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Factors Associated with Venous Thromboembolism Pharmacoprophylaxis Initiation in Hospitalized Medical Patients: The Medical Inpatients Thrombosis and Hemostasis (MITH) Study

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Authorship Addendum

A. Repp participated in the concept and design, interpretation of data, initial drafting of manuscript, critical writing and revising of the manuscript, and final approval of the manuscript prior to submission.
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Abstract

Background: Although guidelines recommend risk assessment for hospital-acquired venous thromboembolism (HA-VTE) to inform prophylaxis decisions, studies demonstrate inappropriate utilization of pharmacoprophylaxis in hospitalized medical patients. Predictors of pharmacoprophylaxis initiation in medical inpatients remain largely unknown.

Objective: To determine factors associated with HA-VTE pharmacoprophylaxis initiation in adults hospitalized on medical services.

Design: Cohort study using electronic health record data from adult patients hospitalized on medical services at four academic medical centers between 2016 and 2019.

Participants: Among 111,550 admissions not on intermediate or full-dose anticoagulation, 48,520 (43.5%) received HA-VTE pharmacoprophylaxis on the day of or the day after admission.

Main Measures: Candidate predictors of HA-VTE pharmacoprophylaxis initiation, including known HA-VTE risk factors, predicted HA-VTE risk, and bleeding diagnoses present on admission.

Key Results: After adjustment for age, sex, race/ethnicity, and study site, the strongest clinical predictors of HA-VTE pharmacoprophylaxis initiation were malnutrition and chronic obstructive pulmonary disease. Thrombocytopenia and history of gastrointestinal bleeding were associated with decreased odds of HA-VTE pharmacoprophylaxis initiation. Patients in the highest two tertiles of predicted HA-VTE risk were less likely to receive HA-VTE pharmacoprophylaxis than patients in the lowest (1st) tertile (OR 0.84, 95% CI [0.81, 0.86] for 2nd tertile, OR 0.95, 95% CI [0.92, 0.98] for 3rd tertile).

Conclusions: Among patients not already receiving anticoagulants, HA-VTE pharmacoprophylaxis initiation during the first two hospital days was lower in patients with

higher predicted HA-VTE risk and those with risk factors for bleeding. Reasons for not initiating pharmacoprophylaxis in those with higher predicted risk could not be assessed.

Keywords

Anticoagulants / therapeutic use; Healthcare Disparities; Hospitalization; Risk Factors; Venous Thromboembolism / prevention & control

Introduction

Venous thromboembolism (VTE) is a common, serious, and potentially preventable complication in hospitalized medical patients. Approximately 200,000 VTE events in the United States (US) occur during hospitalization or within 3 months of hospital discharge [1–3]. When administered to hospitalized medical patients at elevated risk for hospital-acquired VTE (HA-VTE), pharmacoprophylaxis with low-dose anticoagulants reduces the odds of pulmonary embolism (PE) (OR 0.66, 95% CI [0.43, 1.02]) while increasing the odds of major bleeding (OR 1.65, 95% CI [1.01, 2.71]) [4].

Ideally, clinicians should tailor the decision to use pharmacoprophylaxis based on each patient's risk for HA-VTE and bleeding. Although guidelines recommend risk stratification for HA-VTE using validated risk assessment models (RAMs) to guide prophylaxis decisions [5, 6], studies consistently demonstrate both over- and under-utilization of VTE pharmacoprophylaxis in hospitalized patients [7–12]. Furthermore, single-center studies have shown sex and race differences in the ordering and administration of HA-VTE prophylaxis [13–15].

In a survey of hospitalists, only one third reported using validated RAMs to assess HA-VTE risk, whereas most endorsed performing informal HA-VTE risk assessment [16]. The actual patient-related factors associated with pharmacoprophylaxis initiation in a broad, diverse population of medical inpatients remain largely unknown [16]. Understanding the factors that influence the decision to administer VTE pharmacoprophylaxis is essential to improving clinical practice, reducing potential disparities, and enhancing outcomes. To address this knowledge gap, we assessed the demographic and clinical factors associated with HA-VTE pharmacoprophylaxis initiation and the association between predicted HA-VTE risk and HA-VTE pharmacoprophylaxis in a large, diverse population of hospitalized adults. Uniquely, we assessed use of HA-VTE pharmacoprophylaxis stratified by absolute HA-VTE risk using a recently validated HA-VTE RAM to determine whether those at highest risk were offered HA-VTE pharmacoprophylaxis [17].

Methods

Study Design, Setting, and Participants

Medical admissions from four academic health systems were included in the study: (1) the University of Michigan Medical Center, Ann Arbor, MI (Michigan Health), a 1107-bed tertiary care hospital; (2) Hennepin County Medical Center, Minneapolis, MN (Hennepin Healthcare), a 484 bed safety-net hospital; (3) Harris Health System, Houston, TX (Ben Taub Hospital and Lyndon B. Johnson Hospital), safety-net hospitals with a total of 850

beds; and (4) the University of Vermont (UVM) Medical Center, Burlington, VT, a 562-bed tertiary care hospital. Medical admissions were defined by the admitting clinical service and comprised of admissions to general internal medicine, hospital medicine, family medicine, cardiology, hematology, and oncology services. Patient admissions were included from January 1, 2016 to September 7, 2019 for UVM Medical Center and from January 1, 2018 to December 31, 2019 for the other sites. All patients aged ≥18 years at the time of admission were included. Patients admitted with VTE, admitted to the ICU, or who received intermediate or therapeutic-level anticoagulation on hospital day 1 or 2 were excluded (Figure 1, Supplementary Appendix Table 1). During the study period, the University of Michigan Medical Center required HA-VTE risk assessment based on the Caprini Score as part of the admission workflow for hospitalized patients [18], but the other participating hospitals had not incorporated a systematic approach to HA-VTE risk assessment.

Variable Selection and Definitions

All participating hospitals used Epic Systems electronic health records (EHRs) during the study period. We selected the Medical Inpatients Thrombosis and Hemostasis (MITH) risk model for HA-VTE in medical inpatients to predict HA-VTE risk in this study as it was developed and validated in the hospitals assessed in this study [17]. The MITH model uses objective data points that are readily available to clinicians for most medical patients at the time of admission, the principal time when clinicians make decisions regarding the prescription of HA-VTE pharmacoprophylaxis. It includes seven HA-VTE risk factors: (1) history of VTE, (2) renal dysfunction, (3) active cancer, (4) low hemoglobin, (5) high red cell distribution width (RDW), (6) low serum sodium, and (7) malnutrition. Definitions and data sources for the risk factors are provided in Supplementary Appendix Table 1.

