Research Square

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Thromboembolic complications following major trauma. Updated epidemiology and outcomes from the TraumaRegister DGU®

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Abstract

Background

Thromboembolic events (TE) remain a major source of morbidity and mortality following severe trauma. Given advances in trauma care and thromboprophylaxis, contemporary epidemiological data are needed to reassess their incidence and clinical impact.

Methods

Data from the TraumaRegister DGU® were analyzed for patients treated in German-speaking countries between 2014 and 2023. Adult trauma patients with complete documentation who survived at least 48 hours after admission were included. Patient characteristics, TE subtypes, and clinical outcomes were evaluated descriptively, and multivariate logistic regression was used to assess the association between TE and mortality.

Results

Among 104,084 eligible patients, 3.4% developed at least one TE. Pulmonary embolism was the most common event (38.0%), followed by deep vein thrombosis (20.7%), stroke (17.7%), and myocardial infarction (9.1%). Patients with TE were older, had more severe injuries, and more frequently presented with coagulopathy and shock. Despite thromboprophylaxis in 91.9% of affected patients, TE were associated with increased mortality (21.3% vs. 6.6%), prolonged intensive care treatment, and longer hospital stays. TE independently predicted in-hospital mortality (OR 1.99, 95% CI 1.79–2.21).

Conclusions

Thromboembolic complications remain common after major trauma and are associated with substantially worse outcomes. Improved risk stratification and individualized thromboprophylaxis strategies are needed to reduce their burden.

Introduction

Thromboembolic events (TE) after major trauma are among the most deadly adverse complications. Since the concept of trauma-induced coagulopathy was first introduced, medical societies have tried to optimize the treatment of trauma patients by standardization of hemorrhage and thromboembolism management and prevention (Heim et al., 2024; Peiniger et al., 2012; Rogers et al., 2002; Yorkgitis et al., 2022).

Although standardization in this context means that a greater proportion of patients receive guideline-based screening and therapy, emphasis has to be put on the need for individualized strategies once standard care has been established.

Due to valuable previous work, we know that the rate of thromboembolic events in polytraumatized patients lies around 2.8% in a cohort from the German TraumaRegister DGU® (TR-DGU) during the years 2005–2012 (Lichte et al., 2015). Since then, most hospitals engaging in care of severely injured patients established protocols for prevention and detection of thromboembolism especially in subgroups of patients at high risk for TE (i.e. patients with pelvic injuries or severe traumatic brain injury). Furthermore, the use of direct oral anticoagulants has emerged in variety of diseases, thus also having a direct impact on trauma patients (Ageno et al., 2024).

Altogether, rates of TE may have altered during the last decade. Objectives of this study were to assess the development of thromboembolic complication rates since the above-mentioned period and to describe possible changes in epidemiology and etiology.

Methods

For this study, we used datasets provided by the TraumaRegister DGU® of the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie, DGU). Prior to the acquisition of data, approval by the Committee on Emergency Medicine, Intensive Care and Trauma Management (Sektion NIS) of the DGU was obtained under project ID 2024-041. It also received approval from the local ethics committee (ethics committee Westfalen Lippe application number 2025-204-f-S).

Since its formation in 1993, the TraumaRegister DGU® collects data from severely injured patients starting at the site of the accident up to hospital discharge. While most of the participating hospitals are located in German-speaking countries, there are numerous institutions contributing data from of the rest of Europe and around the world. For individual patients, participation is voluntary. Informed consent was obtained from all individual participants included in the database. Hospitals that are part of the German Trauma Network (TraumaNetzwerk DGU®) however, have to transfer a basic dataset due to quality assurance.

Data are collected prospectively in four consecutive phases, spanning from the accident scene to hospital discharge: the pre-hospital phase, the emergency department and initial surgical intervention, the intensive care unit (ICU), and hospital discharge. The registry encompasses comprehensive data on patient demographics, injury characteristics, pre-existing comorbidities, pre-hospital and in-hospital management, ICU course, pertinent laboratory findings, transfusion data, and patient outcomes. The inclusion criteria comprise patients admitted to the hospital via the emergency department who subsequently require intensive care monitoring (ICU/ICM), as well as those who arrive at the hospital with vital signs but decease prior to ICU admission.

