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Development and evaluation of a national administrative code-based system for estimation of hospital-acquired venous thromboembolism in Ireland.

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Abstract

Title:

Development and evaluation of a national administrative code-based system for estimation of hospital-acquired venous thromboembolism in Ireland.

Background:

Hospital-acquired venous thromboembolism (HA-VTE) is a significant patient safety concern contributing to preventable deaths. Internationally, estimating hospital-associated VTE (HASS-VTE) relies on administrative codes, in particular International Classification of Disease (ICD) codes, but their accuracy has been debated. The Irish Health Service Executive (HSE) launched a National Key Performance Indicator (KPI) in 2019 for monitoring HASS-VTE rates using the Australian modification of ICD-10 (ICD-10-AM) codes.

Objectives:

This study aims to:

- Describe the development of the national HSE KPI.
- Determine the national HASS-VTE occurrence rate per 1000 discharges in 2022.
- Assess the contribution of each VTE ICD-10-AM code to the national HASS-VTE figure.
- Estimate the positive predictive value (PPV) of the HSE KPI, measuring the predictive value of HASS-VTE against true HA-VTE, in a single large tertiary (Irish Model 4) hospital.

Methods:

A retrospective observational study utilized national data from Irish publicly funded acute hospitals, focusing on discharges from 2022. The HSE HASS-VTE definition was based on an assessment of HASS-VTE as a rate, against hospital discharges (as per the national metadata). Inclusion criteria were: inpatient only, length of stay ≥ 2 days, age ≥ 16 and non-maternity admission type (elective or Emergency only). Maternity and paediatric hospitals were excluded.

The PPV was determined through a detailed review of suspected HA-VTE cases from April 2020 to October 2022 in a single large tertiary referral center. Data analysis employed GraphPad Prism (Horsham, PA, USA)

[1] Shared first authors.

Results:

The national mean monthly HASS-VTE rate was 11.38 per 1000 discharges in 2022. Pulmonary embolism (PE) without acute cor pulmonale (I26.9) was the most frequent contributor (59%). The mean PPV in the tertiary hospital was 0.37, with false positives attributed to acute illnesses, historical VTE coding errors, and dual VTE diagnoses at admission.

Discussion:

HA-VTE is a preventable cause of morbidity and mortality, necessitating accurate measurement. Administrative codes, while cost-effective, reveal limitations in precision. This study identifies opportunities to improve code accuracy, address coding challenges, and enhance PPV through quality improvement initiatives.

Conclusion:

The HSE's KPI provides valuable insights into HASS-VTE rates (which is an indication of HA-VTE rates), the contribution of each individual ICD-10-AM code to the overall HASS-VTE rate, and in a large model 4 hospital, PPV of 0.37 (which are similar to those reported internationally).

Strengths and limitations of this study:

- The study includes all patients admitted to publicly funded hospitals in Ireland during a 12-month period, providing a broad and representative sample for assessing the occurrence of hospital-associated venous thromboembolism.
- This study introduces the development and implementation of a National KPI for estimating HA-VTE in Ireland and it provides insights into the overall annual estimated HASS-VTE occurrence rate per 1000 discharges, the contribution of different VTE ICD-10-AM codes, and the PPV of the HSE KPI in a single large hospital.
- The estimation of PPV is based on a sample of patients from a single large tertiary referral center, potentially limiting the generalizability of the findings to other healthcare settings.
- The determination of the PPV involves a thorough chart review by a multidisciplinary team, enhancing the accuracy and reliability of the PPV estimation.

Introduction

Venous thromboembolism (VTE) comprises deep vein thrombosis (DVT) and pulmonary embolism (PE) and is a large contributor to global disease burden, affecting millions of individuals every year around the world[1]. Hospital acquired VTE (HA-VTE) is defined as a VTE that happens either during or up to 90 days following hospitalization[1]. It is estimated that up to 50-60 percent of all VTE cases occurring during or after hospitalization, such that HA-VTE is a leading preventable cause of hospital-associated mortality and morbidity[1-4]. We have similarly reported that HA-VTE accounts for at least 47% of all VTE events arising within the Ireland East Hospital Group (serving ~ 1 million individuals)[5]. VTE also causes serious morbidity in those who survive. Approximately 400,000 Europeans every year are diagnosed with chronic thromboembolic pulmonary hypertension (CTEPH) and lower limb post-thrombotic syndrome[6]. As well as harming patients, HA-VTE can also impose increased length of stay[6]. Finally, HA-VTE is reported to be the leading contributor to disability adjusted life years (DALYs) in middle and low-income countries and is reported to be the second leading contributor in the developed world[1].

HA-VTE is a leading cause of preventable death in hospital[1-3]. HA-VTE is potentially preventable by identification of patients with risk factors for VTE and bleeding and by administration of appropriate thromboprophylaxis to patient whose risk profile warrants it[1, 7, 8].

Baseline determination of HA-VTE rates is important when planning quality improvement initiatives aimed at improving patient safety by prevention of blood clots in hospitals[5]. Estimation of HA-VTE rates at a population level usually requires the use of administrative codes for VTE. International Classification of Disease (ICD) codes remain the most commonly utilized method[9]. National recommendations for inclusion of ICD codes in the diagnosis of HA-VTE have been published[3, 5, 10]. However, there is significant variability in the individual codes used in published literature[3]. Moreover, while sensitivity of ICD codes for estimation of HA-VTE appears reasonable, and should of course be prioritized from a patient safety perspective, positive predictive value (PPV) and specificity is reported to be low[3, 11].

In 2017 the Irish Health Service Executive (HSE) commenced work towards developing a National Key Performance Indicator (KPI) estimating HASS-VTE in Ireland, which was launched in 2019. Australian modification of ICD-10 codes (ICD-10-AM) codes that were used to define HASS-VTE in international recommendations and publications were reviewed and an iterative process was undertaken to select ICD-10-AM codes for the HSE KPI[10, 11].

Following a period of data gathering, we aimed to conduct a descriptive analysis of data from the HSE HASS-VTE KPI. Our objectives were: (1) To determine the overall annual estimated HASS-VTE occurrence rate per 1000 discharges using the HSE KPI for 2022, (2) To determine the percentage contribution of each VTE ICD-10-AM code to the overall estimated HASS-VTE rate, (3) To estimate the PPV of the HSE KPI in a sample of patients from a single large tertiary referral centre (defined as a "model 4 hospital" in Ireland) and (4) to define a quality improvement project for the next phase of work, building on these results.

For clarity, throughout the manuscript, the constitutional name of the state (Ireland) will be used and refers to the 26 counties also known as the "Republic of Ireland".

Methods

Population and study design

Aims 1-3 were achieved with a retrospective observational study design. All patients with an admission to a publicly funded hospital according to criteria listed below during the 12 month period between 1st January and 31st December 2022 were included in order to determine: (a) the HASS-VTE occurrence rate per 1000 discharges in Ireland, (b) the percentage contribution of each HASS-VTE-relevant ICD-10-AM code (**Table 1**) to the overall estimated HASS-VTE rate and (c) the contribution of cases including a VTE ICD-10-AM code as a primary diagnosis to the overall HASS-VTE rate in Ireland.

In contrast, for estimation of the PPV of the HSE HA-VTE in a sample of patients from a single large tertiary referral centre in Ireland (the Mater Misericordiae University hospital (MMUH), Dublin), between 1st April 2020 and 31st October 2022 were included.

The "rate of VTE associated with hospitalisation", was calculated by determining the rate per 1,000 inpatient discharges with a length of stay of 2 or more days. The numerator was the (number of adult in-patient discharges with a length of stay of ≥ 2 days with a diagnosis of VTE) *1000. In the numerator, "additional diagnosis of VTE (HA-VTE)" was defined as any of the ICD-10-AM codes listed in **Table 1** in positions 2-30. Inclusion criteria were: inpatient only, length of stay ≥ 2 days (therefore excludes discharges with 0 or 1 overnight stays), age ≥ 16 and non-maternity admission type (elective or Emergency only). Maternity and paediatric hospitals were excluded. The denominator was the number of adult in-patient discharges with a length of stay of ≥ 2 days in the index month.

Data source

The data source for this study was the consolidated hospital inpatient enquiry records (HIPE; a commonly used data source in Irish hospitals) of all Irish publicly funded Acute Hospitals.

HIPE data in Ireland are entered and validated at the time of a patient's hospital discharge by trained HIPE coders. Data are extracted from standardised discharge forms that are completed by a clinician caring for the patient. Following data entry by HIPE coders at the hospital level, further validation is undertaken by a centralized HSE HIPE Healthcare Pricing Office (HPO) after the data are uploaded from each hospital.

In HIPE, the term "Primary Diagnosis" is the primary assigned diagnosis upon presentation to a hospital and the principal reason for admission. The term "Subsequent (secondary) Diagnoses" refer to diagnoses arising during hospitalization. Consequently, "Subsequent (secondary) Diagnoses" data can be considered to represent a surrogate marker for HASS-VTE.

Development of a National KPI estimating HASS-VTE by administrative codes

In 2017 the Acute Hospitals and Quality Improvement divisions of the Irish HSE were commissioned to commence a workpackage aiming to estimate HASS-VTE rates in Irish Acute Hospitals using administrative codes (specifically, the ICD-10-AM). A multidisciplinary team was assembled and an iterative process was commenced in order to determine which administrative codes should be included as outlined in the next section.

The recommendations of international consensus statements and publications guided this work.

Development of a national HSE definition for estimating HASS-VTE

We based the definition of suspected HA-VTE cases on ICD-10 discharge diagnostic codes for VTE outlined in the UK National Health Service Outcomes Framework (NHSOF) 2013/14 Technical Appendix which guided UK-based quality improvement initiatives[3, 7, 10]. In this document, determination of the rate of hospital admissions for VTE is recommended in order to determine the incidence of healthcare-related VTE (section 5.1). The numerator in the UK-NHSOF is the number of hospital admissions with a primary or secondary diagnosis of VTE using the following ICD10 codes: I260, I269, I800, I801, I802, I803, I808, I809, I821, I822, I823, I828, I829, O223, O229, O871, O87.0, O87.9.

We also referred to similar quality improvement initiatives internationally, such as that performed in New South Wales[9]. In Australia, the Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicators include post- and perioperative PE and DVT as measures of quality healthcare[12, 13].

