Disparities in coronary artery bypass grafting between high- and low-volume surgeons and hospitals

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**ABSTRACT**

**Background:** High-volume surgeons and hospitals performing coronary artery bypass grafting have been associated with improved patient outcomes. However, patients of increased socioeconomic distress may have worse outcomes because of health care disparities. We sought to identify trends and outcomes in patients of elevated distress undergoing bypass grafting.

**Methods:** The Florida Agency for Healthcare Administration administrative data set was merged with Centers for Medicare and Medicaid Services Physician and Hospital Compare and Economic Innovation Group Distressed Community Index data sets to build a comprehensive database. The data set was queried to identify patients undergoing coronary artery bypass procedures between 2016 and 2020. High- and low-volume hospitals and surgeons were compared. Patient and hospital demographics, comorbidities, length of stay, and postoperative complications were analyzed by \( \chi^2 \) and \( t \) test where appropriate.

**Results:** A total of 41,571 coronary artery bypass grafting procedures were performed by 174 surgeons at 67 Florida hospitals. Low- and high-volume hospitals did not differ with respect to hospital ownership, overall star rating, national comparisons of mortality, readmission, or cost effectiveness. Patients from at-risk and distressed communities were more likely to undergo surgery at low-volume hospitals. Hospital length of stay was increased for low-volume hospitals (10.2 vs 9.4 days, \( P < .05 \)). Postoperative complications including pneumonia, arrhythmia, respiratory failure, acute renal failure, shock, pleural effusion, and sepsis were more frequent at low-volume hospitals and for low-volume surgeons.

**Conclusion:** High-volume hospitals and surgeons have improved postoperative outcomes and hospital length of stay when compared to low-volume hospitals and surgeons performing coronary artery bypass grafting. At-risk and distressed populations are more likely to undergo bypass surgery at low-volume hospitals, potentially contributing to worse patient outcome. Efforts should be made to mitigate the potential impact of low socioeconomic status to improve outcomes in this population.

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**BACKGROUND**

Various patient-, hospital-, and surgeon-level factors affect outcomes in cardiac surgery [1–6]. The complex interplay of factors in the health care macroenvironment has been shown to significantly impact length of hospital stay, postoperative outcome, morbidity, and mortality. Surgeon and hospital coronary artery bypass grafting (CABG) procedural volume is one such factor that has previously been explored to determine its impact on health care quality, patient morbidity, and mortality with varying results [6–9]. While high-volume centers and surgeons have been associated with improved outcomes in some series, the accessibility and utilization of these centers by patients from at-risk or distressed socioeconomic communities using comprehensive metrics for socioeconomic status are largely unknown. Several socioeconomic determinants, including educational level, race, and poverty status, have been used to further characterize the relationship of low socioeconomic status with morbidity and mortality. Although these surrogates have provided some context, the ability to account for the entirety of socioeconomic factors and incorporate them in outcomes research has remained elusive. Recently, a composite ranking of community-level socioeconomic factors was developed by the Economic Innovation Group to better understand and integrate these determinants [10].

Assessing economic well-being at the zip code level, the Distressed Communities Index (DCI) integrates 7 metrics that include community educational level, poverty rate, median income, job growth, housing vacancies, unemployment, and business establishments into a composite...
scoring system of 0 (no distress) to 100 (maximal distress). Through this composite score, the DCI aims to understand the spatial distribution of economic well-being in the United States [10]. In this study, we sought to characterize trends and outcomes in patients of distressed socioeconomic status undergoing coronary artery bypass grafting at high- and low-volume centers and with high- and low-volume surgeons. We hypothesized that patients of increased socioeconomic distress were more likely to be treated at low–CABG volume hospitals by low-volume surgeons, potentially leading to disparities in outcome.