The infrastructure for data documentation, management, and analysis is provided by the AUC – Academy for Trauma Surgery (AUC – Akademie der Unfallchirurgie GmbH), an institution affiliated with the German Trauma Society (DGU). Scientific oversight is ensured by the Committee on Emergency Medicine, Intensive Care, and Trauma Management (Section NIS) of the DGU. Participating hospitals submit pseudonymized data to a centralized database through a web-based platform. Scientific analyses are conducted following a peer-review process in accordance with the publication guidelines of the TraumaRegister DGU®.

The study adhered to the Declaration of Helsinki in its present form. No funding was received for conducting this study. The authors have no relevant financial or non-financial interests to disclose.

Patient selection

A total of 397,910 patients were documented in the TR-DGU from 01.01.2014–31.12.2023. We excluded those who were registered only with a reduced data form for purpose of quality management (no data on TE), those that were transferred out to another hospital, or died within 48 hours, and patients younger than 16 years (Fig. 1.). In addition, patients with incomplete datasets (i.e. missing information about thromboembolic events) were excluded. For reasons of therapy comparability we only included datasets from patients treated in German-speaking countries (GER, AUT, CH). In summary, a total of 104,084 patients from 272 hospitals were eligible for final analysis (cf. Figure 1).

Data on thromboembolic events were reported by the respective hospital and specified as deep venous thrombosis (DVT), pulmonary embolism (PE), myocardial infarction (MI), stroke or other. Patients without documentation concerning TE were excluded from analysis. Presence of prophylactic agents against thromboembolism in case of a TE was also reported.

ISS was calculated according to AIS version 2005, update 2008 (Gennarelli et al., 2008). Sepsis was defined according to Sepsis-2 or -3 Consensus-Definition depending on the year of data inclusion (Singer et al., 2016), multi organ failure was defined as a Sequential Organ Failure Assessment (SOFA) score of 3 or more points concerning 2 or more organs. Shock on admission was defined as systolic blood pressure ≤ 90 mmHg, coagulopathy as a prothrombin time (Quick's test) < 70% of normal activity, an activated partial thromboplastin time (aPTT) > 40 sec, or a platelet count < 100,000/µl.

Statistical analysis

Statistical analyses were conducted using SPSS® statistical software (version 29, IBM Corporation, Armonk, NY, USA). Descriptive statistics used number and percentages for categorical data and mean with standard deviation (SD) for metric data. In case of skewed data, median and quartiles (Q) were added. Due to the large sample size no formal statistical testing was performed.

Multivariate logistic regression was performed to analyse risk-factors for in-hospital-mortality. In addition to thromboembolic events, sepsis, MOF, and need for ventilation on ICU or massive transfusion (≥ 10 PRBCs) were included in the analysis. Effects were presented as adjusted odds ratios (OR) with 95% confidence intervals (CI95).

Results

Patient characteristics

Characteristic	**TE** **N = 3,561**	**No TE** **N = 100,523**
Age (years, *mean, SD)*	57.4 (19.3)	53.9 (20.7)
Gender male (%)	2,670 (75.0)	71,873 (71.5)
ASA III-IV (%)	898 (27.8)	18,599 (20.2)
Blunt trauma (%)	3,277 (96.2)	92,526 (96.1)
ISS (points, *mean)*	26.5 (12.5)	20.8 (10.2)
AIS head ≥ 3 (%)	1,867 (52.4)	44,489 (44.3)
AIS chest ≥ 3 (%)	1,821 (47.2)	47,469 (51.1)
AIS abdomen ≥ 3 (%)	654 (18.4)	11,923 (11.9)
AIS extremities ≥ 3 (%)	1,397 (39.2)	29,929 (29.8)
AIS pelvis ≥ 3 (%)	680 (19.1)	12,179 (12.1)
Blood transfusion (%)	788 (22.1)	9,161 (9.1)
Mass transfusion (≥ 10 PRBCs) (%)	133 (3.7)	891 (0.9)
Shock prehospital (%)	378 (15.0)	6,079 (8.0)
More than 1L fluids pre-hospital (%)	561 (22.6)	10,105 (13.6)

