The American Journal of Surgery 236 (2024) 115785

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Original Research Article

Caprini guideline indicated venous thromboembolism (VTE) prophylaxis among inpatient surgical patients: are there racial/ethnic differences in practice patterns and outcomes?

Michael A. Edwards [a,*], Mark Falstin [a], Akash Uddandam [b], Emily Brennan [c], Aaron Spaulding [c]

[a] Mayo Clinic, Department of Surgery, Division of Advanced GI and Bariatric Surgery, Jacksonville, FL, 32224, USA
[b] McMaster University, Department of Health Sciences, Hamilton, Ontario, L8S 4L8, Canada
[c] Mayo Clinic, Robert D. and Patricia E. Kern Center, Division of Health Care Delivery Research, Jacksonville, FL, 32224, USA

ARTICLE INFO

Keywords:
Venous thromboembolism
Caprini score
Prophylaxis
Race/ethnic
Disparity

ABSTRACT

Background: While racial disparity in surgical mortality due to venous thromboembolism (VTE) has improved, a gap persists. Our study aim was to determine differences in VTE prevention practices and their impact on outcomes among racial surgical cohorts.

Methods: Elective surgeries performed between 1.1.2016 and 5.31.2021 were included. Racial/ethnic cohorts were propensity-matched 1:1 to non-Hispanic White (NHW) patients, and outcomes were compared using unadjusted logistic regression. Match cohort balance was assessed using absolute standardized mean differences and linear model analysis of variance (ANOVA). Pearson's Chi-square tests evaluated bi-variate associations. Conditional logistic regression to compare outcomes between matched groups. Odds ratios, 95 % confidence intervals, and p-values are reported. Analyses were performed using R version 4.1.2 and the R package Matchit.

Results: Non-Hispanic other race (NHOR) (vs. NHW) patients were less likely to receive inpatient prophylaxis (OR 0.86, CI:0.76–0.98). Appropriate prophylaxis resulted in similar VTE for NHB ($p = 0.71$) and Hispanic ($p = 0.06$), compared to NHW patients. Inpatient bleeding was higher in Hispanic patients with a higher likelihood of receiving appropriate prophylaxis (OR 1.94, CI:1.16–3.32) and NHOR patients with a lower likelihood (OR 1.90, CI:1.10–3.36)

Conclusion: Postoperative VTE was similar for minority patients receiving appropriate prophylaxis, compared to NHW patients. Inpatient bleeding was more likely in Hispanic and NHOR patients but may not be related to receiving appropriate prophylaxis. NHOR patients were less likely to receive inpatient thromboprophylaxis.

1. Introduction

Postoperative venous thromboembolism (VTE) is a common postoperative complication that is associated with serious morbidity and mortality risks.[1] The reported incidence of postoperative VTE ranges between 0.14 % and 3.5 %, and thirty-day VTE-related mortality is reported to be 4.4 %–16.9 %, with both reported as procedure-dependent.[2,3] Identifying patients at risk and implementing preventive measures, including pharmacological prophylaxis, are paramount to mitigate the burden of VTE-related mortality and morbidity.[4] VTE risk assessment measures (RAMs) have been developed and validated, including the Caprini score, which has been validated in multiple surgical cohorts.[5,6] The degree to which these VTE RAMs are used remains unclear, as studies have shown significant variability in VTE risk stratification.[7,8]

In addition to procedure dependence, VTE risk may vary based on patient characteristics, including race.[9,10] Several studies have reported racial/ethnic differences in postoperative VTE.[11–16] Compared to non-Hispanic white (NHW) patients, postoperative VTE incidence has been reported to be higher in non-Hispanic black (NHB) (OR: 1.7)[11,12] and Hispanic (OR: 1.68)[13] patients. Compared to NHB patients, Asian/-Pacific Islander patients are reported to have a 70 % lower incidence of VTE.[9] Brown et al. also showed that African American patients had a higher incidence of VTE compared to Caucasian patients, suggesting a need for targeted interventions to reduce this disparity.[15] Abdol Razak et al. examined the impact of race/ethnicity on the risk of postoperative VTE in cancer patients and showed that Hispanic patients were at a higher risk of postoperative VTE compared to non-Hispanic patients.[16]

* Corresponding author. Mayo Clinic Alix School of Medicine, Department of Surgery, Mayo Clinic, 4500 San Pablo Rd S, Jacksonville, FL, 32224, USA.
E-mail address: Edwards.michael@mayo.edu (M.A. Edwards).

https://doi.org/10.1016/j.amjsurg.2024.115785
Received 17 December 2023; Received in revised form 4 March 2024; Accepted 27 May 2024

Studies have also demonstrated increased postoperative VTE-related mortality and morbidity[17,18] in some racial/ethnic patient cohorts. For example, Edwards et al.[17] reported a higher incidence of postoperative VTE-related mortality in Black patients following bariatric surgery. Similarly, Okike et al. showed significant racial and ethnic differences in postoperative events, including VTE, contributing to heightened morbidity among Black and Hispanic patients compared to their White counterparts.[18]

While studies have shown racial/ethnic disparities in VTE risk and outcomes, the underlying reasons remain unclear. Reported contributing factors to racial/ethnic differences in VTE risk have included patient genetics/biology, sociological factors, access, disease presentation, and social determinants.[19–21] Variations in practice patterns for VTE risk assessment and prevention strategies, as well as compliance, may also contribute to differences in VTE incidence among racial cohorts.[22,23] For instance, in a bariatric patient cohort, Reddy et al.[24] show that IVC filter use correlated with an increased risk of DVT (OR 6.33) and pulmonary embolism/in-hospital mortality (OR 3.75) risk. Additionally, in a cohort of bariatric surgery patients, Edwards et al.[25] also found that despite having a lower VTE risk profile, IVC filter use was 3-fold higher in Black bariatric surgery patients. Given studies showing variability in VTE and bleeding risk among racial/ethnic cohorts,[26] a patient-centered approach that considers risk not only based on VTE RAMs but also patient demographics like race/ethnicity may be of benefit.

In this study, we aimed to 1) determine if there are racial/ethnic disparities in VTE prevention practices by assessing the utilization of Caprini guideline indicated VTE prophylaxis in a cohort of surgical patients, and 2) determine if such practice variations correlate with disparate outcomes in postoperative VTE and bleeding during hospitalization or after hospital discharge.

