Surgery Open Science 26 (2025) 39–46

Contents lists available at ScienceDirect

Surgery Open Science

journal homepage: www.journals.elsevier.com/surgery-open-science

Research Paper

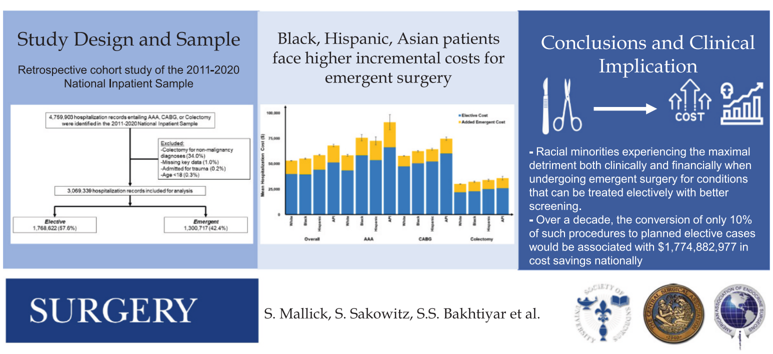
Race based disparities in clinical and financial outcomes associated with major elective and emergent surgery☆

Saad Mallick, MD [a], Sara Sakowitz, MS MPH [a], Syed Shahyan Bakhtiyar, MD MBE [b], Nam Yong Cho, BS [a], Troy Coaston, BS [a], Esteban Aguayo, MD [a], Peyman Benharash, MD [a,*]

[a] Center for Advanced Surgical & Interventional Technology, Department of Surgery, David Geffen School of Medicine, University of California, Los Angeles, Los Angeles, CA, USA

[b] Department of Surgery, University of Colorado, Denver, CO, USA

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Elective surgery
Emergent surgery
Racial disparities

ABSTRACT

Background: Racial health disparities are responsible for ~$50 billion in excess annual healthcare expenditures, driven in part by unequal access to preventive services. We thus studied cost differences in abdominal aortic aneurysm repair (AAA), coronary artery bypass graft (CABG), and colon resection for malignancy (COL), as the elective status of these procedures suggest greater access to preventive care and screening.

Methods: All adult hospitalizations for AAA, CABG, and COL were identified using the 2011–2020 National Inpatient Sample. Generalized linear models were developed to assess cost differences for emergent versus elective surgeries across different racial groups.

Results: Of an estimated 3,069,339 patients, 1,300,717 (42.4%) underwent an emergent operation. The proportion of procedures performed emergently increased from 39.4 in 2011 to 44.5% in 2020 ($p < 0.001$). After risk adjustment, emergent procedures were associated with a $13,645 (95%CI 13,470-13,820) increment in per-patient hospitalization costs compared with elective, representing a 33% relative difference. The overall adjusted cost difference of emergent surgery was higher for Black ($15,552), Hispanic ($14,525), and Asian/Pacific Islanders ($16,887) patients as compared to White patients ($13,086; all $p < 0.001$). Emergent surgery was

☆ Accepted for oral presentation at the 19th Annual Academic Surgical Congress, Washington DC, February 2024

* Corresponding author at: UCLA Division of Cardiac Surgery, 62-249 Center for Health Sciences, Los Angeles, CA, 90095, USA.
E-mail address: pbenharash@mednet.ucla.edu (P. Benharash).
@CoreLabUCLA, @UCLASurgery (P. Benharash)

https://doi.org/10.1016/j.sopen.2025.04.010
Received 16 February 2025; Received in revised form 16 April 2025; Accepted 25 April 2025
Available online 29 April 2025

associated with increased adjusted odds of experiencing in-hospital mortality and all major examined postoperative complications, as well as being linked with increased length of stay.

Conclusions: Over a decade, the conversion of only 10% of such procedures to planned elective cases would be associated with $1,774,882,977 in cost savings nationally. With racial minorities experiencing the maximal detriment both clinically and financially, implementing proven strategies can help reduce race-based disparities and annual healthcare expenditures.

Introduction

Healthcare-related expenditures in the United States have exhibited overwhelming growth over the last several decades, with a more rapid rate of rise noted in recent years [1]. Such expenditures are anticipated to account for nearly 20% of the US Gross Domestic Product (GDP) by 2028 [1]. Thus, a myriad of strategies to curb spending and ensure the sustainability of the current paradigms- including bundled payments and pay-for-performance models- have been enacted with mixed results [2]. With >45 million inpatient operations performed annually, marginal savings in surgical admissions hold the potential to yield substantial reductions in costs of care at a large scale [3]. A large body of literature has identified patients and hospital factors that may influence the costs of surgical care across a wide spectrum of procedures [4].

Using data ending in 2010, Haider et al. suggested reducing the burden of emergency operations to provide meaningful cost savings while yielding better clinical outcomes for select diagnoses that are amenable to generalized screening [5]. The authors posited that a modest 10% reduction in the proportion of emergent procedures for conditions that the Affordable Care Act provides screening service for without a co-pay/coinsurance- such as coronary artery disease, abdominal aortic aneurysm (AAA) repair and colon cancer- would result in nearly $1 billion in savings over a decade. Subsequent reports have reached conflicting conclusions on whether the proportion of emergency cases has actually declined [6–9]. Such lack of equipoise may, in part, be explained by known socioeconomic disparities in the prevalence of screening and operative outcomes across the US. Wallace et al. noted Black patients to receive far less screening for colorectal cancer with a persistent gap noted in recent years even after controlling for gender, family income, education level, and number of physician visits per year [10]. While previous work has shown that ethnic minority patients with colorectal cancer are more likely to present as emergencies requiring surgery [11]. This is similar when considering both coronary artery bypass grafting (CABG) in which Black patients are less likely to undergo elective operations, as well as AAA repair in which Black patients have been shown to present with more severe disease at the time of initial major vascular operation [12–14]. Although multiple studies have underscored the role of early screening in reducing the incidence of emergent procedures, the evolution of cost disparities between emergent and elective procedures and the potential influence of race remain uncharacterized in contemporary practice [15,16]. Given recent endeavors to benchmark healthcare costs at a large scale, the quantification of unplanned procedures and their associated costs are particularly relevant.