Patient outcomes

Outcomes	TE	No TE
Hospital mortality (n, %)	760 (21.3)	6,640 (6.6)
Sepsis (n, %)	675 (20.4)	5,123 (5.6)
MOF (n, %)	1,528 (45.1)	15,264 (16.7)
ICU treatment (%)	3,476 (97.6)	91,731 (91.3)
Mechanical ventilation (days, *mean, median, Q*)	10.4 5 (0–16)	3.5 0 (0–2)
ICU LOS (days, *mean, median, Q*)	18.0 13 (5–25)	7.7 3 (1–10)
Hospital LOS (days, *mean, median, Q*)	31.8 25 (15–40)	18.7 14 (8–23)

Patient characteristics

From a total of 104,084 patients included between 2014 and 2023, 3.4% experienced at least one thromboembolic event (TE). Figure 2 shows a slight increase in the incidence of TEs until reaching a peak around the age of 70 before decreasing again (cf. Figure 2). Over the course of 10 years, a steady and slow increase can be observed (cf. Figure 3).

The mean age of patients with TE was higher compared to those without TE (57.4 vs. 53.9 years). Males were more frequently affected, with a slightly higher prevalence among TE patients (75.0% vs. 71.5%).

Patients with TE showed higher injury severity, as reflected by the ISS (26.5 vs. 20.8), and higher rates of severe injuries across multiple body regions, particularly the head (AIS head ≥ 3: 52.4% vs. 44.3%), abdomen (18.4% vs. 11.9%), extremities (39.2% vs. 29.8%), and pelvis (19.1% vs. 12.1%).

A markedly higher proportion of TE patients presented with relevant comorbidities (ASA III–IV: 27.8% vs. 20.2%) and signs of hemorrhagic shock (15.0% vs. 8.0%). Furthermore, TE patients received more prehospital fluid resuscitation (more than 1 liter: 22.6% vs. 13.6%) and acute blood transfusions (22.1% vs. 9.1%), accordingly rates of massive transfusion (≥ 10 PRBCs) were higher in the TE group (3.7% vs. 0.9%). Notably, coagulopathy on admission was present in 82.3% of TE patients, and patients who received tranexamic acid (TXA) either before hospital admission or in the emergency department had higher TE rates (5.7% with TXA vs. 2.7% without). Patients with TE had a higher RISC III-Score (abbr. revised injury severity classification score, version 3, Lefering et al., 2026) (19.19) compared to patients without TE (11.4).

Despite the high incidence of use of prophylactic agents (91.9% in TE patients), thromboembolic complications still occurred.

Thromboembolic event subtypes

Among all documented TE, pulmonary embolism (PE) was the most common (38.0%), followed by deep vein thrombosis (DVT) (20.7%), stroke (17.7%), myocardial infarction (MI) (9.1%), and other or unspecified events (24.9%). Patients suffering from MI represented the oldest subgroup (mean age 71.0 ± 14.1 years), while DVT patients were younger (mean age 51.3 ± 17.8 years). Notably, 90.4% of patients experienced only one TE, while the remainder had multiple events.

Clinical outcomes and complications

Patients with thromboembolic complications had significantly worse outcomes. Hospital mortality was more than threefold higher in the TE group (21.3% vs. 6.6%). TE patients had prolonged ICU stays (18.0 vs. 7.7 days, *mean*) and longer durations of mechanical ventilation (10.4 vs. 3.5 days, *mean)*. Total hospital length of stay was also significantly longer (31.8 vs. 18.7 days, *mean)*.

Sepsis (OR 1.37, CI95 1.27–1.49, $p < 0.001$) and multiple organ failure (MOF, OR 3.08, CI95 2.89–3.29, $p < 0.001$) were strong predictors of death and were more frequently observed in the TE cohort. TE was independently associated with an almost twofold increase in hospital mortality (OR 1.99, CI95 1.79–2.21, $p < 0.001$).