We elected to exclude the terms I800 (phlebitis/thrombophlebitis superficial vessels lower extremities) and I821 (thrombophlebitis migrans) which *are* included in the UK NHSOF as HIPE stakeholders estimated that the inclusion of these terms would reduce the PPV of the HA-VTE term without improving sensitivity, because miscoding of DVT as either of these terms would be unlikely, while the numerator would be likely to be inflated by the inclusion of superficial vein thrombosis, which is not a true HASS-VTE event. I823 (Embolism and thrombosis of renal vein) was excluded because the working group did not agree that a renal vein thrombosis represented a HASS-VTE (in that it is not *both* provoked by hospitalization and theoretically preventable by appropriate administration of thromboprophylaxis). O082 (Embolism following abortion and ectopic and molar pregnancy) *was* included as the team argued that these events *are* procedural/hospitalization-related (the numerator of the HSE KPI would require only those procedures resulting in a hospitalization of at least two days to be included). 0223 and 0882 were both included as their exclusion was predicted to reduce the sensitivity of the HSE KPI (due to the high predicted likelihood of sole coding of a HASS-VTE event occurring in a women who is admitted with a medical condition but is pregnant as one of these codes). O871, O87.0 and O87.9 were excluded given the far greater likelihood that a woman admitted in the puerperium is admitted solely because of her postpartum state[14]. A VTE occurring in this scenario would be pregnancy/postpartum-provoked rather than a HASS-VTE, which is in the scope of a separate QI project.

VTE events managed through an Emergency Department-based ambulatory care pathway were not admitted and therefore not captured.

Final HSE definition for HASS-VTE

The title of the final agreed HSE HASS-VTE estimation method (which contributes to a national KPI is "Rate of venous thromboembolism (VTE, blood clots) associated with hospitalisation", described as "The rate, per 1,000 inpatient discharges, with length of stay of 2 or more days, of venous thromboembolism (VTE) (blood clot) occurring during hospitalisation or within 90 days of discharge", and aims to provide hospitals with an estimate of their rate of VTE occurring during and after hospitalisation and to act as a driver to improve prevention of VTE.

The numerator and denominator of the HSE HASS-VTE definition are outlines in "methods". HASS-VTE is defined as any of the following ICD-10 codes in positions 2-30 **(Table 1)**

The currently included list of ICD-10-AM codes used to define HASS-VTE in the Irish HSE is outlined in **Table 1**, with UK national recommendations included for context.

ICD-10 Code-AM	Description	HSE HASS-VTE definition	UK NHS Outcomes Framework 2013/14 HA-VTE definition
I26.0	Pulmonary embolism with mention of acute cor pulmonale	**x**	**x**
I26.9	Pulmonary embolism without mention of acute cor pulmonale	**x**	**x**
I80.0	Phlebitis/thrombophlebitis superficial vessels lower extremities	-	**x**
I80.1	Phlebitis and thrombophlebitis of femoral vein	**x**	**x**
I80.2	Phlebitis and thrombophlebitis of other deep vessels of lower extremities	**x**	**x**
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	**x**	**x**
I80.8	Phlebitis and thrombophlebitis of other sites	**x**	**x**
I80.9	Phlebitis and thrombophlebitis of unspecified site	**x**	**x**
I82.1	Thrombophlebitis migrans	-	**x**
I82.2	Embolism and thrombosis of vena cava	**x**	**x**
I82.3	Embolism and thrombosis of renal vein	-	**x**
I82.8	Embolism and thrombosis of other specified veins	**x**	**x**
I82.9	Embolism and thrombosis of unspecified vein	**x**	**x**
O08.2	Embolism following abortion and ectopic and molar pregnancy	**x**	-
O22.3	Deep phlebothrombosis in pregnancy	-	**x**

O22.9	Venous complication in pregnancy, unspecified	-	**x**
O87.1	Deep phlebothrombosis in the purperium	-	**x**
O87.0	Superficial thrombophlebitis in the puerperium	-	**x**
O87.9	Venous compliations in the puerperium, unspecified	-	**x**
O88.2	Obstetric blood clot embolism	**x**	-

TABLE 1: Definition of HASS-VTE (Encompassing both pulmonary embolism and deep venous thrombosis) ICD-10 Diagnosis Codes in "additional diagnosis" positions in UK-NHS and Irish HSE-defined HASS-VTE events.

Determination of the PPV of HSE HASS-VTE administrative codes for HA-VTE definition

The PPV of administrative codes for identification of HASS-VTE in the tertiary referral hospital was defined as the number of true positive events (those events predicted by administrative codes to represent HASS-VTE and subsequently objectively verified by chart review to represent HA-VTE) divided by the sum of the true positive events and the false positive events (the latter being those events predicted by administrative codes to represent HASS-VTE but subsequently determined not to be HA-VTE upon review).

In order to estimate the PPV of the Irish HSE-defined KPI, a detailed review of suspected HASS-VTE (defined by the HSE KPI) was performed in a large academic tertiary referral hospital, the MMUH. In this hospital, a VTE committee reporting to the hospital Quality Director performs a monthly detailed multidisciplinary review of all HSE-defined HASS-VTE, including a detailed chart review by two consultant haematologists with a specialist interest in VTE, a quality manager, a senior pharmacist, thrombosis nursing staff and multidisciplinary clinical fellows. The number of true and false positive HA-VTE events are determined on a monthly basis.

Descriptive statistics

Data were analysed using GraphPad Prism (Horsham, PA, USA). Categorical data in were expressed as proportions and continuous data as mean ± standard deviation (SD) if normally distributed or median ± interquartile range (IQR) if non-normally distributed.

Results

Determination of the overall annual estimated HASS-VTE occurrence rate per 1000 discharges using the HSE KPI tool

Between January and December 2022, for inpatients ≥16 years in an acute hospital with a length of stay greater than 1 day, the mean (SD) monthly numbers of HASS-VTE cases and the number of discharges according to the above criteria were 253 (16) and 22264 (997) respectively. The National mean monthly HASS-VTE rate per 1000 discharges mean (SD), defined by the presence of any of the 12 ICD-10-AM codes listed in table 1 in diagnostic positions 2-30, was 11.38 (1.02)

Determination of the percentage contribution of each VTE ICD-10 code to the overall estimated HASS-VTE rate

The contribution of each VTE ICD-10-AM code to the overall HASS-VTE rate is shown in Table 2 (below).

The most commonly occurring VTE codes were: I26.9 (Pulmonary embolism without mention of acute cor pulmonale) with 59% and I80.2 (Phlebitis and thrombophlebitis in other deep vessels of lower extremities) with 22%. I80.1 (Phlebitis and thrombophlebitis of femoral vein) represented 9%. I82.8 (Embolism and thrombosis of other specified veins) was 4%.

ICD-10-AM Code	Description	Number of cases (Jan-Dec 2022)	Proportion of total HA-VTE (n=3033)
I26.0	Pulmonary embolism with mention of acute cor pulmonale	51	0.02
I26.9	Pulmonary embolism without mention of acute cor pulmonale	1,800	0.59
I80.1	Phlebitis and thrombophlebitis of femoral vein	258	0.09
I80.2	Phlebitis& thrombophlebitis: other deep vessels of lower extremities	674	0.22
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	65	0.02
I80.8	Phlebitis and thrombophlebitis of other sites	21	0.01
I80.9	Phlebitis and thrombophlebitis of unspecified site	16	0.01
I82.2	Embolism and thrombosis of vena cava	0	0.00
I82.8	Embolism and thrombosis of other specified veins	128	0.04
I82.9	Embolism and thrombosis of unspecified vein	18	0.01
O08.2	Embolism following abortion and ectopic and molar pregnancy	0	0.00
O88.2	Obstetric blood clot embolism	2	0.00

Table 2: Contribution of each ICD-10-AM code to the overall HSE HASS-VTE rate between January-December 2022 inclusive

Estimation of PPV of the HSE KPI in a large tertiary referral centre

Between April 2020 and October 2022 (inclusive), all HASS-VTE events reported for the MMUH by the HSE were reviewed as described in "methods". The median (IQR) number of discharges per month during this time was 1254 (1132-1286). The mean (SD) HSE-defined HASS-VTE event monthly rate for the hospital was 18.7 (4.7) per 1000 discharges during this time and the mean absolute number of events per month was 22.53 (5.78). The mean (SD) PPV was 0.37 (0.1), with a range of 0.22-0.56. The

commonest reasons for false positive HASS-VTE reporting included (a) patients presenting with multiple acute illnesses (including acute VTE), such that the VTE was appropriately coded in a secondary position, but did not represent a HA-VTE; (b) Prior historical VTE (not present on the current admission but erroneously coded in a secondary position for the current admission); (c) Dual VTE diagnosis at admission (PE + DVT, with one coded appropriately in a secondary position while not representing true HA-VTE).

Contribution of cases including a VTE code in a primary position to overall HASS-VTE rate

In order to estimate the contribution of category (c) above to the national HASS-VTE rate, the proportion of patients with a VTE code in a secondary position but without a VTE code in a primary position were determined during a 12-month period (January-December 2022 inclusive) for each Irish hospital. The mean (SD) hospital proportion of VTE cases with a VTE code in the secondary but not in the primary position was 0.89 (0.09), suggesting that the PPV could be improved by assigning this rule in the definition of HASS-VTE. Further work could determine whether this represents a method by which the PPV of the KPI could be improved.

As an exploratory analysis, we next sought to determine whether assignment of a formal "hospital-Acquired event" flag by the hospital coders was a reliable indicator of HA-VTE. The median proportion of cases per hospital that had this flag assigned was only 0.15 (0.05-0.2), suggesting that searching only for cases that have been formally assigned a "hospital-acquired event" flag is an unreliable method for HASS-VTE case identification currently.

Discussion

In this study we describe the process through which HASS-VTE was defined within the Irish HSE, which are now further supported and informed by our reporting of a review of the use of ICD-10-AM codes in the definition of HASS-VTE. We report that the national mean (SD) monthly HASS-VTE rate according to this definition was 11.38 (1.02) per 1000 discharges. Finally, we report a mean (SD) monthly PPV for the Irish HASS-VTE definition of 0.37 (0.1) in a single large tertiary referral centre.

It is well-established that healthcare "big data" (summarized in[15]) do not reach the same precision standards as research data. Data are complex and therefore interpretation can be challenging. Administrative data based on ICD are increasingly being utilized for this purpose. They are inexpensive and readily available, and can provide data pertaining to large numbers of patients[16]. However, secondary diagnoses codes were originally not intended to measure adverse events. They were developed to describe the prevalence of causes of morbidity and mortality, and then began to be used in hospital reimbursement. However, there are major challenges, including clinical and coding interpretation and the fact that colleagues who code are dependent on clinicians' notes. Therefore, the accuracy of administrative data in describing clinical events may not always be optimal. The KPI is not an absolute measure of HA-VTE but that measuring rates of these ICD-10-AM codes in non-primary diagnosis includes HA-VTE. The rates in a particular setting provide some insights for hospitals in comparing to similar hospitals, and for the hospital tracking its rates over time.