2. Material and methods

Our Institutional Review Board approved the study. We obtained data about all inpatient elective surgeries performed between January 1, 2016, and May 31, 2021, at our academic multi-site hospital system from the electronic medical record. Excluded cases are detailed in Fig. 1. Specifically, patients with no research authorization, orthopedic or pediatric surgeries, donor nephrectomies, subsequent surgeries occurring during the same admission, surgeries lasting less than a minute, as well as surgeries on patients on preoperative therapeutic anticoagulants, those with preoperative anticoagulants of unknown use, those experiencing a VTE between admission and surgery start, or those missing data for matching were excluded. From the included cases, surgeries occurring in the following surgical departments were included: Neurosurgery, Bariatric, Cardiothoracic, Colorectal, Otolaryngology, General, Gynecological, Organ Transplantation, Plastic, Urology, and Vascular. Cohorts of non-Hispanic Black (NHB), Hispanic, and non-Hispanic other race (NHOR) patients were matched to non-Hispanic White (NHW) patients. Our primary dependent variable was the receipt of Caprini guideline indicated VTE prophylaxis. Secondary outcomes included inpatient, 30- and 90-day post-discharge VTE and bleeding complications.

Patients' risk of experiencing a VTE event after surgery was identified by retrospective calculation of the Caprini score and operationalized as low (score 1–2), moderate (score 3–4), high (score 5–8), and highest (score 9 or above) risk for postoperative VTE. Based on patients' VTE risk category, the VTE prophylaxis regimen comprises individual or combined use of in-hospital mechanical prophylaxis, in-hospital use of anticoagulant, and 7–29 or 30–60 days of discharge anticoagulants (***Appendix 1***). In-hospital mechanical prophylaxis involves using a sequential compression device during the surgical admission. In-hospital use of anticoagulants was identified based on administering prophylactic doses of anticoagulants on each day of the admission (***Appendix 2***). Duration of discharge prophylaxis was identified by the dosage strength and frequency of medication orders to determine the number of days the patient received anticoagulants at discharge. VTE prophylaxis regimens consistent with Caprini score-based recommendations were categorized as "appropriate prophylaxis".

Inpatient, 30-, and 90-day post-discharge deep vein thrombosis (DVT) and pulmonary embolism (PE) events were determined using ICD-10 codes, as well as confirmatory radiology impressions (ultrasound for DVT and chest computed tomography for PE). Experiencing a DVT or PE during the postoperative period or within 30 or 90 days of discharge was classified as a VTE event. Inpatient, 30- and 90-day post-discharge bleeding episodes were also evaluated. Three bleeding criteria were used: diagnostic codes, changes in laboratory values, and blood transfusion.[18] Diagnostic criteria included the ICD-10 codes for postoperative hemorrhage listed under the Patient Safety Indicators (PSI-9), according to the Agency for Health Care Quality. Laboratory value change criteria include a 4-g drop in hemoglobin or 12 % in hematocrit between the first collection after the end of surgery and any measurement before discharge for the inpatient cohort and between the last measurement during the surgical admission and any other measurement in 30 or 90 days after discharge for the discharge cohorts. The third criterion for identifying hemorrhage was the receipt of a transfusion of red blood cells. Cases that satisfied at least two of the three criteria were categorized as a postoperative bleeding complication.[27]

Our primary predictor variable of interest was self-reported patient race and ethnicity. This data was retrieved from the electronic health records and categorized into four groups: NHW, NHB, NHOR, and Hispanic patients. Analyses were subdivided into the inpatient and discharge periods, as reflected in Fig. 1. For the inpatient period, all included patients were assessed, and appropriate prophylaxis and outcomes only included events or conditions occurring until discharge. Appropriate prophylaxis for the inpatient cohort included only inpatient mechanical and chemical prophylaxis criteria. For discharge analyses, patients from the inpatient cohort who experienced VTE or were administered anticoagulants for therapeutic or unknown use during the admission were excluded. For the discharge period, appropriate prophylaxis and outcomes only included events or conditions occurring after discharge. "Appropriate prophylaxis" categorization for the discharge cohort requires both inpatient and discharge mechanical and chemical prophylaxis criteria to be met.

Patients from the NHB, NHOR, and Hispanic groups were propensity matched to NHW patients using a 1:1 greedy nearest neighbor match without replacement in six subsets: inpatient overall, inpatient with appropriate prophylaxis, inpatient without appropriate prophylaxis, discharge overall, discharge with appropriate prophylaxis, and discharge without appropriate prophylaxis. Propensity scores, including sex, ASA score, medical system site, Charlson score, Caprini score, and surgical department, were estimated using a generalized linear model, and a 0.01 distance caliper was used for all variables. Following the match, cohort balance was assessed using absolute standardized mean differences and linear model analysis of variance (ANOVA). Pearson's Chi-square tests evaluated bi-variate associations between patient characteristics and treatment group before and after matching. After matching, we used conditional logistic regression to compare outcomes between matched groups (all groups compared to the NHW group). Odds ratios, 95 % confidence intervals, and p-values are reported. Associations were considered statistically significant at $p < 0.05$, and all tests were two-sided. Statistical analyses were performed using R version 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria), and propensity matches were performed using the R package Matchit.

3. Results

Of 79,069 cases analyzed, 47.1 % were female, 89.6 % were NHW, 3.37 % were NHB, 4.36 % were Hispanic, and 2.69 % were NHOR. At baseline, there were significant differences in every patient characteristic assessed in this study between racial/ethnic cohorts (all $p < 0.001$, Table 1). NHW patients were older, more likely to be male, and had higher Caprini scores than patients from the other racial/ethnic groups,

