Persistent income-based disparities in clinical outcomes of cardiac surgery across the United States: A contemporary appraisal

Sara Sakowitz, MS, MPH,[a] Syed Shahyan Bakhtiyar, MD, MBE,[a,b] Saad Mallick, MD,[a] Arjun Verma, BS,[a] Yas Sanaiha, MD,[a,c] Richard Shemin, MD,[a,c] and Peyman Benharash, MD[a,c]

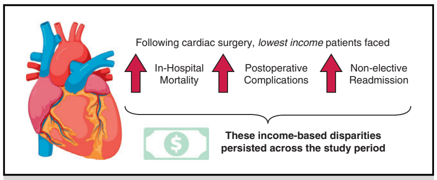
ABSTRACT

Objective: Although national efforts have aimed to improve the safety of inpatient operations, income-based inequities in surgical outcomes persist, and the evolution of such disparities has not been examined in the contemporary setting. We sought to examine the association of community-level household income with acute outcomes of cardiac procedures over the past decade.

Methods: All adult hospitalizations for elective coronary artery bypass grafting/valve operations were tabulated from the 2010-2020 Nationwide Readmissions Database. Patients were stratified into quartiles of income, with records in the 76th to 100th percentile designated as highest and those in the 0 to 25th percentile as lowest. To evaluate the change in adjusted risk of in-hospital mortality, complications, and readmission over the study period, estimates were generated for each income level and year.

Results: Of approximately 1,848,755 hospitalizations, 406,216 patients (22.0%) were classified as highest income and 451,988 patients (24.4%) were classified as lowest income. After risk adjustment, lowest income remained associated with greater likelihood of in-hospital mortality (adjusted odds ratio, 1.61, 95% CI, 1.51-1.72), any postoperative complication (adjusted odds ratio, 1.19, CI, 1.15-1.22), and nonelective readmission within 30 days (adjusted odds ratio, 1.07, CI, 1.05-1.10). Overall adjusted risk of mortality, complications, and nonelective readmission decreased for both groups from 2010 to 2020 ($P < .001$). Further, the difference in risk of mortality between patients of lowest and highest income decreased by 0.2%, whereas the difference in risk of major complications declined by 0.5% (both $P < .001$).

Conclusions: Although overall in-hospital mortality and complication rates have declined, low-income patients continue to face greater postoperative risk. Novel interventions are needed to address continued income-based disparities and ensure equitable surgical outcomes. (JTCVS Open 2024;20:89-100)



Income-based inequities in cardiac surgical outcomes remain with minimal change since 2010.

CENTRAL MESSAGE

Although overall morbidity has declined since 2010, socioeconomic disparities in cardiac surgical outcomes remain, such that low-income patients face greater mortality, complications, and readmission.

PERSPECTIVE

Despite significant advances in technique and care, as well as the implementation of national quality improvement efforts over the last decade, socioeconomic inequities in cardiac surgical outcomes persist. The present work found that incremental improvements have not closed the income-based disparity gap, such that low-income patients continue to face greater mortality, complications, and readmissions.

For decades, across nations and healthcare systems, socioeconomic disadvantage has been linked with greater incidence and severity of cardiovascular disease.[1-3] A large body of evidence has demonstrated adverse socioeconomic status to be associated with a greater risk of mortality and complications after coronary, valvular, and aortic operations.[4-7] Although the exact mechanisms of such inequities continue to be elucidated, prior work has suggested socioeconomically disadvantaged patients to more frequently present with diabetes, hypertension, or smoking history, all contributors to coronary artery disease. Yet, the so-called social gradient in health remains even after adjusting for such individual risk factors.[8]

From the [a]Cardiovascular Outcomes Research Laboratories (CORELAB), Department of Surgery, University of California, Los Angeles, Calif; [b]Department of Surgery, University of Colorado, Aurora, Colo; and [c]Division of Cardiac Surgery, Department of Surgery, University of California, Los Angeles, Calif.

Read at the 49th Annual Meeting of the Western Thoracic Surgical Association, Coeur d'Alene, Idaho, June 21-24, 2023.

Received for publication June 20, 2023; revisions received May 5, 2024; accepted for publication May 28, 2024; available ahead of print July 20, 2024.

Address for reprints: Peyman Benharash, MD, UCLA Division of Cardiac Surgery, 64-249 Center for Health Sciences, Los Angeles, CA 90095 (E-mail: PBenharash@mednet.ucla.edu).

2666-2736

https://doi.org/10.1016/j.xjon.2024.05.015

Abbreviations and Acronyms

AOR	= adjusted odds ratio
CABG	= coronary artery bypass grafting
MI	= myocardial infarction
NRD	= Nationwide Readmissions Database

The socioeconomic milieu of one's neighborhood is thought to modulate health and mortality beyond the effect of individual income.[9,10] In a study of 51,591 insured Canadian patients, each \$10,000 decrement in neighborhood income was linked with a 10% relative increase in all-cause mortality after myocardial infarction (MI).[11] Prior work has also linked neighborhood socioeconomic disadvantage, as measured through the Distressed Communities Index or Area Deprivation Index, with inferior outcomes after coronary artery bypass grafting,[12] cardiac transplantation,[13] and vascular procedures.[14] Community socioeconomic status appears to act as a structural factor that can significantly influence outcomes after cardiac procedures. To battle persistent healthcare disparities in the United States, numerous policies and interventions have been implemented at the local, regional, and national scale, yielding inconsistent results.[15,16] While the Affordable Care Act expanded access to insurance coverage and outpatient care, it does not appear to have improved the outcomes of cardiac or surgical hospitalizations.[17,18] Although Newell and colleagues[5] noted income- and sex-based differences in outcomes of cardiac operations, the time evolution of such disparities remains unexplored. This information might better guide future efforts aimed at providing equitable healthcare across the United States.

The present study examined the association of median household income with acute clinical outcomes of elective cardiac operations over the past decade. We hypothesized low household income to remain linked with greater mortality, complications, and nonelective readmission, without significant change over the study period.

MATERIAL AND METHODS

Data Source and Study Population

All adult (≥18 years) hospitalizations for elective, first-time coronary artery bypass grafting (CABG) or aortic, mitral, tricuspid, or pulmonic valve operations were ascertained from the 2010 to 2020 Nationwide Readmissions Database (NRD) using previously published International Classification of Diseases, 9th and 10th Revisions procedure codes.[19] As the largest publicly available, all-payer readmission database, the NRD provides accurate survey estimates for more than 60% of all US hospitalizations.[20] Records were excluded from analysis if they were missing data regarding median household income (1.5%), in-hospital mortality (<0.1%) or hospitalization expenditures (1.0%), or entailed concurrent left ventricular assist device placement, heart transplantation, or endocarditis (Figure 1).