METHODS

The Florida Agency for Healthcare Administration data set was merged with the Centers for Medicare and Medicaid Services (CMS) Physician and Hospital Compare and the Economic Innovation Group (ECIG) data sets to build a comprehensive database. The Florida Agency for Healthcare Administration administrative data set provides data from all discharges from licensed acute care hospitals, ambulatory surgery centers, emergency departments, and cardiac catheterization laboratories in the state of Florida [11]. Combined with the CMS Physician and Hospital Compare data set, information pertaining to surgeon operative volume by National Provider Identifier and hospital case volume by Medicare identification numbers was obtained. The Economic Innovation Group DCI covers nearly 25,500 zip codes and 99% of the United States population and is composed of 7 metrics to form a single summary statistic: adults not working, poverty rate, housing vacancy rate, median household income, change in employment, change in establishments, and high school diploma [10]. Composite DCI scores are then classified into 5 tiers: distressed, at risk, mid-tier, comfortable, and prosperous. The merged data set was queried by International Classification of Diseases, Tenth Revision, Procedure Coding System (ICD-10) codes for isolated coronary artery bypass grafting surgeries between 2016 and 2020.

Data were categorized on the basis of physician and hospital CABG volume by quintile and DCI score by quintile. High- and low-volume surgeons and hospitals were compared by demographics, comorbid conditions, length of hospital stay, and postoperative complications using Pearson $\chi^2$ and Student $t$ test where appropriate. Patients were also evaluated by DCI quintile, comparing prosperous (DCI score ≥ 80) and distressed (DCI score ≤ 20) communities with respect to demographics, preoperative comorbidities, and postoperative complications.

Data preparation, database merging, cleaning, and computation of various descriptive statistics were performed using Stata software version 16 (StataCorp, College Station, TX, USA). Analysis was conducted in R (R Core Team, 2014) using R Studio (RStudio, PBC, Boston, MA). Quantitative data are reported as number and percentage ($n$, %), and mean and standard deviation ($\mu$, $\sigma$). This study was exempt from institutional review given the deidentified retrospective database nature of this analysis.

RESULTS

A total of 41,571 isolated coronary artery bypass surgical procedures were performed by 174 surgeons at 67 Florida hospitals between 2016 and 2020. Patients presented from 911 distinct zip codes to CABG procedure codes for isolated coronary artery bypass grafting surgeries between 2016 and 2020.

### Table 1: Hospital and physician volume grouped by volume quartiles

| Hospital volume quartiles | Hospitals, n | Volume range | Procedures, n |
|---------------------------|--------------|--------------|---------------|
| Bottom quartile           | 36           | 79–511       | 10,858        |
| 265–500                   | 15           | 540–901      | 10,530        |
| 51%–75%                   | 10           | 902–1171     | 10,078        |
| Top quartile              | 6            | 1178–2549    | 10,105        |

| Physician volume quartiles | Physicians, n | Volume range | Procedures, n |
|----------------------------|---------------|--------------|---------------|
| Bottom quartile            | 265–500       | 1–249        | 13,248        |
| 51%–75%                    | 35            | 251–392      | 10,950        |
| Top quartile               | 22            | 408–486      | 9791          |

### High- and Low-Volume Surgeons

High-volume CABG-performing surgeons ($n = 17$ surgeons, average yearly volume $99–172$ procedures) and low-volume surgeons ($n = 100$ surgeons, average yearly volume $1–50$ procedures) were compared (Table 3). High- and low-volume surgeons did not differ with respect to ages of patients, Charlson Comorbidity Index category, and patients with preoperative dementia or metastatic solid tumor burden. Low-volume surgeons saw significantly more African American (8.07% vs 6.67%, $P < .001$) and Hispanic Latino (17.96% vs 11.05%, $P < .001$) patients and had more cases classified as “emergent” (39.28% vs 32.58%, $P < .001$), patients with Medicaid (5.33% vs 4.65%, $P < .001$), and patients from community classified as “distressed” by DCI (9.81% vs 8.73%, $P < .001$). Low-volume surgeons had a higher proportion of patients discharged to home (23.08% vs 12.12%, $P < .001$), inpatients rehabilitation (8.04% vs 4.54%, $P < .001$), and long-term acute care facilities (1.11% vs 0.67%, $P < .001$). The remainder of discharge locations also differed between groups (Table 3).