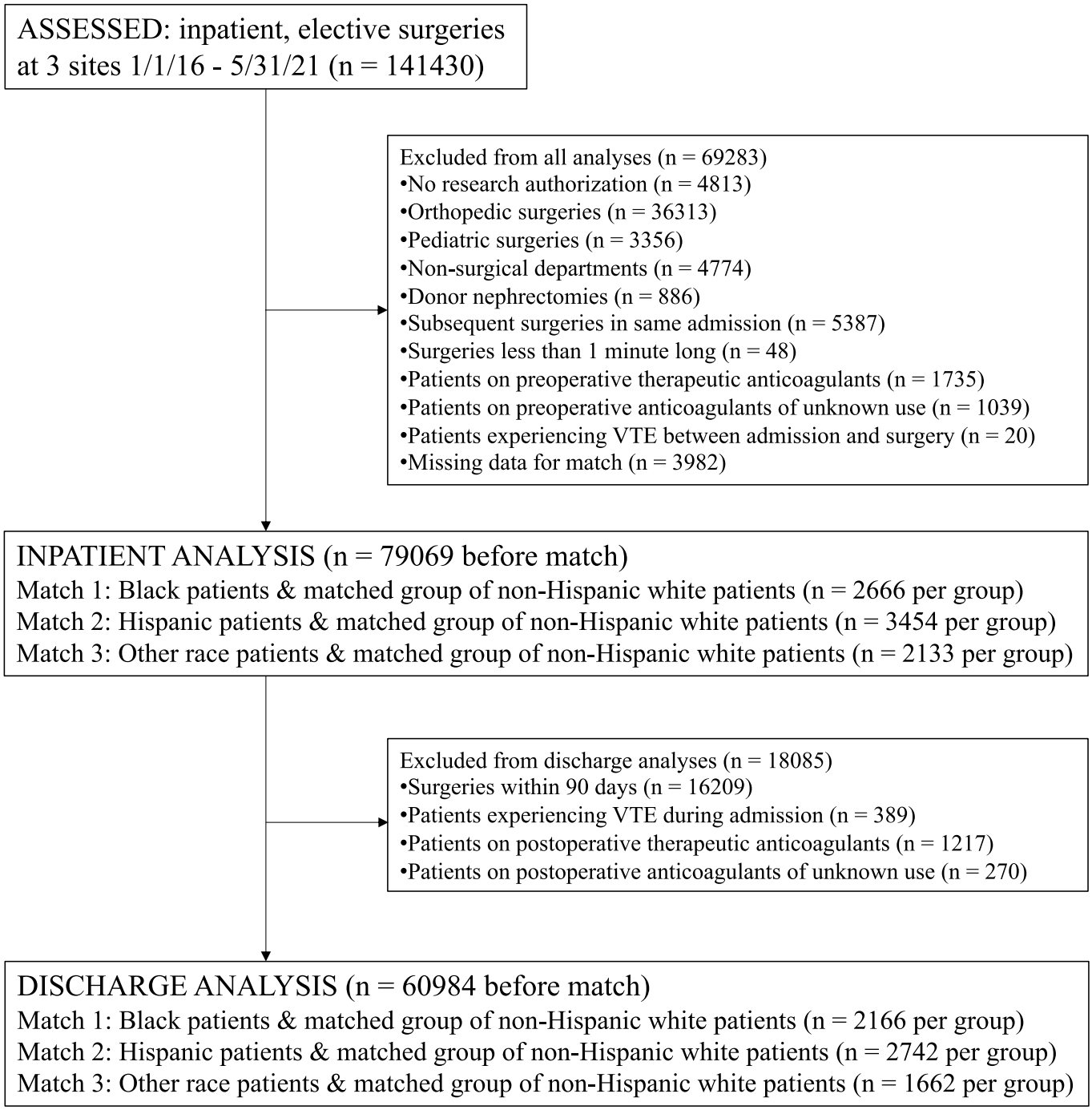

Fig. 1. Consort diagram for inclusion and exclusion criteria.

while Hispanic patients had lower Charlson comorbidity scores than the other racial/ethnic groups. The racial/ethnic distributions in the three hospital sites, five ASA classes, and 11 clinical departments were also significantly different at baseline.

Patient characteristics in racial/ethnic cohorts, including 2666 NHB, 3454 Hispanic, and 2133 NHOR patients matched 1:1 to NHW patients is detailed in Table 2. All patient characteristics were similar between matched racial/ethnic cohorts following propensity matching based on bi-variate tests of association and standardized mean differences (Supplemental Figures). Table 3 describes the receipt of appropriate prophylaxis, VTE, and bleeding events in the matched cohorts. In the inpatient cohort, NHB (42.4 % vs. 44.9 %, p = 0.068) and NHOR (32.7 % vs. 36.0 %, p = 0.056) were less likely to receive appropriate prophylaxis compared to NHW, while Hispanic patients were more likely to receive appropriate prophylaxis compared to NHW patients (40.7 % vs. 38.7 %, p = 0.085); however, these were not significantly different. In those receiving appropriate prophylaxis, VTE was similar between racial cohorts, except for a non-significantly lower rate in Hispanic (0 % vs. 0.4 %, p = 0.062) compared to NHW patients. Bleeding was similar between NHB and NHW patients receiving appropriate prophylaxis, but higher in Hispanic patients (3.0 % vs. 1.6 %, p = 0.011) and NHOR (5.3 % vs. 2.9 %, p = 0.032), compared to NHW patients. In the inpatient cohort not receiving appropriate prophylaxis, VTE incidence was higher compared to VTE incidence in the appropriate prophylaxis cohort, but similar between matched racial/ethnic cohorts compared. Postoperative bleeding in those not receiving appropriate inpatient prophylaxis was higher in

Table 1
Patient characteristics.