Discussion

This study represents a large contemporary analysis of thromboembolic events (TEs) in polytrauma patients, using data from the TraumaRegister DGU® between 2014 and 2023. Compared to earlier findings from the 2005–2012 period (Lichte et al., 2015), the incidence of clinically relevant TEs increased from 2.8% to 3.4%. Despite a high rate of thromboprophylaxis (91.9%) in affected patients, thromboembolic complications still occurred, suggesting room for improvement in targeted risk stratification and adaption of prophylactic strategies.

The rise in TE incidence may reflect improved detection, changes in injury patterns, or shifts in patient demographics, such as an increase in age or comorbidity burden. This is supported by the higher proportion of patients with ASA class III–IV in the TE group (27.8%) and increased average age (57.4 years in our TE-cohort vs. 53.8 years in 2005–2012). While prophylactic measures were widely applied, the data suggest that current strategies may be insufficient to mitigate TE risk in high-risk populations. Due to the heterogeneity of TE assessment, treatment and data acquisition, reported TE rates differ greatly in international comparison (Bassa et al., 2024).

Although incidence in our cohort rose in comparison to earlier findings, in-hospital-mortality was nearly consistent, probably reflecting improvement in TE therapy.

Whereas early initiation of thromboprophylaxis in polytraumatized patients was thought to be dangerous only a couple of years ago, research showed that early-initiation-protocols were beneficial and safe and were therefore adapted in clinical settings. Our data showed that 91.9% of TE patients received thromboprophylaxis. In addition to a mortality rate that remained consistent, it could suggest that whereas thromboprophylactic agents could not completely prevent TE, they could probably alter rates of severe courses.

Patients with TE demonstrated a significantly higher injury burden (mean ISS 26.5 vs. 20.8), higher rates of head, abdominal, pelvic and extremity trauma, as well as elevated transfusion requirements and rates of shock on admission. These findings are consistent with previous studies identifying injury severity, head and pelvic trauma, and surgical burden as important TE risk factors (Bassa et al., 2024; Chen et al., 2024; Kirchner et al., 2021). Moreover, the presence of coagulopathy in over 80% of TE patients at initial admission underlines the relevance of early haemostatic derangement in TE pathophysiology (Moore et al., 2021).

Although it is not mandatory, screening programs for detection of TE in polytraumatized patients were established in a rising number of trauma centers (Kay et al., 2021), thus probably also contributing to higher incidences. Additionally, diagnostic possibilities improved, reflected by the now widespread availability of point-of-care-ultrasound in nearly every intensive care unit and emergency department and the accessibility and rising use of computed tomography pulmonary angiography for detection of DVT and PE (Hood et al., 2025; Waydhas et al., 2023).

Interestingly, patients receiving tranexamic acid (TXA) had a higher rate of TE development (5.7% vs. 2.7%), which raises questions about the thrombotic safety profile of antifibrinolytics in this population. While causality cannot be inferred from our data, this finding supports the need for individualized risk–benefit assessments when administering TXA. In other

studies, administration of TXA in polytraumatized patients was evaluated a safe treatment option, though differences in patient selection should be accounted for (Imach et al., 2021; Mazzei et al., 2024).

TE were strongly associated with poor clinical outcomes, including significantly higher in-hospital mortality (21.3% vs. 6.6%), increased ICU utilization, and prolonged mechanical ventilation and hospital stay. These results underscore the clinical and economic burden of TE complications. In multivariate regression, TE remained an independent predictor of mortality (OR 1.99), along with other critical factors such as sepsis and MOF.

Of note, myocardial infarctions (9.1%) and strokes (17.7%) constituted a substantial proportion of TE and were associated with the highest mean patient age. This highlights the need for improved cardiovascular monitoring and secondary prevention strategies, particularly in elderly or comorbid trauma patients.

Whereas this study focused on the in-hospital course and its complications, other data emphasizes the role of major trauma in coagulopathy even months after hospital discharge (Dougherty et al., 2025).

Strengths and limitations

The main strength of this study lies in its large, multicenter dataset with prospectively collected data over a decade. However, some limitations must be acknowledged. First, TE documentation was based on clinical diagnosis rather than standardized imaging or laboratory criteria, potentially leading to underreporting. Second, important confounders such as pharmacological agents, timing of prophylaxis, or comorbidity profiles could not be fully assessed due to registry limitations. Finally, the observational nature of the study precludes conclusions on causality.