The present study characterized national trends as well as acute clinical and financial outcomes of all hospitalizations for coronary artery bypass grafting, abdominal aortic aneurysm repair, or colectomy for malignancy over the past decade. We hypothesized a reduction in the proportion of emergency operations over the past decade but persistently higher mortality, complications, and costs of care in non-elective cases. We further hypothesized that minority races to be associated with increased odds of warranting emergency surgery and increased hospitalization costs.

Methods

All adult (≥18 years) hospitalizations for coronary artery bypass grafting, abdominal aortic aneurysm repair, or colectomy for malignancy were tabulated from the 2011–2020 National Inpatient Sample (NIS). Maintained as part of the Healthcare Cost and Utilization Project, the NIS is the largest publicly available all-payer inpatient database in the United States. Using validated sampling methodology and discharge survey weighting, the NIS provides national estimates for 97% of all inpatient US hospitalizations.

Using previously validated International Classification of Diseases 9th and 10th Revision (ICD-9 and ICD-10) codes, procedures and diagnoses of interest were identified [5,17–19]. These diagnoses were selected due to their potential to be identified on routine screening, thus avoiding emergency operations, as previously described [5]. Patients with concurrent admission diagnosis codes for trauma or injury were excluded. Records missing information on key data including hospitalization costs, and race, were excluded (Supplemental Fig. 1). Patients were classified as *Elective* if they underwent a planned procedure and were otherwise considered *Emergent*.

Patient and hospital attributes were ascertained using ICD-9/10 codes in alignment with the NIS HCUP data dictionary and included age, sex, race, primary payer type, zip code–adjusted income quartile, hospital ownership, hospital teaching status, and hospital region [20]. The modified Elixhauser Comorbidity Index, a previously validated composite score encompassing 30 comorbidities, was employed to numerically estimate the burden of comorbidities of each patient [21]. Additionally, postoperative complications were analyzed using previously reported ICD-10 codes and included neurologic, cardiac, respiratory, intraoperative, renal, thromboembolic, and infectious complications. Hospitals were divided into low-, medium- and high-volume tertiles based upon annual institutional operative caseload each year. Accordingly, hospitals performing ≤20 procedures annually were categorized as low-volume centers, where as those conducting between 21 and 104 procedures per year were classified as medium-volume institutions. All others were classified as high-volume hospitals.

The primary outcome of interest was hospitalization costs, which were generated through the application of hospital-specific cost-to-charge ratios (CCRs) to overall inpatient charges, with further inflation adjustment and conversion into 2020 US Dollars using the Bureau of Labor Statistics Personal Healthcare Price Index [22]. NIS-provided hospital-specific CCRs are formulated using standardized data on inpatient costs and charges reported by hospitals to the Centers for Medicare and Medicaid. More specifically, inpatient charges, outpatient charges, and total costs extracted from the Healthcare Cost Report Information System are divided into cost centers, with Routine Care, Specialty Care, Labor & Delivery, and Ancillary Services Groups cost centers being used for the calculation of the inpatient CCR. This categorization of inpatient charge proportions, delineated by service groups, serves the purpose of mitigating the potential impact of data entry errors and facilitates more precise estimations of inpatient costs [23]. Thus, the provided CCRs are specific to individual hospitals, hospital systems, and peer groups and allow for the estimation of the total costs of each patient stay. The primary aim of this study was to characterize the impact of emergent surgery on inflation-adjusted hospitalization costs. Secondary outcomes included associated mortality, trends over time, complications, and postoperative length of stay (LOS).

The significance of temporal trends was determined using a non-parametric rank-based test developed by Cuzick [24]. Continuous variables are reported as medians with interquartile range (IQR) or mean with standard deviation, while categorical variables are shown as proportions (%). The Adjusted Wald and Pearson's χ2 tests were used to assess the significance of intergroup differences for continuous and categorical variables, respectively. Given the potential differences in characteristics between the *Elective* and *Emergent* cohorts, entropy balancing was utilized prior to the application of regression models to provide a doubly robust adjustment [25]. Entropy balancing is a reweighting method that has been shown to be superior to propensity matching as it retains the entire sample while simultaneously addressing the balance of covariates between the groups. Following entropy balancing, we used generalized linear models with gamma distributions for costs were used to evaluate the association of emergency surgery with outcomes of interest. Subset analyses were performed separately within different racial groups so as to further assess potential cost differences, with White, Black, Hispanic, and Asian/Pacific Islander (API) comprising the four subgroups. As previously described, mean cost differences between elective versus emergent procedures were then paired with national weighted estimates of total cases to calculate potential cost savings if 10% of emergent procedures were performed electively [5]. Additionally, risk-adjusted models were developed to evaluate the association between emergent admission status and other outcomes of interest, as well as identify index patient and hospital factors associated with non-elective admission. Covariate selection was performed using elastic net regularization, which is an automated method that reduces collinearity and optimizes model generalizability [26]. Regression outputs are reported as adjusted odds ratios (AOR) for discrete and beta coefficients (β) for continuous variables, both with 95% confidence intervals. Statistical analysis was performed using Stata 16.0 (StataCorp LLC, College Station, TX) with significance set at $\alpha = 0.05$. This study was deemed exempt from full review by the Institutional Review Board at the University of California, Los Angeles.

Results

Of an estimated 3,069,339 patients meeting inclusion criteria, 1,300,717 (42.4%) underwent an emergent operation. Detailed cohort characteristics are shown in Table 1. The majority of the *Emergent* cohort was admitted for CABG (71.8 vs 50.1%), while the *Elective* cohort was more commonly admitted for AAA repair (10.7 vs 6.6%), and colectomy (39.2 vs 21.6%, all $p < 0.001$). Compared with *Elective, Emergent* patients were on average younger (67 [58–75] vs 68 [60–75] years, $p = 0.01$), more commonly male (67.6 vs 65.9%, $p < 0.001$), and had a higher Elixhauser comorbidity index (2.06 ± 2.38 vs 1.72 ± 2.18, $p < 0.001$). Moreover, *Emergent* patients were more frequently in the lowest income quartile (29.1 vs 25.5%), uninsured (4.7 vs 1.4%), and received operations at high volume centers (87.8 vs 84.7%, all $p < 0.001$). While the majority of patients in this study were insured by Medicare, Black, Hispanic, and API patients more frequently underwent emergent procedures, were uninsured, and were treated at governmental, non-federal hospitals as compared to White patients (Fig. 1, all $p < 0.001$).