	NHW (N = 70,816)	Hispanic (N = 3454)	NHB (N = 2666)	NHOR (N = 2133)	Total (N = 79,069)	p-value
Age, mean (sd)	59.37 (15.87)	51.28 (16.44)	52.07 (15.49)	52.50 (16.07)	58.58 (16.05)	<0.001
Female sex	32,910 (46.47 %)	1801 (52.14 %)	1443 (54.13 %)	1117 (52.37 %)	37,271 (47.14 %)	<0.001
ASA Class						<0.001
1	1652 (2.33 %)	167 (4.83 %)	64 (2.40 %)	87 (4.08 %)	1970 (2.49 %)	
2	26,233 (37.04 %)	1450 (41.98 %)	948 (35.56 %)	865 (40.55 %)	29,496 (37.30 %)	
3	36,801 (51.97 %)	1613 (46.70 %)	1417 (53.15 %)	985 (46.18 %)	40,816 (51.62 %)	
4	6112 (8.63 %)	224 (6.49 %)	235 (8.81 %)	196 (9.19 %)	6767 (8.56 %)	
5	18 (0.03 %)	0 (0.00 %)	2 (0.08 %)	0 (0.00 %)	20 (0.03 %)	
Hospital Site						<0.001
Hospital Site 1	46,768 (66.04 %)	1316 (38.10 %)	1012 (37.96 %)	1312 (61.51 %)	50,408 (63.75 %)	
Hospital Site 2	12,967 (18.31 %)	837 (24.23 %)	1346 (50.49 %)	288 (13.50 %)	15,438 (19.52 %)	
Hospital Site 3	11,081 (15.65 %)	1301 (37.67 %)	308 (11.55 %)	533 (24.99 %)	13,223 (16.72 %)	
Charlson, mean (sd)	1.90 (1.66)	1.65 (1.58)	1.86 (1.72)	1.90 (1.70)	1.89 (1.66)	<0.001
Caprini, mean (sd)	8.52 (3.50)	7.74 (3.37)	7.88 (3.35)	7.60 (3.34)	8.44 (3.50)	<0.001
Caprini score category						<0.001
1-2	1266 (1.79 %)	116 (3.36 %)	74 (2.78 %)	81 (3.80 %)	1537 (1.94 %)	
3-4	6337 (8.95 %)	464 (13.43 %)	323 (12.12 %)	295 (13.83 %)	7419 (9.38 %)	
5–8	31,622 (44.65 %)	1594 (46.15 %)	1271 (47.67 %)	1010 (47.35 %)	35,497 (44.89 %)	
9 or higher	31,591 (44.61 %)	1280 (37.06 %)	998 (37.43 %)	747 (35.02 %)	34,616 (43.78 %)	
Departments						<0.001
Neurosurgery	14,449 (20.40 %)	832 (24.09 %)	536 (20.11 %)	436 (20.44 %)	16,253 (20.56 %)	
Bariatric	1434 (2.02 %)	116 (3.36 %)	214 (8.03 %)	28 (1.31 %)	1792 (2.27 %)	
Cardiothoracic	14,869 (21.00 %)	530 (15.34 %)	328 (12.30 %)	461 (21.61 %)	16,188 (20.47 %)	
Colorectal	9159 (12.93 %)	355 (10.28 %)	206 (7.73 %)	200 (9.38 %)	9920 (12.55 %)	
ORL	4489 (6.34 %)	177 (5.12 %)	94 (3.53 %)	135 (6.33 %)	4895 (6.19 %)	
General	7314 (10.33 %)	396 (11.46 %)	278 (10.43 %)	262 (12.28 %)	8250 (10.43 %)	
Gynecological	4285 (6.05 %)	256 (7.41 %)	307 (11.52 %)	229 (10.74 %)	5077 (6.42 %)	
Organ Transplantation	1884 (2.66 %)	218 (6.31 %)	173 (6.49 %)	108 (5.06 %)	2383 (3.01 %)	
Plastic	1179 (1.66 %)	66 (1.91 %)	42 (1.58 %)	31 (1.45 %)	1318 (1.67 %)	
Urology	8623 (12.18 %)	426 (12.33 %)	428 (16.05 %)	194 (9.10 %)	9671 (12.23 %)	
Vascular	3131 (4.42 %)	82 (2.37 %)	60 (2.25 %)	49 (2.30 %)	3322 (4.20 %)	

NHW = non-Hispanic white, NHB = non-Hispanic black, NHOR = non-Hispanic other race, sd = standard deviation, ASA = American Society of Anesthesiologists, ORL = Otorhinolaryngology.

Table 2
Matched patient characteristics.

	NHW (N = 2666)	NHB (N = 2666)	p-value	NHW (N = 3454)	Hispanic (N = 3454)	p-value	NHW (N = 2133)	NHOR (N = 2133)	p-value
Sex									
Male	1238 (46.4 %)	1223 (45.9 %)	0.68	1642 (47.5 %)	1653 (47.9 %)	0.79	1025 (48.1 %)	1016 (47.6 %)	0.78
Female	1428 (53.6 %)	1443 (54.1 %)		1812 (52.5 %)	1801 (52.1 %)		1108 (51.9 %)	1117 (52.4 %)	
ASA score									
1	58 (2.2 %)	64 (2.4 %)	0.84	151 (4.4 %)	167 (4.8 %)	0.67	102 (4.8 %)	87 (4.1 %)	0.52
2	966 (36.2 %)	948 (35.6 %)		1453 (42.1 %)	1450 (42.0 %)		868 (40.7 %)	865 (40.6 %)	
3	1415 (53.1 %)	1417 (53.2 %)		1641 (47.5 %)	1613 (46.7 %)		987 (46.3 %)	985 (46.2 %)	
4	223 (8.4 %)	235 (8.8 %)		209 (6.1 %)	224 (6.5 %)		176 (8.3 %)	196 (9.2 %)	
5	4 (0.2 %)	2 (0.1 %)		0 (0.0 %)	0 (0.0 %)		0 (0.0 %)	0 (0.0 %)	
Hospital site									
1	1026 (38.5 %)	1012 (38.0 %)	0.91	1331 (38.5 %)	1316 (38.1 %)	0.81	1340 (62.8 %)	1312 (61.5 %)	0.49
2	1338 (50.2 %)	1346 (50.5 %)		814 (23.6 %)	837 (24.2 %)		263 (12.3 %)	288 (13.5 %)	
3	302 (11.3 %)	308 (11.6 %)		1309 (37.9 %)	1301 (37.7 %)		530 (24.8 %)	533 (25.0 %)	
Charlson score	1.8 (1.7)	1.9 (1.7)	0.78	1.6 (1.5)	1.6 (1.6)	0.53	1.9 (1.7)	1.9 (1.7)	0.44
Caprini score	7.9 (3.3)	7.9 (3.4)	0.88	7.7 (3.3)	7.7 (3.4)	0.84	7.6 (3.3)	7.6 (3.3)	0.87
Department									
Neurologic	528 (19.8 %)	536 (20.1 %)	0.99	821 (23.8 %)	832 (24.1 %)	1.00	441 (20.7 %)	436 (20.4 %)	0.98
Bariatric	324 (12.2 %)	328 (12.3 %)		528 (15.3 %)	530 (15.3 %)		467 (21.9 %)	461 (21.6 %)	
Cardiothoracic	202 (7.6 %)	206 (7.7 %)		358 (10.4 %)	355 (10.3 %)		197 (9.2 %)	200 (9.4 %)	
Colorectal	414 (15.5 %)	428 (16.1 %)		417 (12.1 %)	426 (12.3 %)		177 (8.3 %)	194 (9.1 %)	
ORL	284 (10.7 %)	278 (10.4 %)		405 (11.7 %)	396 (11.5 %)		266 (12.5 %)	262 (12.3 %)	
General	328 (12.3 %)	307 (11.5 %)		275 (8.0 %)	256 (7.4 %)		242 (11.3 %)	229 (10.7 %)	
Gynecological	102 (3.8 %)	94 (3.5 %)		185 (5.4 %)	177 (5.1 %)		138 (6.5 %)	135 (6.3 %)	
Organ Transplantation	51 (1.9 %)	60 (2.3 %)		72 (2.1 %)	82 (2.4 %)		54 (2.5 %)	49 (2.3 %)	
Plastic	210 (7.9 %)	214 (8.0 %)		113 (3.3 %)	116 (3.4 %)		30 (1.4 %)	28 (1.3 %)	
Urology	42 (1.6 %)	42 (1.6 %)		64 (1.9 %)	66 (1.9 %)		31 (1.5 %)	31 (1.5 %)	
Vascular	181 (6.8 %)	173 (6.5 %)		216 (6.3 %)	218 (6.3 %)		90 (4.2 %)	108 (5.1 %)	