In addition to the overall MITH HA-VTE predicted risk and the individual MITH risk factors, we included components of the past medical history, laboratory results from the time of admission, present on admission bleeding diagnoses, presence of systemic inflammatory response syndrome (SIRS), and two Elixhauser Comorbidity Scores as candidate predictor variables. The variable definitions and data sources are presented in Table 1 of the Supplementary Appendix. The Elixhauser Comorbidity Scores utilize 38 pre-existing conditions identified through secondary diagnoses contained in hospital billing data to predict risk of in-hospital mortality and 30-day all cause readmission [19]. A description of the Elixhauser comorbidity measures and software refined for International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes are publicly available [20].

All anticoagulant medications administered on the day of or day after admission were categorized as prophylactic dose, intermediate dose, or full dose based on medication administration records at each participating hospital (Supplementary Appendix Table 1). Initiation of HA-VTE pharmacoprophylaxis was defined as administration of prophylactic dose anticoagulation on the day of or day after admission (hospital day 1 or 2), consistent with the VTE-1 quality measure developed by The Joint Commission and the National Quality Foundation, which assesses for patients who received VTE prophylaxis “between the day of arrival and the day after hospital admission” [21]. Patients who did not

receive any administration of anticoagulation in this period were assigned to the no pharmacoprophylaxis category.

Race and ethnicity were captured based on EHR documentation, which included patient-reported and hospital staff documented race. Race was categorized as White, Black, Asian, and Other based on US Census specifications [22]. Patients with ethnicity designated as Hispanic or Latino were assigned to the Hispanic category even if a separate race was additionally reported for that patient. Due to the relatively small sample sizes, Asian, Other, and Unknown categories were combined into one group for analysis.

Statistics Analysis

To determine the association between demographic factors and HA-VTE pharmacoprophylaxis, we used multivariable logistic regression with age, sex, race/ethnicity, and site as predictors. We then used age-, sex-, race/ethnicity-, and site-adjusted mixed effects logistic regression to determine the clinical factors associated with VTE pharmacoprophylaxis initiation. Age, sex, and race/ethnicity were treated as fixed effects and site as a random effect. Predicted HA-VTE risk, based on the MITH RAM, was modeled using risk tertiles [17]. The first tertile corresponded to the lowest predicted HA-VTE risk (<0.19%), the second tertile to intermediate risk (0.19%−0.36%), and the third tertile to the highest risk (>0.36%). In secondary stratified analyses, we assessed whether age, sex, or race/ethnicity were effect modifiers of the association between predicted HA-VTE risk and HA-VTE pharmacoprophylaxis initiation. As clinicians may elect not to prescribe HA-VTE pharmacoprophylaxis to patients with a short expected length of stay, we performed a sensitivity analysis and stratified by length of stay <2 days vs ≥2 days. As clinicians may elect not to prescribe HA-VTE pharmacoprophylaxis to patients who are actively bleeding or have low platelet counts, we also performed a sensitivity analysis excluding patients with a present on admission bleeding diagnosis or platelet count <50 K/cm^2. Individuals missing specific risk factors were dropped from the regression analyses. Statistical analysis was performed using R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria) and SAS version 9.4 (SAS Institute Inc., Cary, NC).

Ethical Considerations

This study was conducted in accord with the principles of the Code of Ethics of the World Medical Association (Declaration of Helsinki) [23]. The Institutional Review Boards at each participating institution approved the study or determined the study to be exempt. Participating institutions executed a data use agreement allowing UVM access to limited datasets as defined by the US Health Insurance Portability and Accountability Act (Public Law 104–191, 20 August 1996).

Results

Characteristics of the Analytic Population

After exclusions, the analytic data set included 111,550 hospital admissions on medical services, representing 71,842 unique patients. Figure 1 presents the workflow for constructing the cohort. Among the 111,550 hospital admissions, 48,520 (43.4%) patients

received and 63,030 (56.5%) did not receive VTE pharmacoprophylaxis on the day of or the day after admission. Table 1 presents the characteristics of the study population stratified by prophylaxis initiation. The mean age of patients at the time of admission was 57 years [standard deviation (SD) 17 years]. The racial/ethnic composition of the population was 53.8% White, 21.0% Black, 19.0% Hispanic, and 6.2% Asian/Other. The primary payor was Medicare for 33.8% and Medicaid for 18.4% of patient admissions, while patients had no insurance for 19.6% of admissions. As shown in Supplementary Appendix Table 2, the observed HA-VTE risk for the analytic population was 0.30%.

Association of Patient and Clinical Factors with Pharmacoprophylaxis Initiation

In a multivariable model, older age, female sex, Black race, underweight, and severe obesity were associated with higher odds of HA-VTE pharmacoprophylaxis initiation (Table 2). The clinical factors most strongly associated with higher odds of HA-VTE pharmacoprophylaxis initiation were malnutrition (OR 1.40, 95% CI 1.35–1.46), chronic obstructive pulmonary disease (OR 1.32, 95% CI 1.27–1.37), diabetes (OR 1.26, 95% CI 1.22–1.29), and active cancer (OR 1.22, 95% CI 1.19–1.26) (Table 3). Higher overall Elixhauser Readmission Score and the presence of SIRS were also associated with higher incidence of HA-VTE pharmacoprophylaxis initiation (OR per SD increment 1.25, 95% CI 1.23–1.26; OR 1.31, 95% CI 1.27–1.35; respectively).

Platelet count <50 (OR 0.11, 95% CI 0.09–0.12), present on admission bleeding diagnoses (OR 0.37, 95% CI 0.35–0.39), atrial fibrillation (OR 0.49, 95% CI 0.47–0.51), and history of gastrointestinal bleeding (OR 0.69, 95% CI 0.64–0.72) were the clinical factors most strongly associated with lower odds of HA-VTE pharmacoprophylaxis initiation (Table 3).

Association of Predicted HA-VTE Risk with Pharmacoprophylaxis Initiation

After adjustment for age, sex, race/ethnicity, and clinical site, higher predicted HA-VTE risk was associated with decreased odds of initiation of HA-VTE pharmacoprophylaxis on the day of or the day after hospital admission (Table 3). Compared with patients in the lowest (1st) tertile of predicted HA-VTE risk, patients in the higher tertiles of predicted HA-VTE risk were less likely to receive HA-VTE pharmacoprophylaxis (OR 0.84, 95% CI 0.81–0.86 for 2nd tertile; OR 0.95, 95% CI 0.92–0.98 for 3rd tertile). HA-VTE pharmacoprophylaxis was initiated in 48% of patient admissions in the lowest tertile of predicted risk and in 44% of admissions in each of the upper two tertiles of predicted risk (Table 1).