How do other jurisdictions systematically measure HASS-VTE by utilizing administrative codes? The Department of Health in England mandated the use of a risk assessment tool for VTE in 2010 through the Commissioning for Quality and Innovation (CQIN) scheme[7]. The implementation of this patient safety programme has significantly reduced the incidence of and mortality from HA-VTE[3, 7]. These and other data demonstrate HA-VTE is potentially preventable with risk assessment and implementation of appropriate thromboprophylaxis[2, 3]. In the US, Governmental and regulatory agencies such as the Agency for Healthcare Research and Quality, the Joint Commission, and the Centers for Medicare & Medicaid Services (CMS) have adopted VTE measures to assess hospital quality[12, 17]. A postoperative DVT/PE indicator (determined by ICD codes) is included in the Patient Safety Indicators (PSIs; a tool for systematically screening adverse events in hospital administrative data published by the (US) Agency for Healthcare Research and Quality (AHRQ)[13, 18-22].

Are administrative data valid when measuring HASS-VTE in hospitals? The extent to which the ICD codes identify HASS-VTE correctly and reliably is an important question. To answer this question, VTE events flagged by administrative codes can be compared with a "gold standard", often review of medical records. In this context, the **PPV** of ICD codes in identifying HA-VTE is calculated as the proportion of HASS-VTE cases identified by ICD codes and then confirmed by review of medical records. Several studies have sought to evaluate the PPV of administrative codes for identification of true HA-VTE and, as we report herein, low PPVs have previously been reported on many occasions, ranging from ~30-80%[11, 16, 23-31]. This phenomenon was realized early in the process of administrative code utilization for this purpose: in 2007, Zhan et al compared postoperative VTE event reporting using ICD-9 codes and medical record review in hospital records of over 20,000 medicare patients from 2002-2004 and reported ICD9-CM coding PPV estimates of 31% (72/232 cases) for DVT, 24% (23/95) for PE, and 29% (90/308) for DVT/PE combined[26], suggesting even then that close attention to validity is important when using administrative code-based event rate estimates for safety performance assessment.

We report that flagging cases in which VTE is in a primary coding position, in other words, "present on admission" may avoid false positive HASS-VTE reports. Additional improvement measures may impact PPV: a multidisciplinary team including the National Healthcare Pricing Office has commenced a quality improvement initiative aimed at increasing the PPV of our HASS-VTE definition which will include training and written instruction to coding staff and the formation of a dedicated Working Group under the auspices of the National VTE Programme.

Limitations

This study has some limitations. The KPI examines in-hospital HASS-VTE only and does not capture HA-VTE occurring after discharge, resulting in readmission or out-patient management. Readmission to the same hospital with VTE as a primary diagnosis was originally part of the KPI, but data was reported 5 months in arrears, to allow for readmission within 90 days of discharge, this resulted in the KPI being less useful as performance data and the readmission portion was removed from the KPI. The rate of primary VTE admissions is also captured in HIPE data but not as part of the KPI. A proportion of these are readmissions with HASS-VTE which occurred after discharge. Out-patient management of VTE is not captured in the HIPE system. Efforts are ongoing to provide a structure through which to capture such events. Further the comparison of data with other countries has a slight caveat, in that they more often than not have electronic and structured documentation. Much of the Irish documentation is a handwritten format and therefore less structured, so extracting data from this can be a challenge.

Future proposed work

Quality improvement initiatives are dependent on robust data. Therefore, our reported PPV for HA-VTE (which is in line with international publications) highlights the urgent need to improve the definition of HASS-VTE events, so that data can reliably inform policy on the success of VTE risk reduction protocols. The more widespread future availability in Ireland of electronic health records and the likely introduction of a unique patient identifier will improve the accuracy of data collection. A quality improvement programme has been initiated through the National VTE Programme, aiming to improve the PPV of the HSE KPI for HASS-VTE definition. Initial proposed Plan-Do-Study-Act (PDSA) cycles might include provision of guidance to HIPE coding colleagues and to medical practitioners, the introduction of a mandatory "flag" for HASS-VTE and integration with National Medical Imaging reports.

Conclusion

This paper outlines the development and implementation of a National KPI for estimating HASS-VTE in Ireland, using administrative codes, specifically the ICD-10-AM. There are challenges associated with using administrative codes for estimating HASS-VTE, revealing the importance of continuous quality improvement initiatives. Limitations, including potential underestimation of cases due to exclusion of readmissions to other hospitals and exclusion of certain DVT events managed in an ambulatory manner are important considerations.

The clinical, patient and economic impact of VTE is enormous with well-established prevention programmes in other countries. The National Venous Thromboembolism Programme aims to understand and improve VTE prevention, management and treatment. This study proposes quality improvement measures, including training and instructions for coding staff, the formation of a dedicated working group, and integration with national medical imaging reports. The authors acknowledge the limitations of the current system and highlight the ongoing efforts to enhance the

accuracy of HASS-VTE data collection in Ireland, anticipating improvements with the future availability of electronic health records. Further examination of national VTE incidence rates and trends is vital.

In conclusion, this paper contributes valuable insights into the development, implementation, and evaluation of a national HASS-VTE estimation mechanism in Ireland, emphasizing the need for ongoing refinement and quality enhancement in utilizing administrative codes for patient safety assessments.

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Figure 1 provides a summary of the absolute numbers of each ICD-10-AM code during January-December 2022 inclusive.

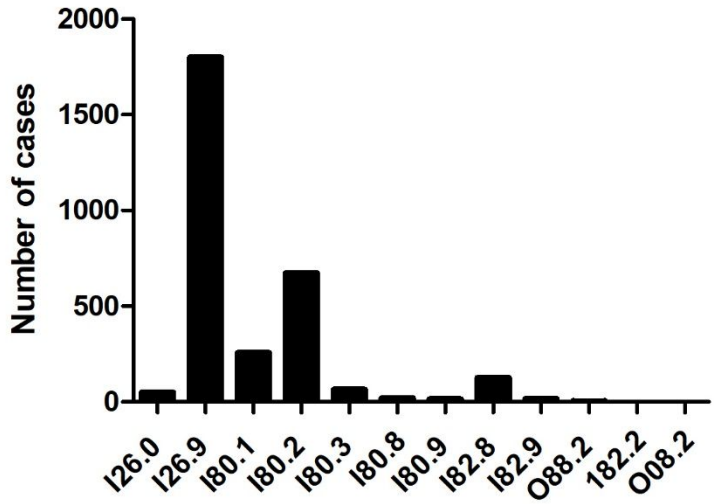

Figure 1: Number of VTE cases for each of the ICD-10-AM codes used to define HA-VTE (see table 1) in secondary diagnostic positions (2-30) during January to December 2022. I26.0 Pulmonary embolism with mention of acute cor pulmonale. I26.9: Pulmonary embolism without mention of acute cor pulmonale; I80.1: Phlebitis and thrombophlebitis of femoral vein; I80.2 Phlebitis and thrombophlebitis of other deep vessels of lower extremities; I80.3 Phlebitis and thrombophlebitis of lower extremities, unspecified; I80.8: Phlebitis and thrombophlebitis of other sites; I80.9 Phlebitis and thrombophlebitis of unspecified site; I82.8 Embolism and thrombosis of other specified veins; I82.9 Embolism and thrombosis of unspecified vein; O08.2 Embolism following abortion and ectopic and molar pregnancy; I82.2 Embolism and thrombosis of vena cava; O88.2 Obstetric blood clot embolism

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Abstract

Title:

Development and evaluation of a national administrative code-based system for estimation of hospital-acquired venous thromboembolism in Ireland.

Background:

Hospital-acquired venous thromboembolism (HA-VTE) is a significant patient safety concern contributing to preventable deaths. Internationally, estimating hospital-acquired VTE (HA-VTE) relies on administrative codes, in particular the International Classification of Disease (ICD) codes, but their accuracy has been debated. The Irish Health Service Executive (HSE) launched a National Key Performance Indicator (KPI) in 2019 for monitoring HA-VTE rates using the Australian modification of ICD-10 (ICD-10-AM) codes.

Objectives:

This study aims to:

- Describe the development of the national HSE KPI.
- Determine the national HA-VTE occurrence rate per 1000 discharges in 2022.
- Assess the contribution of each VTE ICD-10-AM code to the national HA-VTE figure.
- Estimate the positive predictive value (PPV) of the HSE KPI against true HA-VTE, in a single large tertiary (Irish Model 4) hospital.

Methods:

A retrospective observational study utilized national data from Irish publicly funded acute hospitals, focusing on discharges from 2022. The HSE KPI was based on an assessment of HA-VTE as a rate per 1000 hospital discharges (as per the national metadata). Inclusion criteria were: inpatient only, length of stay ≥ 2 days, age ≥ 16 and non-maternity admission type (elective or emergency only). Maternity and paediatric hospitals were excluded.

The PPV was determined through a detailed review of HA-VTE cases identified through the HSE KPI from April 2020 to October 2022 in a single large tertiary referral center and determining the proportion indicating a true HA-VTE. Data analysis employed GraphPad Prism (Horsham, PA, USA).

[1] Shared first authors.

Results:

The national mean monthly HA-VTE rate was 11.38 per 1000 discharges in 2022. Pulmonary embolism (PE) without acute cor pulmonale (I26.9) was the most frequent contributor (59%). The mean PPV in the tertiary hospital was 0.37, with false positives attributed to acute illnesses, historical VTE coding errors, and dual VTE diagnoses at admission.

Discussion:

HA-VTE is a preventable cause of morbidity and mortality, necessitating accurate measurement. Administrative codes, while cost-effective and timely, reveal limitations in precision. This study identifies opportunities to improve code accuracy, address coding challenges, and enhance PPV.

Conclusion:

This study provides valuable insights into estimated HA-VTE rates, the contribution of each individual ICD-10-AM code to the overall HA-VTE rate, and the PPV of the measure. Ongoing refinement and quality enhancement are needed.

Strengths and limitations of this study:

- The study includes all adult medical and surgical patients discharged from publicly funded hospitals in Ireland during a 12-month period, providing a broad and representative sample for assessing the occurrence of HA-VTE.
- This study introduces the development and implementation of a national KPI for estimating the HA-VTE rate in Ireland. It provides insights into the overall annual HA-VTE occurrence rate per 1000 discharges, the contribution of different VTE ICD-10-AM codes, and the PPV of the HSE KPI in a single large hospital.
- Estimating HA-VTE using this administrative dataset has a poor PPV, thus the strength of the measure is largely in measuring rates of HA-VTE over time, to identify patient safety concerns and monitor quality improvement efforts.
- The estimation of PPV is based on a sample of patients from a single large tertiary referral center, potentially limiting the generalizability of the findings to other healthcare settings. The findings may not be generalizable to other countries, due to differences in clinical management, coding and data processing.
- The determination of the PPV involves a thorough chart review by a multidisciplinary team, enhancing the accuracy and reliability of the PPV estimation.