Income Stratification

The Agency for Healthcare Research and Quality provides estimates of median household income based on ZIP codes and US census data.[20,21] Within the NRD, these estimates are reported as quartiles (0-25th, 26th-50th, 51st-75th, and 76th-100th percentiles).

We initially evaluated all income quartiles as an exploratory analysis. To facilitate comparison of income and adjusted risk of various outcomes, we elected to compare only the lowest and highest quartiles for further investigation. Thus, patients were stratified as lowest, comprising records in the 0 to 25th percentile for income, or highest, representing those in the 76th to 100th percentile for income.

Of note, information on race/ethnicity is not provided by the NRD. However, prior work has suggested that disparities in outcomes after cardiac procedures may be more related to economic disadvantage rather than race.[22]

Variable Definitions and Study Outcomes

Patient and hospital characteristics were tabulated using the NRD data dictionary. The van Walraven modification of the Elixhauser Comorbidity Index was used to numerically capture the burden of chronic illness.[23] Relevant comorbidities and complications were defined using International Classification of Diseases, 9th and 10th Revisions codes, as previously detailed.[19] Center volume was calculated for each procedure and year and used to stratify institutions into low-, medium-, and high-volume terciles. Hospitalization expenditures were computed using institution-specific, cost-to-charge ratios within the NRD and then inflation adjusted based on the 2020 Personal Healthcare Price Index.[24]

The primary study outcome was in-hospital mortality. Secondary outcomes included perioperative complications, nonhome discharge, and nonelective readmission within 30 days of discharge.

Statistical Analysis

The significance of intergroup differences was assessed using the Mann–Whitney U, adjusted Wald, or Pearson's chi-square tests, as appropriate. Multivariable models were constructed to assess the independent associations of income with outcomes of interest. Elastic net regularization was used to guide variable selection.[25] Covariates included for risk adjustment included age, sex, operation type, insurance, relevant comorbidities, smoking status, history of MI, history of percutaneous coronary intervention, hospitalization year, hospital annual operative volume, and teaching status. Interaction terms were used when appropriate. Model discrimination was optimized using receiver operator characteristics (C-statistic). To account for patient clustering effects, we repeated our analysis using mixed-effects, multilevel models. Within each model, the first level represented patient factors, and the second level accounted for institutional effects.

For each year, the predicted risk of key outcomes was calculated at various income levels. The difference in risk between lowest and highest was then estimated across years for each end point.

Logistic and linear model outputs are reported as adjusted odds ratios (AORs) and beta-coefficients (β), respectively, with 95% CI. Statistical significance was set at $\alpha = 0.05$. All statistical analyses were performed using Stata 16.1 (StataCorp). The Institutional Review Board at the University of California, Los Angeles, approved the study protocol and publication of data. Patient written consent for the publication of the study data was waived by the Institutional Review Board because of the deidentified nature of the NRD (#17-001112).

RESULTS

Exploratory Analysis

Of an estimated 1,848,755 patients, 406,216 (22.0%) were of 76th percentile or greater income, 486,011 (26.3%) were of 51st to 75th percentile, 504,540 (27.3%) were of 26th to 50th percentile, and 451,988 (24.4%) were of 25th percentile or less.

Upon unadjusted analysis, we noted a stepwise increase in mortality rates with decreasing income (≥76th percentile: 1.5%, 51st-75th percentile: 1.7%, 26th-50th percentile: 1.9%, ≤25th percentile: 2.1%, $P < .001$). As income decreased, rates of major complications, nonhome discharge, and nonelective readmission increased. After risk adjustment, lower-income quartiles remained associated with greater likelihood of in-hospital mortality and any perioperative complication, as well as nonhome discharge and nonelective readmission within 30 days (Table E1 and Figure 2).

Study Cohort

We subsequently compared the highest-income and lowest-income cohorts in a pairwise manner. The proportion of patients with lowest income declined over the study period (28.3% in 2010 to 22.6% in 2020, P for trend < .001) (Figure 3).

On average, the lowest-income cohort was younger (68 [60-75] vs 70 years [61-78], $P < .001$) and more commonly female (36.2% vs 31.3%, $P < .001$), but less often privately insured (24.9% vs 33.4%, $P < .001$), relative to the highest-income cohort. The lowest-income cohort more frequently underwent isolated CABG (51.1% vs 37.3%, $P < .001$). A complete characterization of the study cohorts is detailed in Table 1.

Perioperative Outcomes

The lowest-income cohort more frequently experienced in-hospital mortality (2.1% vs 1.5%, $P < .001$) and any postoperative complication (30.9% vs 27.4%, $P < .001$). In addition, the lowest-income cohort more often faced nonhome discharge (15.3% vs 13.5%, $P < .001$) and nonelective readmission within 30 days (10.1% vs 9.3%, $P < .001$) compared with the highest-income cohort (Table 2).

After risk adjustment, lowest income remained associated with increased odds of in-hospital mortality (AOR, 1.61; CI, 1.51-1.72; C-statistic: 0.84) and any postoperative complication (AOR, 1.19; CI, 1.15-1.22), including cardiac arrest, ventricular fibrillation, cardiogenic shock, and MI. Moreover, patients in the lowest-income cohort demonstrated greater odds of infectious, respiratory, stroke, and renal complications. Finally, those of lowest income faced increased likelihood of nonhome discharge and nonelective readmission within 30 days of discharge (Figure 4). These findings remained true following multilevel modeling to account for patient clustering (Table E2).

Temporal Trends in the Outcomes Gap

When evaluating the change in adjusted risk of mortality between lowest and highest incomes, we observed a 0.2% reduction (CI, −0.3 to 0.1) from 2010 to 2020. Considering postoperative complications, we noted a 0.5% decrease (CI, −0.7 to −0.3) in the risk differential between lowest and highest incomes over the study period. Likewise, we identified a 0.7% reduction (CI, −0.9 to −0.5) in the difference in risk of nonhome discharge and a 0.1% decrease (CI, −0.2 to −0.1) in the difference in risk of nonelective readmission within 30 days (Figure 5).