Higher-volume surgeons saw patients with higher rates of a preoperative history of peripheral vascular disease, chronic obstructive pulmonary disease, and dementia. However, high-volume surgeons had markedly less postoperative incidences of respiratory failure (10.06% vs 15.01%, $P < .001$), acute renal failure (19.78% vs 23.44%, $P < .001$), pleural effusion (11.16% vs 14.15%, $P < .001$), congestive heart failure (25.82% vs 28.98%, $P < .001$), cardiac arrest (1.19% vs 1.54%, $P < .001$), and stroke (1.23% vs 1.88%, $P < .001$). The mean length of hospital stay was longer for low-volume CABG-performing surgeons ($n = 10.24$ vs 9.38 days, $P < .001$).

### Table 2: High- and Low-Volume CABG Hospitals

| Hospital volume quartiles | Physicians, n | Volume range | Procedures, n |
|---------------------------|---------------|--------------|---------------|
| Bottom quartile           | 265–500       | 1–249        | 13,248        |
| 51%–75%                   | 35            | 251–392      | 10,950        |
| Top quartile              | 22            | 408–486      | 9791          |

### High- and Low-Volume CABG Hospitals

A larger proportion of patients from at-risk (17.54% vs 17.01%, $P < .001$) and distressed (8.73% vs 6.84%, $P < .001$) communities received care at low–CABG volume hospitals (Table 2). Conversely, a higher proportion of patients from comfortable (30.78% vs 26.99%, $P < .001$) and prosperous (22.05% vs 17.57%, $P < .001$) communities were more likely present to high-volume hospitals. High-volume hospitals overall were composed of less males (75.53% vs 76.69%, $P < .05$), had less cases classified as “emergent” (28.1% vs 42.51%, $P < .001$), and had fewer patients with a Charlson Comorbidity Index classified as “severe” (66.03% vs 67.64%, $P < .05$). Additionally, high-volume hospitals had fewer patients with preoperative comorbidities including history of myocardial infarction (43.59% vs 47.59%, $P < .001$), congestive heart failure (32.51% vs 36.64%, $P < .001$), peripheral vascular disease (18.66% vs 14.39%, $P < .001$), and chronic obstructive pulmonary disease (23.51% vs 25.76%, $P < .001$). Postoperative complications also varied between high- and low-volume hospitals, with high-volume hospitals experiencing less respiratory failure (8.77% vs 17.22%, $P < .001$), acute renal failure (20.06% vs 23.54%, $P < .001$), pneumonia (4.35% vs 5.89%, $P < .001$), pleural effusion (12.11% vs 13.81%, $P < .001$), cardiac arrest (1.19% vs 1.54%, $P < .001$), and urinary tract infection (5.46% vs 6.44%, $P < .001$). Length of hospital stay was increased for low-volume hospitals ($n = 10.24$ vs 9.38 days, $P < .001$).

### Prosperous and Distressed Communities

Patients residing in prosperous and distressed communities as classified by DCI quintile were evaluated. Overall, distressed communities were composed of more African American (20.57% vs 3.76%, $P < .001$) and Hispanic Latino (12.51% vs 10.22%, $P < .001$) patients, with a higher proportion of patients with
### Table 2
Comparison of patient demographics, payer types, discharge status, preoperative comorbidities, and postoperative complications between high- and low-volume CABG hospitals. N is total number of procedures included in analysis; data are presented as number and percentage (n, %), or mean and standard deviation.