NHW = non-Hispanic white, NHB = non-Hispanic black, NHOR = non-Hispanic other race, sd = standard deviation, ASA = American Society of Anesthesiologists, ORL = Otorhinolaryngology.

Table 3
Outcomes of matched patient cohorts.

INPATIENT COHORT	NHW (N = 2666)	NHB (N = 2666)	p-value	NHW (N = 3454)	Hispanic (N = 3454)	p-value	NHW (N = 2133)	NHOR (N = 2133)	p-value
Not appropriate	1469 (55.1 %)	1535 (57.6 %)	0.068	2118 (61.3 %)	2048 (59.3 %)	0.085	1366 (64.0 %)	1436 (67.3 %)	0.056
Appropriate	1197 (44.9 %)	1131 (42.4 %)		1336 (38.7 %)	1406 (40.7 %)		767 (36.0 %)	697 (32.7 %)	
APPROPRIATE VTE PROPHYLAXIS	**NHW (N = 1131)**	**NHB (N = 1131)**	**p-value**	**NHW (N = 1406)**	**Hispanic (N = 1406)**	**p-value**	**NHW (N = 697)**	**NHOR (N = 697)**	**p-value**
Postoperative VTE	3 (0.3 %)	4 (0.4 %)	0.71	5 (0.4 %)	0 (0.0 %)	0.062	2 (0.3 %)	1 (0.1 %)	1.00
Postoperative Bleeding	37 (3.3 %)	34 (3.0 %)	0.72	22 (1.6 %)	42 (3.0 %)	**0.011**	20 (2.9 %)	37 (5.3 %)	0.032
NO APPROPRIATE VTE PROPHYLAXIS	**NHW (N = 1535)**	**NHB (N = 1535)**	**p-value**	**NHW (N = 2048)**	**Hispanic (N = 2048)**	**p-value**	**NHW (N = 1436)**	**NHOR (N = 1436)**	**p-value**
Postoperative VTE	15 (1.0 %)	17 (1.1 %)	0.72	19 (0.9 %)	21 (1.0 %)	0.75	14 (1.0 %)	13 (0.9 %)	0.84
Postoperative Bleeding	75 (4.9 %)	80 (5.2 %)	0.68	71 (3.5 %)	91 (4.4 %)	0.11	61 (4.2 %)	93 (6.5 %)	0.005
DISCHARGE COHORT	**NHW (N = 2166)**	**NHB (N = 2166)**	**p-value**	**NHW (N = 2742)**	**Hispanic (N = 2742)**	**p-value**	**NHW (N = 1662)**	**NHOR (N = 1662)**	**p-value**
Not appropriate	2049 (94.6 %)	2039 (94.1 %)	0.55	2555 (93.2 %)	2535 (92.5 %)	0.30	1537 (92.5 %)	1555 (93.6 %)	0.94
Appropriate	117 (5.4 %)	127 (5.9 %)		187 (6.8 %)	207 (7.5 %)		125 (7.5 %)	107 (6.4 %)	
APPROPRIATE DISCHARGE VTE PROPHYLAXIS	**NHW (N = 127)**	**NHB (N = 127)**	**p-value**	**NHW (N = 207)**	**Hispanic (N = 207)**	**p-value**	**NHW (N = 107)**	**NHOR (N = 107)**	**p-value**
90-day VTE	0 (0.0 %)	0 (0.0 %)	N/A	0 (0.0 %)	0 (0.0 %)	N/A	1 (0.9 %)	1 (0.9 %)	1.00
90-day Bleeding	0 (0.0 %)	0 (0.0 %)	N/A	0 (0.0 %)	0 (0.0 %)	N/A	0 (0.0 %)	1 (0.9 %)	1.00
NO APPROPRIATE DISCHARGED VTE PROPHYLAXIS	**NHW (N = 2039)**	**NHB (N = 2039)**	**p-value**	**NHW (N = 2535)**	**Hispanic (N = 2535)**	**p-value**	**NHW (N = 1555)**	**NHOR (N = 1555)**	**p-value**
90-day VTE	19 (0.9 %)	15 (0.7 %)	0.49	24 (0.9 %)	19 (0.7 %)	0.44	16 (1.0 %)	3 (0.2 %)	0.007
90-day Bleeding	17 (0.8 %)	17 (0.8 %)	1.00	10 (0.4 %)	19 (0.7 %)	0.094	9 (0.6 %)	7 (0.5 %)	0.80

NHW = non-Hispanic white, NHB = non-Hispanic black, NHOR = non-Hispanic other race, VTE = venous thromboembolism.
P-values results from Pearson's Chi square tests or Fisher's Exact tests for comparisons with at least 25 % of cell counts <5.

NHOR patients than NHW patients (6.5 % vs. 4.2 %, p = 0.005), but was similar in NHB and Hispanic patients compared to NHW patients.

The racial/ethnic cohorts receiving appropriate discharge prophylaxis were significantly less than those receiving inpatient appropriate prophylaxis, with no significant difference in receiving discharge prophylaxis between racial/ethnic cohorts. In the matched discharged cohort receiving appropriate VTE prophylaxis, both VTE and bleeding were uncommon and were similar between matched racial/ethnic cohorts. In the discharged cohort not receiving appropriate prophylaxis, VTE events were more common. They were similar between NHB and NHW patients, as well as Hispanic and NHW patients, but lower in NHOR (0.2 % vs. 1.0 %, p = 0.007) compared to NHW patients.

