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Research Paper

Differences in outcomes by race/ethnicity after thoracic surgery in a large integrated health system

Kian C. Banks, MD [a,b,*], Julia Wei, MPH [c], Leyda Marrero Morales, BS [d], Zeuz A. Islas, BS [e], Nathan J. Alcasid, MD [a,b], Cynthia J. Susai, MD [a,b], Angela Sun, BS [c], Katemanee Burapachaisri, BS [d], Ashish R. Patel, MD [a,b], Simon K. Ashiku, MD [a,b], Jeffrey B. Velotta, MD [a,b,d,e]

[a] *Division of Thoracic Surgery, Kaiser Permanente Oakland Medical Center, 3600 Broadway, Oakland, CA 94611, USA*
[b] *Department of Surgery, University of California, San Francisco- East Bay, 1411 E 31st St, Oakland, CA 94602, USA*
[c] *Division of Research, Kaiser Permanente Northern California, 2000 Broadway, Oakland, CA 94612, USA*
[d] *University of California, San Francisco, School of Medicine, 533 Parnassus Ave, San Francisco, CA 94143, USA*
[e] *Kaiser Permanente Bernard J. Tyson School of Medicine, 98 S Los Robles Ave, Pasadena, CA 91101, USA*

HIGHLIGHTS

- Outcome disparity studies within the field of thoracic surgery are limited.
- Hispanic patients in our system are more likely to return to the ED postoperatively.
- Granular outcomes beyond mortality and treatment administration must be tracked.

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ABSTRACT

Background: Disparities exist throughout surgery. We aimed to assess for racial/ethnic disparities among outcomes in a large thoracic surgery patient population.

Methods: We reviewed all thoracic surgery patients treated at our integrated health system from January 1, 2016–December 31, 2020. Post-operative outcomes including length of stay (LOS), 30-day return to the emergency department (30d-ED), 30-day readmission, 30- and 90-day outpatient appointments, and 30- and 90-day mortality were compared by race/ethnicity. Bivariate analyses and multivariable logistic regression were performed. Our multivariable models adjusted for age, sex, body mass index, Charlson Comorbidity Index, surgery type, neighborhood deprivation index, insurance, and home region.

Results: Of 2730 included patients, 59.4 % were non-Hispanic White, 15.0 % were Asian, 11.9 % were Hispanic, 9.6 % were Black, and 4.1 % were Other. Median (Q1-Q3) LOS (in hours) was shortest among non-Hispanic White (37.3 (29.2–76.1)) and Other (36.5 (29.3–75.4)) patients followed by Hispanic (46.8 (29.9–78.1)) patients with Asian (51.3 (30.7–81.9)) and Black (53.7 (30.6–101.6)) patients experiencing the longest LOS ($p < 0.01$). 30d-ED rates were highest among Hispanic patients (21.3 %), followed by Black (19.2 %), non-Hispanic White (18.1 %), Asian (13.4 %), and Other (8.0 %) patients ($p < 0.01$). On multivariable analysis, Hispanic ethnicity (Odds Ratio (OR) 1.43 (95 % CI 1.03–1.97)) and Medicaid insurance (OR 2.37 (95 % CI 1.48–3.81)) were associated with higher 30d-ED rates. No racial/ethnic disparities were found among other outcomes.

Conclusions: Despite parity across multiple surgical outcomes, disparities remain related to patient encounters within our system. Health systems must track such disparities in addition to standard clinical outcomes.

Key message: While our large integrated health system has been able to demonstrate parity across many major surgical outcomes among our thoracic surgery patients, race/ethnicity disparities persist including in the number of post-operative return trips to the emergency department. Tracking outcome disparities to a granular level such as return visits to the emergency department and number of follow up appointments is critical as health systems strive to achieve equitable care.

* Corresponding author at: Department of Surgery, UCSF- East Bay, 1411 E 31st St, Oakland, CA 94602, USA.
E-mail address: kian.banks@ucsf.edu (K.C. Banks).

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Introduction

Outcome disparities by race/ethnicity have been documented across multiple surgical specialties [1–4]. Such studies have revealed findings including delays to surgery, fewer procedures offered, and higher mortality among non-White patients compared to White patients [1–4]. Studies assessing such disparities within the field of thoracic surgery are limited, however, and represent a small proportion of the content presented at recent national thoracic surgery meetings [5]. Among publications evaluating race/ethnicity outcome disparities within thoracic surgery, populations studied are largely drawn from national databases which limits the granularity of the data and makes it difficult to relate to individual health center populations [6–18]. Similarly, the outcomes studied are frequently limited to rudimentary outcomes such as mortality and treatment performed [6–11,16,18,19].