| Hospitals | Low volume (n = 10,858) | High volume (n = 10,105) | P value |
|-----------|-------------------------|--------------------------|---------|
| Sex       |                         |                          |         |
| Male      | 8327 (76.69)            | 7632 (75.53)             | .048    |
| Age categories (y)  |              |                          |         |
| ≤30       | 4 (0.04)                | 6 (0.06)                 | <.001   |
| 31–50     | 655 (6.03)              | 576 (5.70)               |         |
| 51–70     | 5941 (54.72)            | 5318 (53.63)             |         |
| 71–90     | 4238 (39.03)            | 4198 (41.54)             |         |
| 90+       | 20 (0.18)               | 7 (0.07)                 |         |
| Race      |                         |                          |         |
| White     | 9120 (83.99)            | 8540 (84.51)             | .983    |
| Black     | 781 (7.19)              | 531 (5.52)               |         |
| Asian     | 141 (1.3)               | 129 (1.28)               |         |
| Others    | 816 (7.52)              | 905 (8.96)               |         |
| Ethnicity |                         |                          |         |
| Non-Hispanic | 9575 (88.18)        | 8910 (88.17)             | .16     |
| Hispanic Latino | 1283 (11.82)     | 1195 (11.83)             |         |
| Charlson Comorbidity Index |     |                          | .016    |
| Low       | 1176 (10.83)            | 1206 (11.93)             |         |
| Moderate  | 2338 (21.53)            | 2227 (22.04)             |         |
| Severe    | 7344 (67.64)            | 6672 (66.03)             |         |
| Length of stay (d) | 10.24 (6.41)         | 9.38 (6.97)               | <.001   |
| Admission priority |         |                          | <.001   |
| Emergency | 4616 (42.51)            | 2840 (28.10)             |         |
| Urgent    | 1410 (12.99)            | 3329 (32.94)             |         |
| Elective  | 4826 (44.45)            | 3932 (38.91)             |         |
| Trauma    | 6 (0.06)                | 4 (0.04)                 |         |
| Payer types |                     |                          | .01     |
| Medicare  | 6856 (63.14)            | 6534 (64.86)             |         |
| Medicaid  | 509 (4.69)              | 422 (4.18)               |         |
| Commercial health insurance | 2673 (24.62) | 2375 (23.50)             |         |
| All others | 535 (4.93)            | 461 (4.56)               |         |
| Self-pay  | 285 (2.62)              | 313 (3.10)               |         |
| Distressed Communities Index quintiles |     |                          | <.001   |
| Prosperous | 1908 (17.57)           | 2228 (22.05)             |         |
| Comfortable | 2931 (26.99)          | 3110 (30.78)             |         |
| Mid-tier  | 3166 (29.16)            | 2357 (23.33)             |         |
| At risk   | 1905 (17.54)            | 1719 (17.01)             |         |
| Distressed | 948 (8.73)             | 691 (6.84)               |         |
| Discharge status |         |                          | <.001   |
| Home or self-care (routine discharge) | 2258 (20.80) | 1332 (13.18)             |         |
| To a short-term general hospital for inpatient care | 49 (0.45) | 33 (0.33)                |         |
| Skilled nursing facility with Medicare certification | 1446 (13.32) | 1601 (15.84)             |         |
| Home under care of home health care organization service | 5619 (51.75) | 6593 (65.24)             |         |
| Left the hospital against medical advice/discontinued care | 23 (0.21) | 6 (0.06)                 |         |
| Expired   | 207 (1.91)              | 162 (1.60)               |         |
| Hospice   | 48 (0.44)               | 23 (0.23)                |         |
| Inpatient rehabilitation facility | 1036 (9.54) | 283 (2.80)               |         |
| Medicare-certified long-term care hospital | 104 (0.96) | 43 (0.43)                |         |
| All others | 68 (0.63)              | 29 (0.29)                |         |
| Patient preoperative comorbidities |     |                          |         |
| Myocardial infarction | 5167 (47.59) | 4405 (43.59)             | <.001   |
| Congestive heart failure | 3978 (36.64) | 3285 (32.51)             |         |
| Peripheral vascular disease | 1563 (14.39) | 1886 (18.66)             | <.001   |
| Chronic obstructive pulmonary disease | 2797 (25.76) | 2376 (23.51)             | <.001   |
| Renal disorders | 2503 (23.05) | 2162 (21.40)             | .004    |
| Diabetes without chronic complications | 3081 (28.38) | 2870 (28.40)             | .996    |
| Diabetes with chronic complications | 2281 (21.01) | 2086 (20.64)             | .516    |
| Dementia  | 192 (1.77)              | 150 (1.48)               | .105    |
| Metastatic solid tumor | 16 (0.15) | 21 (0.21)                | .297    |
| Postoperative complications |     |                          |         |
| Respiratory failure | 1870 (17.22) | 886 (8.77)               | <.001   |
| Acute renal failure | 2556 (23.54) | 2027 (20.06)             | <.001   |
| Pneumonia | 639 (5.89)              | 444 (4.39)               | <.001   |
| Pleural effusion | 1499 (13.81) | 1224 (12.11)             | <.001   |
| Cardiac arrhythmia | 4423 (40.73) | 4527 (44.80)             | <.001   |
| Congestive heart failure | 3085 (28.41) | 2443 (24.37)             | <.001   |
| Cardiac arrest | 186 (1.71) | 128 (1.27)               | <.05    |
| Urinary tract infection | 699 (6.44) | 552 (5.46)               | .003    |
| Cerebral infarction | 175 (1.61) | 136 (1.54)               | .093    |
| Malnutrition | 500 (4.60) | 373 (3.69)               | .001    |
| Delirium   | 340 (3.13)              | 400 (3.96)               | .001    |
## Table 3
Comparison of patient demographics, payer types, discharge status, preoperative comorbidities, and postoperative complications between high- and low-volume physicians performing CABG. N is total number of procedures included in analysis; data are presented as number and percentage (n, %), or mean and standard deviation.