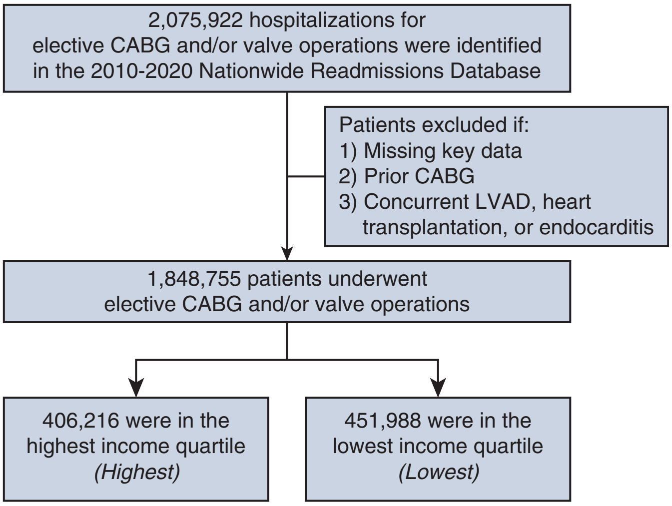


FIGURE 1. CONSORT diagram of survey-weighted estimates. Of 1,848,755 hospitalizations for elective CABG or valve operations included for analysis, 451,988 patients (24.4%) were of the lowest-income quartile. All estimates represent survey-weighted methodology. *CABG*, Coronary artery bypass grafting; *LVAD*, left ventricular assist device.

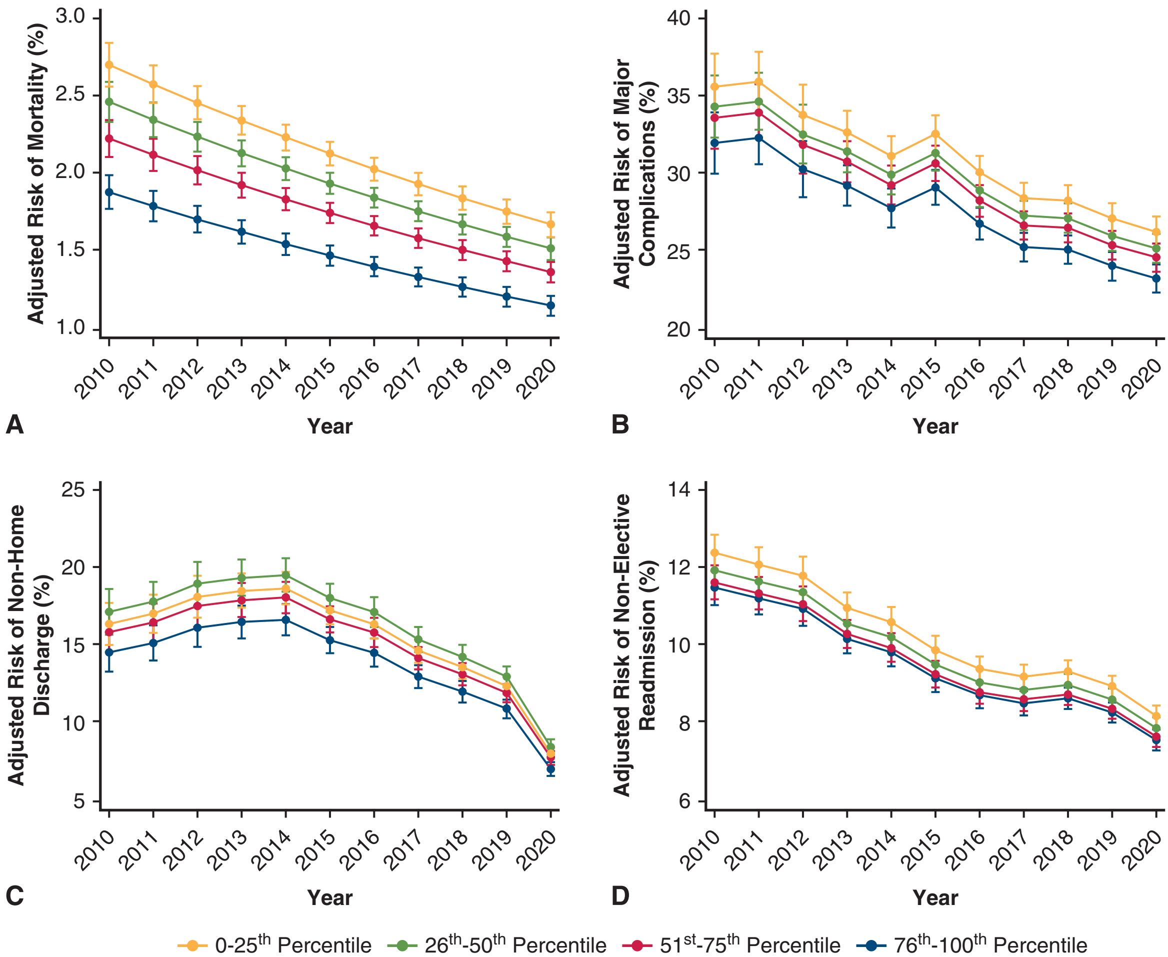


FIGURE 2. Stepwise association of median household income with adjusted risk of morbidity and discharge outcomes. From 2010 to 2020, higher median household income remained inversely associated with adjusted risk of (A) in-hospital mortality, (B) perioperative complications, (C) discharge to nonhome facilities, and (D) nonelective readmission within 30 days.

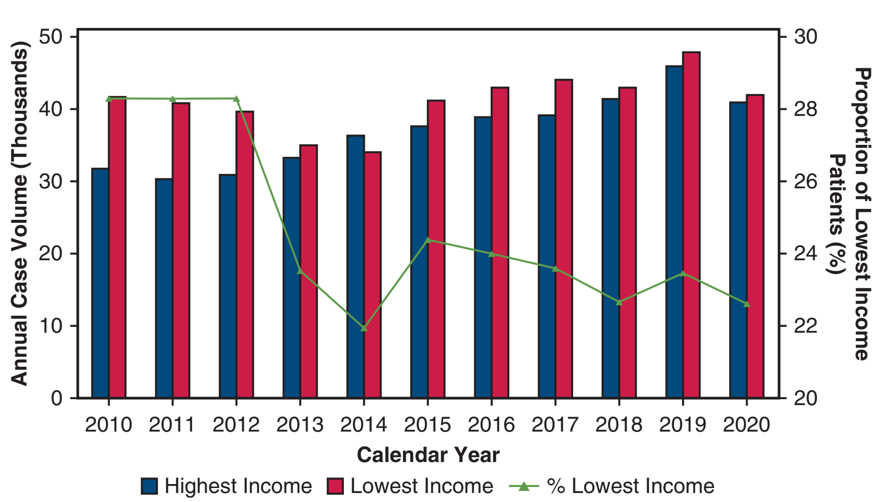


FIGURE 3. Trends in case volume stratified by income. The proportion of patients in the lowest-income quartile undergoing cardiac operations significantly decreased over the study period, from 28.3% in 2010 to 22.6% in 2020 (P for trend < .001). However, patients of lowest income (*red*) consistently demonstrated greater case volume each year, relative to those of highest income (*blue*).