Conclusion

Thromboembolic events remain a serious and increasingly prevalent complication in trauma care, despite the widespread use of prophylactic strategies. Higher age, comorbidity, coagulopathy, and injury severity are major contributors to TE risk. Given their strong association with mortality and adverse outcomes, future research should focus on developing tailored, risk-adapted thromboprophylaxis protocols and on identifying modifiable risk factors in this vulnerable population.

Declarations

Competing Interests

UH is part of the advisory board of this Journal. There are no competing financial interests.

Author Contribution

AS and UH wrote the main manuscript text, whereas RL did the statistical analysis. All authors reviewed the manuscript.

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Figures

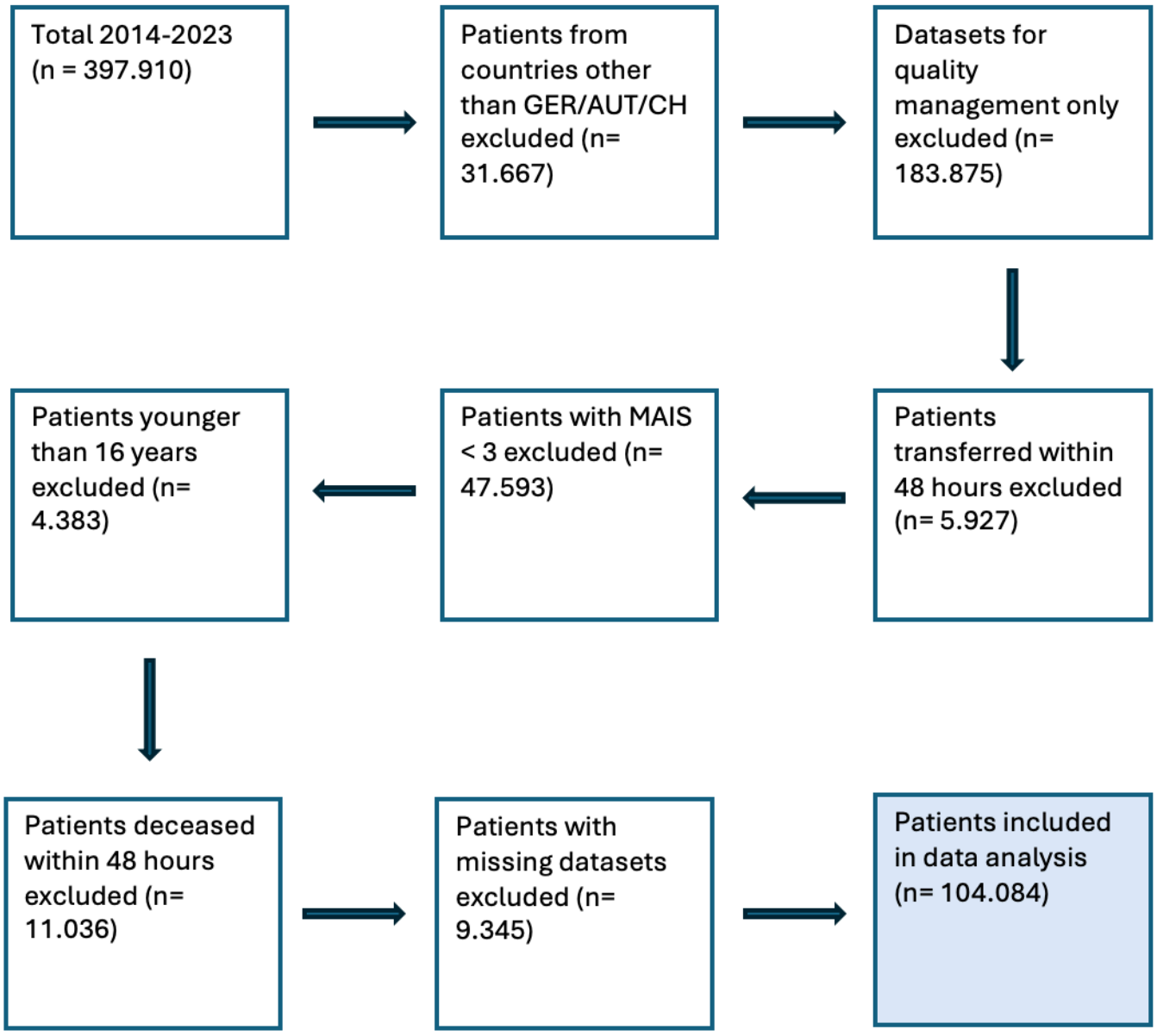


Figure 1

Process of patient selection. A total of 104,084 patients were included in final analysis.