The proportion of procedures performed emergently increased from 39.4 in 2011 to 44.5% in 2020 (nptrend<0.001, Fig. 2A). Although the proportion of emergent colectomy cases (28.5 to 30.6%, $p = 0.22$) remained the same throughout the study period, there was a substantial rise in non-elective AAA repair (28.3 to 43.0%, $p < 0.001$) and CABG procedures (49.1 to 51.8%, $p = 0.01$), with a similar pattern across races. Similarly, the proportion of White, Black, and Hispanic patients undergoing emergent operations increased significantly over the 10-year period (Fig. 2B). Additionally, the unadjusted differential in costs between emergent and elective procedures increased each year, with emergent operations portending a $19,982 increment in hospitalization costs in 2020 as compared to $17,059 in 2011 (Fig. 3, $p < 0.001$).

After risk adjustment using generalized linear models, emergent procedures were associated with a $13,645 (95% confidence interval (CI) 13,470–13,820) increment in per-patient hospitalization costs compared with elective, representing a 33% relative difference. The mean cost difference was $15,992 (95% CI 15199–16,783; 35% increase) for AAA repair, $10,848 (95% CI 10628–11,067; 22% increase) for CABG, and $8694 (95% CI 8446–8942; 39% increase) for colon resection. Subset analyses were performed for different racial groups,

Table 1
Demographic, clinical, and hospital characteristics.

	Elective (*n* = 1,768,622)	Emergent (n = 1,300,717)	*P*-Value
Age (years, median [IQR])	68 [60–75]	67 [58–75]	0.01
Sex (%)			<0.001
Female	34.1	32.4	
Male	65.9	67.6	
Race/Ethnicity (%)			<0.001
White	80.6	75.0	
Black	7.7	9.7	
Hispanic	6.1	8.3	
API	2.6	3.0	
Other	3.0	4.0	
Primary Operation (%)			<0.001
AAA	10.7	6.6	
CABG	50.1	71.8	
Colectomy	39.2	21.6	
Elixhauser Comorbidity Index (mean ± SD)	1.72 ± 2.18	2.06 ± 2.38	<0.001
Community Income Percentile (%)			<0.001
>75%	21.8	18.9	
51–75%	24.8	23.5	
26–50%	26.2	26.5	
0–25%	25.5	29.1	
Insurance Coverage (%)			<0.001
Private	32.2	27.4	
Medicare	58.9	55.6	
Medicaid	5.1	8.8	
Uninsured	1.4	4.7	
Comorbidities (%)			
Congestive Heart Failure	14.0	25.6	<0.001
Coronary Artery Disease	51.4	63.1	<0.001
Cardiac Arrythmias	32.7	41.2	<0.001
Valvular Disease	18.2	17.5	<0.001
Hypertension	74.1	79.0	<0.001
Pulmonary Hypertension	3.7	5.8	<0.001
Peripheral Vascular Disease	19.3	17.4	<0.001
Chronic Lung Disease	20.3	22.5	<0.001
Chronic Liver Disease	1.2	1.0	<0.001
Obesity	20.6	22.9	<0.001
Electrolyte/Fluid Disorders	24.3	40.4	<0.001
Coagulopathy	7.4	10.3	<0.001
Anemia	4.7	7.9	<0.001
Diabetes	33.4	40.4	<0.001
Hypothyroidism	9.8	8.7	<0.001
Chronic Kidney Disease	1.9	3.6	<0.001
Rheumatologic Disease	2.2	2.3	0.02
Cerebrovascular Disease	4.0	7.2	<0.001
Hospital Location/Teaching Status (%)			<0.001
Rural	5.6	4.4	
Urban Non-Teaching	24.7	24.5	
Urban Teaching	69.8	71.1	
Hospital Volume Status (%)			<0.001
Low	2.6	2.0	
Intermediate	12.7	10.2	
High	84.7	87.8	
Hospital Region (%)			<0.001
Northeast	17.0	18.4	
Midwest	22.6	19.7	
South	43.0	45.0	
West	17.4	16.9	
Hospital Ownership (%)			<0.001
Government, Nonfederal	8.7	9.4	
Private, Non-Profit	78.5	75.2	
Private, Investor-Owned	12.7	15.3	

- Values are reported as proportions (%) unless otherwise specified.
*IQR, Inter-Quartile Range; SD, Standard Deviation; API, Asian/Pacific Islander; AAA, Abdominal Aortic Aneurysm Repair; CABG, Coronary Artery Bypass Graft.

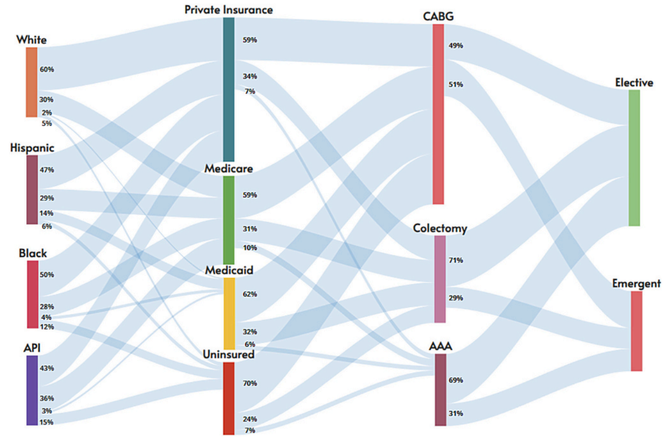


Fig. 1. Proportions of Patients Requiring Elective vs Emergent Operations by Racial Group, Insurance Type and Procedure Type.

with similarly higher associated costs noted for emergency surgery in all groups. The overall adjusted cost difference of emergent surgery was higher for Black ($15,552; 95% CI 14934–16,171), Hispanic ($14,525; 95% CI 13828–15,223), and API ($16,887; 95% CI 15567–18,208) patients as compared to White patients ($13,086; 95% CI 12897–13,275; all $p < 0.001$). This increased cost difference observed in non-White races was consistent even when each procedure was analyzed individually (Fig. 4; all $p < 0.001$).