In logistic regression models, the odds of receiving appropriate inpatient VTE prophylaxis was lower for NHOR (0.86, CI: 0.76–0.98, p = 0.024) compared to NHW patients, but similar for NHB (OR 0.90) and Hispanic (OR 1.09), compared to NHW patients (Table 4). In those receiving appropriate inpatient VTE prophylaxis, postoperative VTE rates were not significantly different for NHB (OR 1.33) and NHOR (OR 0.50) compared to NHW patients. Inpatient bleeding among patients receiving appropriate inpatient prophylaxis was also similar between NHB compared to NHW patients (OR 0.92) but more likely in Hispanic (OR 1.94, CI: 1.16–3.32, p = 0.013) and NHOR (OR 1.90, CI: 1.10–3.36, p = 0.024), compared to NHW patients. For the inpatient cohort who did not receive prophylaxis, VTE and bleeding outcomes were similar between racial/ethnic cohorts, except for a higher likelihood of bleeding in NHOR (OR 1.56, CI: 1.12–2.18, p = 0.008) compared to NHW patients. At discharge, the likelihood of receiving appropriate discharged prophylaxis was not significantly different for NHB (OR 1.08), Hispanic (OR 1.12), or

Table 4
Logistic regression models for appropriate prophylaxis, venous thromboembolism, and bleeding.

Reference: NHW	NHB			Hispanic			NHOR		
INPATIENT COHORT	**N**	**OR (95 % CI)**	**p-value**	**N**	**OR (95 % CI)**	**p-value**	**N**	**OR (95 % CI)**	**p-value**
Appropriate prophylaxis	2666	0.90 (0.81, 1.01)	0.068	3454	1.09 (0.99, 1.20)	0.085	2133	0.86 (0.76, 0.98)	0.024
APPROPRIATE VTE PROPHYLAXIS									
Postoperative VTE	1131	N/A	N/A	1406	N/A	N/A	697	N/A	N/A
Postoperative Bleeding	1131	0.92 (0.57, 1.47)	0.72	1406	1.94 (1.16, 3.32)	0.013	697	1.90 (1.10, 3.36)	0.024
NO APPROPRIATE VTE PROPHYLAXIS									
Postoperative VTE	1535	1.13 (0.56, 2.31)	0.72	2048	1.11 (0.59, 2.08)	0.75	1436	0.93 (0.43, 1.99)	0.85
Postoperative Bleeding	1535	1.07 (0.77, 1.48)	0.68	2048	1.29 (0.94, 1.78)	0.11	1436	1.56 (1.12, 2.18)	0.008
DISCHARGE COHORT	**N**	**OR (95 % CI)**	**p-value**	**N**	**OR (95 % CI)**	**p-value**	**N**	**OR (95 % CI)**	**p-value**
Appropriate prophylaxis	2166	1.08 (0.84, 1.40)	0.55	2742	1.12 (0.91, 1.37)	0.30	1662	0.85 (0.65, 1.11)	0.22
APPROPRIATE VTE PROPHYLAXIS									
90-day VTE	127	N/A	N/A	207	N/A	N/A	107	N/A	N/A
90-day Bleeding	127	N/A	N/A	207	N/A	N/A	107	N/A	N/A
NO APPROPRIATE VTE PROPHYLAXIS									
90-day VTE	2039	0.79 (0.39, 1.55)	0.49	2535	0.79 (0.43, 1.44)	0.45	1555	0.19 (0.04, 0.56)	0.008
90-day Bleeding	2039	1.00 (0.51, 1.98)	1.00	2535	1.91 (0.9, 4.28)	0.099	1555	0.78 (0.28, 2.09)	0.62

NHW = non-Hispanic white, NHB = non-Hispanic black, NHOR = non-Hispanic other race, VTE = venous thromboembolism.

NHOR (OR 0.85) compared to NHW patients. Regression analysis for the discharge appropriate prophylaxis cohort was not feasible due to the small sample and low event rates. For the discharge cohort not receiving appropriate prophylaxis, VTE complications were similar between racial/ethnic cohorts, except for lower VTE odds in NHOR (OR 0.19, CI: 0.04–0.56, $p = 0.008$). There were no differences in 90-day bleeding complications between racial/ethnic cohorts not receiving appropriate discharge VTE prophylaxis.

4. Discussion

In this study, we explored VTE risk assessment and prevention practice patterns in surgical patients to determine if disparity exists and its associated impact on outcomes. We found that receipt of appropriate Caprini guideline indicated inpatient thromboprophylaxis resulted in similar VTE incidence between racial/ethnic cohorts. Given the small sample size and very low VTE events in the racial/ethnic cohorts compared, our finding that appropriate inpatient thromboprophylaxis resulted in similar VTE incidence in our racial/ethnic cohorts should be interpreted with caution. The receipt of Caprini guideline indicated discharge thromboprophylaxis was overall low and did not significantly differ between racial/ethnic cohorts. Definitive conclusion about the impact of discharge thromboprophylaxis practice patterns among racial/ethnic cohorts could not be made given the limited VTE events in the discharge cohort. We also found that compared to NHW patients, Hispanic patients had a similar rate of receiving appropriate inpatient thromboprophylaxis ($p = 0.085$), but a higher risk of postoperative bleeding ($p = 0.011$). In contrast, the NHOR cohort had a significantly lower likelihood of receiving in-hospital appropriate VTE prophylaxis based on Caprini practice guidelines, but a significantly higher risk of postoperative bleeding ($p = 0.032$). This suggests that postoperative bleeding risk is more likely to be related to variables other than receiving Caprini guideline indicated thromboprophylaxis.

While likely underpowered to show significant differences, our study suggests that there is variability in VTE prophylaxis practice patterns across racial/ethnic cohorts. This is consistent with other studies showing variability in VTE practice patterns based on race.[22,28,29] For example, Douds et al. found that black race was a significant risk factor for lower rates of VTE prophylaxis.[15] Next, Nathan et al. found that black compared to white patients were less likely to receive VTE prophylaxis, particularly with medications such as direct oral anticoagulants (DOACs).[28] In contrast, Zebley et al.[29] showed that in trauma settings, black patients were 4 % more likely to receive VTE prophylaxis, highlighting the impact that practice type may have on VTE practice patterns.