TABLE 1. Demographic, clinical, and hospital characteristics of highest- and lowest-income patients

Characteristics	Highest (n = 406,216)	Lowest (n = 451,988)	*P* value
Age (y [IQR])	70 [61-78]	68 [60-75]	<.001
Female (%)	127,046 (31.3)	163,684 (36.2)	<.001
Elixhauser Comorbidity Index (mean ± SD)	4.2 ± 1.9	4.1 ± 1.8	.03
Smoker (%)	118,710 (29.2)	161,640 (35.8)	<.001
Type of procedure (%)			<.001
Isolated CABG	151,630 (37.3)	230,766 (51.1)	
Isolated valve	194,795 (48.0)	161,190 (35.7)	
Combined CABG valve	45,762 (11.3)	47,851 (10.6)	
Multi-valve	14,029 (3.5)	12,182 (2.7)	
Insurance coverage (%)			<.001
Private	135,566 (33.4)	112,190 (24.9)	
Medicare	250,638 (61.7)	286,115 (63.5)	
Medicaid	10,393 (2.6)	30,797 (6.8)	
Self-payer	2560 (0.6)	7982 (1.8)	
Other payer	6796 (1.7)	13,474 (3.0)	
Cardiac history (%)			
Previous MI	43,418 (10.7)	59,785 (13.2)	<.001
Previous PCI	55,063 (13.6)	65,644 (14.5)	<.001
Previous pacemaker/ICD	20,607 (5.1)	21,040 (4.7)	<.001
Comorbidities (%)			
Congestive heart failure	139,687 (34.4)	161,710 (35.8)	.005
Peripheral vascular disease	65,753 (16.2)	70,221 (15.5)	.002
Pulmonary circulation disorders	38,454 (9.5)	41,942 (9.3)	.30
Hypertension	298,103 (73.4)	348,862 (77.2)	<.001
Chronic pulmonary disease	76,047 (18.7)	111,571 (24.7)	<.001
Diabetes	113,861 (28.0)	163,155 (36.1)	<.001
Late-stage kidney disease	8086 (2.0)	13,421 (3.0)	<.001
Liver disease	10,017 (2.5)	11,332 (2.5)	.50
Coagulopathy	91,203 (22.5)	79,617 (17.6)	<.001
Cerebrovascular disorders	16,219 (4.0)	21,071 (4.7)	<.001
Annual hospital volume (%)			<.001
Lowest tertile	3404 (0.8)	3229 (0.7)	
Mid tertile	59,283 (14.6)	79,659 (17.6)	
Highest tertile	343,530 (84.6)	369,101 (81.7)	
Hospital teaching status (%)			<.001
Nonmetropolitan	191 (<0.1)	24,180 (5.3)	
Metropolitan nonteaching	64,057 (15.8)	98,258 (21.7)	
Metropolitan teaching	341,969 (84.2)	329,550 (72.9)	

Reported as survey-weighted estimates with group proportions in parentheses, unless otherwise noted. Statistical significance was set at $\alpha = 0.05$. *IQR*, Interquartile range; *CABG*, coronary artery bypass grafting; *MI*, myocardial infarction; *PCI*, percutaneous coronary intervention; *ICD*, implantable cardioverter defibrillator.

DISCUSSION

In the present work, we evaluated the evolution of income-based inequities in outcomes after cardiac procedures over the last decade and made several observations. Although risk-adjusted morbidity rates significantly declined for the entire population, low-income patients continued to face greater mortality, complications, nonhome discharge, and readmissions. We noted incremental reductions in the disparity gap between lowest- and highest-income patients over the study period. Yet, despite the numerous quality improvement efforts implemented since 2010, our findings show that cardiac surgical outcomes continue to significantly differ by community income level. Given the implications for policy and practice, these findings merit further discussion.

After comprehensive risk adjustment, lowest-income patients faced greater risk of postoperative mortality, complications, nonhome discharge, and nonelective

TABLE 2. Unadjusted and adjusted outcomes of lowest income compared with highest income

Study outcome	Unadjusted Highest	Unadjusted Lowest	Unadjusted *P*	Adjusted Lowest	Adjusted CI	Adjusted *P*
In-hospital mortality	1.5	2.1	<.001	1.61	1.51-1.72	<.001
Any complication	27.4	30.9	<.001	1.19	1.15-1.22	<.001
Cardiac complications	9.8	11.8	<.001	1.17	1.13-1.21	<.001
Arrest	0.9	1.1	<.001	1.25	1.15-1.35	<.001
Ventricular tachycardia	3.5	3.0	<.001	0.89	0.85-0.94	<.001
Ventricular fibrillation	1.1	1.3	.03	1.15	1.04-1.27	.006
Tamponade	0.6	0.6	.03	1.06	0.96-1.18	.23
Cardiogenic shock	2.8	3.5	<.001	1.25	1.17-1.34	<.001
Myocardial infarction	2.3	4.4	<.001	1.41	1.33-1.50	<.001
Infectious complications	1.4	1.8	<.001	1.40	1.31-1.49	<.001
Respiratory complications	10.7	12.9	<.001	1.20	1.15-1.26	<.001
Blood transfusion	23.0	22.4	.29	0.90	0.85-0.96	.001
Thrombotic complication	0.5	0.5	.59	1.07	0.96-1.20	.23
Stroke complications	1.2	1.4	<.001	1.15	1.07-1.24	<.001
Renal complications	10.0	11.3	<.001	1.26	1.21-1.30	<.001
Failure to rescue	6.0	6.7	<.001	1.33	1.23-1.43	<.001
Nonhome discharge	13.5	15.3	<.001	1.20	1.15-1.25	<.001
Nonelective 30-day readmission	9.3	10.1	<.001	1.07	1.04-1.10	<.001

Unadjusted outcomes are reported as proportions (%). Adjusted outcomes are detailed as AORs with 95% CI. Reference: lowest.

readmissions after elective cardiac procedures. These findings are consistent with literature over preceding decades that associated lower socioeconomic status with inferior postsurgical outcomes.[4,5,26-31] Koch and colleagues[22] reported low socioeconomic status to be linked with inferior survival up to 10 years after CABG/valve operations. Notably, this relationship has been reported in the setting of universal healthcare[11,27] and across different countries