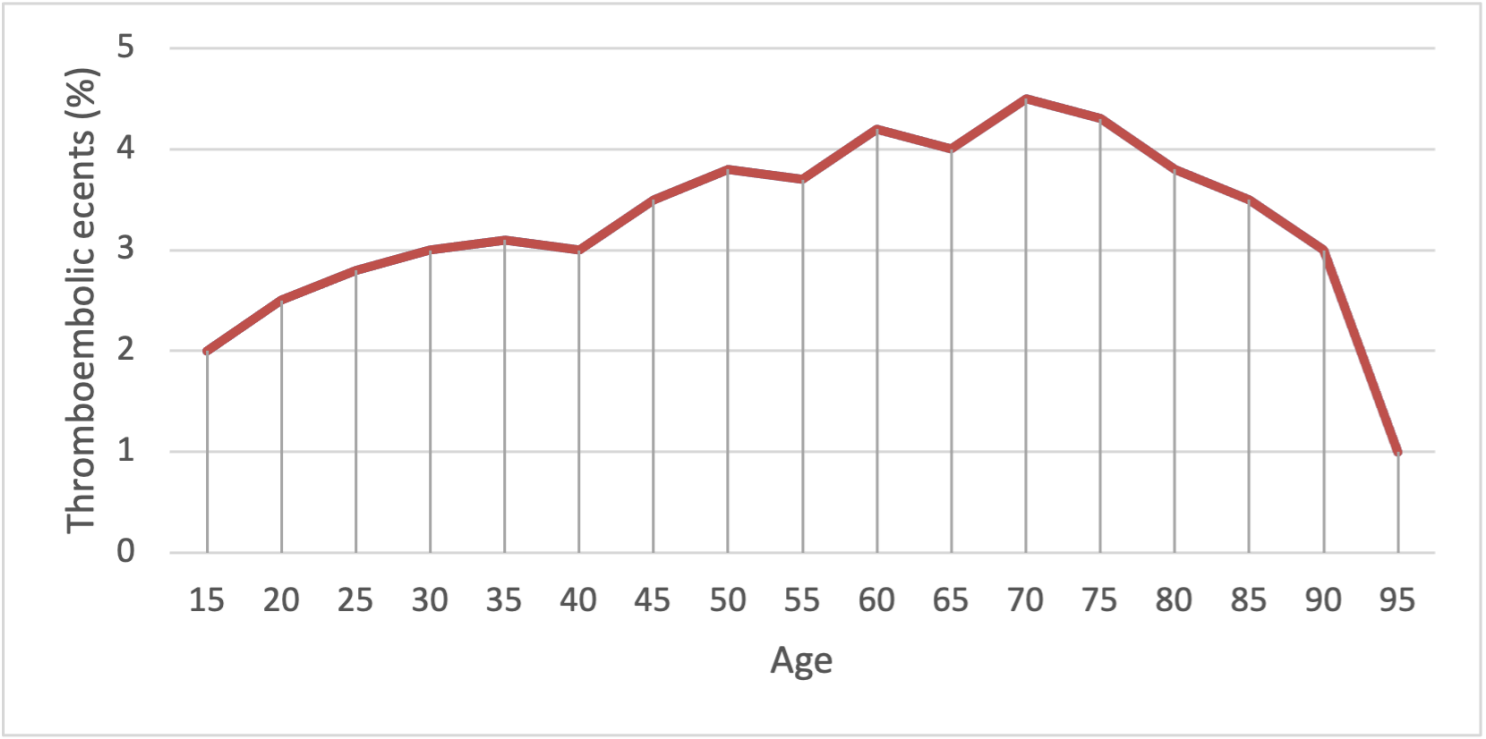


Figure 2

Age-related incidence of thromboembolic events.