| Physicians | Low volume (n = 10,514) | High volume (n = 10,316) | P value |
|------------|-------------------------|--------------------------|---------|
| Sex        |                         |                          | <.001   |
| Male       | 8083 (76.88)            | 7690 (74.54)             |         |
| Age categories (y) |                  |                          | .466   |
| ≤30        | 4 (0.04)                | 8 (0.08)                 |         |
| 31–50      | 710 (6.75)              | 715 (6.93)               |         |
| 51–70      | 5843 (55.57)            | 5742 (55.66)             |         |
| 71–90      | 3948 (37.55)            | 3847 (37.29)             |         |
| 90+        | 9 (0.09)                | 4 (0.04)                 |         |
| Race       |                         |                          | <.001   |
| White      | 8699 (82.74)            | 8764 (84.96)             |         |
| Black      | 849 (8.07)              | 688 (6.67)               |         |
| Asian      | 152 (1.45)              | 150 (1.45)               |         |
| Others     | 814 (7.74)              | 714 (6.92)               |         |
| Ethnicity  |                         |                          | <.001   |
| Non-Hispanic | 8626 (82.04)        | 9176 (88.95)             |         |
| Hispanic Latino |                  | 1888 (17.96)            |         |
| Charlson Comorbidity Index |         |                          | .256   |
| Low        | 1219 (11.59)            | 1128 (10.93)             |         |
| Moderate   | 2253 (21.43)            | 2188 (21.21)             |         |
| Severe     | 7042 (66.98)            | 7000 (67.86)             |         |
| Length of stay (d) |                 | 10.39 (7.42)             | 9.68 (7.42) | <.001 |
| Admission priority |                  |                          | <.001   |
| Emergency  | 4130 (39.28)            | 3361 (32.58)             |         |
| Urgent     | 1707 (16.24)            | 2811 (27.25)             |         |
| Elective   | 4674 (44.46)            | 4142 (40.15)             |         |
| Trauma     | 3 (0.03)                | 2 (0.02)                 |         |
| Payer types |                         |                          | <.001   |
| Medicare   | 6295 (59.87)            | 6340 (61.46)             |         |
| Medicaid   | 560 (5.33)              | 480 (4.65)               |         |
| Commercial health insurance |           | 2774 (26.38)             | 2545 (24.67) | <.001 |
| All others | 557 (5.30)              | 486 (4.71)               |         |
| Self-pay   | 328 (3.21)              | 465 (4.51)               |         |
| Distressed Communities Index quintiles |         |                          | .001   |
| Prosperous | 2299 (21.87)            | 2195 (21.28)             |         |
| Comfortable| 2899 (27.57)            | 2776 (26.91)             |         |
| Mid-tier   | 2450 (23.30)            | 2629 (25.48)             |         |
| At risk    | 1835 (17.45)            | 1815 (17.59)             |         |
| Distressed | 1031 (9.81)             | 901 (8.73)               |         |
| Discharge status |                  |                          | <.001   |
| Home or self-care (routine discharge) |       | 2427 (23.08)             | 1250 (12.12) |         |
| To a short-term general hospital for inpatient care | 42 (0.40) | 42 (0.41) | |