On counterfactual analysis, we calculated the potential cost savings if 10% of emergent procedures had been conducted in an elective manner, as suggested by Haider et al. [5] Total cost savings of $137,026,052, $1,012,930,091, and $244,585,721 would be realized if 10% of emergent AAA repair, CABG, and colectomy for neoplasm, were converted to elective procedures respectively (Table 2). Over a decade, the conversion of only 10% of such procedures to planned elective cases would be associated with $1,774,882,977 in cost savings nationally.

Emergent surgery was associated with increased unadjusted and adjusted odds of experiencing in-hospital mortality and all major examined postoperative complications, as well as being linked with an increased LOS (Supplemental Table 1). During the study period, the proportion of White and API patients experiencing in-hospital mortality declined significantly after emergent surgery, while the rate remained steady among Black and Hispanic patients (Supplemental Fig. 2A). Alternatively, major complication rates after emergent surgery remained statistically similar over the study period, with the White race exhibiting the lowest unadjusted rate (Supplemental Fig. 2B).

Risk-adjusted analysis stratified by race revealed non-White race to be associated with generally inferior outcomes after emergent surgery as compared to White (Table 3). While the Hispanic race was associated with lower odds of in-hospital mortality, Black and API patients faced similar odds relative to their White counterparts. Notably, Black, Hispanic, and API races were all associated with higher odds of experiencing major complications and facing a longer LOS relative to patients of the White race. Additionally, Black, Hispanic, and API race were associated with increased odds of experiencing multiple postoperative

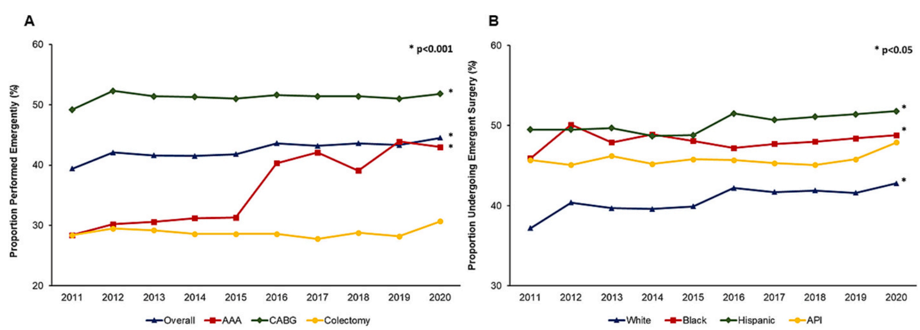


Fig. 2. Trends in Proportion of Procedures Performed Urgently from 2011 to 2020 Stratified by (A) Procedure Type and (B) Race.

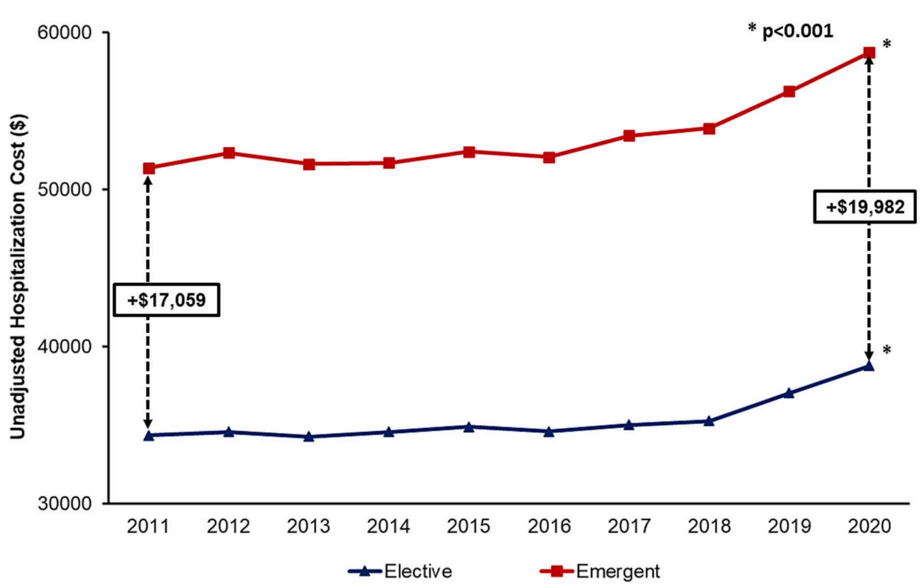


Fig. 3. Unadjusted Difference in Hospitalization Costs of Elective vs Emergent Procedures over Time.

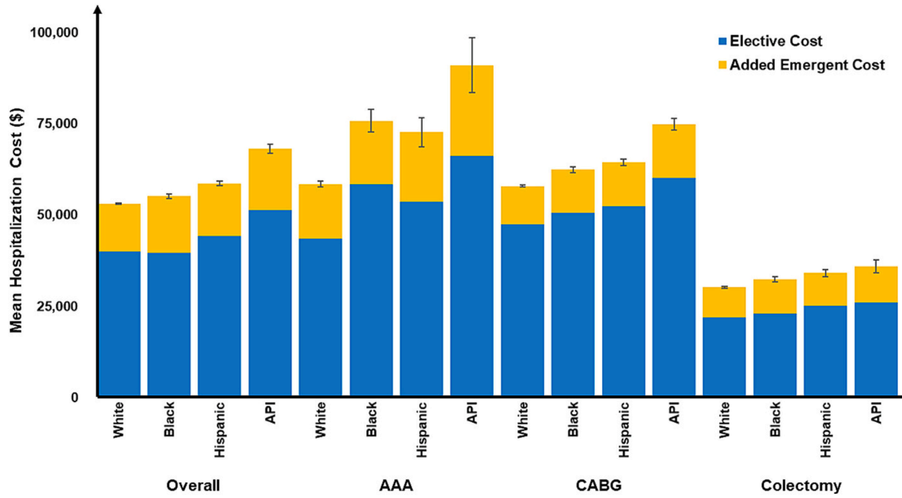


Fig. 4. Adjusted Mean Per-patient Hospitalization Costs for Emergent and Elective Admissions Among Patients Who Underwent AAA Repair, CABG, or Colon Resection stratified by race.

Table 2
National estimates of potential costs savings for 10% conversion of emergent to elective admission.