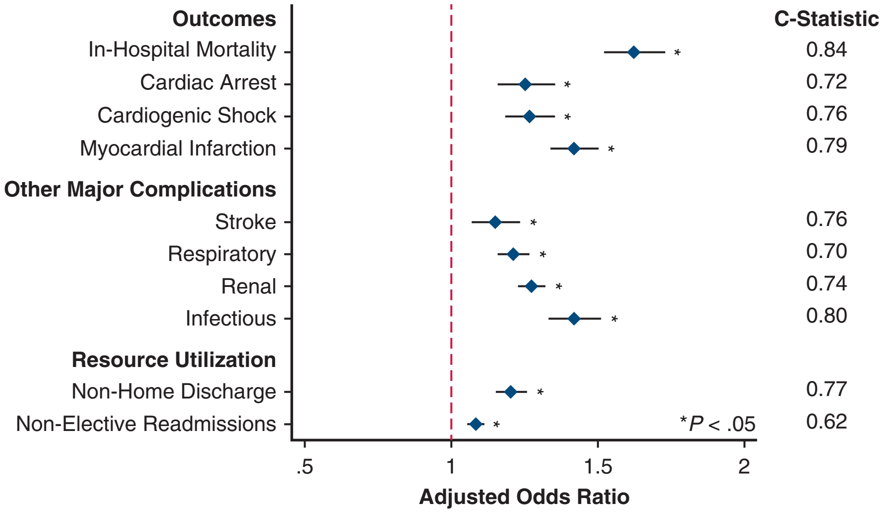


FIGURE 4. Association of lowest-income quartile with select outcomes of interest after risk adjustment, lowest income was associated with significantly greater odds of in-hospital morbidity, nonhome discharge, and nonelective readmission within 30 days of discharge. The C-statistic for each model, representing model discrimination, is displayed on the right. *Statistical significance, $P < .05$. Reference: highest-income quartile. Error bars represent 95% CIs.

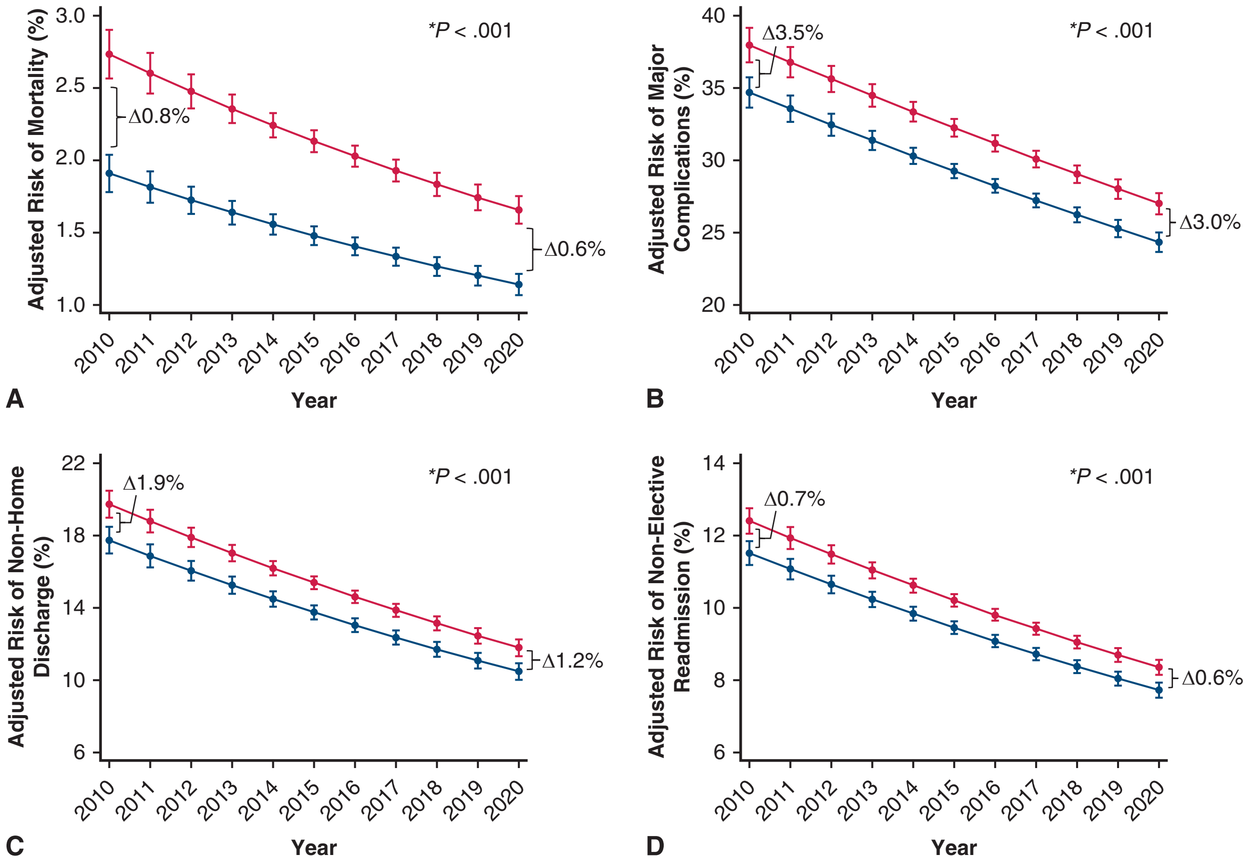


FIGURE 5. Difference in adjusted risk of mortality, complications, nonhome discharge, and readmissions between highest- and lowest-income quartiles across the study period. Patients of lowest income demonstrated greater in-hospital mortality, perioperative complications, and nonelective readmissions within 30 days of discharge, relative to patients of highest income. A, Analyzing the difference in adjusted risk over the study period, we observed a 0.2% reduction in the delta between highest and lowest incomes for in-hospital mortality, such that the difference between highest- and lowest-income patients declined from Δ0.8% to Δ0.6%. B, We found a 0.5% reduction in the difference in risk of major complications between highest and lowest incomes (Δ3.5% difference in 2010 to Δ3.0% in 2020). C, Considering risk of nonhome discharge, a 0.7% reduction in the risk differential was noted between highest- and lowest-income patients (Δ1.9% delta in 2010 to Δ1.2% in 2020). D, We found a 0.1% decrease in nonelective readmission risk (Δ0.7% in 2010 to Δ0.6% in 2020).

and health systems.[8,32] Altogether, disadvantaged socioeconomic status remains an independent risk factor for inferior outcomes after cardiac operations in the contemporary setting.