Introduction

Venous thromboembolism (VTE) comprises deep vein thrombosis (DVT) and pulmonary embolism (PE) and is a large contributor to global disease burden, affecting millions of individuals every year around the world[1]. Hospital-acquired VTE (HA-VTE) is defined as a VTE that happens either during or up to 90 days following hospitalization[1]. It is estimated that up to 50-60 percent of all VTE cases occur during or after hospitalization and HA-VTE is a leading preventable cause of hospital-associated mortality and morbidity[1-4]. We have reported that HA-VTE accounts for at least 47% of all VTE events arising within the Ireland East Hospital Group (serving ~1 million individuals)[5]. VTE also causes serious morbidity in those who survive. Approximately 400,000 Europeans every year are diagnosed with chronic thromboembolic pulmonary hypertension and lower limb post-thrombotic syndrome[6]. As well as harming patients, HA-VTE can also impose increased length of stay[6]. VTE is reported to be the leading hospitalization-associated contributor to disability adjusted life years in middle and low-income countries and is reported to be the second leading contributor in high-income countries[1].

HA-VTE is potentially preventable by identification of patients with risk factors for VTE and bleeding and by administration of appropriate thromboprophylaxis to patient whose risk profile warrants it[1 7 8].

Baseline determination of HA-VTE rates is important when planning quality improvement initiatives aimed at improving patient safety by prevention of blood clots in hospitals[5]. Estimation of HA-VTE rates at a population level often employs the use of administrative codes for VTE. International Classification of Disease (ICD) codes remain the most utilized method[9]. Administrative codes are used to derive VTE rates in the perioperative period following hip or knee replacement by the OECD [10] and AHRQ [11]. VTE in any adult inpatient is measured as a hospital-acquired complication in Australia [12]. Administrative codes are also used in research studies determining the rates of VTE occurrence [3 9 13]

[14]. There is significant variability in the individual codes used in published literature and in patient safety measures. Moreover, while sensitivity of ICD codes for estimation of HA-VTE appears reasonable, and should of course be prioritized from a patient safety perspective, positive predictive value (PPV) and specificity is reported to be low[3 5 15].

The Irish Health Service Executive (HSE) commenced work towards developing a National Key Performance Indicator (KPI) estimating HA-VTE rate in Ireland in 2017, which was launched in 2019. Australian modification of ICD-10 codes (ICD-10-AM) codes that were used to define HA-VTE in international recommendations and publications were reviewed and an iterative process was undertaken to select ICD-10-AM codes for the HSE KPI [3 9-11 13 14].

Following a period of data gathering, we aimed to conduct a descriptive analysis of data from the HSE HA-VTE KPI. Our objectives were: (1) To determine the national annual estimated HA-VTE occurrence rate per 1000 discharges using the HSE KPI for 2022, (2) To determine the percentage contribution of each VTE ICD-10-AM code to the overall estimated HA-VTE rate, (3) To estimate the PPV of the HSE KPI in a sample of patients from a single large tertiary referral centre (defined as a "model 4 hospital" in Ireland) and (4) to define a quality improvement project for the next phase of work, building on these results.

For clarity, throughout the manuscript, the constitutional name of the state (Ireland) will be used and refers to the 26 counties also known as the "Republic of Ireland".

Methods

Patient and public involvement

The HSE's VTE work and this study have been carried out in close collaboration with our co-author Ann-Marie O'Neill, representing Thrombosis Ireland. Ann-Marie has advised on the design and reporting on the study and will share results with patients and the public via Thrombosis Ireland.

Population and study design

Aims 1-3 were achieved with a retrospective observational study design.

All patients discharged following an admission to a publicly funded hospital according to inclusion criteria: inpatient only, length of stay ≥ 2 days, age ≥ 16 and non-maternity admission type (elective or Emergency only). This was during the 12 month period between 1st January and 31st December 2022 in order to determine: (a) the HA-VTE occurrence rate per 1000 discharges in Ireland and (b) the percentage contribution of each HA-VTE-relevant ICD-10-AM code (**Table 1**) to the overall estimated HA-VTE rate.

For estimation of the PPV of the HSE HA-VTE, all patients from a single large tertiary referral centre in Ireland (the Mater Misericordiae University hospital (MMUH), Dublin), identified by the HSE KPI as having HA-VTE and discharged between 1st April 2020 and 31st October 2022, were included.

Data source

The data source for this study was the consolidated hospital inpatient enquiry records (HIPE) of all Irish publicly funded acute hospitals.

HIPE data in Ireland are entered and validated at the time of a patient's hospital discharge by trained HIPE coders. Data are extracted from standardised discharge forms that are completed by a clinician caring for the patient. Following data entry by HIPE coders at the hospital level, further validation is undertaken by a centralized HSE HIPE Healthcare Pricing Office (HPO) after the data are uploaded from each hospital.

The Australian modification of ICD-10 (ICD-10-AM) codes is used in HIPE coding for all Irish publicly funded acute hospitals. In HIPE, the term "Primary Diagnosis" is the diagnosis assigned as the principal reason for admission to hospital. The term "Additional Diagnosis" refers to a diagnosis arising or diagnosed during hospitalisation. Consequently, "Additional Diagnosis" data includes hospital-acquired conditions.

Development of a national KPI estimating HA-VTE by administrative codes

In 2017 the Acute Hospitals and Quality Improvement Divisions of the Irish HSE were commissioned to commence a workpackage aiming to estimate HA-VTE rates in Irish acute hospitals using administrative codes. A multidisciplinary team was assembled and an iterative process was commenced in order to determine which administrative codes should be included as outlined in the next section. The recommendations of international consensus statements and publications guided this work.

Development of a national HSE definition for estimating HA-VTE

We based the definition of suspected HA-VTE cases on ICD-10 discharge diagnostic codes for VTE outlined in the UK National Health Service Outcomes Framework (NHSOF) 2013/14 Technical Appendix which guided UK-based quality improvement initiatives[3 7 16]. In this document, determination of the rate of hospital admissions for VTE is recommended in order to determine the incidence of healthcare-related VTE (section 5.1). The numerator in the UK-NHSOF is the number of hospital admissions with a primary or secondary diagnosis of VTE using the following ICD10 codes: I260, I269, I800, I801, I802, I803, I808, I809, I821, I822, I823, I828, I829, O223, O229, O871, O87.0, O87.9.

We also referred to international VTE measures, including OECD [10], AHRQ [11] and Australian [12] measures, and studies reported in the literature, including Liu et al [17].

Our rationale for inclusion and exclusion of particular codes is outlined further in appendix 1.

VTE events managed through an Emergency Department-based ambulatory care pathway were not admitted and therefore not captured.

Final HSE definition for HA-VTE

The title of the final agreed HSE HA-VTE estimation method, which forms the national KPI, is "Rate of venous thromboembolism (VTE, blood clots) associated with hospitalisation". This is described as "The rate, per 1,000 inpatient discharges, with length of stay of 2 or more days, of venous thromboembolism (VTE) (blood clot) occurring during hospitalisation". Thisaims to provide hospitals with an estimate of their rate of VTE occurring during hospitalisation on a monthly basis and to act as a driver to improve prevention of VTE.

The "rate of VTE associated with hospitalisation" (HA-VTE occurrence rate) was calculated for patients discharged in 2022. The numerator was the number of adult in-patient discharges with a length of stay of ≥ 2 days with an additional diagnosis of VTE *1000. "Additional diagnosis of VTE" was defined as any of the ICD-10-AM codes listed in **Table 1** in positions 2-30. The VTE code in the highest position was included, i.e. each VTE code denotes a unique patient. Inclusion criteria were: inpatient only, length of stay ≥ 2 days (therefore excludes discharges with 0 or 1 overnight stays), age ≥ 16 and non-maternity admission type (elective or Emergency only). Maternity and paediatric hospitals were excluded. The denominator was the number of adult in-patient discharges with a length of stay of ≥ 2 days in the index month.

The ICD-10-AM codes used to define HA-VTE in the Irish HSE is outlined in **Table 1**, with UK national recommendations included for context.

ICD-10 Code-AM	Description	HSE HA-VTE definition	UK NHS Outcomes Framework 2013/14 HA-VTE definition
I26.0	Pulmonary embolism with mention of acute cor pulmonale	**x**	**x**

I26.9	Pulmonary embolism without mention of acute cor pulmonale	**x**	**x**
I80.0	Phlebitis/thrombophlebitis superficial vessels lower extremities	**-**	**x**
I80.1	Phlebitis and thrombophlebitis of femoral vein	**x**	**x**
I80.2	Phlebitis and thrombophlebitis of other deep vessels of lower extremities	**x**	**x**
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	**x**	**x**
I80.8	Phlebitis and thrombophlebitis of other sites	**x**	**x**
I80.9	Phlebitis and thrombophlebitis of unspecified site	**x**	**x**
I82.1	Thrombophlebitis migrans	**-**	**x**
I82.2	Embolism and thrombosis of vena cava	**x**	**x**
I82.3	Embolism and thrombosis of renal vein	**-**	**x**
I82.8	Embolism and thrombosis of other specified veins	**x**	**x**
I82.9	Embolism and thrombosis of unspecified vein	**x**	**x**
O08.2	Embolism following abortion and ectopic and molar pregnancy	**x**	**-**
O22.3	Deep phlebothrombosis in pregnancy	**-**	**x**
O22.9	Venous complication in pregnancy, unspecified	**-**	**x**
O87.1	Deep phlebothrombosis in the purperium	**-**	**x**
O87.0	Superficial thrombophlebitis in the puerperium	**-**	**x**
O87.9	Venous compliations in the puerperium, unspecified	**-**	**x**
O88.2	Obstetric blood clot embolism	**x**	**-**

TABLE 1: ICD-10-AM diagnosis Codes (encompassing both pulmonary embolism and deep venous thrombosis) in UK-NHS and Irish HSE-defined HA-VTE events. "x" indicates inclusion and "–" indicates exclusion from the definitions.

Determination of the PPV of HSE HA-VTE KPI for HA-VTE

In order to estimate the PPV of the Irish HSE-defined KPI, a detailed review of suspected HA-VTE (defined by the HSE KPI) was performed in a large academic tertiary referral hospital, the MMUH. In this hospital, a VTE committee reporting to the hospital Quality Director performs a monthly detailed multidisciplinary review of all HSE-defined HA-VTE, including a detailed chart review by two consultant haematologists with a specialist interest in VTE, a quality manager, a senior pharmacist, thrombosis nursing staff and multidisciplinary clinical fellows. The number of true and false positive HA-VTE events are determined on a monthly basis.