Surgery	Weighted Emergent Cohort	Mean Cost Difference ($)	Accrued Cost Savings After 10% Conversion¥ ($)	95% CI of Accrued Cost Savings
AAA	85,686	15,991.65	137,026,052.19	130,239,978-143,812,041
CABG	933,725	10,848.27	1,012,930,090.58	992,416,152-1,033,444,029
Colectomy	281,306	8694.65	244,585,721.29	237,603,509-251,568,130
Total	**1,300,717**	**13,645.42**	**1,774,882,976.61**	**1,752,132,136-1,797,633,818**

- All costs in 2020 US Dollars ($).
* AAA, Abdominal Aortic Aneurysm Repair; CABG, Coronary Artery Bypass Graft; CI, Confidence Interval.
¥ Calculated by multiplying 10% of weighted emergent cohort by mean cost differences between emergent and elective admissions

complications as compared to White race.

A number of factors, including Black (Adjusted Odds Ratio (AOR): 1.19, 95% CI 1.16–1.22), Hispanic (AOR: 1.21, 95% CI 1.16–1.25), and API (AOR: 1.11, 95% CI 1.07–1.15; all $p < 0.001$) races remained associated with increased odds of requiring emergent surgery (Ref: White) (Supplemental Fig. 3). Increasing income quartile was inversely related to decreasing odds of undergoing emergent surgery. Furthermore, being treated at private non-profit hospitals (AOR: 0.92, 95% CI 0.87–0.97, $p = 0.003$) was associated with a decreased likelihood of undergoing emergent surgery, which was in contrast to private investor-owned hospitals (AOR: 1.12, 95% CI 1.05–1.20, $p = 0.001$) that exhibited increased odds relative to government/non-federal hospitals.

Discussion

This national retrospective cohort study examined decade-long trends in the burden of emergency operations, as well as associated costs and clinical outcomes. Focusing on specific pathologies deemed potentially modifiable in urgency through screening, we found the proportion of emergency AAA repair, CABG, and colectomy for neoplasms to have continued to rise. In particular, emergent surgery expenditures continued to rise over the study period and were associated with a +$13,645 mean per-patient cost difference compared to their elective counterparts. Disparities in the augmented costs of emergent operations were especially amplified among Black, Hispanic, and API patients. Importantly, a modest conversion of 10% of emergent cases to scheduled elective procedures could have potentially generated cost savings surpassing $1.7 billion. Additionally, in-hospital mortality was significantly higher in patients undergoing unplanned procedures. Taken together, our data suggests that, despite abundant literature emphasizing the risks associated with emergency operations, there has been limited progress in augmenting the share of planned cases.

The proportion of AAA repair, CABG, and colectomy cases performed emergently aligns with prior reports [9,27]. Notably, the proportion of

Table 3
Adjusted clinical outcomes of patients undergoing AAA, CABG or colectomy stratified by race.

	Black			Hispanic			API		
	AOR/ β	95%CI	P-Value	AOR/ β	95%CI	P-Value	AOR/ β	95%CI	P-Value
In-Hospital Mortality (%)	1.02	0.95–1.09	0.56	0.87	0.80–0.93	<0.001	1.02	0.91–1.14	0.75
Major Complications (%)	1.24	1.21–1.27	<0.001	1.24	1.21–1.27	<0.001	1.25	1.20–1.30	<0.001
Neurologic	1.22	1.14–1.31	<0.001	1.01	0.94–1.09	0.75	1.06	0.94–1.20	0.31
Cardiac	0.98	0.95–1.01	0.28	1.05	1.02–1.09	0.001	1.02	0.97–1.07	0.57
Respiratory	1.11	1.08–1.14	<0.001	1.16	1.12–1.20	<0.001	1.05	0.99–1.11	0.07
Intraoperative	1.13	1.06–1.20	<0.001	1.18	1.10–1.26	<0.001	1.24	1.13–1.37	<0.001
Renal	1.46	1.42–1.50	<0.001	1.04	1.01–1.07	0.02	1.06	1.01–1.11	0.03
Thromboembolic	1.33	1.23–1.43	<0.001	0.98	0.89–1.08	0.69	0.79	0.67–0.93	0.01
Infectious	1.11	1.06–1.17	<0.001	1.14	1.08–1.21	<0.001	1.05	0.96–1.14	0.31
Multiple Complications (%)	1.34	1.24–1.44	<0.001	1.13	1.06–1.19	<0.001	1.08	1.04–1.12	<0.001
LOS	0.82	0.71–0.92	<0.001	0.16	0.06–0.27	0.002	0.16	0.02–0.31	0.03

* API, Asian-Pacific Islander; AOR, Adjusted Odds Ratio; β, Beta-Coefficient; CI, Confidence Interval; LOS, Length of Stay.
¥ Adjusted odds ratio/beta-coefficients are shown for patients undergoing surgery with white race as reference.

emergent procedures grew over the study period, with CABG and AAA repairs exhibiting a particular rise. A parallel increase in the rate of emergent procedures was observed across White, Black, and Hispanic patient groups, with the latter two consistently demonstrating the highest rates of nonelective procedures. These findings are consistent with existing literature on this issue. In the case of AAA, several studies employing Medicare data have demonstrated Black patients to be more at risk of requiring urgent or emergency surgery compared to their non-Black counterparts [28,29]. Additionally, Black patients are more likely to undergo repair in the nonelective setting, despite having similar rates of symptomatic nonruptured and ruptured aneurysms to White and Asian patients [30]. Similar trends have been observed in atherosclerotic disease, with nuances in disease presentation, risk factors, and treatment among different racial and ethnic groups [31]. A recent systematic review highlighted that African American, Hispanic, and Asian candidates for coronary revascularization more frequently present with a greater number and extent of comorbidities and with increased non-calcified atherosclerotic lesions, factors that likely influence treatment decisions [13]. Racial and ethnic disparities are also well recognized in colorectal cancer, with Howard et al. showing rates of emergency surgery to be highest among Black non-Hispanic patients, followed by Hispanics [32]. The noted increase in emergent care is striking as the diagnoses chosen for the present work have been shown to be responsive to early primary care intervention and diagnosis [5].