Age-, Sex-, and Race-Stratified Models

The stratified analysis (Table 4) revealed that the higher tertiles of predicted HA-VTE risk were associated with lower odds of HA-VTE pharmacoprophylaxis in most strata. Interactions between predicted HA-VTE risk and both age and race were statistically significant. In the age-stratified models, patients aged ≥65 years who were in the highest tertile of predicted HA-VTE risk had lower odds of receiving pharmacologic prophylaxis than those in the lowest tertile of predicted HA-VTE risk. In the race/ethnicity stratified models, the highest tertile of predicted HA-VTE risk, compared with the lowest tertile, was associated with higher odds of pharmacoprophylaxis initiation among Asian/other patients, but not among other race/ethnic groups.

Sensitivity Analyses

The overall patterns and effect sizes were similar for patients with length of stay <2 days, for those with a ≥2 day length of stay, and when patients with low platelets and present on admission bleeding diagnoses were excluded: compared with patients in the lowest tertile (1st tertile) of predicted VTE risk, patients in the higher tertiles of risk (2nd and 3rd tertiles) were less likely to receive HA-VTE pharmacoprophylaxis. The results of the analysis are provided in Tables 3 and 4 of the Supplementary Appendix.

Discussion

Among a diverse population of adults hospitalized on medical services at four US health systems, higher predicted HA-VTE risk was associated with lower odds of HA-VTE pharmacoprophylaxis within the first two hospital days. Initiation of HA-VTE pharmacoprophylaxis was inconsistently associated with established risk factors for HA-VTE, and markers of bleeding or bleeding risk were associated with lower odds of HA-VTE pharmacoprophylaxis. Older age, female sex, Black race, and high body mass index (BMI) were associated with provision of HA-VTE prophylaxis despite not being associated with HA-VTE risk in the MITH RAM.

The current analysis expands on the findings of other studies, which have reported suboptimal use of HA-VTE pharmacoprophylaxis in hospitalized patients [7, 8, 10, 11]. Particularly notable in the current study is the potential overuse of pharmacoprophylaxis in patients at low predicted risk for HA-VTE. In our study, 48% of patients in the lowest tertile of predicted HA-VTE risk received pharmacoprophylaxis during the first two days of hospitalization. These findings are similar to the results of two previous multi-institutional studies. Grant *et al.* used the Padua score to estimate HA-VTE risk among patients admitted to medical units at 52 hospitals in Michigan and found 31% of low-risk patients received HA-VTE pharmacoprophylaxis [10]. Kocher *et al.* used the Padua, International Medical Prevention Registry on Venous Thromboembolism (IMPROVE), and Geneva scores to estimate HA-VTE risk among medical inpatients at 3 Swiss hospitals and found 37–48% of low-risk patients received pharmacoprophylaxis [11].

In our study, 56% of patients in the highest two tertiles of predicted HA-VTE risk did not receive pharmacoprophylaxis during the first two days of hospitalization, raising the possibility of pharmacoprophylaxis underuse. In comparison, 21% of high-risk patients in the study by Grant *et al.* did not receive either pharmacologic or mechanical HA-VTE prophylaxis, and 37–41% of high-risk patients in the study by Kocher *et al.* did not receive pharmacologic HA-VTE prophylaxis [10, 11]. In our study it was not possible to determine the reasons for clinicians' decisions to prescribe or withhold pharmacoprophylaxis. For example, withholding HA-VTE pharmacoprophylaxis in patients with a high HA-VTE risk and a high bleeding risk may reflect sound clinical judgment. It is reasonable to hypothesize that some risk factors for HA-VTE, such as active cancer, may overlap with risk factors for bleeding, and some patients at high risk for HA-VTE may also be at high risk for bleeding [24]. However, when patients with established clinical reasons to withhold HA-VTE pharmacoprophylaxis – namely, thrombocytopenia or present on admission bleeding diagnoses – were excluded from our sample, patients at higher predicted HA-VTE risk

continued to have lower odds of pharmacoprophylaxis initiation than those at low predicted HA-VTE risk (Supplementary Appendix Table 4).

Race is a sociopolitical construct and racial categories do not reflect genetic variation, leading to calls to avoid using race in clinical decision algorithms and other clinical prediction tools [25, 26]. Several studies have demonstrated disparities in HA-VTE pharmacoprophylaxis administration, suggesting non-biologic factors such as systemic racism may influence HA-VTE pharmacoprophylaxis [13–15, 27]. Thus, we felt it was important to examine the relationship between race and HA-VTE pharmacoprophylaxis in this study. Indeed, Black patients in the current analysis were more likely to have HA-VTE pharmacoprophylaxis initiated compared with other race/ethnic categories. Lau et al. observed a similar trend on the medical services at one academic health center, where a greater proportion of Black patients than White patients were prescribed risk-appropriate VTE prophylaxis [13]. The stratified models in the current analysis revealed a more complex interaction between race, predicted HA-VTE risk, and HA-VTE pharmacoprophylaxis. Like most of the race/ethnic groups, Black patients in the upper tertiles of risk had lower odds of receiving HA-VTE pharmacoprophylaxis than Black patients in the lowest tertile of risk. The exception to this pattern was among the Asian/Other/Unknown group, in which patients with the highest tertile of predicted HA-VTE risk had higher odds of receiving HA-VTE prophylaxis. Older patients and patients with a high BMI were also more likely to receive pharmacoprophylaxis in our study. Notably, in the development of the MITH model at the participating academic medical centers, sex, race/ethnicity and age were not predictive of HA-VTE risk and were not included as risk factors [17]. However, numerous studies have demonstrated that obesity is a risk factor for VTE in the general population [28, 29] and several HA-VTE RAMs include older age as a risk factor [30, 31]. This evidence might have influenced clinician decisions regarding HA-VTE prophylaxis for hospitalized medical patients. Our data suggest that without objective measures of risk, underuse or overuse of thromboprophylaxis may occur with potential disparities by age, race, or BMI.