Our integrated health system treats a socioeconomically and ethnically diverse population of over 4.9 million active members that is representative of the heterogenous population in Northern California [20,21]. Thoracic surgery care is regionalized to several centers of excellence including our institution. We therefore aimed to evaluate for racial/ethnic disparities across several outcomes among our thoracic surgery patient population. We hypothesized that patients undergoing thoracic surgery within our health system experience parity in terms of mortality and type of surgery, but also that disparities may exist in terms of unplanned post-operative encounters within our health system.

Material and methods

Study population

Utilizing our electronic health record, we identified all adult patients who underwent thoracic surgery at our regional thoracic surgery center from January 1st, 2016 through December 31st, 2020. The start date was chosen based on the year that our health system initially regionalized thoracic surgery care [22–24]. Patients were excluded if they were not managed by our thoracic surgery service post-operatively, which is not routine at our institution. The study was approved by our Institutional Review Board with a waiver of informed consent.

Study design

Our study was conducted with the use of existing data from clinical and administrative data systems. Patients were identified by thoracic surgery procedure codes. Collected patient characteristics included age, sex, race/ethnicity, neighborhood deprivation index, body mass index (BMI), Charlson Comorbidity Index (CCI), primary language, insurance type, home region, surgical approach, and surgery type. Based on residential address, neighborhood deprivation index was calculated from eight census variables in the domains of income/poverty, education, employment, housing, and occupation with patients classified into quartiles (with quartile 1 being the least deprived and quartile 4 being the most deprived). Home regions were broken into local, North, West, South, Northeastern, and Southeastern regions. Home region was included as a proxy for potential unmeasured differences in care delivery such as travel distance. Surgical approaches were classified as open, video-assisted thoracoscopic surgery (VATS), robot-assisted thoracoscopic surgery (RATS), and mediastinoscopy. Collected post-operative outcomes included intensive care unit (ICU) admission, hospital length of stay, 30-day return to emergency department, 30-day readmission, number of overall outpatient appointments within 30 and 90 days, number of surgical outpatient appointments within 30 and 90 days, number of nonsurgical outpatient appointments within 30 and 90 days, and mortality within 30 and 90 days. Outcomes were compared by race/ethnicity.

Statistical analysis

Chi-square and Fisher's Exact tests were used to compare categorical variables. Kruskal-Wallis tests were used to compare non-normally distributed continuous variables. Multivariable regression models were performed to assess for variable associations with clinical outcomes of interest. For models in which the outcome of interest was hospital length of stay, a continuous variable, linear regression models were performed and betas (β) with accompanying 95 % confidence intervals are reported. For models in which the outcome of interest 30-day return to ED, logistic regression models were performed and adjusted odds ratios (aOR) with accompanying 95 % confidence intervals (CI) are reported. Variables included in the multivariable models included age, sex, race/ethnicity, neighborhood deprivation index, BMI, CCI, insurance type, patient home region, and surgical approach. Due to high correlation between race/ethnicity and primary language, the model was run again with language in place of race/ethnicity. A p-value of <0.05 was considered significant. All analyses were performed using SAS 9.4 (Cary, NC, USA).

Results

Overall, 2730 participants were included. Of these, 59.4 % were non-Hispanic White ($n = 1622$), 15.0 % were Asian ($n = 410$), 11.9 % were Hispanic ($n = 324$), 9.6 % were Black ($n = 261$), and 4.1 % were "Other" race/ethnicity ($n = 113$); 49.0 % of patients were female ($n = 1337$) and 51.0 % were male ($n = 1393$). Patients underwent one of four surgical approaches: 14.3 % open surgery ($n = 389$), 76.9 % video-assisted thoracoscopic surgery ($n = 2099$), 2.5 % robot-assisted thoracoscopic surgery ($n = 69$), or 6.3 % mediastinoscopy ($n = 173$). Table 1 reveals baseline characteristics by race/ethnicity. Notably, there was no difference in the distribution of surgical approach performed across race/ethnicity. Also, while most patients spoke English as a primary language, those who spoke an Asian language as a primary language were predominantly Asian, and those who spoke Spanish as a primary language were predominantly Hispanic.

Thoracic surgery outcomes

Outcomes by race/ethnicity can be found in Table 2. There was no significant difference by race/ethnicity for 30-day hospital readmission, ICU admission, 30-day mortality, or 90-day mortality. There was also no significant difference by race/ethnicity for median number of overall outpatient, surgical outpatient, and nonsurgical outpatient appointments within 30 or 90 days. Median (Q1-Q3) LOS (in hours) was shortest among non-Hispanic White (37.3 (29.2–76.1)) and Other (36.5 (29.3–75.4)) patients followed by Hispanic (46.8 (29.9–78.1)) patients, with Asian (51.3 (30.7–81.9)) and Black (53.7 (30.6–101.6)) patients experiencing the longest LOS ($p < 0.01$). 30d-ED rates were highest among Hispanic patients (21.3 %), followed by Black (19.2 %), non-Hispanic White (18.1 %), Asian (13.4 %), and Other (8.0 %) patients ($p < 0.01$). The reasons for 30d-ED visits were quite variable. Pain was the most common reason, but this accounted for just 13.8 % of emergency department return visits. Of patients that returned to the emergency department, 28 % were admitted to the hospital. There were no racial/ethnic disparities found among other outcomes.