Notably, the adjusted mean cost difference between elective and emergent procedures increased throughout the study period. Moreover, and for individual procedures, minority races incurred notably higher hospital costs for unplanned interventions as compared to White patients. This discrepancy is likely attributed to observed differences in clinical outcomes, with minority races having elevated odds of major complications and prolonged hospital stays. The increased cost associated with surgical complications has also been extensively documented across various surgical procedures, with cost differences being explained by heightened services and staff required for managing such complications [33]. In a study of the National Surgical Quality Improvement Program database, Liu et al. found that the payment amount per complication increased at a rate of $10,996 for colectomy patients [34]. Moreover, minority race patients were more likely to experience multiple complications after emergent surgery, likely resulting in the higher expenditures observed. Given comparable adjusted in-hospital mortality rates across all races, except for the Hispanic race, it is likely that prolonged recovery needed to survive complications drove the observed cost difference. Indeed, Pradarelli et al. used Medicare data to show a 2- to 3-fold increase in postoperative costs associated with rescuing patients experiencing multiple complications at specific hospitals [35]. Moreover, a substantial share (40% to 60%) of the excess cost differentials in these minority groups has previously been linked to residing in areas characterized by high medical expenditures [36]. The 2010 Affordable Care Act has allowed for a reduction in coverage disparities related to race, with improvements in standard measures of healthcare access noted among minority groups [37]. Despite such gains, substantial disparities in coverage remain, with Black and Hispanic adults still substantially more likely to be uninsured than their White counterparts [38]. With the lack of continuous health insurance leading to a four-fold increase in the likelihood of receiving preventive services, efforts to increase coverage must be increased.

In the present study, the Emergent cohort faced worse clinical outcomes relative to patients undergoing elective procedures, a finding that is well recognized in the literature. Prior research has consistently reported notably elevated mortality rates in emergent AAA repair, CABG, and colectomy procedures compared to their elective counterparts [33–35]. The complex presentation attributed to advanced disease stands out as the frequently cited explanation for these disparities. Existing literature indicates that older Black and Hispanic patients have greater odds than their White counterparts of developing a majority of postoperative complications [33]. This effect is amplified in emergent surgery as the inherent lack of preoperative optimization leads to potentially more difficult procedures that may partly explain the heightened morbidity seen. Another possible explanation for the poor clinical outcomes seen in minority races can be traced back to decades of diminished healthcare access. In line with this, Ly et al. posited that Black individuals are more likely to live in areas with greater exposure to hazards such as air pollution, which might increase the prevalence and severity of chronic diseases [42]. Moreover, Black patients have also been shown to have less rigorous preoperative optimization and generally reside in neighborhoods with under-resourced hospitals [43,44]. Indeed, a national study of Medicare beneficiaries demonstrated that while 30-day postoperative mortality following cancer surgery improved over time for both Black and White patients, the disparity in cancer-related mortality between the groups persisted [45]. The authors proposed several potential drivers of the overall mortality improvement, including the centralization of surgical care, advancements in operative techniques, and evolving perioperative practices. Importantly, they noted that enhanced screening and earlier detection may have allowed patients in populations with greater access to preventive care to undergo surgery at earlier stages of disease, contributing to improved outcomes. A more nuanced understanding of structural factors that ultimately manifest as inferior clinical outcomes among racial minorities are paramount to the development of more effective health equity programs and legislation.

An important finding of the present work is the $1.7 billion in savings to the US populous over a decade that could be accomplished by a modest conversion of 10% of emergent procedures to the elective setting. This figure is notable and nearly double the savings reported by Haider et al. whose projections were based on data from 2000 to 2010 [5]. Critically, when facets such as unpaid leave, disparities in mortality, patient-reported outcomes, and quality-adjusted life years are considered, the accrued benefits of elective surgery are anticipated to expand further. Indeed, the association between minority races with increased odds of unplanned operations in our study is a phenomenon that has been extensively linked in the literature with poor access to care. More specifically, these patients are at higher risk of lack of regular primary care, failure in appropriate evaluation, reduced referral for symptoms, and greater travel distance when seeking care - all factors that have been shown to be associated with receipt of delayed care [39–41]. Several interventions, such as telehealth initiatives, community outreach, and educational campaigns, hold the potential to augment screening and diagnosis rates within minority populations [46]. Extensive work has revealed screening programs for colorectal cancer, AAA, and cardiovascular disease to be effective in reducing both costs and mortality [43–45]. The Delaware Cancer Treatment Program, for example, implemented targeted community outreach, patient navigation, and reimbursement for screening costs to successfully eradicate colorectal cancer screening disparities over a 5-year period [47]. The program reduced the percentage of Black patients presenting with regional and distant disease from 79% to 40% and nearly eliminated the differences in colorectal cancer-related mortality between Black and White patients. Taking the pragmatic and economically viable interventions discussed into account as well as the implications of the current study, these methodologies present a promising blueprint that could be disseminated at large.

This study has several important limitations. As an administrative data repository, the NIS lacks the ability to link hospital records, which limits the capturing of all hospitalization cost data beyond initial admission. However, this limitation could potentially accentuate the observed cost disparities between elective and emergent surgery, given the substantial evidence of increased readmission visits following unplanned procedures. Secondly, the NIS does not report laboratory values, intraoperative events, and other physiologic parameters. Third, information about the complexity of the operation and stage of the disease is not available, and we were not able to adjust for it. Finally, reliance on accurate ICD coding for the NIS introduces a potential limitation, given that ICD codes primarily serve financial reimbursement purposes. While cost-to-charge ratios offer valuable insights into total hospitalization costs, our analysis cannot encompass costs related to preoperative and postoperative outpatient care, operating room expenses, and long-term expenditures. Nonetheless, we used robust statistical methods and automated variable selection to reduce the risk of bias and enhance the generalizability of our findings.

In conclusion, the present study noted significantly worse clinical and financial outcomes after emergent operations. In light of the lack of progress made on reducing the burden of emergency surgery, interventions addressing access to preventive care and screening are necessitated at a national level. With racial minorities experiencing the maximal detriment both clinically and financially, implementing proven strategies can help reduce race-based disparities and annual healthcare expenditures in the US.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2025.04.010.