One study site, the University of Michigan Medical Center, mandated the calculation of the Caprini score at the time of admission. This site also had the lowest overall percentage (32.2%, Table 1) of medical admissions with HA-VTE pharmacoprophylaxis initiation during the first 2 hospital days. Although prior studies conducted at a collaborative of hospitals in the state of Michigan, including the University of Michigan Medical Center, have shown higher rates of pharmacoloprophylaxis initiation than we report in the current study [32, 33], this likely reflects differences in the eligibility criteria. Notably, these prior studies variably excluded patients on observation status, patients with contraindications to anticoagulation, and patients with low risk of HA-VTE (Caprini score <2). Interestingly, the authors of one of these studies concluded that “the Caprini RAM was unable to identify a subset of medical patients who benefit from pharmacologic prophylaxis” [32]. This conclusion may be unsurprising, as the Caprini score was developed for VTE risk assessment in surgical rather than medical patients, and several studies have demonstrated that the Caprini model has poor predictive performance in medical inpatients [34, 35].

We found that patients with a history of VTE or atrial fibrillation were less likely to receive HAVTE pharmacoprophylaxis. Patients with these conditions often are treated with

full-dose anticoagulation. The analytic population in the current study excluded patients on full-dose and intermediate-dose anticoagulation. Individuals with these conditions who were retained in the cohort may have had contraindications to or complications associated with anticoagulation, potentially explaining the inverse association with receipt of HA-VTE pharmacoprophylaxis.

The strengths of the current study include the inclusion of a large population of medical inpatients with substantial geographic, racial, and socioeconomic diversity. Since the MITH model was recently validated using data from hospital systems included in this study, its predictive performance in this population of patients is established [17]. However, several limitations of the current study deserve attention. Medication orders were not available in the data set, and thus we only examined administration of HA-VTE prophylaxis based on medication administration records. Other studies have shown gaps between ordering and administration of HA-VTE pharmacoprophylaxis, and it is possible that the factors associated with ordering HA-VTE pharmacoprophylaxis differ from the factors associated with administration [14, 15, 36]. Since the indication for treatment was not available in our data, we were not able to determine the clinical rationale for decisions regarding HA-VTE pharmacoprophylaxis and not able to gauge appropriateness at the individual patient level. Furthermore, a threshold level of predicted HA-VTE risk at which to offer pharmacoprophylaxis is not established. Ideally, clinicians would weigh HA-VTE risk with bleeding risk when deciding whether to prescribe HA-VTE pharmacoprophylaxis for an individual patient. The current study focuses on the initiation of HA-VTE pharmacoprophylaxis on the day of or the day after admission, consistent with the VTE-1 quality measure developed by The Joint Commission and the National Quality Foundation [21]. Future studies to examine changes in predicted HA-VTE risk and pharmacoprophylaxis administration over a hospital course are warranted. Due to data limitations, we were not able to explore the use of mechanical prophylaxis in the current study population and were unable to determine the associations between mechanical prophylaxis use, predicted HA-VTE risk, and pharmacoprophylaxis use. While our analyses included a diverse population of patients with White, Black, and Hispanic group identities that approximated the composition of the US population [37], future studies evaluating the association between other group identities and HA-VTE prophylaxis remain warranted.

Despite these limitations, this study offers novel insights into HA-VTE pharmacoprophylaxis administration in hospitalized medical patients. It revealed persistent evidence of potential HA-VTE pharmacoprophylaxis overuse in low-risk patients and potential underuse in high-risk patients, and variation in HA-VTE pharmacoprophylaxis initiation based on race, age, and sex.

However, the reasons for withholding pharmacoprophylaxis in those with higher predicted HA-VTE risk could not be assessed, and the percentage of underuse should be interpreted cautiously. Although a systematic review and metanalysis concluded that the use of RAMs was associated with an increase in HA-VTE pharmacoprophylaxis and a reduction in symptomatic HA-VTE events in pooled studies of hospitalized medical and surgical patients [38], the performance of the most common RAMs for HA-VTE in medical inpatients has been shown to be suboptimal, and the best RAM for hospitalized medical patients

remains uncertain [39, 40]. Further work is needed to determine effective strategies for implementing validated HA-VTE RAMs into clinical practice and understanding their impact on prescribing, disparities, and clinical outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References

1. Heit JA, Melton LJ, Lohse CM, et al. Incidence of Venous Thromboembolism in Hospitalized Patients vs Community Residents. Mayo Clin Proc. 2001;76(11):1102–1110. doi:10.4065/76.11.1102 [PubMed: 11702898]
2. Heit JA, Spencer FA, White RH. The epidemiology of venous thromboembolism. J Thromb Thrombolysis. 2016;41(1):3–14. doi:10.1007/s11239-015-1311-6 [PubMed: 26780736]
3. Wendelboe AM, Campbell J, Ding K, et al. Incidence of Venous Thromboembolism in a Racially Diverse Population of Oklahoma County, Oklahoma. Thromb Haemost. 2021;121(6):816–825. doi:10.1055/s-0040-1722189 [PubMed: 33423245]
4. Alikhan R, Forster R, Cohen AT. Heparin for the prevention of venous thromboembolism in acutely ill medical patients (excluding stroke and myocardial infarction). Cochrane Database Syst Rev. 2014;(5). doi:10.1002/14651858.CD003747.pub4
5. Schünemann HJ, Cushman M, Burnett AE, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: prophylaxis for hospitalized and nonhospitalized medical patients. Blood Adv. 2018;2(22):3198–3225. doi:10.1182/bloodadvances.2018022954 [PubMed: 30482763]
6. Henke PK, Kahn SR, Pannucci CJ, et al. Call to Action to Prevent Venous Thromboembolism in Hospitalized Patients: A Policy Statement From the American Heart Association. Circulation. 2020;141(24):e914–e931. doi:10.1161/CIR.0000000000000769 [PubMed: 32375490]
7. Kim PS, Gasparis AP, Probeck K, Elitharp D, Tassiopoulos A, Labropoulos N. Accuracy of venous thromboembolism assessment and compliance to prophylaxis in a tertiary care center. Phlebology. 2016;31(8):541–545. doi:10.1177/0268355515604758 [PubMed: 26354287]
8. Holleck JL, Jalbut MM, Rodwin BA, Chang JJ, Holleck ME, Merchant N. Improving Adherence to Risk Stratification Guidelines Regarding Venous Thromboembolism Prophylaxis. Jt Comm J Qual Patient Saf. 2022;48(5):301–303. doi:10.1016/j.jcjq.2022.02.004 [PubMed: 35489805]