Racial/ethnic disparities

Multivariable linear regression (Table 3) showed increasing age (β 0.34 (95 % CI 0.02, 0.66)), Black race/ethnicity (β 25.4 (95 % CI 9.78, 41.03), reference: White), male sex (β 13.66 (95 % CI 5.16, 22.16)), 4+ CCI (β 14.85 (95 % CI 5.65, 24.06)), open surgery (β 59.7 (95 % CI 47.25, 72.15), reference: VATS), and home region (Southeastern β 44.13 (95 % CI 18.59, 69.66), Northeastern β 41.1 (95 % CI 8.45, 73.7), and South β 70.95 (95 % CI 33.34, 108.57), reference: local) were associated with longer hospital length of stay. Higher BMI (Overweight β −16.26 (95 % CI -26.37, −6.15) and Obese β −14.29 (95 % CI -24.96, −3.61), reference: Normal) and mediastinoscopy (β −46.27 (95 % CI -63.66, −28.87), reference: VATS) were associated with shorter hospital lengths of stay. When surgery type was substituted into this multivariable model in place of surgical approach, the independent association between Black race/ethnicity (β 24.5 (95 % CI 8.85, 40.15), reference: White) and longer length of stay remained.

Multivariable logistic regression analysis revealed (Table 4) Hispanic ethnicity (aOR 1.43 (95 % CI 1.03–1.97), reference: non-Hispanic White), 4+ CCI (aOR 1.47 (95 % CI 1.16–1.85)), open surgery (aOR 1.40 (95 % CI 1.05–1.86), reference: White), Medicaid insurance (aOR 2.37 (95 % CI 1.48–3.81)) and Northeastern home region (aOR 2.51 (95 % CI (1.30–4.85), reference: local) were associated with higher likelihood of returning to the ED within 30 days. Conversely, Asian (aOR 0.66 (95 % CI 0.47–0.93)) and Other (aOR 0.42 (95 % CI 0.21–0.85)) race/ethnicity as well as obesity (aOR 0.75 (95 % CI 0.57–0.98)) were associated with lower likelihood of returning to the ED within 30 days. When surgery type was substituted into this multivariable model in place of surgical approach, the independent associations of Asian race/ethnicity (β 0.63 (95 % CI 0.45, 0.89), reference: White), Hispanic race/ethnicity (β 1.42 (95 % CI 1.03, 1.97), reference: White), and Other race/ethnicity (β 0.41 (95 % CI 0.20, 0.83), reference: White) with likelihood of returning to the ED within 30 days remained.

Due to the correlation between race/ethnicity and primary language, both multivariable models were run with language in place of race/ethnicity. In the model for hospital length of stay, only male sex, elevated CCI, open surgery, Southeast home region, and South home region were associated with longer length of stay (Table 5). Elevated BMI, mediastinoscopy, and being in the least deprived quartile of neighborhood deprivation index were associated with shorter length of stay.

When race/ethnicity was replaced by language in the multivariable model for 30-day return to the ED, Spanish as a primary language was

Table 1
Thoracic surgery cohort characteristics by race/ethnicity ($N = 2730$).

