations. First, a known limitation of Medicare claims data is the limited reliability in identifying complications. To address this, codes from the Complication Screening Project, that have been shown to have a high level of specificity in Medicare claims data, were used.[20–22] Second, using Medicare beneficiaries as the population of interest may limit the generalizability of our findings. However, our cohort is representative of older patients more likely to undergo high-risk surgery and reflects the population most relevant to policymakers who created the health professional shortage area designation in question. Further, we were unable to assess underlying disease prevalence related to these operations in these shortage areas to assess whether or not it is proportional to the general population. Lastly, the reported time traveled between the patient and hospital utilized ZIP code centroids and was estimated using Google Maps and may not reflect the true travel time or mode of transportation used by the patient. However, any measurement error was likely equally present in both patient cohorts and thus should not threaten the validity of our results.

The findings in this study have several implications for both policymakers and providers on how access to high-risk surgical care can be optimized in these communities. First, policymakers could consider subsidy policies for health professional shortage area patients who

are faced with significant travel burdens to obtain high-risk surgical care. Additionally, policymakers could consider an infrastructural investment to provide travel to obtain surgical care for more vulnerable patient populations to promote equity in obtaining high-risk surgical care. Policymakers must keep in mind the possible regional variability that appears to exist within shortage areas and will ultimately need to tailor policy interventions accordingly. At the provider level, hospital systems and surgeons, especially those who serve a large proportion of health professional shortage area residents, could pursue the development of outreach clinics in rural communities to increase the catchment of vulnerable populations in need of high-risk surgical care who otherwise may not possess the means to present to clinic for evaluation of their condition.[33] Additionally, or alternatively, the COVID-19 pandemic has required surgeons to become even more flexible and innovative in providing outpatient clinic care to their surgical patients in the form of telehealth visits in the perioperative setting. Careful and measured considerations will have to be made with respect to emerging technologies, such as telehealth, and the reality that a considerable proportion of rural patients lack access to broadband. Providers could potentially better serve health professional shortage area-residing patients by continuing to lean into and perhaps expand virtual visits in both the preoperative and postoperative settings to alleviate the travel burden this population experiences with respect to the outpatient management of their high-risk surgical care.

## CONCLUSIONS

This study found similar quality of high-risk surgical care for health professional shortage area and nonshortage area Medicare beneficiaries but identified a significant travel burden that is experienced by shortage area patients. While outcomes may be similar between these cohorts, additional policy and provider efforts should be undertaken to mitigate the travel burden patients experience to obtain this care.

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### CONFLICT OF INTEREST STATEMENT

Data from this manuscript have been accepted for podium presentation at the 2022 American College of Surgeons Clinical Congress in October 2022. Dr. Dimick is a cofounder of ArborMetrix, Inc, a company that makes software for profiling hospital quality and efficiency. Dr. Ibrahim is a Principal at HOK architects, a global design and architecture firm. The authors have no conflict of interest pertaining to the work herein.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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