9. Flanders SA, Greene MT, Grant P, et al. Hospital Performance for Pharmacologic Venous Thromboembolism Prophylaxis and Rate of Venous Thromboembolism: A Cohort Study. JAMA Intern Med. 2014;174(10):1577–1584. doi:10.1001/jamainternmed.2014.3384 [PubMed: 25133488]
10. Grant PJ, Conlon A, Chopra V, Flanders SA. Use of Venous Thromboembolism Prophylaxis in Hospitalized Patients. JAMA Intern Med. 2018;178(8):1122–1124. doi:10.1001/jamainternmed.2018.2022 [PubMed: 29800008]
11. Kocher B, Darbellay Farhoumand P, Pulver D, et al. Overuse and underuse of thromboprophylaxis in medical inpatients. Res Pract Thromb Haemost. 2023;7(6):102184. doi:10.1016/j.rpth.2023.102184 [PubMed: 37745158]
12. Barlow B, Barlow A, Breu AC. Things We Do for No Reason™: Universal Venous Thromboembolism Chemoprophylaxis in Low-Risk Hospitalized Medical Patients. J Hosp Med. 2021;16(5):301–303. doi:10.12788/jhm.3502 [PubMed: 33357322]
13. Lau BD, Haider AH, Streiff MB, et al. Eliminating Healthcare Disparities Via Mandatory Clinical Decision Support: The Venous Thromboembolism (VTE) Example. Med Care. 2015;53(1):18–24. doi:10.1097/MLR.0000000000000251 [PubMed: 25373403]
14. Lau BD, Streiff MB, Kraus PS, et al. Missed Doses of Venous Thromboembolism (VTE) Prophylaxis at Community Hospitals: Cause for Alarm. J Gen Intern Med. 2018;33(1):19–20. doi:10.1007/s11606-017-4203-y [PubMed: 29043537]
15. Shermock KM, Lau BD, Haut ER, et al. Patterns of Non-Administration of Ordered Doses of Venous Thromboembolism Prophylaxis: Implications for Novel Intervention Strategies. PLOS ONE. 2013;8(6):e66311. doi:10.1371/journal.pone.0066311 [PubMed: 23799091]
16. Cruden P, Cushman M, Repp AB. Hospitalist assessment of venous thromboembolism and bleeding risk: A survey study. Thromb Res. 2019;178:155–158. doi:10.1016/j.thromres.2019.04.015 [PubMed: 31030035]
17. Zakai NA, Wilkinson K, Sparks AD, et al. Development and Validation of a Risk Model for Hospital-Acquired Venous Thrombosis: The Medical Inpatients Thrombosis and Hemostasis (MITH) Study. J Thromb Haemost JTH. Published online October 31, 2023:S1538–7836(23)00784–5. doi:10.1016/j.jtha.2023.10.015
18. Bahl V, Hu HM, Henke PK, Wakefield TW, Campbell DA, Caprini JA. A Validation Study of a Retrospective Venous Thromboembolism Risk Scoring Method: Ann Surg. 2010;251(2):344–350. doi:10.1097/SLA.0b013e3181b7fca6 [PubMed: 19779324]
19. Moore BJ, White S, Washington R, Coenen N, Elixhauser A. Identifying Increased Risk of Readmission and In-hospital Mortality Using Hospital Administrative Data: The AHRQ Elixhauser Comorbidity Index. Med Care. 2017;55(7):698. doi:10.1097/MLR.0000000000000735 [PubMed: 28498196]
20. Elixhauser Comorbidity Software Refined for ICD-10-CM. Accessed June 4, 2023. https://hcup-us.ahrq.gov/toolssoftware/comorbidityicd10/comorbidity_icd10.jsp
21. Venous Thromboembolism | The Joint Commission. Accessed June 9, 2023. https://www.jointcommission.org/measurement/measures/venous-thromboembolism/
22. Bureau UC. Measuring Racial and Ethnic Diversity for the 2020 Census. The United States Census Bureau. Accessed June 10, 2023. https://www.census.gov/newsroom/blogs/random-samplings/2021/08/measuring-racial-ethnic-diversity-2020-census.html
23. WMA - The World Medical Association-WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. Accessed June 11, 2023. https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/
24. Klok FA, Huisman MV. How I assess and manage the risk of bleeding in patients treated for venous thromboembolism. Blood. 2020;135(10):724–734. doi:10.1182/blood.2019001605 [PubMed: 31951652]
25. Vyas DA, Eisenstein LG, Jones DS. Hidden in Plain Sight — Reconsidering the Use of Race Correction in Clinical Algorithms. N Engl J Med. 2020;383(9):874–882. doi:10.1056/NEJMms2004740 [PubMed: 32853499]