The PPV of administrative codes for identification of HA-VTE in the tertiary referral hospital was defined as the number of true positive events (those events predicted by administrative codes to represent HA-VTE and subsequently objectively verified by chart review to represent HA-VTE) divided by the sum of the true positive events and the false positive events (the latter being those events predicted by administrative codes to represent HA-VTE but subsequently determined not to be HA-VTE upon review).

Descriptive statistics

Data were analysed using GraphPad Prism (Horsham, PA, USA). Categorical data in were expressed as proportions and continuous data as mean ± standard deviation (SD) if normally distributed or median ± interquartile range (IQR) if non-normally distributed.

Ethics

Formal Research Ethics Committee approval was not required, as it was a national work programme commissioned by the HSE, reporting from an existing administrative dataset to improve quality and patient safety.

Results

Determination of the overall annual estimated HA-VTE occurrence rate per 1000 discharges using the HSE KPI tool

Between January and December 2022, for inpatients ≥16 years discharged from an acute hospital with a length of stay of ≥ 2 days, the mean (SD) monthly numbers of HA-VTE cases and the number of discharges according to the above criteria were 253 (16) and 22264 (997) respectively. The national mean monthly HA-VTE rate per 1000 discharges (SD), defined by the presence of any of the 12 ICD-10-AM codes listed in table 1 in diagnostic positions 2-30, was 11.36 (1.02).

Determination of the percentage contribution of each VTE ICD-10-AM code to the overall estimated HA-VTE rate

The contribution of each VTE ICD-10-AM code to the overall HA-VTE rate is shown in Table 2.

The most commonly occurring VTE codes (Fig 1) were: I26.9 (Pulmonary embolism without mention of acute cor pulmonale) accounting for 59% and I80.2 (Phlebitis and thrombophlebitis in other deep vessels of lower extremities) with 22%. I80.1 (Phlebitis and thrombophlebitis of femoral vein) represented 9% and I82.8 (Embolism and thrombosis of other specified veins) accounted for 4%. Although maternity admissions and maternity hospitals were excluded, two cases of obstetric blood clot embolism (O88.2) were recorded, denoting women admitted with a medical or surgical condition while pregnant who developed VTE.

ICD-10-AM Code	Description	Number of cases (Jan-Dec 2022)	Percentage of total HA-VTE (n=3033)
I26.9	Pulmonary embolism without mention of acute cor pulmonale	1,800	59
I80.2	Phlebitis& thrombophlebitis: other deep vessels of lower extremities	674	22
I80.1	Phlebitis and thrombophlebitis of femoral vein	258	9
I82.8	Embolism and thrombosis of other specified veins	128	4
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	65	2
I26.0	Pulmonary embolism with mention of acute cor pulmonale	51	2
I80.8	Phlebitis and thrombophlebitis of other sites	21	1
I82.9	Embolism and thrombosis of unspecified vein	18	1
I80.9	Phlebitis and thrombophlebitis of unspecified site	16	1
O88.2	Obstetric blood clot embolism	2	0
I82.2	Embolism and thrombosis of vena cava	0	0
O08.2	Embolism following abortion and ectopic and molar pregnancy	0	0

Table 2: Contribution of each ICD-10-AM code to the overall HSE HA-VTE rate

Estimation of PPV of the HSE KPI in a large tertiary referral centre

Between April 2020 and October 2022 (inclusive), all HA-VTE events reported for the MMUH by the HSE were reviewed as described in "methods". The median (IQR) number of discharges per month during this time was 1254 (1132-1286). The mean (SD) HSE-defined HA-VTE event monthly rate for the hospital was 18.7 (4.7) per 1000 discharges during this time and the mean absolute number of events per month was 22.53 (5.78). The mean (SD) PPV was 0.37 (0.1), with a range of 0.22-0.56. The commonest reasons for false positive HA-VTE reporting included (a) patients presenting with multiple acute illnesses (including acute VTE), such that the VTE was appropriately coded in an additional diagnosis position, but did not represent a HA-VTE; (b) Prior historical VTE (not present on the current admission but erroneously coded in an additional diagnosis position for the current admission); (c) Dual VTE diagnosis at admission (PE + DVT, with one coded appropriately in an additional diagnosis position while not representing true HA-VTE).

Contribution of cases including a VTE code in a primary position to overall HA-VTE rate

In order to estimate the contribution of category (c) above to the national HA-VTE rate, the proportion of patients with a VTE code in an additional diagnosis position but without a VTE code in a primary position were determined during a 12-month period (January-December 2022 inclusive) for each Irish hospital. The mean (SD) hospital proportion of VTE cases with a VTE code in an additional diagnosis position but not in the primary position was 0.89 (0.09), suggesting that the PPV could be improved by assigning this rule in the definition of HA-VTE. Further work could determine whether this represents a method by which the PPV of the KPI could be improved.

As an exploratory analysis, we next sought to determine whether assignment of a formal "Hospital-Acquired event" flag by the hospital coders was a reliable indicator of HA-VTE. The median proportion of cases per hospital that had this flag assigned was only 0.15 (95% CI 0.05-0.2), suggesting that searching only for cases that have been formally assigned a "hospital-acquired event" flag is an unreliable method for HA-VTE case identification currently.

Discussion

In this study we describe the process through which HA-VTE was defined within the Irish HSE and reviewed of the use of ICD-10-AM codes in the definition of HA-VTE. We report that the national mean (SD) monthly HA-VTE rate according to this definition was 11.38 (1.02) per 1000 discharges. Finally, we report a mean (SD) monthly PPV for the Irish HA-VTE definition of 0.37 (0.1) in a single large tertiary referral centre.

It is well-established that healthcare "big data" [18] do not reach the same precision standards as research data. Administrative data based on ICD codes are inexpensive and readily available, and can provide data pertaining to large numbers of patients[19] with a short timelag before data is available. These ICD codes were developed to describe the prevalence of causes of morbidity and mortality and have subsequently been used for other purposes, including financial reimbursement and as patient safety measures. The accuracy of administrative data in quantifying clinical events may not always be optimal. Major challenges include clinical and coding interpretation and dependency on the completeness and clarity of clinicians' notes. A lack of overlap between administrative coding and diagnostic test reporting has been reported, with 40% of ICD coded VTE lacking a positive diagnostic test report and 45% of such reports lacking a corresponding ICD code in one study[15]. The HSE KPI is not an absolute measure of true HA-VTE. The rates in a particular setting provide some insights for hospitals in comparing to similar hospitals, and for each hospital tracking its rates over time.

HA-VTE is potentially preventable with risk assessment and implementation of appropriate thromboprophylaxis[3 20]. The Department of Health in England mandated the use of a VTE risk assessment tool in 2010 through the Commissioning for Quality and Innovation (CQIN) scheme[7 21]. This patient safety programme has significantly reduced the incidence of and mortality from HA-VTE[3 7]. An improvement collaborative increased the percentage of patients with appropriate prophylaxis in participating hospitals in Ireland, from 61% to 81%, utilising a quality improvement approach [22]. Introduction of the HSE's KPI was designed to facilitate monitoring of the effect of patient safety efforts over time, with clinical and organisational governance both locally and nationally.

The extent to which administrative data identifies HA-VTE correctly and reliably is an important question. To answer this question, VTE events flagged by administrative codes can be compared with a "gold standard", often review of medical records, determining the PPV[23]. Low PPVs have previously been reported on many occasions, ranging from ~30-80%[15 19 24-32]. Even early studies such as Zhan et al [27] suggested that close attention to validity is important when using administrative code-based event rate estimates for safety performance assessment. A recent analysis of data obtained from electronic health records found ICD-10 codes had moderate to high pooled sensitivity (72%) and specificity (82%) for any VTE; higher for PE (91%) than for DVT (58%)[17].

The national mean (SD) monthly HA-VTE rate according to the current HSE definition was 11.38 (1.02) per 1000 discharges. Although similar data is collected elsewhere, comparison is challenging due to lack of public reporting of data and differences in what is reported. A similar rate was found in a cohort study, where 1.2% of medical non-intensive care in-patients developed HA-VTE during or after discharge, with an increasing rate over time [33]. A recent study also reported an increasing incidence over time, with a lower overall incidence of 2.96 in-patient VTE events per 1000 hospitalizations [34].Following hip and knee surgeries, Ireland had 597 VTE cases per 100,000 patients, which is above the OECD average at 467 [10]. UK data reported a VTE rate determined from secondary diagnosis codes of just 1.08 per 1000 discharges in 2006/7, which rose rapidly in 2008, 2009 and

2010 and then declined to 1.21 in 2011, attributed to the patient safety programme in place [2]. A previous Irish study identified potential hospital-acquired VTE by reviewing radiological records, then validating with clinical records, reporting an incidence of 4 cases of true HA-VTE per 1000 discharges [35]. Our PPV results indicate that this does not reflect the true rate. Commentary in OECD reports suggests that some of the observed variations in DVT rates may be due to differences in diagnostic practices and differences in the way that countries report, code and calculate rates of adverse events. Higher rates may indicate more developed safety monitoring systems and a stronger patient safety culture. Improvements in coding and classification may drive the increased rates noted over time in many of the studies cited above. The usefulness of the HSE HA-VTE currently is largely in measuring rates of HA-VTE over time, to identify patient safety concerns and monitor quality improvement efforts.

Limitations

This study has some limitations. The KPI examines in-hospital HA-VTE only and does not capture HA-VTE occurring after discharge, resulting in readmission or out-patient management. Readmission to the same hospital with VTE as a primary diagnosis was originally part of the KPI, but data was reported 5 months in arrears, to allow for readmission within 90 days of discharge. This resulted in the KPI being less useful as performance data and the readmission portion was removed from the KPI. The rate of primary VTE admissions is also captured in HIPE data but not as part of the KPI. A proportion of these are readmissions with HA-VTE which occurred after discharge. Out-patient management of VTE is not captured in the HIPE system. Efforts are ongoing to provide a structure through which to capture such events. Further the comparison of data with other countries has a slight caveat, in that they more often than not have electronic and structured documentation. Much of the Irish documentation is a handwritten format and therefore less structured, so extracting data from this can be a challenge.

Future proposed work

Quality improvement initiatives are dependent on robust data. Our reported PPV for HA-VTE (which is in line with international publications) highlights the urgent need to improve the definition of HA-VTE events, so that data can reliably inform policy on the success of VTE risk reduction protocols. While validation of each case would increase accuracy, it would not currently be feasible nationally.

A multidisciplinary working group has commenced a quality improvement initiative aimed at increasing the PPV of our HA-VTE definition, under the auspices of the National VTE Programme. We report that excluding cases in which VTE is also recorded as a primary diagnosis may reduce the number of false positive HA-VTE reports. Initial proposed Plan-Do-Study-Act (PDSA) cycles may include provision of guidance to HIPE coding colleagues and to medical practitioners, the introduction of a mandatory “flag” for HA-VTE and integration with National Medical Imaging reports. Improvements in sensitivity and specificity of administrative codes for VTE is anticipated with wider implementation of electronic health records and the likely introduction of a unique patient identifier, facilitating data linkage.