We noted an incremental, statistically significant reduction in the income-based disparities gap over the study period. Although suggestive of some beneficial effect, our findings reveal that the impact of national quality improvement efforts was not sufficient to adequately mitigate socioeconomic inequities in outcomes. Ultimately, we proffer 3 potential explanations for these persistent disparities. First, patients of lowest income may present with key differences in disease severity or comorbidities that influence therapeutic approach.[33] In our study, low-income patients more frequently had a history of MI and underwent revascularization of 3 or more vessels, which may suggest more extensive disease. Differences may also exist in the care these patients receive.[34] For example, in a Swedish cohort of CABG candidates, Nielsen and colleagues[26] noted lower-income patients to be less likely to receive secondary prevention medications, including statins and platelet inhibitors. Although reasons for this phenomenon remain unclear, additional work is needed to identify whether gaps in medical management stem from care fragmentation or different center-specific recovery pathways. Finally, aspects of socioeconomic disadvantage that persist outside of hospital-focused quality improvement programs—poverty, food or housing instability, unemployment, lack of social support—may contribute to significantly greater levels of psychosocial stress, with subsequent impacts on health.[35,36] For instance, the β-Blocker Heart Attack Trial found patients who had greater social isolation demonstrated a 4-fold increase in risk of death after MI.[37] Although we could not access data regarding these factors in our analysis, future studies should seek to more comprehensively evaluate their impact on contemporary postsurgical outcomes.

Over the last decade, numerous programs have aimed to improve the safety of inpatient operations.[38,39] We report declines in morbidity after cardiac procedures across our entire cohort that may be suggestive of their impact. However, our work also underscores that policies aimed at reducing inequities in health outcomes have not made sufficient progress in the cardiac surgical arena. Thus, innovative, reimagined efforts are needed to target the continued disparities gap. Although prior interventions such as the Affordable Care Act have focused on expanding insurance access, new programs could focus on broadening health literacy, enhancing engagement with preventative care at the local level, and addressing unmet social needs and postoperative care coordination before hospital discharge. For example, patients could be connected with housing or food resources or be integrated into telehealth programs to improve medication adherence and health literacy.[40] Finally, systemic-level interventions that address environmental or residential segregation, food deserts, and lack of social cohesion are warranted to address the fundamental root causes of inequities in cardiovascular disease.[9]

Study Limitations

The present work has several limitations. The NRD lacks granular perioperative information including ejection fraction, vessel size, extent of disease, and bypass time. Although we adjusted for annual center volume, we could not evaluate cumulative surgeon or institutional expertise. We considered median household income to represent patient income. However, this community-level factor may not wholly represent a patient's socioeconomic circumstances. The NRD does not permit assessment of ZIP code–based indices of neighborhood socioeconomic disadvantage, such as the Distressed Communities Index or the Area Deprivation Index. Yet, future work should consider the impact of these metrics on both in-hospital and long-term outcomes. Last, although the NRD does not include cardiac-specific risk scoring systems, we carefully assessed model calibration and report a similar C-statistic as that of the STS Predicted Risk of Mortality score. Altogether, we

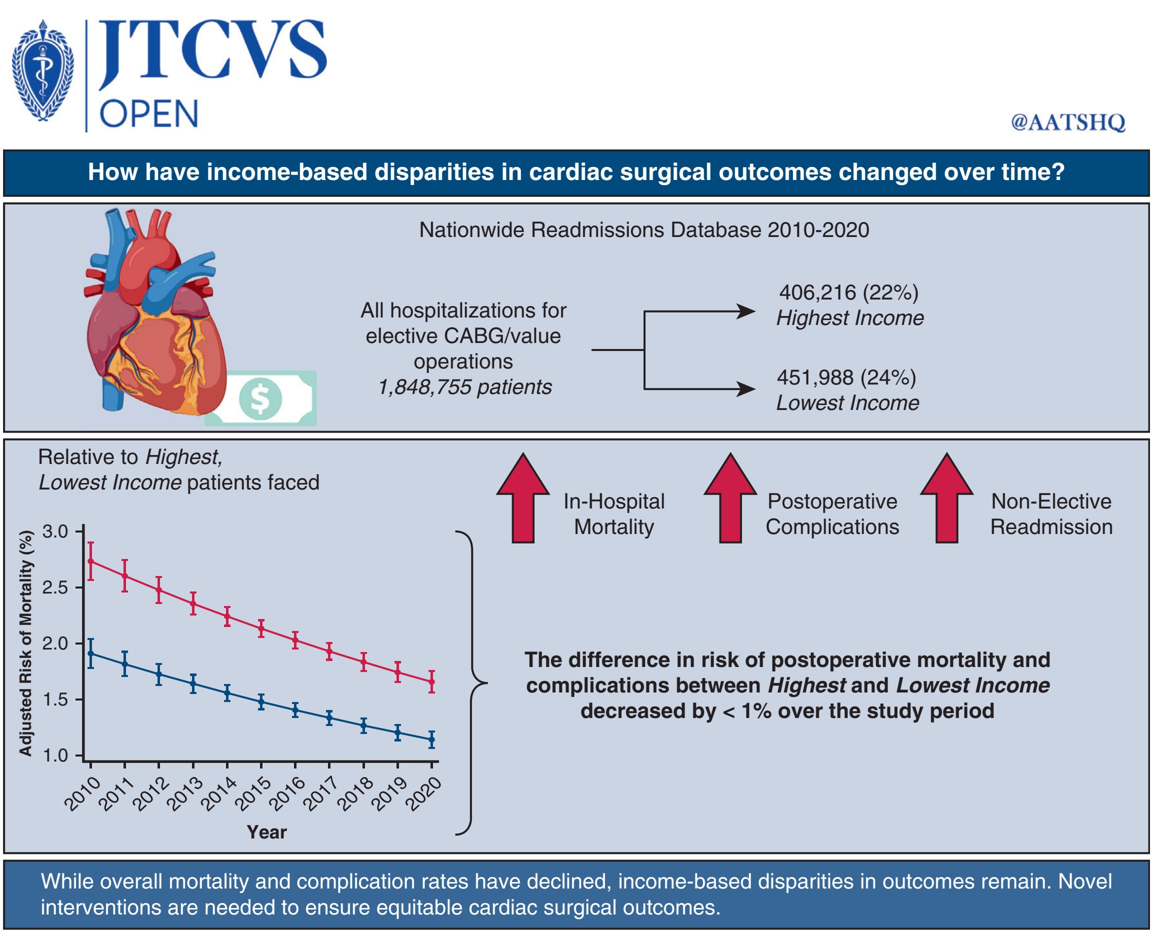


FIGURE 6. Graphical abstract.

applied robust statistical methods and a multilevel approach to comprehensively evaluate changes in socioeconomic disparities in cardiac surgical outcomes over time.