| Skilled nursing facility with Medicare certification | 1367 (13.0) | 1620 (15.70) | |
| Home under care of home health care organization service | 5372 (51.09) | 6881 (64.76) | |
| Left the hospital against medical advice/discontinued care | 24 (0.23) | 9 (0.09) | |
| Expired    | 217 (2.06)              | 130 (1.26)               |         |
| Hospice    | 34 (0.32)               | 21 (0.20)                |         |
| Inpatient rehabilitation facility | 845 (8.04) | 468 (4.54) | |
| Medicare-certified long-term care hospital | 117 (1.11) | 69 (0.67) | |
| All others | 69 (0.66)               | 26 (0.25)                |         |
| Patient preoperative comorbidities |          |                          |         |
| Myocardial infarction | 4851 (46.14) | 4884 (47.34) | .081   |
| Congestive heart failure | 3816 (36.29) | 3632 (35.21) | .102   |
| Peripheral vascular disease | 1553 (14.77) | 1706 (16.54) | <.001 |
| Chronic obstructive pulmonary disease | 2408 (22.90) | 2629 (25.48) | <.001 |
| Renal disorders | 2403 (22.86) | 2203 (21.36) | .009   |
| Diabetes without chronic complications | 2973 (28.28) | 3124 (30.28) | .001   |
| Diabetes with chronic complications | 2299 (21.87) | 2111 (20.46) | .13   |
| Dementia   | 137 (1.30)              | 158 (1.53)               | .163   |
| Metastatic solid tumor | 16 (0.15) | 25 (0.24) | .142   |
| Postoperative complications |          |                          |         |
| Respiratory failure | 1578 (15.01) | 1038 (10.06) | <.001 |
| Acute renal failure | 2465 (23.44) | 2041 (19.78) | <.001 |
| Pneumonia   | 604 (5.74)              | 530 (5.14)               | .054   |
| Pleural effusion | 1488 (14.15) | 1151 (11.16) | <.001 |
| Cardiac arrhythmia | 4350 (41.37) | 4219 (40.90) | .485   |
| Congestive heart failure | 3047 (28.98) | 2664 (25.82) | <.001 |
| Cardiac arrest | 162 (1.54) | 123 (1.19) | .03   |
| Urinary tract infection | 600 (5.71) | 621 (6.02) | .336   |
| Cerebral infarction | 198 (1.88) | 127 (1.23) | <.001 |
| Malnutrition | 602 (5.73) | 509 (4.93) | .011   |
| Delirium    | 258 (2.45)              | 210 (2.04)               | .042   |
Charlson Comorbidity Index classified as "severe" (72.38% vs 61.68%, P < .001), and cases classified as "emergent" (40.95% vs 30.71%, P < .001) (Table 4). Patients from distressed communities were also more likely to have Medicaid (9.63% vs 2.94%, P < .001) and less likely to have commercial health insurance (20.74% vs 29.39%, P < .001). Distressed community patients had a higher proportion of histories of myocardial infarction, congestive heart failure, peripheral vascular disease, chronic obstructive pulmonary disease, renal disorders, diabetes, and dementia. Patients from these communities also had higher rates of postoperative respiratory failure (14.89% vs 12.62%, P < .05), acute renal failure (23.45% vs 21.59%, P < .05), pneumonia (6.45 vs 4.70, P < .001), congestive heart failure (29.95% vs 22.77%, P < .001), cardiac arrest (1.87% vs 1.48%, P < .001), urinary tract infection (6.5% vs 4.51%, P < .001), and delirium (2.66% vs 2.05%, P < .05). Distressed communities also experienced increased mean lengths of hospital stay when compared with prosperous communities (10.72 vs 9.32 days, P < .001), with a higher proportion discharged to skilled nursing facilities (16.87% vs 13.81%, P < .001) and inpatient rehabilitation facilities (6.75% vs 5.66%, P < .001).