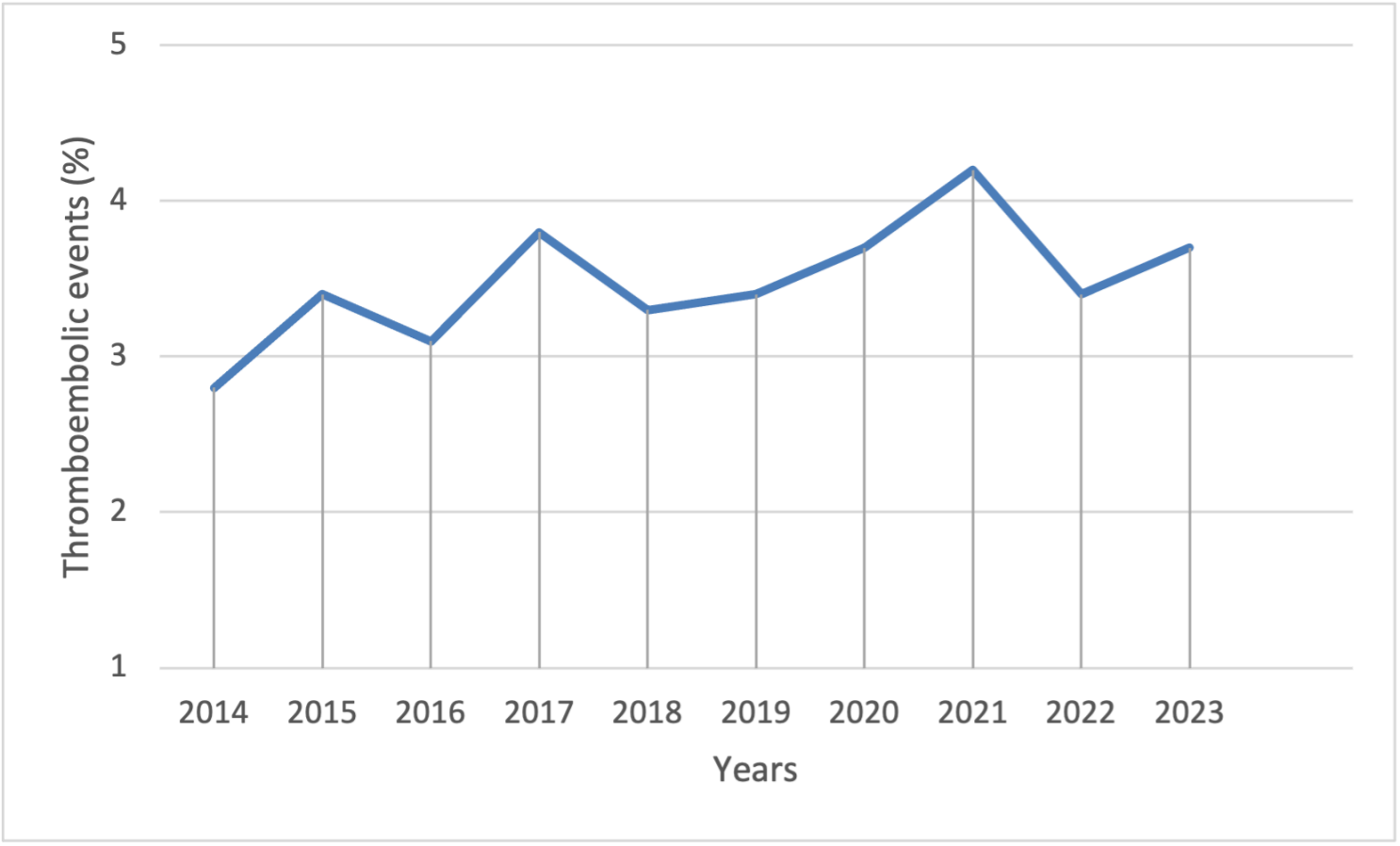


Figure 3

Prevalence of thromboembolic events per year during the period 2014-2023