26. Gau J, Nwora C, Eldakar-Hein ST, Goel MS, Lahey T, Repp AB. Things We Do for No Reason™: Routine inclusion of race in the history of present illness. J Hosp Med. 2022;17(2):123–126. doi:10.12788/jhm.3650
27. Owodunni OP, Lau BD, Wang J, et al. Effectiveness of Healthcare Delivery, Quality, and Safety a Patient Education Bundle on Venous Thromboembolism Prophylaxis Administration by Sex. J Surg Res. 2022;280:151–162. doi:10.1016/j.jss.2022.07.015 [PubMed: 35969933]
28. Ageno W, Becattini C, Brighton T, Selby R, Kamphuisen PW. Cardiovascular Risk Factors and Venous Thromboembolism. Circulation. 2008;117(1):93–102. doi:10.1161/CIRCULATIONAHA.107.709204 [PubMed: 18086925]
29. Gregson J, Kaptoge S, Bolton T, et al. Cardiovascular Risk Factors Associated With Venous Thromboembolism. JAMA Cardiol. 2019;4(2):163–173. doi:10.1001/jamacardio.2018.4537 [PubMed: 30649175]
30. Darzi AJ, Repp AB, Spencer FA, et al. Risk-assessment models for VTE and bleeding in hospitalized medical patients: an overview of systematic reviews. Blood Adv. 2020;4(19):4929–4944. doi:10.1182/bloodadvances.2020002482 [PubMed: 33049056]
31. Darzi AJ, Karam SG, Charide R, et al. Prognostic factors for VTE and bleeding in hospitalized medical patients: a systematic review and meta-analysis. Blood. 2020;135(20):1788–1810. doi:10.1182/blood.2019003603 [PubMed: 32092132]
32. Grant PJ, Greene MT, Chopra V, et al. Assessing the Caprini Score for risk assessment of venous thromboembolism in hospitalized medical patients. Am J Med. 2016;129(5):528–535. doi:10.1016/j.amjmed.2015.10.027 [PubMed: 26551977]
33. Flanders SA, Greene MT, Grant P, et al. Hospital performance for pharmacologic venous thromboembolism prophylaxis and rate of venous thromboembolism: A cohort study. JAMA Intern Med. 2014;174(10):1577–1584. doi:10.1001/jamainternmed.2014.3384 [PubMed: 25133488]
34. Moumneh T, Riou J, Douillet D, et al. Validation of risk assessment models predicting venous thromboembolism in acutely ill medical inpatients: A cohort study. J Thromb Haemost. 2020;18(6):1398–1407. doi:10.1111/jth.14796 [PubMed: 32168402]
35. Hayssen H, Sahoo S, Nguyen P, et al. Ability of Caprini and Padua risk-assessment models to predict venous thromboembolism in a nationwide Veterans Affairs study. J Vasc Surg Venous Lymphat Disord. 2024;12(2):101693. doi:10.1016/j.jvsv.2023.101693 [PubMed: 37838307]
36. Fanikos J, Stevens LA, Labreche M, et al. Adherence to Pharmacological Thromboprophylaxis Orders in Hospitalized Patients. Am J Med. 2010;123(6):536–541. doi:10.1016/j.amjmed.2009.11.017 [PubMed: 20569760]
37. U.S. Census Bureau QuickFacts: United States. Accessed January 8, 2024. https://www.census.gov/quickfacts/fact/table/US/PST045223
38. Kahn SR, Diendéré G, Morrison DR, et al. Effectiveness of interventions for the implementation of thromboprophylaxis in hospitalised patients at risk of venous thromboembolism: an updated abridged Cochrane systematic review and meta-analysis of randomised controlled trials. BMJ Open. 2019;9(5):e024444. doi:10.1136/bmjopen-2018-024444
39. Häfliger E, Kopp B, Darbellay Farhoumand P, et al. Risk assessment models for venous thromboembolism in medical inpatients. JAMA Netw Open. 2024;7(5):e249980. Published 2024 May 1. doi:10.1001/jamanetworkopen.2024.9980 [PubMed: 38728035]
40. Roberts LN, Arya R. Venous thromboembolism risk assessment models for acutely ill medical patients—Back to the drawing board? JAMA Netw Open. 2024;7(5):e249952. doi:10.1001/jamanetworkopen.2024.9952 [PubMed: 38728038]

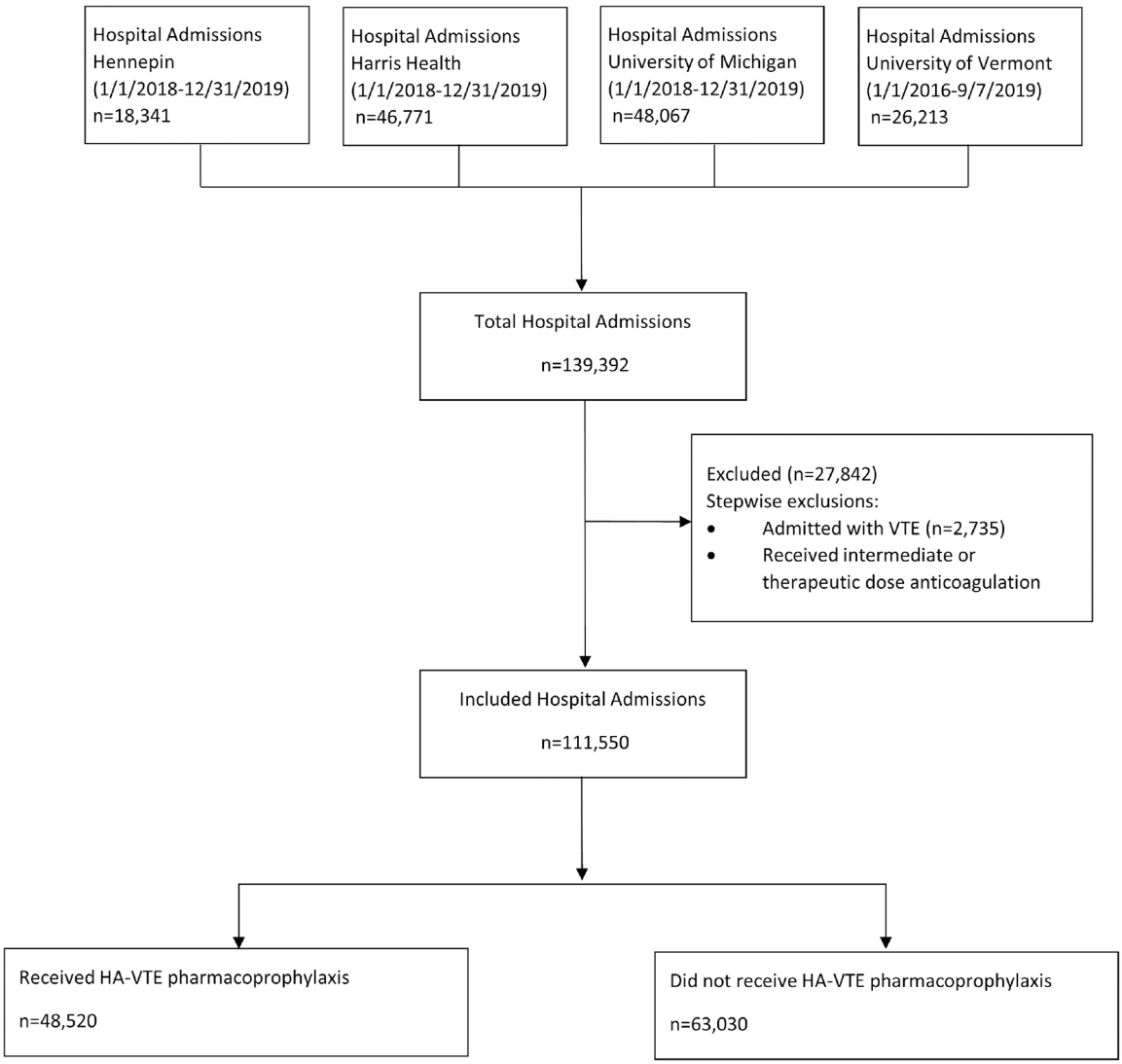

Figure 1.