Conclusion

This paper outlines the development and implementation of a National KPI for estimating HA-VTE in Ireland, using ICD-10-AM administrative codes. There are challenges associated with using administrative codes for estimating HA-VTE, revealing the importance of validation and continuous quality improvement initiatives to address national and local variation. Limitations, including

potential underestimation of cases due to exclusion of readmissions and exclusion of certain DVT events managed in an ambulatory manner are important considerations.

The clinical, patient and economic impact of VTE is enormous with well-established prevention programmes in other countries. The National Venous Thromboembolism Programme aims to understand and improve VTE prevention, management and treatment. The authors acknowledge the limitations of the current system and highlight the ongoing efforts to enhance the accuracy of HA-VTE data collection in Ireland, anticipating improvements with the future availability of electronic health records. Further examination of national VTE incidence rates and trends is vital.

In conclusion, this paper contributes valuable insights into the development, implementation, and evaluation of a national HA-VTE estimation mechanism in Ireland, emphasizing the need for ongoing refinement and quality enhancement in utilizing administrative codes for patient safety assessments.

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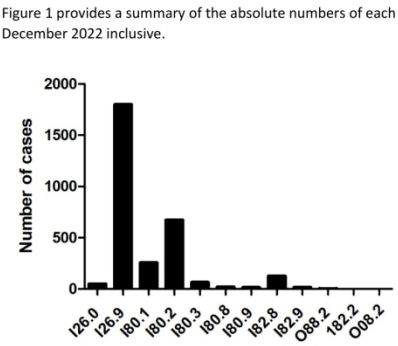
Figure 1: Number of VTE cases for each of the ICD-10-AM codes used to define HA-VTE (see table 1) in secondary diagnostic positions (2-30) during January to December 2022. I26.0 Pulmonary embolism with mention of acute cor pulmonale. I26.9: Pulmonary embolism without mention of acute cor pulmonale; I80.1: Phlebitis and thrombophlebitis of femoral vein; I80.2 Phlebitis and thrombophlebitis of other deep vessels of lower extremities; I80.3 Phlebitis and thrombophlebitis of lower extremities, unspecified; I80.8: Phlebitis and thrombophlebitis of other sites; I80.9 Phlebitis and thrombophlebitis of unspecified site; I82.8 Embolism and thrombosis of other specified veins; I82.9 Embolism and thrombosis of unspecified vein; O08.2 Embolism following abortion and ectopic and molar pregnancy; I82.2 Embolism and thrombosis of vena cava; O88.2 Obstetric blood clot embolism



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531x752mm (79 x 79 DPI)

Supplementary Appendix 1. Further rationale for select inclusion and exclusion criteria

We elected to exclude the codes I80.0 (phlebitis/thrombophlebitis superficial vessels lower extremities) and I82.1 (thrombophlebitis migrans) which *are* included in the UK NHSOF as HIPE stakeholders estimated that the inclusion of these terms would reduce the PPV of the HA-VTE term without improving sensitivity. We felt that miscoding of DVT as either of these terms would be unlikely, while the numerator would be likely to be inflated by the inclusion of superficial vein thrombosis, which is not a true HA-VTE event.

I82.3 (Embolism and thrombosis of renal vein) was excluded because the working group did not agree that a renal vein thrombosis represented a HA-VTE (in that it is not *both* provoked by hospitalization and theoretically preventable by appropriate administration of thromboprophylaxis).

O08.2 (Embolism following abortion and ectopic and molar pregnancy) *was* included as the team argued that these events *are* procedural/hospitalization-related (the numerator of the HSE KPI would require only those procedures resulting in a hospitalization of at least two days to be included).

O88.2 was included as its exclusion was predicted to reduce the sensitivity of the HSE KPI (due to the high predicted likelihood of sole coding of a HA-VTE event occurring in a women who is admitted with a medical condition but is pregnant as this code).

O87.1, O87.0 and O87.9 were excluded given the far greater likelihood that a woman admitted in the puerperium is admitted solely because of her postpartum state[36]. A VTE occurring in this scenario would be pregnancy/postpartum-provoked rather than a HA-VTE, which is in the scope of a separate project.

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Development and evaluation of a national administrative code-based system for estimation of hospital-acquired venous thromboembolism in Ireland.

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Abstract

Title:

Development and evaluation of a national administrative code-based system for estimation of hospital-acquired venous thromboembolism in Ireland.

Background:

Hospital-acquired venous thromboembolism (HA-VTE) is a significant patient safety concern contributing to preventable deaths. Internationally, estimating hospital-acquired VTE (HA-VTE) relies on administrative codes, in particular the International Classification of Disease (ICD) codes, but their accuracy has been debated. The Irish Health Service Executive (HSE) launched a National Key Performance Indicator (KPI) in 2019 for monitoring HA-VTE rates using the Australian modification of ICD-10 (ICD-10-AM) codes.

Objectives:

This study aims to:

- Describe the development of the national HSE KPI and determine the national HA-VTE occurrence rate per 1000 discharges in 2022.
- Assess the contribution of each VTE ICD-10-AM code to the national HA-VTE figure.
- Estimate the positive predictive value (PPV) of the HSE KPI against true HA-VTE, in a single large tertiary (Irish Model 4) hospital.

Methods:

A retrospective observational study utilized national data from Irish publicly funded acute hospitals, focusing on discharges from 2022. The HSE KPI was based on an assessment of HA-VTE as a rate per 1000 hospital discharges (as per the national metadata). Inclusion criteria were: inpatient only, length of stay ≥ 2 days, age ≥ 16 and non-maternity admission type (elective or emergency only). Maternity and paediatric hospitals were excluded.

The PPV was determined through a detailed review of HA-VTE cases identified through the HSE KPI from April 2020 to October 2022 in a single large tertiary referral center and determining the proportion indicating a true HA-VTE. Data analysis employed GraphPad Prism (Horsham, PA, USA).

[1] Shared first authors.

Results:

The national mean monthly HA-VTE rate was 11.38 per 1000 discharges in 2022. Pulmonary embolism (PE) without acute cor pulmonale (I26.9) was the most frequent contributor (59%). The mean PPV in the tertiary hospital was 0.37, with false positives attributed to acute illnesses, historical VTE coding errors, and dual VTE diagnoses at admission.

Discussion:

HA-VTE is a preventable cause of morbidity and mortality, necessitating accurate measurement. Administrative codes, while cost-effective and timely, reveal limitations in precision. This study identifies opportunities to improve code accuracy, address coding challenges, and enhance PPV.

Conclusion:

This study provides valuable insights into estimated HA-VTE rates, the contribution of each individual ICD-10-AM code to the overall HA-VTE rate, and the PPV of the measure. Ongoing refinement and quality enhancement are needed.

Strengths and limitations of this study:

- The study includes all adult medical and surgical patients discharged from publicly funded hospitals in Ireland during a 12-month period, providing a broad and representative sample for assessing the occurrence of HA-VTE.
- This study introduces the development and implementation of a national KPI for estimating the HA-VTE rate in Ireland. It provides insights into the overall annual HA-VTE occurrence rate per 1000 discharges, the contribution of different VTE ICD-10-AM codes, and the PPV of the HSE KPI in a single large hospital.
- Estimating HA-VTE using this administrative dataset has a poor PPV, thus the strength of the measure is largely in measuring rates of HA-VTE over time, to identify patient safety concerns and monitor quality improvement efforts.
- The estimation of PPV is based on a sample of patients from a single large tertiary referral center, potentially limiting the generalizability of the findings to other healthcare settings. The findings may not be generalizable to other countries, due to differences in clinical management, coding and data processing.
- The determination of the PPV involves a thorough chart review by a multidisciplinary team, enhancing the accuracy and reliability of the PPV estimation.

Introduction

Venous thromboembolism (VTE) comprises deep vein thrombosis (DVT) and pulmonary embolism (PE) and is a large contributor to global disease burden, affecting millions of individuals every year around the world[1]. Hospital-acquired VTE (HA-VTE) is defined as a VTE that happens either during or up to 90 days following hospitalization[1]. It is estimated that up to 50-60 percent of all VTE cases occur during or after hospitalization and HA-VTE is a leading preventable cause of hospital-associated mortality and morbidity[1-4]. We have reported that HA-VTE accounts for at least 47% of all VTE events arising within the Ireland East Hospital Group (serving ~1 million individuals)[5]. VTE also causes serious morbidity in those who survive. Approximately 400,000 Europeans every year are diagnosed with chronic thromboembolic pulmonary hypertension and lower limb post-thrombotic syndrome[6]. As well as harming patients, HA-VTE can also impose increased length of stay[6]. VTE is reported to be the leading hospitalization-associated contributor to disability adjusted life years in middle and low-income countries and is reported to be the second leading contributor in high-income countries[1].

HA-VTE is potentially preventable by identification of patients with risk factors for VTE and bleeding and by administration of appropriate thromboprophylaxis to patient whose risk profile warrants it[1, 7, 8].

Baseline determination of HA-VTE rates is important when planning quality improvement initiatives aimed at improving patient safety by prevention of blood clots in hospitals[5]. Estimation of HA-VTE rates at a population level often employs the use of administrative codes for VTE. International Classification of Disease (ICD) codes remain the most utilized method[9]. Administrative codes are used to derive VTE rates in the perioperative period following hip or knee replacement by the Organisation for Economic Co-operation and Development (OECD) [10] and Agency for Healthcare Research and Quality (AHRQ) [11]. VTE in any adult inpatient is measured as a hospital-acquired complication in Australia [12]. Administrative codes are also used in research studies determining the rates of VTE occurrence [3, 9, 13, 14]. There is significant variability in the individual codes used in published literature and in patient safety measures. Moreover, while sensitivity of ICD codes for estimation of HA-VTE appears reasonable, and should of course be prioritized from a patient safety perspective, positive predictive value (PPV) and specificity is reported to be low[3, 5, 15].

The Irish Health Service Executive (HSE) commenced work towards developing a National Key Performance Indicator (KPI) estimating HA-VTE rate in Ireland in 2017, which was launched in 2019. This aims to provide hospitals with an estimate of their rate of VTE occurring during hospitalisation on a monthly basis and to act as a driver to improve prevention of VTE.

Following a period of data gathering, we aimed to conduct a descriptive analysis of data from the HSE HA-VTE KPI. Our objectives were: (1) To determine the national annual estimated HA-VTE occurrence rate per 1000 discharges using the HSE KPI for 2022, (2) To determine the percentage contribution of each VTE ICD-10-AM code to the overall estimated HA-VTE rate and (3) To estimate the PPV of the HSE KPI in a sample of patients from a single large tertiary referral centre (defined as a "model 4 hospital" in Ireland).