Patient characteristic	Total N = 2730 (100 %)	Asian *n* = 410 (15.0 %)	Black n = 261 (9.6 %)	Hispanic *n* = 324 (11.9 %)	Other n = 113 (4.1 %)	Non-Hispanic White *n* = 1622 (59.4 %)	p-Value
Age at Index, Mean (SD)	62.8 (15.0)	60.7 (15.3)	60.9 (15.1)	54.9 (17.7)	60.9 (14.5)	65.4 (13.7)	<0.01[*]
Age at Index, Median (Q1-Q3)	66.0 (55.5–73.5)	64.2 (52.4–71.8)	64.0 (53.0–72.2)	57.7 (42.5–68.5)	63.6 (55.7–70.5)	68.4 (59.4–474.5)	<0.01[?]
Gender, N (%)							
Female	1337 (49.0 %)	208 (50.7 %)	143 (54.8 %)	149 (46.0 %)	63 (55.8 %)	774 (47.7 %)	0.08[||]
Male	1393 (51.0 %)	202 (49.3 %)	118 (45.2 %)	175 (54.0 %)	50 (44.3 %)	848 (52.3 %)	
BMI, Median (Q1-Q3)	26.4 (23.1–30.7)	24.2 (21.7–27.5)	27.2 (23.0–32.7)	28.0 (24.6–32.4)	26.4 (22.7–30.8)	26.7 (23.5–31.0)	<0.01[?]
BMI							
Normal	1043 (38.2 %)	237 (57.8 %)	91 (34.9 %)	86 (26.5 %)	42 (37.5 %)	587 (36.2 %)	<0.01[||]
Overweight	904 (33.1 %)	116 (28.3 %)	81 (31.0 %)	120 (37.0 %)	39 (34.8 %)	548 (33.8 %)	
Obese	782 (28.7 %)	57 (13.9 %)	89 (34.1 %)	118 (36.4 %)	31 (27.7 %)	487 (30.0 %)	
Charlson Comorbidity Index							
Score 0	274 (10.0 %)	41 (10.0 %)	33 (12.6 %)	54 (16.7 %)	16 (14.2 %)	130 (8.0 %)	<0.01[||]
Score 1–2	641 (23.5 %)	111 (27.1 %)	47 (18.0 %)	83 (25.6 %)	31 (27.4 %)	369 (22.8 %)	
Score 3–4	720 (26.4 %)	108 (26.3 %)	53 (20.3 %)	78 (24.1 %)	23 (20.4 %)	458 (28.2 %)	
Score 5–6	389 (14.3 %)	51 (12.4 %)	41 (15.7 %)	39 (12.0 %)	12 (10.6 %)	246 (15.2 %)	
Score 7+	706 (25.9 %)	99 (24.2 %)	87 (33.3 %)	70 (21.6 %)	31 (27.4 %)	419 (25.8 %)	
Surgical approach							
Mediastinoscopy	173 (6.3 %)	21 (5.1 %)	18 (6.9 %)	22 (6.8 %)	11 (9.7 %)	101 (6.2 %)	0.4[||]
Open	389 (14.3 %)	51 (12.4 %)	39 (14.9 %)	58 (17.9 %)	17 (15.0 %)	224 (13.8 %)	
Robotic	69 (2.5 %)	6 (1.5 %)	5 (1.9 %)	8 (2.5 %)	3 (2.7 %)	47 (2.9 %)	
Video-Assisted	2099 (76.9 %)	332 (81.0 %)	199 (76.3 %)	236 (72.8 %)	82 (72.6 %)	1250 (77.1 %)	
Type of thoracic surgery							
Chest Wall/Diaphragm	141 (5.2 %)	6 (1.5 %)	8 (3.1 %)	21 (6.5 %)	2 (1.8 %)	104 (6.4 %)	<0.01[||]
Esophagus	214 (7.8 %)	27 (6.6 %)	10 (3.8 %)	23 (7.1 %)	8 (7.1 %)	146 (9.0 %)	
Lobectomy/Pneumonectomy	748 (27.4 %)	134 (32.7 %)	72 (27.6 %)	66 (20.4 %)	27 (23.9 %)	449 (27.7 %)	
Mediastinum	473 (17.3 %)	78 (19.0 %)	56 (21.5 %)	65 (20.1 %)	29 (25.7 %)	245 (15.1 %)	
Other Bronchus/Pulmonary/ Pleura	434 (15.9 %)	77 (18.8 %)	51 (19.5 %)	58 (17.9 %)	19 (16.8 %)	229 (14.1 %)	
Segmentectomy/Wedge	720 (26.4 %)	88 (21.5 %)	64 (24.5 %)	91 (28.1 %)	28 (24.8 %)	449 (27.7 %)	
NDI							
Q1 (least deprived)	896 (32.8 %)	142 (34.7 %)	32 (12.3 %)	48 (14.8 %)	42 (37.2 %)	632 (39.0 %)	<0.01[||]
Q2	828 (30.3 %)	116 (28.4 %)	59 (22.6 %)	83 (35.6 %)	39 (34.5 %)	531 (32.7 %)	
Q3	610 (22.4 %)	85 (20.8 %)	72 (27.6 %)	103 (31.8 %)	20 (17.7 %)	330 (20.4 %)	
Q4 (most deprived)	395 (14.5 %)	66 (16.1 %)	98 (37.6 %)	90 (27.8 %)	12 (10.6 %)	129 (8.0 %)	
Language							
Asian	103 (3.8 %)	99 (24.2 %)	0 (0.0 %)	0 (0.0 %)	4 (3.6 %)	0 (0.0 %)	<0.01[||]
English	2526 (92.7 %)	304 (74.3 %)	261 (100.0 %)	238 (73.5 %)	105 (93.8 %)	1618 (99.9 %)	
Other	9 (0.3 %)	4 (1.0 %)	0 (0.0 %)	1 (0.3 %)	2 (1.8 %)	2 (0.1 %)	
Spanish	88 (3.2 %)	2 (0.5 %)	0 (0.0 %)	85 (26.2 %)	1 (0.9 %)	0 (0.0 %)	
Medicaid							
Yes	105 (3.9 %)	29 (7.3 %)	20 (7.8 %)	18 (5.7 %)	7 (6.4 %)	31 (1.9 %)	<0.01[||]
No	2571 (96.1 %)	366 (92.7 %)	235 (92.2 %)	300 (94.3 %)	102 (93.6 %)	1568 (98.1 %)	
Facility Region							
North	928 (36.0 %)	118 (31.1 %)	56 (22.1 %)	101 (33.3 %)	48 (44.4 %)	605 (39.4 %)	<0.01[||]
Local	795 (30.8 %)	155 (40.8 %)	162 (64.0 %)	103 (34.0 %)	32 (29.6 %)	343 (22.3 %)	
Southeast	83 (3.2 %)	1 (0.3 %)	4 (1.6 %)	22 (7.3 %)	1 (0.9 %)	55 (3.6 %)	
Northeast	46 (1.8 %)	5 (1.3 %)	1 (0.4 %)	7 (2.3 %)	1 (0.9 %)	32 (2.1 %)	
South	34 (1.3 %)	8 (2.1 %)	2 (0.8 %)	6 (2.0 %)	3 (2.8 %)	15 (1.0 %)	
West	695 (26.9 %)	93 (24.5 %)	28 (11.1 %)	64 (21.1 %)	23 (21.3 %)	487 (31.7 %)	