Studies have also shown the impact of Caprini guideline indicated VTE prophylaxis on VTE reduction, without increasing bleeding risk.[30] While these studies clearly show benefits in VTE risk reduction, the cohorts analyzed were not stratified by race/ethnicity. Similar to the results of our study, which suggests that with appropriate risk based VTE prophylaxis, VTE outcomes are similar between racial/ethnic cohorts, Folsom et al.[31] showed that VTE rates did not differ between black and white patients. They further suggested that the frequently reported higher incidence of VTE may be explained by higher VTE risk factors in black patients. The lack of racial disparity in VTE outcomes noted in our study may also reflect the lack of significant differences in receipt of Caprini guideline-indicated prophylaxis. In addition to differences in VTE risk factors and adherence to recommended VTE prevention practice guidelines, differences in VTE incidence by race also must be evaluated in the context variables that may impact VTE incidence, such as genetic risks or social determinants of health.[32,33]

For Hispanic patients in our study, there was a trend towards being more likely to receive Caprini guideline-indicated prophylaxis, which may have correlated with a trend towards less VTE but higher bleeding. This contrasts with the study by Zebley et al.[29] showing that Hispanics were found to be 8 % less likely to receive VTE prophylaxis compared to White patients ($p < 0.01$). However, this study is like prior studies showing reduced VTE risk with guideline indicated VTE prophylaxis prevention measures. In the non-Hispanic other racial cohort in this study, there was a reduced likelihood of receiving Caprini guideline indicated VTE prophylaxis, with no difference in VTE outcomes, but a significantly higher bleeding risk. The finding in our study of reduced odds of risk based VTE prophylaxis, but increased bleeding risk suggests that unaccounted for variables, other than appropriate thromboprophylaxis, contributes to bleeding risk. Edwards et al. have shown in multiple studies[34,35] and in different surgical cohorts that factors other than Caprini guideline indicated VTE thromboprophylaxis independently contribute to increased postoperative bleeding risk, including higher Charlson comorbidity, ASA, and Caprini scores. However, it is also possible that our findings may suggest a selection bias in who received appropriate prophylaxis, not accounted for in our analysis, such as procedure.

In our study, receipt of Caprini guideline indicated discharge thromboprophylaxis was overall low compared to inpatient appropriate prophylaxis and was similar between racial/ethnic cohorts. Across race/ethnic cohorts, discharge VTE events occurred primarily in cohorts not receiving appropriate prophylaxis. Low sample and event rates limited the ability to identify independent associations between discharge prophylaxis practice and outcomes and draw definitive conclusions about the impact of discharge prophylaxis practice patterns in racial/ethnic cohorts.

Consistent with our study results, Keane et al. found poor chemoprophylaxis utilization (33 %) in high-risk patients.[36]

The impact of extended VTE prophylaxis in surgical cohorts has been well-documented in the literature.[37,38] In our discharge cohort, small cohort sizes and low event rates limit any definitive conclusion about discharge practice patterns between racial cohorts and outcomes. It is important to acknowledge several limitations of our study. This is a retrospective study from a single hospital system, which may limit generalizability of our findings. However, the three hospital sites included in this health system analysis are in different regions of the United States, which make our results applicable to many other contexts across the country. The study relied on coding and radiology impressions to identify VTE and bleeding events, introducing the possibility of measurement bias.

While variations in practice may contribute to the differences noted, the study does not account for other reasons that may have contributed to the differences observed, such as patient preferences, healthcare provider decision-making, or cultural factors. Interpretation of our analyzed discharged cohort is limited by the small sample size, resulting in an underpowered analysis. In addition, the low event rates also limited the ability to perform regression models to identify independent associations between discharge prophylaxis measures, race/ethnicity, and outcomes. While the inpatient cohort accounted for VTE prophylaxis medication ordered and administered, the discharge cohort accounted for discharge medication orders, but not for compliance. Due to socioeconomic or other social determinants of health, ordered discharged VTE prophylaxis medications may not have been filled or, if filled, not taken as recommended, which further limits our interpretation of the discharged cohort analyzed. Finally, our study does not account for other variables that may have impacted VTE risk, such as procedure type. Given the sample in our cohort and low VTE event rates, assessing the impact of procedure was not feasible.

5. Conclusion

In this study, receipt of appropriate prophylaxis resulted in similar VTE incidence between racial/ethnic cohorts analyzed, suggesting that when risk based VTE prophylaxis is used, disparities in VTE incidence could be mitigated. Postoperative bleeding occurrence was not consistently associated with receipt of appropriate prophylaxis. NHOR had a significantly lower likelihood of receiving appropriate prophylaxis, but a higher risk of postoperative bleeding, which suggests that postoperative

bleeding may be associated with variables other than receipt of risk-guided prophylaxis. A larger sample is needed to validate the findings of our study.

Funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Michael A. Edwards: Conceptualization, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. **Mark Falstin:** Writing – original draft. **Akash Uddandam:** Writing – original draft. **Emily Brennan:** Data curation, Formal analysis, Validation, Writing – review & editing. **Aaron Spaulding:** Formal analysis, Methodology, Writing – review & editing.

Declaration of competing interest

The authors have no conflicts of interest nor relevant financial disclosures.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2024.115785.