Flow diagram showing selection of records for analysis.

Abbreviations: HA-VTE, hospital acquired venous thromboembolism; ICU, intensive care unit; VTE, venous thromboembolism

Table 1.

Characteristics of the study population.

	Entire Population	Prophylaxis	No Prophylaxis
Analytic Population (N, %)	111,550 (100%)‡	48,520 (43.5%)§	63,030 (56.5%)§
Site			
Harris Health (Houston, Texas)	37,651 (33.8%)	18,501 (49.1%)	19,150 (50.9%)
Hennepin Healthcare (Minneapolis, Minnesota)	15,125 (13.6%)	7,732 (51.1%)	7,393 (48.9%)
University of Michigan (Ann Arbor, Michigan)	36,636 (32.8%)	11,783 (32.2%)	24,853 (67.8%)
University of Vermont (Burlington, Vermont)	22,138 (19.9%)	10,504 (47.4%)	11,634 (52.6%)
Demographics			
Age (mean, SD)	57 ± 17	59 ± 17	56 ± 18
Sex, Female (n, %)	52,607 (47.2%)	23,533 (44.7%)	29,074 (55.3%)
Missing (n, %)	33 (<0.1%)	14 (42.4%)	19 (57.6%)
Race / Ethnicity (n, %)			
White, non-Hispanic	60,059 (53.8%)	24,263 (40.4%)	35,796 (59.6%)
Black, non-Hispanic	23,378 (21.0%)	11,096 (47.5%)	12,282 (52.5%)
Asian / Other / Unknown, non-Hispanic	6,915 (6.2%)	3,092 (44.7%)	3,823 (55.3%)
Hispanic	21,198 (19.0%)	10,069 (47.5%)	11,129 (52.5%)
Body mass index (n, %)			
<18.5	5,146 (4.6%)	2,540 (49.4%)	2,606 (50.6%)
18.5–<25	31,448 (28.2%)	13,774 (43.8%)	17,674 (56.2%)
25–<30	28,833 (25.9%)	12,493 (43.3%)	16,340 (56.7%)
30–<35	18,267 (16.4%)	7,960 (43.6%)	10,307 (56.4%)
35–<40	9,144 (8.2%)	4,272 (46.7%)	4,872 (53.3%)
40+	8,702 (7.8%)	4,400 (50.6%)	4,302 (49.4%)
Missing	10,010 (9.0%)	3,081 (30.8%)	6,929 (69.2%)
Payor (n, %)			
Private Insurance	29,600 (26.5%)	10,430 (35.2%)	19,170 (64.8%)
Medicare	37,734 (33.8%)	17,711 (46.9%)	20,023 (53.1%)
Medicaid	20,516 (18.4%)	10,269 (50.1%)	10,247 (49.9%)
None	21,814 (19.6%)	10,062 (46.1%)	11,752 (53.9%)
Missing	1,886 (1.7%)	48 (2.5%)	1,838 (97.5%)
Past Medical History (n, %)			
Active cancer*	29,249 (26.2%)	13,298 (45.5%)	15,951 (54.5%)
Atrial fibrillation	8,840 (7.9%)	2,719 (30.8%)	6,121 (69.2%)
Chronic obstructive pulmonary disease	12,254 (11.0%)	6,074 (49.6%)	6,180 (50.4%)
Diabetes	31,085 (27.9%)	15,115 (48.6%)	15,970 (51.4%)
Gastrointestinal bleed	5,722 (5.1%)	2,236 (39.1%)	3,486 (60.9%)
Intracranial hemorrhage	1,714 (1.5%)	822 (48.0%)	892 (52.0%)
Malnutrition*	11,238 (10.1%)	5,266 (46.9%)	5,972 (53.1%)
Prior myocardial infarction	9,511 (8.5%)	4,164 (43.8%)	5,347 (56.2%)
Prior stroke	8,219 (7.4%)	3,739 (45.5%)	4,480 (54.5%)

	Entire Population	Prophylaxis	No Prophylaxis
Prior venous thromboembolism *	6,365 (5.7%)	2,520 (39.6%)	3,845 (60.4%)
Laboratory Findings (n, %)			
High RDW *	40,672 (36.5%)	17,820 (43.8%)	22,852 (56.2%)
Missing	11,342 (10.2%)	4,179 (36.8%)	7,163 (63.2%)
Low hemoglobin *	58,009 (52.0%)	24,916 (43.0%)	33,093 (57.0%)
Missing	8,678 (7.8%)	3,127 (36.0%)	5,551 (64.0%)
Low serum sodium *	24,878 (22.3%)	12,168 (48.9%)	12,710 (51.1%)
Missing	9,003 (8.1%)	3,084 (34.3%)	5,919 (65.7%)
MCV < 81 fL	9,324 (8.4%)	4,018 (43.1%)	5,306 (56.9%)
Missing	11,448 (10.3%)	3,426 (29.9%)	8,022 (70.1%)
Platelet count			
<50	2,599 (2.3%)	202 (7.8%)	2,397 (92.2%)
50–99	4,092 (3.7%)	1,404 (34.3%)	2,688 (64.7%)
Missing	11,755 (10.5%)	3,582 (30.5%)	8,173 (69.5%)
Creatinine >2.0 mg/dL or on dialysis *	13,594 (12.2%)	7,142 (52.5%)	6,452 (47.5%)
Missing (n, %)	10,133 (9.1%)	3,723 (36.7%)	6,410 (63.3%)
Clinical Presentation (n, %)			
SIRS †	25,487 (22.9%)	12,521 (49.1%)	12,966 (50.9%)
Missing	992 (0.9%)	518 (52.2%)	474 (47.8%)
Discharge Diagnoses			
Bleeding diagnosis, present on admission	9,243 (8.3%)	2,169 (23.5%)	7,074 (76.5%)
Elixhauser Comorbidity Score, readmission (mean, SD)	9 ± 8	9 ± 8	8 ± 8
Elixhauser Comorbidity Score, mortality (mean, SD)	7 ± 14	7 ± 14	7 ± 14
Predicted HA-VTE Risk per MITH Model			
Predicted risk (mean, SD)	0.36% ± 0.35%	0.35% ± 0.34%	0.37% ± 0.36%
Missing (n, %)	22,393 (20.1%)	8,002 (35.7%)	14,391 (64.3%)
Tertile of predicted risk (range of risk) (n, %)			
1 (<0.19%, reference)	33,269 (29.8%)	15,906 (47.8%)	17,363 (52.2%)
2 (0.19% – 0.36%)	27,313 (24.5%)	11,911 (43.6%)	15,402 (56.4%)
3 (>0.36%)	28,575 (25.6%)	12,701 (44.4%)	15,874 (55.6%)
Missing	22,393 (20.1%)	8,002 (35.7%)	14,391 (64.3%)

* Component of the MITH HA-VTE risk model

† Two or more criteria: T <36C or >38C, HR >90 beats/min, RR >20 breaths/min, WBC <4,000/mm3 or >12,000 mm3

‡ Percentages for categorical variables represent column percentages

§ Percentages for categorical variables represent row percentages

Abbreviations: HA-VTE, hospital acquired venous thromboembolism; MCV, mean corpuscular volume; MITH, Medical Inpatients Thrombosis and Hemostasis; SD, standard deviation; SIRS, systemic inflammatory response syndrome

Table 2.