[*] p-value calculated using ANOVA test.
[?] p-value calculated using Kruskal-Wallis test.
[||] p-value calculated using chi-square test.

strongly associated with return to the ED within 30 days (aOR 2.17 (95 % CI 1.28–3.65)) while speaking an Asian language as a primary language was associated with reduced likelihood of returning to the ED within 30 days (aOR 0.41 (95 % CI 0.20, 0.85)). Similar associations with elevated CCI, open surgery, Medicaid status, obesity, and Northeast home region persisted (Table 6).

Discussion

Studies examining outcome disparities in thoracic surgery are limited and largely focus on national database data with rudimentary outcomes such as mortality or whether or not treatment was performed [6–18]. We utilized electronically extracted data from our integrated health system electronic health record to identify all thoracic surgery patients who underwent surgery at our institution from 2016 through 2020 and to assess for outcome disparities by race/ethnicity. While parity was found across most measured outcomes, multivariable regression revealed Black race/ethnicity to be an independent predictor of prolonged length of stay and Hispanic race/ethnicity to be an independent predictor of increased return to the emergency department within 30 days.

The finding that Black race/ethnicity was associated with prolonged hospital length of stay prompts further questions. While median length of stay for Black patients was less than a day longer than that of non-Hispanic White patients, the roughly 16 h difference is difficult to explain within the context of our study. This difference remained despite controlling for neighborhood deprivation index, insurance status, and home region; however, it is worth noting that transportation type from the hospital was not included in our analysis. Similarly, while home region was accounted for, the exact distance from home was not included. These variables could potentially help to further account for the difference seen.

The finding that Hispanic race/ethnicity was associated with increased return to the emergency department within thirty days is also somewhat challenging to interpret. However, similar findings of increased emergency department utilization among racial/ethnic minorities have been previously reported [25,26]. It is possible that this difference is related to the fact that Spanish was the primary language for over one quarter of our Hispanic patients. In fact, the multivariable model replacing race/ethnicity for language pointed toward a potentially more profound association between Spanish as a primary language and increased rate of return to the emergency department compared to the association with Hispanic race/ethnicity. This provides a potential targetable outcome disparity that may be improved with increased emphasis on utilization of interpreter services and alternative language discharge instructions. Given that readmission rates were not significantly different across race/ethnicity, it seems possible that the increased returns to the emergency department among Hispanic patients may be related more to a lack of clarity in relation to written and oral discharge instructions and follow up rather than post-operative complications requiring readmission. The fact that only 28 % of patients that returned to the emergency department were readmitted suggests that a majority of return visits may be preventable. Interestingly, such a finding of increased return to emergency department visits was not found among Asian patients or patients primarily speaking an Asian language. In fact, both of these characteristics were associated with reduced return to the emergency department within 30 days. While the reason for this is not entirely clear, patients speaking Spanish as a primary language appear to represent a vulnerable patient population within our system.

The recognition of such disparities is the first step in learning ways to improve them. As shown through data from the ACCURE Trial,

Table 2
Outcomes after thoracic surgery by race ethnicity (N = 2730).