CRediT authorship contribution statement

Saad Mallick: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Conceptualization. **Sara Sakowitz:** Writing – review & editing, Writing – original draft, Methodology. **Syed Shahyan Bakhtiyar:** Software, Methodology, Formal analysis. **Nam Yong Cho:** Writing – review & editing, Writing – original draft. **Troy Coaston:** Writing – review & editing, Writing – original draft, Conceptualization. **Esteban Aguayo:** Writing – review & editing, Software, Methodology, Conceptualization. **Peyman Benharash:** Writing – review & editing, Resources, Project administration, Conceptualization.

Ethics approval

This study was deemed exempt from full review by the Institutional Review Board at the University of California, Los Angeles.

Funding sources

No direct or indirect financial support by extramural sources was received for this research.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Peyman Benharash reports a relationship with AtriCure Inc. that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

None.

References

[1] Keehan SP, Fiore JA, Poisal JA, et al. National health expenditure projections, 2022–31: growth to stabilize once the COVID-19 public health emergency ends. Health Aff 2023;42(7):886–98. https://doi.org/10.1377/hlthaff.2023.00403.
[2] Agarwal R, Liao JM, Gupta A, Navathe AS. The impact of bundled payment on health care spending, utilization, and quality: a systematic review. Health Aff 2020;39(1):50–7. https://doi.org/10.1377/hlthaff.2019.00784.
[3] Medicare Payments for Common Inpatient Procedures: Implications for Episode-Based Payment Bundling - Birkmeyer - 2010 - Health Services Research - Wiley Online Library. Accessed January 31, 2024. https://doi.org/10.1111/j.1475-6773.2010.01150.x.
[4] Factors Associated With Increases in US Health Care Spending, 1996–2013 | Health Care Economics, Insurance, Payment | JAMA | JAMA Network. Accessed January 31, 2024. https://jamanetwork.com/journals/jama/fullarticle/2661579.
[5] Haider AH, Obirieze A, Velopulos CG, et al. Incremental cost of emergency versus elective surgery. Ann Surg 2015;262(2):260. https://doi.org/10.1097/SLA.0000000000001080.
[6] Keeling WB, Binongo J, Wei J, Leshnower BG, Farrington W, Halkos ME. National trends in emergency coronary artery bypass grafting. Eur J Cardiothorac Surg 2023;64(5):ezad352. https://doi.org/10.1093/ejcts/ezad352.
[7] Schlottmann F, Strassle PD, Cairns AL, Herbella FAM, Fichera A, Patti MG. Disparities in emergent colectomy for colorectal cancer contribute to inequalities in postoperative morbidity and mortality in the US health care system. Scand J Surg 2020;109(2):102–7. https://doi.org/10.1177/1457496919826720.
[8] Decker KM, Lambert P, Nugent Z, Biswanger N, Samadder J, Singh H. Time trends in the diagnosis of colorectal cancer with obstruction, perforation, and emergency admission after the introduction of population-based organized screening. JAMA Netw Open 2020;3(5):e205741. https://doi.org/10.1001/jamanetworkopen.2020.5741.
[9] Alkhouli M, Alqahtani F, Cook CC. Association between surgical volume and clinical outcomes following coronary artery bypass grafting in contemporary practice. J Card Surg 2019;34(10):1049–54. https://doi.org/10.1111/jocs.14205.
[10] Coleman Wallace DA, Baltrus PT, Wallace TC, Blumenthal DS, Rust GS. Black white disparities in receiving a physician recommendation for colorectal cancer screening and reasons for not undergoing screening. J Health Care Poor Underserved 2013;24(3):1115–24. https://doi.org/10.1353/hpu.2013.0132.
[11] Askari A, Nachiappan S, Currie A, et al. Who requires emergency surgery for colorectal cancer and can national screening programmes reduce this need? Int J Surg 2017;42:60–8. https://doi.org/10.1016/j.ijsu.2017.04.050.
[12] Soden PA, Zettervall SL, Deery SE, et al. Black patients present with more severe vascular disease and a greater burden of risk factors than white patients at time of major vascular intervention. J Vasc Surg 2018;67(2):549–556.e3. https://doi.org/10.1016/j.jvs.2017.06.089.
[13] Zea-Vera R, Asokan S, Shah RM, et al. Racial/ethnic differences persist in treatment choice and outcomes in isolated intervention for coronary artery disease. J Thorac Cardiovasc Surg 2023;166(4):1087–1096.e5. https://doi.org/10.1016/j.jtcvs.2022.01.034.
[14] Enumah ZO, Canner JK, Alejo D, et al. Persistent racial and sex disparities in outcomes after coronary artery bypass surgery. Ann Surg 2020;272(4):660–7. https://doi.org/10.1097/SLA.0000000000004335.
[15] Poon M, Cortegiano M, Abramowicz AJ, et al. Associations between routine coronary computed tomographic angiography and reduced unnecessary hospital admissions, length of stay, recidivism rates, and invasive coronary angiography in the emergency department triage of chest pain. J Am Coll Cardiol 2013;62(6):543–52. https://doi.org/10.1016/j.jacc.2013.04.040.
[16] Guirguis-Blake JM, Beil TL, Senger CA, Coppola EL. Primary care screening for abdominal aortic aneurysm: updated evidence report and systematic review for the US preventive services task force. JAMA 2019;322(22):2219–38. https://doi.org/10.1001/jama.2019.17021.
[17] Dobaria V, Hadaya J, Sanaiha Y, Aguayo E, Sareh S, Benharash P. The pragmatic impact of frailty on outcomes of coronary artery bypass grafting. Ann Thorac Surg 2021;112(1):108–15. https://doi.org/10.1016/j.athoracsur.2020.08.028.
[18] Williamson CG, Sanaiha Y, Tran Z, et al. Disparities in cardiac arrest and failure to rescue after major elective noncardiac operations. Surgery 2022;171(5):1358–64. https://doi.org/10.1016/j.surg.2021.09.001.
[19] Braet DJ, Taaffe JP, Singh P, Bath J, Kruse RL, Vogel TR. Readmission and utilization after repair of ruptured abdominal aortic aneurysms in the United States. Vasc Endovascular Surg 2021;55(3):245–53. https://doi.org/10.1177/1538574420980578.
[20] NIS Description of Data Elements. Accessed January 31, 2024. https://hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp.
[21] van Walraven C, Austin PC, Jennings A, Quan H, Forster AJ. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. Med Care 2009;47(6):626–33.
[22] Using Appropriate Price Indices for Expenditure Comparisons. Accessed May 12, 2023. https://meps.ahrq.gov/about_meps/Price_Index.shtml.
[23] HCUP-US Cost-to-Charge Ratio for Inpatient Files. Accessed January 31, 2024. https://hcup-us.ahrq.gov/db/ccr/ip-ccr/ip-ccr.jsp.
[24] Cuzick J. A wilcoxon-type test for trend. Stat Med 1985;4(1):87–90. https://doi.org/10.1002/sim.4780040112.
[25] Zhao Q, Percival D. Entropy balancing is doubly robust. Journal of Causal Inference 2017;5(1):20160010. https://doi.org/10.1515/jci-2016-0010.
[26] Zou H, Hastie T. Regularization and variable selection via the elastic net. J R Stat Soc Series B Stat Methodology 2005;67(2):301–20. https://doi.org/10.1111/j.1467-9868.2005.00503.x.
[27] Xu Z, Becerra AZ, Aquina CT, et al. Emergent colectomy is independently associated with decreased long-term overall survival in colon cancer patients. J Gastrointest Surg 2017;21(3):543–53. https://doi.org/10.1007/s11605-017-3355-8.
[28] Wilson CT, Fisher E, Welch HG. Racial disparities in abdominal aortic aneurysm repair among male medicare beneficiaries. Arch Surg 2008;143(5):506–10. https://doi.org/10.1001/archsurg.143.5.506.
[29] Osborne NH, Mathur AK, Upchurch Jr GR, Dimick JB. Understanding the racial disparity in the receipt of endovascular abdominal aortic aneurysm repair. Arch Surg 2010;145(11):1105–8. https://doi.org/10.1001/archsurg.2010.213.