DISCUSSION

The impact of low socioeconomic status using discrete metrics has been associated with worse health outcomes and may result in decreased overall life expectancy [12–15]. This analysis outlines trends of high- and low-volume CABG-performing hospitals and surgeons and finds potential disparities in patients of high socioeconomic distress, as measured by increased DCI score, which may contribute to worse postoperative outcome and longer lengths of hospital stay.

Traditional socioeconomic metrics, including race, median household income, and educational achievement, have been commonly used in risk-adjusted outcomes research and in risk prediction modeling [16,17]. However, when used in isolation, these metrics may not provide an accurate representation of high socioeconomic burden and consequently may underestimate actual risk in this cohort. In accounting for both patient- and community-level factors, including regional access to health care, the DCI aims to provide superior insight over these conventional methods. Previous analyses have demonstrated worse outcomes following CABG for patients from rural communities likely as a result of worse preoperative comorbidities and access to health care resources [18–20]. Despite this, current risk models do not consistently incorporate data on community-level median household income, poverty level, and housing vacancy rate. By integrating conventional socioeconomic metrics together with distance to area hospitals and primary care clinics, among other factors included in the DCI, the influence of depressed socioeconomic status may be better realized.

Although high- and low-volume CABG-performing hospitals did not significantly differ with respect to hospital quality metrics in this analysis, patients seeking care at these facilities differed by race. Charlson Comorbidity Index, payer type, admission priority, and select postoperative outcomes. Patients from communities at risk or distressed by DCI score were more likely to have surgery at low-volume CABG-performing hospitals. Congruently, the proportion of distressed populations seen and outcomes between high- and low-volume surgeons also showed significant differences with respect to length of hospital stay, respiratory failure, acute renal failure, and stroke. We propose 2 likely mechanisms for the disparate findings in our analysis: the influence of poorer clinical risk profiles in distressed communities and the inherent limitations of hospitals with low CABG volume. In agreement with our findings, Mehaffey and colleagues’ recent analysis using DCI scoring showed that patients from distressed communities were at increased risk from adverse outcomes and death after CABG using the Society of Thoracic Surgeons Adult Cardiac Surgery Database [1]. The complex burden of high socioeconomic distress, including access to routine care, postoperative follow-up, and cardiac rehabilitation, likely contributes to these findings. Regional distribution differences in

| Race          | Distressed (n = 3646) | Prosperous (n = 9081) | P value |
|--------------|---------------------|----------------------|---------|
| White        | 2710 (74.33)        | 8022 (88.34)         |         |
| Black        | 750 (20.57)         | 341 (3.76)           |         |
| Asian        | 19 (0.52)           | 193 (2.13)           |         |
| Others       | 167 (4.58)          | 525 (5.78)           |         |
| Ethnicity    |                     |                      | <.001   |
| Non-Hispanic | 3190 (87.49)        | 8153 (89.78)         |         |
| Hispanic Latino | 456 (12.51)    | 928 (10.22)          |         |
| Charlson Comorbidity Index | | | <.001 |
| Low          | 329 (9.02)          | 1307 (14.39)         |         |
| Moderate     | 678 (18.60)         | 2173 (23.93)         |         |
| Severe       | 2639 (72.38)        | 5601 (61.68)         |         |
| Length of stay (d) | 10.72 (7.87) | 9.32 (6.72)          | <.001   |
| Admission priority | 1403 (40.95) | 2789 (30.71)         |         |
| Emergency    | 786 (21.56)         | 2519 (27.74)         |         |
| Elective     | 1365 (37.44)        | 3770 (41.52)         |         |
| Trauma       | 2 (0.05)            | 3 (0.03)             |         |
| Payer types  |                     |                      | <.001   |
| Medicare     | 2132 (58.48)        | 5545 (61.06)         |         |
| Medicaid     | 351 (9.63)          | 267 (2.94)           |         |
| Commercial health insurance | 756 (20.74) | 2609 (29.39)         |         |
| All others   | 247 (6.77)          | 351 (3.87)           |         |
| Self-pay     | 160 (4.39)          | 249 (2.74)           |         |
| Discharge status |                     |                      | <.001   |
| Home or self-care (routine discharge) | 763 (20.93) | 1344 (14.80)         |         |
| To a short-term general hospital for inpatient care | 27 (0.74) | 39 (0.43)          |         |
| Skilled nursing facility with Medicare certification | 615 (16.87) | 1254 (13.81)         |         |
| Home under care of home health care organization service | 1815 (49.78) | 5681 (62.56)         |         |
| Left the hospital against medical advice/discontinued care | 8 (0.22) | 3 (0.01)           |         |
| Expired      | 66 (1.81)           | 135 (1.49)           |         |
| Hospice      | 13 (0.36)           | 22 (0.24)            |         |
| Inpatient rehabilitation facility | 246 (6.75) | 514 (5.66)          |         |
| Medicare-certified long-term care hospital | 38 (1.04) | 70 (0.77)          |         |
| All others   | 55 (1.51)           | 19 (0.21)            |         |