Patient characteristic	Total N = 2730 (100 %)	Asian N = 410 (15.0 %)	Black N = 261 (9.6 %)	Hispanic N = 324 (11.9 %)	Other N = 113 (4.1 %)	Non-Hispanic White N = 1622 (59.4 %)	p-Value
30-Day readmission to hospital							
Yes	315 (11.6 %)	49 (12.0 %)	23 (8.8 %)	37 (11.4 %)	12 (10.6 %)	195 (12.0 %)	0.66*
No	2414 (88.4 %)	361 (88.0 %)	238 (91.2 %)	287 (88.6 %)	101 (89.4 %)	1427 (88.0 %)	
30-Day return to ED							
Yes	476 (17.4 %)	55 (13.4 %)	50 (19.2 %)	69 (21.3 %)	9 (8.0 %)	293 (18.1 %)	<0.01*
No	2254 (82.6 %)	355 (86.6 %)	211 (80.8 %)	255 (78.7 %)	104 (92.0 %)	1329 (81.9 %)	
ICU transfer							
Yes	146 (5.4 %)	25 (6.1 %)	20 (7.7 %)	13 (4.0 %)	8 (7.1 %)	80 (4.9 %)	0.23*
No	2584 (94.7 %)	385 (93.9 %)	241 (92.3 %)	311 (96.0 %)	105 (92.9 %)	1542 (95.1 %)	
30-Day mortality							
Yes	39 (1.4 %)	5 (1.2 %)	4 (1.5 %)	6 (1.9 %)	1 (0.9 %)	23 (1.4 %)	0.99?
No	2691 (98.6 %)	405 (98.8 %)	257 (98.5 %)	318 (98.2 %)	112 (99.1 %)	1599 (98.6 %)	
90-Day mortality							
Yes	90 (3.3 %)	12 (2.9 %)	10 (3.8 %)	15 (4.6 %)	1 (0.9 %)	52 (3.2 %)	0.36*
No	2640 (96.7 %)	398 (97.1 %)	251 (96.2 %)	309 (95.4 %)	112 (99.1 %)	1570 (96.8 %)	
Number of Outpatient Appointments within 30 days, Median (Q1-Q3)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	0.63‖
Number of Surgical Outpatient Appointments within 30 days, Median (Q1-Q3)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0.32‖
Number of Nonsurgical Outpatient Appointments within 30 days, Median (Q1-Q3)	1 (0–3)	1 (0–3)	1 (0–2)	1 (0–3)	1 (0–3)	1 (0–2)	0.51‖
Number of Outpatient Appointments within 90 days, Median (Q1-Q3)	4 (2–8)	4 (1–8)	4 (2–8)	4 (2–9)	4 (1–8)	4 (2–8)	0.70‖
Number of Surgical Outpatient Appointments within 90 days, Median (Q1-Q3)	1 (0–1)	1 (0–1)	0 (0–1)	1 (0–1)	0 (0–1)	1 (0–1)	0.12‖
Number of Nonsurgical Outpatient Appointments within 90 days, Median (Q1-Q3)	3 (1–7)	3 (1–7)	3 (1–7)	3 (1–7.5)	3 (1–7)	3 (1–7)	0.56‖
Length of Stay, Median (Q1-Q3)	48.0 (29.6–78.8)	51.3 (30.7–81.9)	53.7 (30.6–101.6)	46.8 (29.9–78.1)	36.5 (29.3–75.4)	37.3 (29.2–76.1)	<0.01‖

* p-value calculated using chi-square test.
? *p*-value calculated using Fisher's exact test.
‖ *p*-value calculated using Kruskal-Wallis test.

Table 3
Multivariable linear regression model for associations with hospital length of stay.

Characteristic	Adjusted Beta	95 % CI	p-Value
Age	0.34	(0.02, 0.66)	0.04
Race/Ethnicity			
Asian	6.66	(−6.02, 19.34)	0.3
Black	25.4	(9.78, 41.03)	<0.01
Hispanic	−2.82	(−16.93, 11.28)	0.69
Other	11.59	(−9.78, 32.97)	0.29
White	ref	ref	ref
Gender			
Male	13.66	(5.16, 22.16)	<0.01
Female	ref	ref	ref
BMI			
Normal	ref	ref	ref
Overweight	−16.26	(−26.37, −6.15)	<0.01
Obese	−14.29	(−24.96, −3.61)	0.01
Charlson comorbidity index			
Score 0–3	ref	ref	ref
Score 4+	14.85	(5.65, 24.06)	<0.01
Surgical approach			
Mediastinoscopy	−46.27	(−63.66, −28.87)	<0.01
Open	59.7	(47.25, 72.15)	<0.01
Robotic	−15.16	(−41.82, 11.51)	0.27
Video-assisted	ref	ref	ref
Neighborhood deprivation index			
Q1 (least deprived)	−10.05	(−24.40, 4.30)	0.17
Q2	−1.2	(−15.39, 13.00)	0.87
Q3	3.08	(−11.42, 17.59)	0.68
Q4 (most deprived)	ref	ref	ref
Medicaid			
Yes	6.22	(−16.00, 28.44)	0.58
No	ref	ref	ref
Facility region			
Local	ref	ref	ref
North	−5.44	(−16.17, 5.30)	0.32
Northeast	41.07	(8.45, 73.68)	0.01
Southeast	44.13	(18.59, 69.66)	<0.01
South	70.95	(33.34, 108.57)	<0.01
West	−5.19	(−16.78, 6.41)	0.38