[30] Ribieras AJ, Kang N, Shao T, et al. Racial disparities in presentation and outcomes for endovascular abdominal aortic aneurysm repair. J Vasc Surg 2023;77(1):69–77. https://doi.org/10.1016/j.jvs.2022.06.094.

[31] Graham G. Disparities in cardiovascular disease risk in the United States. Curr Cardiol Rev 2015;11(3):238–45. https://doi.org/10.2174/1573403X11666141122220003.

[32] Howard R, Hendren S, Patel M, et al. Racial and ethnic differences in elective versus emergency surgery for colorectal cancer. Ann Surg 2023;278(1):e51. https://doi.org/10.1097/SLA.0000000000005667.

[33] Carthon JMB, Jarrín O, Sloane D, Kutney-Lee A. Variations in postoperative complications across race, ethnicity and sex among older adults. J Am Geriatr Soc 2013;61(9):1499–507. https://doi.org/10.1111/jgs.12419.

[34] Liu JB, Berian JR, Chen S, et al. Postoperative complications and hospital payment: implications for achieving value. J Am Coll Surg 2017;224(5):779–786.e2. https://doi.org/10.1016/j.jamcollsurg.2017.01.041.

[35] Pradarelli JC, Healy MA, Osborne NH, Ghaferi AA, Dimick JB, Nathan H. Variation in medicare expenditures for treating perioperative complications: the cost of rescue. JAMA Surg 2016;151(12):e163340. https://doi.org/10.1001/jamasurg.2016.3340.

[36] Hanchate A, Kronman AC, Young-Xu Y, Ash AS, Emanuel E. Racial and ethnic differences in end-of-life costs: why do minorities cost more than whites? Arch Intern Med 2009;169(5):493–501. https://doi.org/10.1001/archinternmed.2008.616.

[37] Buchmueller TC, Levinson ZM, Levy HG, Wolfe BL. Effect of the affordable care act on racial and ethnic disparities in health insurance coverage. Am J Public Health 2016;106(8):1416–21. https://doi.org/10.2105/AJPH.2016.303155.

[38] Buchmueller TC, Levy HG. The ACA'S impact on racial and ethnic disparities in health insurance coverage and access to care. Health Aff 2020;39(3):395–402. https://doi.org/10.1377/hlthaff.2019.01394.

[39] Cota AM, Omer AA, Jaipersad AS, Wilson NV. Elective versus ruptured abdominal aortic aneurysm repair: a 1-year cost-effectiveness analysis. Ann Vasc Surg 2005;19(6):858–61. https://doi.org/10.1007/s10016-005-7457-5.

[40] Ascanelli S, Navarra G, Tonini G, et al. Early and late outcome after surgery for colorectal cancer elective versus emergency surgery. Tumori 2003;89(1):36–41. https://doi.org/10.1177/030089160308900108.

[41] Sobolev BG, Kuramoto L, Levy AR, Hayden R. Cumulative incidence for wait-list death in relation to length of queue for coronary-artery bypass grafting: a cohort study. J Cardiothorac Surg 2006;1(1):21. https://doi.org/10.1186/1749-8090-1-21.

[42] Inequities in surgical outcomes by race and sex in the United States: retrospective cohort study | The BMJ. Accessed January 31, 2024. https://www.bmj.com/content/380/bmj-2022-073290.

[43] Racial Disparities in Health Status and Access to Healthcare: The Continuation of Inequality in the United States Due to Structural Racism - Yearby - 2018 - The American Journal of Economics and Sociology - Wiley Online Library. Accessed January 30, 2024. https://doi.org/10.1111/ajes.12230.

[44] Bach PB, Pham HH, Schrag D, Tate RC, Hargraves JL. Primary care physicians who treat blacks and whites. New England Journal of Medicine 2004;351(6):575–84. https://doi.org/10.1056/NEJMsa040609.

[45] Lam MB, Raphael K, Mehtsun WT, et al. Changes in racial disparities in mortality after cancer surgery in the US, 2007-2016. JAMA Netw Open 2020;3(12):e2027415. https://doi.org/10.1001/jamanetworkopen.2020.27415.

[46] Improving Participation in Cancer Screening Programs - Fulfilling the Potential of Cancer Prevention and Early Detection - NCBI Bookshelf. Accessed January 31, 2024. https://www.ncbi.nlm.nih.gov/books/NBK223927/.

[47] Grubbs SS, Polite BN, Carney J, et al. Eliminating racial disparities in colorectal cancer in the real world: it took a village. J Clin Oncol 2013;31(16):1928–30. https://doi.org/10.1200/JCO.2012.47.8412.