For clarity, throughout the manuscript, the constitutional name of the state (Ireland) will be used and refers to the 26 counties also known as the "Republic of Ireland".

Methods

Patient and public involvement

The HSE's VTE work and this study have been carried out in close collaboration with our co-author Ann-Marie O'Neill, representing Thrombosis Ireland. Ann-Marie has advised on the design and reporting on the study and will share results with patients and the public via Thrombosis Ireland.

Population and study design

Aims 1-3 were achieved with a retrospective observational study design.

Figure 1 summarises the study methodology for aims 1 and 2, to determine (1) the HA-VTE occurrence rate per 1000 discharges in Ireland and (2) the percentage contribution of each HA-VTE-relevant ICD-10-AM code (**Table 1**) to the overall estimated HA-VTE rate. The population was all patients discharged from a publicly funded hospital in Ireland in 2022, meeting inclusion criteria.

For estimation of (3) the PPV of the HSE HA-VTE, all patients from a single large tertiary referral centre (the Mater Misericordiae University hospital (MMUH), Dublin), identified by the HSE KPI as having HA-VTE and discharged between 1st April 2020 and 31st October 2022, were included (**Figure 2**).

Data source

The data source for this study was the consolidated hospital inpatient enquiry records (HIPE) of all Irish publicly funded acute hospitals.

HIPE data in Ireland are entered and validated at the time of a patient's hospital discharge by trained HIPE coders. Data are extracted from medical records and from standardised discharge forms that are completed by a clinician caring for the patient. Following data entry by HIPE coders at the hospital level, further validation is undertaken by the centralized HSE HIPE Healthcare Pricing Office (HPO).

The Australian modification of ICD-10 (ICD-10-AM) codes is used in HIPE coding for all Irish publicly funded acute hospitals. In HIPE, the term "Primary Diagnosis" is the diagnosis assigned as the principal reason for admission to hospital. The term "Additional Diagnosis" refers to a diagnosis arising or diagnosed during hospitalisation, which includes hospital-acquired conditions.

Development of a national KPI estimating HA-VTE by administrative codes

In 2017 the Acute Hospitals and Quality Improvement Divisions of the Irish HSE were commissioned to commence a workpackage aiming to estimate HA-VTE rates in Irish acute hospitals using administrative codes. A multidisciplinary team was assembled and an iterative process was commenced in order to determine which administrative codes should be included as outlined in the next section.

We based the definition of suspected HA-VTE cases on ICD-10 discharge diagnostic codes for VTE outlined in the UK National Health Service Outcomes Framework (NHSOF) 2013/14 Technical Appendix (table 1), which guided UK-based quality improvement initiatives[3, 7, 16]. We also referred to international VTE measures, including OECD [10], AHRQ [11] and Australian [12] measures, and studies from the United Kingdom [3,7], Sweden [14], Australia [13].

The ICD-10-AM codes used to define HA-VTE in the Irish HSE is outlined in **Table 1**, with UK national recommendations included for context. The rationale for inclusion and exclusion of particular codes is outlined further in **appendix 1**.

Table 1: ICD-10-AM diagnosis Codes (encompassing both pulmonary embolism and deep venous thrombosis) in UK-NHS and Irish HSE-defined HA-VTE events. "x" indicates inclusion and "–" indicates exclusion from the definitions.

ICD-10 Code-AM	Description	HSE HA-VTE definition	UK NHS Outcomes Framework 2013/14 HA-VTE definition
I26.0	Pulmonary embolism with mention of acute cor pulmonale	**x**	**x**
I26.9	Pulmonary embolism without mention of acute cor pulmonale	**x**	**x**
I80.0	Phlebitis/thrombophlebitis superficial vessels lower extremities	-	**x**
I80.1	Phlebitis and thrombophlebitis of femoral vein	**x**	**x**
I80.2	Phlebitis and thrombophlebitis of other deep vessels of lower extremities	**x**	**x**
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	**x**	**x**
I80.8	Phlebitis and thrombophlebitis of other sites	**x**	**x**
I80.9	Phlebitis and thrombophlebitis of unspecified site	**x**	**x**
I82.1	Thrombophlebitis migrans	-	**x**
I82.2	Embolism and thrombosis of vena cava	**x**	**x**
I82.3	Embolism and thrombosis of renal vein	-	**x**
I82.8	Embolism and thrombosis of other specified veins	**x**	**x**
I82.9	Embolism and thrombosis of unspecified vein	**x**	**x**
O08.2	Embolism following abortion and ectopic and molar pregnancy	**x**	-
O22.3	Deep phlebothrombosis in pregnancy	-	**x**
O22.9	Venous complication in pregnancy, unspecified	-	**x**

O87.1	Deep phlebothrombosis in the purperium	-	**x**
O87.0	Superficial thrombophlebitis in the puerperium	-	**x**
O87.9	Venous complications in the puerperium, unspecified	-	**x**
O88.2	Obstetric blood clot embolism	**x**	-

Final HSE definition for HA-VTE

The title of the final agreed HSE HA-VTE estimation method, which forms the national KPI, is "Rate of venous thromboembolism (VTE, blood clots) associated with hospitalisation". was calculated for patients discharged in 2022.

The numerator was the number of adult in-patient discharges with a length of stay of ≥ 2 days with an additional diagnosis of VTE *1000. "Additional diagnosis of VTE" was defined as any of the ICD-10-AM codes listed in **Table 1** in positions 2-30. If more than one VTE additional diagnosis code was included in the patient's discharge record, the VTE code in the highest position was the only code included. Inclusion criteria were: inpatient only, length of stay ≥ 2 days (therefore excludes discharges with 0 or 1 overnight stays as VTE occurring in short stays is unlikely to be HA-VTE), age ≥ 16 and non-maternity admission type (elective or emergency only). Maternity and paediatric hospitals were excluded. VTE events managed through an Emergency Department-based ambulatory care pathway were not admitted and therefore not captured in the HIPE dataset. The denominator was the number of adult in-patient discharges with a length of stay of ≥ 2 days in the index month.

Determination of the PPV of the HSE KPI for HA-VTE

In order to estimate the PPV of the Irish HSE-defined KPI, a detailed review of suspected HA-VTE (defined by the HSE KPI) was performed in the MMUH. In this hospital, a VTE committee reporting to the hospital Quality Director performs a monthly detailed multidisciplinary review of all HSE-defined HA-VTE, including a detailed chart review by two consultant haematologists with a specialist interest in VTE, a quality manager, a senior pharmacist, thrombosis nursing staff and multidisciplinary clinical fellows. This represents the gold standard for VTE diagnosis.

The number of true and false positive HA-VTE events are determined on a monthly basis. The PPV was defined as the number of true positive events (predicted by administrative codes to represent HA-VTE and subsequently objectively verified to represent HA-VTE) divided by the sum of true positive events and false positive events (the latter being predicted by administrative codes to represent HA-VTE but subsequently determined not to be HA-VTE upon review). The reasons for false positive HA-VTE codes were recorded.

Additional analyses

To estimate the contribution of dual VTE diagnosis at admission (PE and DVT codes, with one coded appropriately in an additional diagnosis position but present on admission) to the national HA-VTE

rate, the proportion of patients with a VTE code in an additional diagnosis position but without a VTE code in a primary position were determined for the national VTE data for 2022.

We also reviewed whether the "Hospital-Acquired event" flag available in the HIPE system was a reliable indicator of HA-VTE.

Descriptive statistics

Data were analysed using GraphPad Prism (Horsham, PA, USA). Categorical data in were expressed as proportions and continuous data as mean ± standard deviation (SD) if normally distributed or median ± interquartile range (IQR) if non-normally distributed.

Ethics

Formal Research Ethics Committee approval was not required, as it was a national work programme commissioned by the HSE, reporting from an existing administrative dataset to improve quality and patient safety.

Results

Determination of the overall annual estimated HA-VTE occurrence rate per 1000 discharges using the HSE KPI tool

Between January and December 2022, for inpatients ≥16 years discharged from an acute hospital with a length of stay of ≥ 2 days, the mean (SD) monthly numbers of HA-VTE cases and the number of discharges according to the above criteria were 253 (16) and 22264 (997) respectively. The national mean monthly HA-VTE rate per 1000 discharges (SD) was 11.38 (1.02).

Determination of the percentage contribution of each VTE ICD-10-AM code to the overall estimated HA-VTE rate

The contribution of each VTE ICD-10-AM code to the overall HA-VTE rate is shown in Table 2.

The most commonly occurring VTE codes were: I26.9 (Pulmonary embolism without mention of acute cor pulmonale) accounting for 59% and I80.2 (Phlebitis and thrombophlebitis in other deep vessels of lower extremities) with 22%. I80.1 (Phlebitis and thrombophlebitis of femoral vein) represented 9% and I82.8 (Embolism and thrombosis of other specified veins) accounted for 4%. Although maternity admissions and maternity hospitals were excluded, two cases of obstetric blood clot embolism (O88.2) were recorded, denoting women admitted with a medical or surgical condition while pregnant who developed VTE.

Table 2: Contribution of each ICD-10-AM code to the overall HSE HA-VTE rate

ICD-10-AM Code	Description	Number of cases (Jan-Dec 2022)	Percentage of total HA-VTE (n=3033)
I26.9	Pulmonary embolism without mention of acute cor pulmonale	1,800	59

I80.2	Phlebitis& thrombophlebitis: other deep vessels of lower extremities	674	22
I80.1	Phlebitis and thrombophlebitis of femoral vein	258	9
I82.8	Embolism and thrombosis of other specified veins	128	4
I80.3	Phlebitis and thrombophlebitis of lower extremities, unspecified	65	2
I26.0	Pulmonary embolism with mention of acute cor pulmonale	51	2
I80.8	Phlebitis and thrombophlebitis of other sites	21	1
I82.9	Embolism and thrombosis of unspecified vein	18	1
I80.9	Phlebitis and thrombophlebitis of unspecified site	16	1
O88.2	Obstetric blood clot embolism	2	0
I82.2	Embolism and thrombosis of vena cava	0	0
O08.2	Embolism following abortion and ectopic and molar pregnancy	0	0

Estimation of PPV of the HSE KPI in a large tertiary referral centre

Between April 2020 and October 2022 (inclusive), all HA-VTE events reported for the MMUH by the HSE were reviewed as described in "methods". The median (IQR) number of discharges per month during this time was 1254 (1132-1286). The mean (SD) HSE-defined HA-VTE event monthly rate for the hospital was 18.7 (4.7) per 1000 discharges during this time and the mean absolute number of events per month was 22.53 (5.78). The mean (SD) PPV was 0.37 (0.1), with a range of 0.22-0.56. The commonest reasons for false positive HA-VTE reporting included (a) patients presenting with multiple acute illnesses (including acute VTE), such that the VTE was appropriately coded in an additional diagnosis position, but did not represent a HA-VTE; (b) Prior historical VTE (not present on the current admission but erroneously coded in an additional diagnosis position for the current admission); (c) Dual VTE diagnosis at admission (PE + DVT, with one coded appropriately in an additional diagnosis position while not representing true HA-VTE).