transparency and feedback to clinical teams regarding race/ethnicity outcome disparities are critical components to help systems achieve more equitable care [27,28]. Additionally, by studying more granular outcomes such as outpatient and emergency department encounter types, institutions can develop a more nuanced understanding of outcome disparities beyond mortality rates and treatment completion. While the latter are critically important, examination of encounter type allows us to delve further into how patients interact with the healthcare system and how patients treated by one institution can experience differences in access to healthcare.

It is worth noting that while we found a statistical difference among surgery types overall by race/ethnicity, clinically the differences do not appear to be particularly large. More importantly, when surgery type was included in our multivariable models for length of stay and return visits to the ED within 30 days, our reported independent associations between race/ethnicity and each outcome remained nearly identical to those prior to inclusion of surgery type in the models.

The rational for why a difference in mortality was not found by race/ethnicity despite such evidence from other institutions may be related to the structure of our health system. Our regional center for thoracic surgery consists of a stable group of thoracic surgeons that follows protocolized workflows for preoperative, intraoperative, and postoperative patient management. Additionally, we have medical staff that helps maintain contact with our patients, ensures prompt scheduling, and reduces loss to follow up. We believe such standardization helps reduce health disparities, however, as evidenced in this study, outcome disparities still can exist within such a system. This also highlights why it is critical for institutions to apply similar strategies to track outcomes with as much granularity as possible because outcome disparities may vary by institution and hence require different strategies to fix them.

Table 4
Multivariable logistic regression model for associations with return to the emergency department within 30 days.

Characteristic	Adjusted odds ratio	95 % CI	p-Value
Age	1.00	(0.99–1.01)	0.15
Race/Ethnicity			
Asian	0.66	(0.47–0.93)	0.02
Black	1.11	(0.76–1.62)	0.58
Hispanic	1.43	(1.03–1.97)	0.03
Other	0.42	(0.21–0.85)	0.01
White	ref	ref	ref
Gender			
Male	1.08	(0.87–1.33)	0.48
Female	ref	ref	ref
BMI			
Normal	ref	ref	ref
Overweight	0.91	(0.71–1.16)	0.43
Obese	0.75	(0.57–0.98)	0.03
Charlson Comorbidity Index			
Score 0–3	ref	ref	ref
Score 4+	1.47	(1.16–1.85)	<0.01
Surgical approach			
Mediastinoscopy	0.86	(0.54–1.36)	0.51
Open	1.4	(1.05–1.86)	0.02
Robotic	1.25	(0.67–2.34)	0.49
Video-Assisted	ref	ref	ref
Neighborhood Deprivation Index			
Q1 (least deprived)	1	(0.70–1.44)	0.99
Q2	1.27	(0.89–1.80)	0.18
Q3	1.15	(0.80–1.64)	0.45
Q4 (most deprived)	ref	ref	ref
Medicaid			
Yes	2.37	(1.48–3.81)	<0.01
No	ref	ref	ref
Facility region			
Local	ref	ref	ref
North	1.19	(0.91–1.55)	0.21
Northeast	2.51	(1.30–4.85)	0.01
Southeast	1.28	(0.69–2.36)	0.44
South	0.75	(0.28–2.01)	0.56
West	1.13	(0.84–1.51)	0.43

Interestingly, higher BMI was associated with better outcomes in each multivariable model for hospital length of stay and return to the emergency department within thirty days. While the reason for the possible protective effect of elevated BMI is not entirely clear, this finding is not necessarily original to our study. Several prior thoracic surgery outcome studies have noted similar if not improved outcomes among overweight and obese patients compared to underweight and normal BMI patients [29–31].

In addition to its retrospective nature, our study has several limitations. While associations can be identified between patient characteristics and outcomes, causation cannot be assumed. Similarly, despite our attempt to control for potentially confounding variables, the non-randomized nature of our study impedes our ability to conclude that associations are truly independent of any other confounder. Lastly, while our institution utilizes additional lines of communication such as direct messaging within the electronic health record, short term follow up phone calls, and 24/7 triage nurse availability by phone, utilization of such services could not be tracked and included in this study. Such

Table 5
Multivariable linear regression model for associations with hospital length of stay with language substituted for race/ethnicity.