Patient preoperative comorbidities

| Myocardial infarction | 1827 (50.11) | 3979 (42.82) | <.001 |
| Congestive heart failure | 1405 (38.54) | 2857 (31.46) | <.001 |
| Peripheral vascular disease | 591 (16.21) | 1330 (14.65) | 0.026 |
| Chronic obstructive pulmonary disease | 1037 (28.44) | 1795 (19.77) | <.001 |
| Renal disorders | 865 (23.72) | 1849 (20.36) | <.001 |
| Diabetes without chronic complications | 1101 (30.20) | 2489 (27.41) | .002 |
| Diabetes with chronic complications | 839 (24.49) | 1625 (17.89) | <.001 |
| Dementia | 57 (1.56) | 109 (1.20) | .103 |
| Metastatic solid tumor | 4 (0.11) | 25 (0.28) | .077 |
| Postoperative complications

| Respiratory failure | 543 (14.89) | 1146 (12.62) | .001 |
| Acute renal failure | 855 (23.45) | 1961 (21.59) | .023 |
| Pneumonia | 235 (6.45) | 427 (4.70) | <.001 |
| Pleural effusion | 469 (12.86) | 1218 (13.41) | .409 |
| Cardiac arrhythmia | 1292 (35.84) | 3527 (43.24) | <.001 |
| Congestive heart failure | 1092 (29.95) | 2068 (22.77) | <.001 |
| Cardiac arrest | 68 (1.87) | 134 (1.48) | .112 |
| Urinary tract infection | 237 (6.50) | 410 (4.51) | <.001 |
| Cerebral infarction | 69 (1.89) | 137 (1.51) | .121 |
| Malnutrition | 172 (4.72) | 451 (4.07) | .556 |
| Delirium | 97 (2.66) | 186 (2.05) | .034 |
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analysis: MPR, HJ; methodology: all authors; roles/writing

Author Contribution
outcomes should be considered.
mitigate the burden of high socioeconomic distress to optimize
surgery at low-volume facilities, potentially contributing to worse
improved postoperative outcomes and hospital length of stay when
surgeons or hospitals and to identify opportunities to mitigate factors
at-risk and distressed communities may be mitigated by high-volume
community hospital resources and availability of referrals to larger
centers for complex cases would likely improve these metrics.

Future work is needed to determine if outcomes in patients from
of factors contributing to socioeconomic status is likely incomplete.

Elections of increased health literacy when compared to areas that are more
affluent. The culmination of these factors can result in a population
that may not, or cannot, seek appropriate medical care in a timely
fashion. The ultimate effect may result in an overall sicker baseline population,
as demonstrated in this analysis with the distressed population
having a higher Charlson Comorbidity Index. Actions at the local,
regional, state, and national level to address these disparities, including
increased societal awareness and funding of projects to rectify these
discrepancies, may improve local population health. Ensuring equitable
community hospital resources and availability of referrals to larger

High-volume CABG-performing surgeons and hospitals have
improved postoperative outcomes and hospital length of stay when
compared to low-volume hospitals and surgeons. A larger proportion of
patients from distressed socioeconomic communities undergo bypass
surgery at low-volume facilities, potentially contributing to worse
patient outcome. Efforts to further identify confounding factors and
mitigate the burden of high socioeconomic distress to optimize
outcomes should be considered.

Author Contribution
Conceptualization: all authors; data curation: all authors; formal
analysis: MPR, HJ; methodology: all authors; roles/writing – original
draft: MR; writing – review & editing: HJ, PCK.

Conflict of Interest
The authors report no conflicts of interests related to this manuscript.

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Ethics Statement
This study was exempt from institutional review board approval
given the deidentified retrospective database nature of this analysis. All
authors have signed and agreed to the respective data use agree-
ments for each data set governing the use of deidentified data.

Supplementary Material
Stata and R markdown files involving various steps of deidentified
data preparation and modeling for this project are available by accessing
the following link: https://github.com/onetonopanalyticis/.

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