CONCLUSIONS

We report a continued disparities gap in outcomes after major cardiac operations (Figure 6). Despite significant advances in care, as well as the implementation of national quality improvement interventions over the last decade, low-income patients continue to face greater morbidity, nonhome discharge, and readmissions. Therefore, our study calls for a national reevaluation of the programs and policies currently in place to address these persistent disparities. Interventions must be innovatively redesigned to directly address established structural barriers to care and ensure equitable outcomes for all patients, irrespective of their socioeconomic status.

Conflict of Interest Statement

R.S. is a consultant to Edwards LifeSciences Advisory Board. P.B. is a proctor for AtriCure. The present work does not reference Edwards or AtriCure products nor did it receive funding from any external sources. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

References

1. Rose G, Marmot MG. Social class and coronary heart disease. *Br Heart J*. 1981;45(1):13-19.
2. Stringhini S, Carmeli C, Jokela M, et al. Socioeconomic status and the 25 × 25 risk factors as determinants of premature mortality: a multicohort study and meta-analysis of 1·7 million men and women. *Lancet*. 2017;389(10075):1229-1237. https://doi.org/10.1016/S0140-6736(16)32380-7
3. Mensah GA, Mokdad AH, Ford ES, Greenlund KJ, Croft JB. State of disparities in cardiovascular health in the United States. *Circulation*. 2005;111(10):1233-1241. https://doi.org/10.1161/01.CIR.0000158136.76824.04
4. Agabiti N, Cesaroni G, Picciotto S, et al. The association of socioeconomic disadvantage with postoperative complications after major elective cardiovascular surgery. *J Epidemiol Community Health*. 2008;62(10):882-889. https://doi.org/10.1136/jech.2007.067470
5. Newell P, Asokan S, Zogg C, et al. Contemporary socioeconomic-based disparities in cardiac surgery: are we closing the disparities gap? *J Thorac Cardiovasc Surg*. 2024;167:967-978.e21. https://doi.org/10.1016/j.jtcvs.2022.02.061
6. Manderbacka K, Arffman M, Lumme S, Keskimäki I. Are there socioeconomic differences in outcomes of coronary revascularizations—a register-based cohort study. *Eur J Public Health*. 2015;25(6):984-989. https://doi.org/10.1093/eurpub/ckv086
7. Ancona C. Coronary artery bypass graft surgery: socioeconomic inequalities in access and in 30 day mortality. A population-based study in Rome, Italy. *J Epidemiol Community Health*. 2000;54(12):930-935. https://doi.org/10.1136/jech.54.12.930
8. Pagano D, Freemantle N, Bridgewater B, et al. Social deprivation and prognostic benefits of cardiac surgery: observational study of 44 902 patients from five hospitals over 10 years. *BMJ*. 2009;338:b902. https://doi.org/10.1136/bmj.b902
9. Diez Roux AV. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001;91(11):1783-1789. https://doi.org/10.2105/AJPH.91.11.1783
10. Tonne C, Schwartz J, Mittleman M, Melly S, Suh H, Goldberg R. Long-term survival after acute myocardial infarction is lower in more deprived neighborhoods. *Circulation*. 2005;111(23):3063-3070. https://doi.org/10.1161/CIRCULATIONAHA.104.496174
11. Alter DA, Naylor CD, Austin P, Tu JV. Effects of socioeconomic status on access to invasive cardiac procedures and on mortality after acute myocardial infarction. *N Engl J Med*. 1999;341(18):1359-1367. https://doi.org/10.1056/NEJM199910283411806
12. Mehaffey JH, Hawkins RB, Charles EJ, et al. Distressed communities are associated with worse outcomes after coronary artery bypass surgery. *J Thorac Cardiovasc Surg*. 2020;160(2):425-432.e9. https://doi.org/10.1016/j.jtcvs.2019.06.104
13. Sakowitz S, Bakhtiyar SS, Mallick S, Curry J, Ascandar N, Benharash P. Impact of community socioeconomic distress on survival following heart transplantation. *Ann Surg*. 2024;279(3):376-382. https://doi.org/10.1097/SLA.0000000000006088
14. Hawkins RB, Charles EJ, Mehaffey JH, et al. Socioeconomic Distressed Communities Index associated with worse limb-related outcomes after infrainguinal bypass. *J Vasc Surg*. 2019;70(3):786-794.e2. https://doi.org/10.1016/j.jvs.2018.10.123
15. Clarke AR, Goddu AP, Nocon RS, et al. Thirty years of disparities intervention research: what are we doing to close racial and ethnic gaps in health care? *Med Care*. 2013;51(11):1020-1026. https://doi.org/10.1097/MLR.0b013e3182a97ba3
16. Purnell TS, Calhoun EA, Golden SH, et al. Achieving health equity: closing the gaps in health care disparities, interventions, and research. *Health Aff*. 2016;35(8):1410-1415. https://doi.org/10.1377/hlthaff.2016.0158
17. Wadhera RK, Bhatt DL, Wang TY, et al. Association of state Medicaid expansion with quality of care and outcomes for low-income patients hospitalized with acute myocardial infarction. *JAMA Cardiol*. 2019;4(2):120-127. https://doi.org/10.1001/jamacardio.2018.4577
18. Hernandez-Morgan M, Stypula C, Fischer M, Grogan T, Neelankavil J. Impact of the affordable care Act on disparities in access to and outcomes after coronary artery bypass grafting. *J Racial Ethn Health Disparities*. 2023;10(6):2783-2791. https://doi.org/10.1007/s40615-022-01455-8
19. Sanaiha Y, Rudasill S, Sareh S, et al. Impact of hospital safety-net status on failure to rescue after major cardiac surgery. *Surgery*. 2019;166(5):778-784. https://doi.org/10.1016/j.surg.2019.05.034
20. Healthcare cost and utilization project. NRD overview. Accessed March 1, 2022. https://www.hcup-us.ahrq.gov/nrdoverview.jsp
21. Population denominator data sources and data for use with HCUP databases (updated with 2020 population data). Accessed June 8, 2023. https://hcup-us.ahrq.gov/reports/methods/MS-2021-04-PopulationReport.jsp
22. Koch CG, Li L, Kaplan GA, et al. Socioeconomic position, not race, is linked to death after cardiac surgery. *Circ Cardiovasc Qual Outcomes*. 2010;3(3):267-276. https://doi.org/10.1161/CIRCOUTCOMES.109.880377
23. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8-27.
24. Agency for Healthcare Research and Quality. Using appropriate price indices for expenditure comparisons. Accessed March 15, 2022. https://meps.ahrq.gov/about_meps/price_index.shtml
25. Zou H, Hastie T. Regularization and variable selection via the elastic net. *J R Stat Soc Series B Stat Methodol*. 2005;67(2):301-320. https://doi.org/10.1111/j.1467-9868.2005.00503.x
26. Nielsen SJ, Karlsson M, Björklund E, et al. Socioeconomic factors, secondary prevention medication, and long-term survival after coronary artery bypass grafting: a population-based cohort study from the SWEDEHEART Registry. *J Am Heart Assoc*. 2020;9(5):e015491. https://doi.org/10.1161/JAHA.119.015491
27. Taylor FC. Socioeconomic deprivation is a predictor of poor postoperative cardiovascular outcomes in patients undergoing coronary artery bypass grafting. *Heart*. 2003;89(9):1062-1066. https://doi.org/10.1136/heart.89.9.1062
28. Kim C, Diez Roux AV, Hofer TP, Nallamothu BK, Bernstein SJ, Rogers MAM. Area socioeconomic status and mortality after coronary artery bypass graft surgery: the role of hospital volume. *Am Heart J*. 2007;154(2):385-390. https://doi.org/10.1016/j.ahj.2007.04.052
29. Charles EJ, Mehaffey JH, Hawkins RB, et al. Socioeconomic distressed communities index predicts risk-adjusted mortality after cardiac surgery. *Ann Thorac Surg*. 2019;107(6):1706-1712. https://doi.org/10.1016/j.athoracsur.2018.12.022
30. Strobel RJ, Kaplan EF, Young AM, et al. Socioeconomic distress is associated with failure to rescue in cardiac surgery. *J Thorac Cardiovasc Surg*. 2024;167(3):1100-1114.e1. https://doi.org/10.1016/j.jtcvs.2022.07.013