References

1. Heit JA. Estimating the incidence of symptomatic postoperative venous thromboembolism: the importance of perspective. *JAMA*. 2012;307(3):306–307.
2. Mukherjee D, et al. Postoperative venous thromboembolism rates vary significantly after different types of major abdominal operations. *J Gastrointest Surg*. 2008;12(11):2015–2022.
3. Rogers SO, et al. Multivariable predictors of postoperative venous thromboembolic events after general and vascular surgery: results from the patient safety in surgery study. *J Am Coll Surg*. 2007;204(6):1211–1221.
4. Jamshidi N, et al. Mechanical thrombectomy of COVID-19 DVT with congenital heart disease leading to phlegmasia cerulea dolens: a case report. *BMC Cardiovasc Disord*. 2021;21(1):592.
5. Hu Y, et al. Comparison between the Khorana prediction score and Caprini risk assessment models for assessing the risk of venous thromboembolism in hospitalized patients with cancer: a retrospective case control study. *Interact Cardiovasc Thorac Surg*. 2020;31(4):454–460.
6. Li K, et al. Establishment of prediction models for venous thromboembolism in non-oncological urological inpatients - a single-center experience. *Int J Gen Med*. 2022;15:3315–3324.
7. Imbus JR, et al. Extended postoperative venous thromboembolism prophylaxis after bariatric surgery: a comparison of existing risk-stratification tools and 5-year MBSAQIP analysis. *Surg Obes Relat Dis*. 2023;19(8):808–816.
8. Caprini JA. Risk assessment as a guide for the prevention of the many faces of venous thromboembolism. *Am J Surg*. 2010;199(1):S3–S10. Supplement.
9. White RH, Keenan CR. Effects of race and ethnicity on the incidence of venous thromboembolism. *Thromb Res*. 2009;123:S11–S17.
10. Keenan CR, White RH. The effects of race/ethnicity and sex on the risk of venous thromboembolism. *Curr Opin Pulm Med*. 2007;13(5).
11. Owens JM, et al. Venous thromboembolism following total knee arthroplasty: does race matter? *J Arthroplasty*. 2018;33(7, Supplement):S239–S243.
12. White RH, et al. Effect of ethnicity and gender on the incidence of venous thromboembolism in a diverse population in California in 1996. *Thromb Haemostasis*. 2005;93(2):298–305.
13. Upfill-Brown A, Paisner N, Sassoon A. Racial disparities in post-operative complications and discharge destination following total joints arthroplasty: a national database study. *Arch Orthop Trauma Surg*. 2023;143(4):2227–2233.
14. Zakai NA, McClure LA. Racial differences in venous thromboembolism. *J Thromb Haemostasis*. 2011;9(10):1877–1882.
15. Upfill-Brown A, Paisner N, Sassoon A. Racial disparities in post-operative complications and discharge destination following total joints arthroplasty: a national database study. *Arch Orthop Trauma Surg*. 2023;143(4):2227–2233.
16. Abdol Razak NB, et al. Cancer-associated thrombosis: an overview of mechanisms, risk factors, and treatment. *Cancers*. 2018;10(10):380.
17. Edwards MA, Muraleedharan D, Spaulding A. Racial disparities in reasons for mortality following bariatric surgery. *Journal of Racial and Ethnic Health Disparities*. 2023;10(2):526–535.
18. Okike K, et al. Association of race and ethnicity with total hip arthroplasty outcomes in a universally insured population. *J Bone Joint Surg Am*. 2019;101(13):1160–1167.
19. Lung BE, et al. Risk factors for venous thromboembolism in total shoulder arthroplasty. *JSES Open Access*. 2019;3(3):183–188.
20. Gohil R, Peck G, Sharma P. The genetics of venous thromboembolism. *A meta-analysis involving ~120,000 cases and 180,000 controls*. 2009;102(8):360–370.
21. Cushman M. Epidemiology and risk factors for venous thrombosis. *Semin Hematol*. 2007;44(2):62–69.
22. Douds GL, et al. Venous thromboembolism in the get with the guidelines-stroke acute ischemic stroke population: incidence and patterns of prophylaxis. *J Stroke Cerebrovasc Dis*. 2014;23(1):123–129.
23. Zebley JA, et al. Racial disparities in administration of venous thromboembolism prophylaxis after severe traumatic injuries. *Am Surg*. 2022:00031348221129519.
24. Reddy S, et al. Prophylactic inferior vena cava filters prior to bariatric surgery. *JACC Cardiovasc Interv*. 2019;12(12):1153–1160.
25. Edwards MA, et al. Racial disparities in inferior vena cava filter use in metabolic and bariatric surgery patients: nationwide insights from the MBSAQIP database. *Am J Surg*. 2021;221(4):749–758.
26. Chen Y-W, et al. Should all patients receive the same prophylaxis? Racial variation in the risk of venous thromboembolism after major abdominal operations. *Am J Surg*. 2021;222(5):884–889.
27. Moriarty JP, et al. Going beyond administrative data: retrospective evaluation of an algorithm using the electronic health record to help identify bleeding events among hospitalized medical patients on warfarin. *Am J Med Qual*. 2017;32(4):391–396.
28. Nathan AS, et al. Racial, ethnic, and socioeconomic inequities in the prescription of direct oral anticoagulants in patients with venous thromboembolism in the United States. *Circulation: Cardiovascular Quality and Outcomes*. 2019;12(4):e005600.
29. Zebley, J.A., et al., Racial disparities in administration of venous thromboembolism prophylaxis after severe traumatic injuries. The American Surgeon™. 0(0): p. 00031348221129519.
30. Edwards MA, et al. Risk stratified venous thromboembolism prophylaxis in bariatric patients using a Caprini assessment: practice patterns and opportunities for improvement. *Surg Obes Relat Dis*. 2023.
31. Folsom AR, et al. Reasons for differences in the incidence of venous thromboembolism in black versus white Americans. *Am J Med*. 2019;132(8):970–976.
32. Kort D, et al. Relationship between neighborhood socioeconomic status and venous thromboembolism: results from a population-based study. *J Thromb Haemostasis*. 2017;15(12):2352–2360.
33. Klarin D, et al. Genome-wide association analysis of venous thromboembolism identifies new risk loci and genetic overlap with arterial vascular disease. *Nat Genet*. 2019;51(11):1574–1579.
34. Edwards MA, et al. Venous thromboembolism and bleeding after hepatectomy: role and impact of risk adjusted prophylaxis. *J Thromb Thrombolysis*. 2023;56(3):375–387.
35. Edwards MA, et al. Can risk-based thromboprophylaxis practice guidelines be safely used in esophagectomy cases? Experience of an academic health system. *J Gastrointest Surg*. 2023;27(10):2045–2056.
36. Keane MG, Ingenito EP, Goldhaber SZ. Utilization of venous thromboembolism prophylaxis in the medical intensive Care unit. *Chest*. 1994;106(1):13–14.
37. Benlice C, et al. Extended venous thromboembolism prophylaxis after elective surgery for IBD patients: nomogram-based risk assessment and prediction from nationwide cohort. *Dis Colon Rectum*. 2018;61(10).
38. Dahl OE, et al. Clinical venous thromboembolism following joint surgery: effect of extended thromboprophylaxis on its annual frequency and postoperative pattern over 22 years. *Clin Appl Thromb Hemost*. 2014;20(2):117–123.