Association of demographic factors with HA-VTE pharmacoprophylaxis administration on hospital day 1 or 2, using multivariable logistic regression in the total sample (n = 111,550) with age, sex, race/ethnicity as predictors

Demographic factor	OR (95% CI)
Age (per 10 years older)	1.10 (1.09, 1.11)
Sex (male versus female)	0.88 (0.86, 0.90)
Race/Ethnicity (reference White)	
White, non-Hispanic	ref
Black, non-Hispanic	1.14 (1.09, 1.18)
Asian/Other/Unknown, non-Hispanic	1.04 (0.99, 1.10)
Hispanic	1.03 (0.98, 1.07)
BMI	
<18.5	1.26 (1.18, 1.34)
18.5–<25	ref
25–<30	0.97 (0.94, 1.00)
30–<35	0.99 (0.95, 1.03)
35–<40	1.13 (1.08, 1.19)
≥40	1.37 (1.30, 1.43)
Payor (reference private insurance)	
Private insurance	ref
Medicare	1.11 (1.07, 1.16)
Medicaid	1.19 (1.14, 1.24)
None	1.03 (0.98, 1.08)

Abbreviations: BMI, body mass index; CI, confidence interval; HA-VTE, hospital acquired venous thromboembolism; OR, odds ratio; ref, reference; SD, standard deviation

Table 3.

Association of clinical factors with HA-VTE pharmacoprophylaxis administration on hospital day 1 or 2, using age-, sex-, race/ethnicity-, and site-adjusted mixed effects logistic regression in the total sample (n = 111,550)

Clinical factor	OR (95% CI)
Past Medical History (present versus absent)	
Active cancer *	1.22 (1.19, 1.26)
Atrial fibrillation	0.49 (0.47, 0.51)
Chronic obstructive pulmonary disease	1.32 (1.27, 1.37)
Diabetes	1.26 (1.22, 1.29)
Prior gastrointestinal bleed	0.69 (0.64, 0.72)
Prior intracranial hemorrhage	1.05 (0.95, 1.16)
Malnutrition *	1.40 (1.35, 1.46)
Prior myocardial infarction	0.96 (0.92, 1.01)
Prior stroke	1.00 (0.96, 1.05)
Prior venous thromboembolism *	0.91 (0.86, 0.96)
Laboratory Findings	
High RDW * (reference <14.7%)	0.97 (0.94, 0.99)
Low hemoglobin* (sex-specific reference above lower limit of normal)	1.01 (0.98, 1.03)
Low serum sodium* (reference ≥136 mmol/L)	1.25 (1.22, 1.29)
MCV < 81 fL (reference ≥81 fL)	0.92 (0.88, 0.96)
Platelet count (reference ≥100 K/cm^2)	
<50	0.11 (0.09, 0.12)
50–99	0.66 (0.62, 0.71)
≥100	ref
Creatinine >2.0 mg/dL or on dialysis * (reference no)	1.39 (1.34, 1.44)
Clinical Presentation	
SIRS † (reference no)	1.31 (1.27, 1.35)
Discharge Diagnoses	
Bleeding diagnosis, present on admission (reference no)	0.37 (0.35, 0.39)
Elixhauser Comorbidity Score, readmission (per SD higher)	1.25 (1.23, 1.26)
Elixhauser Comorbidity Score, mortality (per SD higher)	1.05 (1.03, 1.06)
Predicted HA-VTE Risk per MITH Model	
Tertile of predicted risk (range of risk)	
1 (<0.19%, reference)	ref
2 (0.19% – 0.36%)	0.84 (0.81, 0.86)
3 (>0.36%)	0.95 (0.92, 0.98)

* Component of the MITH HA-VTE risk model

† Two or more criteria: T <36°C or >38°C, HR >90 beats/min, RR >20 breaths/min, WBC <4,000/mm^3 or >12,000 mm^3

Abbreviations: CI, confidence interval; HA-VTE, hospital acquired venous thromboembolism; MCV, mean corpuscular volume; MITH, Medical Inpatients Thrombosis and Hemostasis; OR, odds ratio; ref, reference; RDW, red cell distribution width; SD, standard deviation; SIRS, systemic inflammatory response syndrome

Table 4.

Association between predicted HA-VTE risk and HA-VTE pharmacoprophylaxis initiation, stratified by age, sex, and race.

	Tertile of Predicted Risk (Predicted Risk)			
	1 (<0.19%)	2 (0.19% – 0.36%)	3 (>0.36%)	Interaction
	Reference	OR (95% CI)	OR (95% CI)	p-value
Age				
<65 years	-	0.91 (0.88, 0.95)	1.05 (1.00, 1.09)	<0.001*
≥65 years	-	0.75 (0.71, 0.79)	0.85 (0.80, 0.90)	
Sex				
Female	-	0.79 (0.76, 0.83)	0.92 (0.88, 0.97)	0.047†
Male	-	0.88 (0.84, 0.92)	0.97 (0.93, 1.02)	
Race / Ethnicity				
White, non-Hispanic	-	0.87 (0.83, 0.91)	0.99 (0.94, 1.03)	<0.001‡
Black, non-Hispanic	-	0.76 (0.71, 0.81)	0.95 (0.88, 1.02)	
Hispanic	-	0.83 (0.77, 0.89)	0.83 (0.77, 0.89)	
Asian / Other / Unknown, non-Hispanic	-	0.96 (0.84, 1.09)	1.22 (1.07, 1.39)	

All models adjusted for age, sex, race, and site.

Abbreviations: CI, confidence interval; HA-VTE, hospital-acquired venous thromboembolism; OR, odds ratio