Characteristic	Adjusted Beta	95 % CI	p-Value
Age	0.29	(−0.03, 0.61)	0.07
Language			
English	ref	ref	ref
Asian	18.01	(−4.78, 40.80)	0.12
Other	11.78	(−59.51, 83.08)	0.75
Spanish	−17.53	(−42.42, 7.37)	0.17
Gender			
Male	13.01	(4.49, 21.53)	<0.01
Female	ref	ref	ref
BMI			
Normal	ref	ref	ref
Overweight	−15.3	(−25.44, −5.16)	<0.01
Obese	−13.15	(−23.81, −2.49)	0.02
Charlson Comorbidity Index			
Score 0–3	ref	ref	ref
Score 4+	15.47	(6.25, 24.69)	<0.01
Surgical approach			
Mediastinoscopy	−45.79	(−63.20, −28.39)	<0.01
Open	60.14	(47.66, 72.63)	<0.01
Robotic	−17.1	(−43.78, 9.58)	0.21
Video-Assisted	ref	ref	ref
Neighborhood deprivation index			
Q1 (least deprived)	−14.69	(−28.74, −0.63)	0.04
Q2	−5.52	(−19.54, 8.49)	0.44
Q3	−0.18	(−14.65, 14.28)	0.98
Q4 (most deprived)	ref	ref	ref
Medicaid			
Yes	7.19	(−15.08, 29.47)	0.53
No	ref	ref	ref
Facility region			
Local	ref	ref	ref
North	−8.36	(−18.96, 2.25)	0.12
Northeast	35.28	(2.76, 67.80)	0.03
Southeast	37.64	(12.31, 62.98)	<0.01
South	68.34	(30.71, 105.96)	<0.01
West	−8.77	(−20.15, 2.61)	0.13

metrics could add additional insight into how patients utilize available resources and interact with their health system.

Conclusions

Outcome disparities exist throughout the field of thoracic surgery. While racial/ethnic parity existed in terms of mortality and surgical approach for thoracic surgery patients at our institution, differences related to patient encounters in terms of length of stay and rate of return visits to the emergency department within 30 days were identified. Such disparities may go unnoticed at many institutions, but attention to such detail and transparency regarding these outcome disparities are critical on the path to achieving equitable care.

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Table 6
Multivariable logistic regression model for associations with return to the emergency department within 30 days with language substituted for race/ethnicity.

Characteristic	Adjusted odds ratio	95 % CI	p-Value
Age	1.01	(0.99, 1.01)	0.13
Language			
English	ref	ref	ref
Asian	0.41	(0.20, 0.85)	0.02
Other	1.27	(0.25, 6.50)	0.77
Spanish	2.17	(1.28, 3.65)	<0.01
Gender			
Male	1.1	(0.89, 1.35)	0.4
Female	ref	ref	ref
BMI			
Normal	ref	ref	ref
Overweight	0.89	(0.70, 1.14)	0.35
Obese	0.75	(0.58, 0.98)	0.04
Charlson Comorbidity Index			
Score 0–3	ref	ref	ref
Score 4+	1.47	(1.17, 1.85)	<0.01
Surgical approach			
Mediastinoscopy	0.85	(0.53, 1.34)	0.48
Open	1.39	(1.05, 1.86)	0.02
Robotic	1.28	(0.68, 2.39)	0.44
Video-Assisted	ref	ref	ref
Neighborhood deprivation index			
Q1 (least deprived)	0.96	(0.67, 1.37)	0.81
Q2	1.25	(0.88, 1.77)	0.21
Q3	1.16	(0.81, 1.66)	0.41
Q4 (most deprived)	ref	ref	ref
Medicaid			
Yes	2.35	(1.46, 3.77)	<0.01
No	ref	ref	ref
Facility region			
Local	ref	ref	ref
North	1.17	(0.90, 1.53)	0.24
Northeast	2.59	(1.34, 4.98)	<0.01
Southeast	1.38	(0.75, 2.54)	0.3
South	0.71	(0.26, 1.90)	0.49
West	1.12	(0.84, 1.49)	0.43

Ethics approval

The study was approved by our Institutional Review Board with a waiver of informed consent.

CRediT authorship contribution statement

Kian C. Banks: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. **Julia Wei:** Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Leyda Marrero Morales:** Investigation, Methodology, Validation, Writing – review & editing. **Zeuz A. Islas:** Investigation, Methodology, Validation, Writing – review & editing. **Nathan J. Alcasid:** Investigation, Methodology, Validation, Writing – review & editing. **Cynthia J. Susai:** Investigation, Methodology, Validation, Writing – review & editing. **Angela Sun:** Investigation, Methodology, Validation, Writing – review & editing. **Katemanee Burapachaisri:** Investigation, Methodology, Validation, Writing – review & editing. **Ashish R. Patel:** Conceptualization, Investigation, Supervision, Writing – review & editing. **Simon K. Ashiku:** Conceptualization, Investigation, Supervision, Writing – review & editing. **Jeffrey B. Velotta:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

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