31. Strobel RJ, Charles EJ, Mehaffey JH, et al. Effect of socioeconomic distress on risk-adjusted mortality after valve surgery for infective endocarditis. *Semin Thorac Cardiovasc Surg*. 2023;35:497-507. https://doi.org/10.1053/j.semtcvs.2022.05.007
32. Gusmano MK, Weisz D, Rodwin VG, et al. Disparities in access to health care in three French regions. *Health Policy*. 2014;114(1):31-40. https://doi.org/10.1016/j.healthpol.2013.07.011
33. Qasim M, Andrews RM. Despite overall improvement in surgical outcomes since 2000, income-related disparities persist. *Health Aff (Millwood)*. 2013;32(10):1773-1780. https://doi.org/10.1377/hlthaff.2013.0194
34. Schultz WM, Kelli HM, Lisko JC, et al. Socioeconomic status and cardiovascular outcomes. *Circulation*. 2018;137(20):2166-2178. https://doi.org/10.1161/CIRCULATIONAHA.117.029652
35. Phillips JE, Klein WMP. Socioeconomic status and coronary heart disease risk: the role of social cognitive factors. *Soc Personal Psychol Compass*. 2010;4(9):704-727. https://doi.org/10.1111/j.1751-9004.2010.00295.x
36. Jia J, Fung V, Meigs JB, Thorndike AN. Food insecurity, dietary quality, and health care utilization in lower-income adults: a cross-sectional study. *J Acad Nutr Diet*. 2021;121(11):2177-2186.e3. https://doi.org/10.1016/j.jand.2021.06.001
37. Ruberman W, Weinblatt E, Goldberg JD, Chaudhary BS. Psychosocial influences on mortality after myocardial infarction. *N Engl J Med*. 1984;311(9):552-559. https://doi.org/10.1056/NEJM198408303110902
38. Institute of Medicine (US) Committee on Quality of Health Care in America. *Crossing the Quality Chasm: A New Health System for the 21st Century*. National Academies Press (US); 2001.
39. Hall BL, Hamilton BH, Richards K, Bilimoria KY, Cohen ME, Ko CY. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals. *Ann Surg*. 2009;250(3):363-376. https://doi.org/10.1097/SLA.0b013e3181b4148f
40. Cole MB, Nguyen KH. Unmet social needs among low-income adults in the United States: associations with health care access and quality. *Health Serv Res*. 2020;55(S2):873-882. https://doi.org/10.1111/1475-6773.13555

Key Words: CABG, cardiac surgery, coronary artery bypass grafting, income-based disparities, socioeconomic disparities, surgical outcomes

TABLE E1. Adjusted outcomes stratified by income quartile

Study outcome	≥76th percentile	51st-75th percentile	26th-50th percentile	≤25th percentile
In-hospital mortality	Ref.	1.25 [1.18-1.33]	1.43 [1.34-1.52]	1.61 [1.51-1.72]
Any complication	Ref.	1.08 [1.06-1.10]	1.12 [1.09-1.15]	1.19 [1.16-1.23]
Failure to rescue	Ref.	1.13 [1.05-1.21]	1.21 [1.13-1.30]	1.32 [1.23-1.43]
Nonhome discharge	Ref.	1.11 [1.07-1.14]	1.22 [1.17-1.27]	1.19 [1.14-1.24]
Nonelective 30-d readmission	Ref.	1.01 [0.98-1.03]	1.03 [1.01-1.06]	1.07 [1.04-1.10]

Outcomes reported as AOR with 95% CI. Reference: ≥76th percentile (highest quartile) income.

TABLE E2. Adjusted outcomes of lowest income compared with highest income after multilevel modeling

Study outcome	Adjusted		
	Lowest	CI	*P*
In-hospital mortality	1.53	1.45-1.62	<.001
Any complication	1.14	1.12-1.16	<.001
Cardiac complications	1.14	1.11-1.17	<.001
Arrest	1.26	1.18-1.35	<.001
Ventricular tachycardia	0.91	0.88-0.95	<.001
Ventricular fibrillation	1.09	1.02-1.17	.01
Tamponade	1.11	1.02-1.21	.02
Cardiogenic shock	1.11	1.06-1.16	<.001
Myocardial infarction	1.40	1.34-1.47	<.001
Infectious complications	1.33	1.26-1.41	<.001
Respiratory complications	1.11	1.08-1.14	<.001
Blood transfusion	1.02	1.00-1.05	.12
Thrombotic complication	1.03	0.94-1.13	.55
Stroke complications	1.10	1.03-1.17	.005
Renal complications	1.18	1.15-1.21	<.001
Failure to rescue	1.32	1.24-1.41	<.001
Nonhome discharge	1.26	1.23-1.29	<.001
Nonelective 30-d readmission	1.08	1.06-1.11	<.001

To account for patient clustering, multilevel, mixed-effects logistic regression models were used to model outcomes of interest. The first level constituted patient characteristics, and the second level represented hospital-level factors. Adjusted outcomes are detailed as AORs with 95% CI. Reference: Lowest.