Additional analyses

The mean (SD) hospital proportion of VTE cases with a VTE code in an additional diagnosis position but not in the primary position was 0.89 (0.09). Further work could determine whether this represents a method by which the PPV of the KPI could be improved.

The median proportion of cases per hospital that had the "Hospital-Acquired event" flag assigned was only 0.15 (95% CI 0.05-0.2), suggesting that searching only for cases that have been formally assigned a "hospital-acquired event" flag is an unreliable method for HA-VTE case identification currently.

Discussion

In this study we describe the process through which HA-VTE was defined within the Irish HSE and reviewed of the use of ICD-10-AM codes in the definition of HA-VTE. We report that the national mean (SD) monthly HA-VTE rate according to this definition was 11.38 (1.02) per 1000 discharges. Finally, we report a mean (SD) monthly PPV for the Irish HA-VTE definition of 0.37 (0.1) in a single large tertiary referral centre.

It is well-established that healthcare "big data" do not reach the same precision standards as research data[17]. Administrative data based on ICD codes are inexpensive and readily available, and can provide data pertaining to large numbers of patients with a short timelag before data is available[18]. Healthcare "big data" often inform funding decisions.

These ICD codes were developed to describe the prevalence of causes of morbidity and mortality and have subsequently been used for other purposes, including financial reimbursement and as patient safety measures. The accuracy of administrative data in quantifying clinical events may not always be optimal. Major challenges include clinical and coding interpretation and dependency on the completeness and clarity of clinicians' notes. A lack of overlap between administrative coding and diagnostic test reporting has been reported, with 40% of ICD coded VTE lacking a positive diagnostic test report and 45% of such reports lacking a corresponding ICD code in one study[17]. The HSE KPI is not an absolute measure of true HA-VTE. The rates in a particular setting provide some insights for hospitals in comparing to similar hospitals, and for each hospital tracking its rates over time.

HA-VTE is potentially preventable with risk assessment and implementation of appropriate thromboprophylaxis[3, 19]. The Department of Health in England mandated the use of a VTE risk assessment tool in 2010 through the Commissioning for Quality and Innovation (CQIN) scheme[7, 20]. This patient safety programme has significantly reduced the incidence of and mortality from HA-VTE[3, 7]. An improvement collaborative increased the percentage of patients with appropriate prophylaxis in participating hospitals in Ireland, from 61% to 81%, utilising a quality improvement approach [21]. Introduction of the HSE's KPI was designed to facilitate monitoring of the effect of patient safety efforts over time, with clinical and organisational governance both locally and nationally.

The extent to which administrative data identifies HA-VTE correctly and reliably is an important question. To answer this question, VTE events flagged by administrative codes can be compared with a "gold standard", often review of medical records, determining the PPV[22]. Low PPVs have previously been reported on many occasions, ranging from ~30-80%[15, 18, 23-31]. Even early studies such as Zhan et al suggested that close attention to validity is important when using administrative code-based event rate estimates for safety performance assessment [26]. A recent analysis of data obtained from electronic health records found ICD-10 codes had moderate to high pooled sensitivity (72%) and specificity (82%) for any VTE; higher for PE (91%) than for DVT (58%) [32].

The national mean (SD) monthly HA-VTE rate according to the current HSE definition was 11.38 (1.02) per 1000 discharges. Although similar data is collected elsewhere, comparison is challenging due to lack of public reporting of data and differences in what is reported. A similar rate was found in a cohort study, where 1.2% of medical non-intensive care in-patients developed HA-VTE during or after discharge, with an increasing rate over time [33]. A recent study also reported an increasing incidence over time, with a lower overall incidence of 2.96 in-patient VTE events per 1000 hospitalizations [34].Following hip and knee surgeries, Ireland had 597 VTE cases per 100,000 patients, which is above the OECD average at 467 [10]. UK data reported a VTE rate determined from secondary diagnosis codes of just 1.08 per 1000 discharges in 2006/7, which rose rapidly in 2008, 2009 and 2010 and then declined to 1.21 in 2011, attributed to the patient safety programme in place [2]. A previous Irish study identified potential hospital-acquired VTE by reviewing radiological records, then validating with clinical records, reporting an incidence of 4 cases of true HA-VTE per 1000 discharges [35]. Although a mean of 11.38 patients had one or more HA-VTE codes recorded per 1000 discharges in our study, applying the PPV of 0.37 would yield a similar true HA-VTE rate of 4.22. Commentary in OECD reports suggests that some of the observed variations in DVT rates may be due to differences in diagnostic practices and differences in the way that countries report, code and calculate rates of adverse events. Higher rates may indicate more developed safety monitoring systems and a stronger patient safety culture. Improvements in coding and classification may drive the increased rates noted over time in many of the studies cited above. The usefulness of the HSE HA-VTE currently is largely in measuring rates of HA-VTE over time, to identify patient safety concerns and monitor quality improvement efforts.

Limitations

This study has some limitations. The HSE KPI is not an absolute measure of true HA-VTE, with a high rate of false positives identified in the single-centre study. The KPI examines in-hospital HA-VTE only and does not capture HA-VTE occurring after discharge, resulting in readmission or out-patient management. Readmission to the same hospital with VTE as a primary diagnosis was originally part of the KPI, but data was reported 5 months in arrears, to allow for readmission within 90 days of discharge. This resulted in the KPI being less useful as performance data and the readmission portion was removed from the KPI. The rate of primary VTE admissions is also captured in HIPE data but not as part of the KPI. A proportion of these are readmissions with HA-VTE which occurred after discharge. Out-patient management of VTE is not captured in the HIPE system. Efforts are ongoing to provide a structure through which to capture such events. Further the comparison of data with other countries has a slight caveat, in that they more often than not have electronic and structured documentation. Much of the Irish documentation is a handwritten format and therefore less structured, so extracting data from this can be a challenge.

Future proposed work

Quality improvement initiatives are dependent on robust data. Our reported PPV for HA-VTE highlights the urgent need to improve coding of HA-VTE events, so that data can reliably inform policy on the success of VTE risk reduction protocols. While validation of each case would increase accuracy, it would not currently be feasible nationally.

A multidisciplinary working group has commenced a quality improvement initiative aimed at increasing the PPV of our HA-VTE definition, under the auspices of the National VTE Programme. We report that excluding cases in which VTE is also recorded as a primary diagnosis may reduce the number of false positive HA-VTE reports. Initial proposed Plan-Do-Study-Act (PDSA) cycles may

include provision of guidance to HIPE coding colleagues and to medical practitioners, the introduction of a mandatory "flag" for HA-VTE and integration with National Medical Imaging reports. Improvements in sensitivity and specificity of administrative codes for VTE is anticipated with wider implementation of electronic health records and the likely introduction of a unique patient identifier, facilitating data linkage.

Conclusion

This paper outlines the development and implementation of a National KPI for estimating HA-VTE in Ireland, using ICD-10-AM administrative codes. There are challenges associated with using administrative codes for estimating HA-VTE, revealing the importance of validation and continuous quality improvement initiatives to address national and local variation. Limitations, including potential underestimation of cases due to exclusion of readmissions and exclusion of certain DVT events managed in an ambulatory manner are important considerations.

The clinical, patient and economic impact of VTE is enormous with well-established prevention programmes in other countries. The National Venous Thromboembolism Programme aims to understand and improve VTE prevention, management and treatment. The authors acknowledge the limitations of the current system and highlight the ongoing efforts to enhance the accuracy of HA-VTE data collection in Ireland, anticipating improvements with the future availability of electronic health records. Further examination of national VTE incidence rates and trends is vital.

In conclusion, this paper contributes valuable insights into the development, implementation, and evaluation of a national HA-VTE estimation mechanism in Ireland, emphasizing the need for ongoing refinement and quality enhancement in utilizing administrative codes for patient safety assessments.

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Figure 1. Study methodology for aims 1 and 2

Figure 2. Study methodology for aim 3

Footnotes

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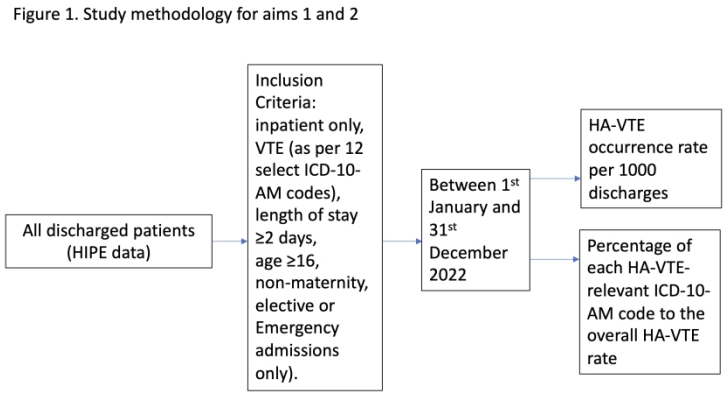

Figure 1. Study methodology for aims 1 and 2

338x190mm (300 x 300 DPI)

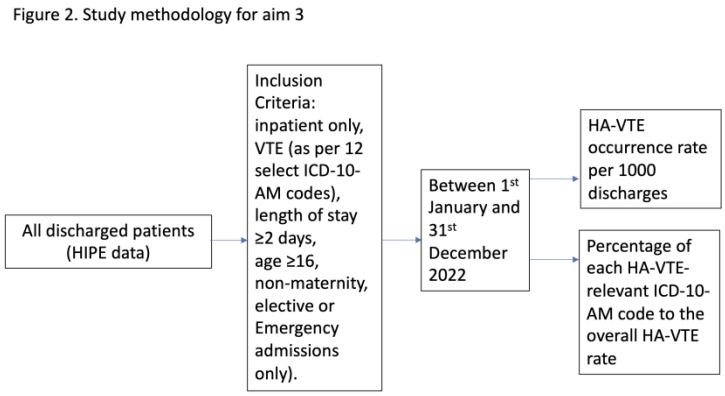

Figure 2. Study methodology for aim 3

338x190mm (300 x 300 DPI)

Supplementary Appendix 1. Further rationale for inclusion and exclusion of codes

We selected codes for consideration with reference to the NHS Outcomes Framework 2013-2014 [16], OECD indicators [10] and Australian hospital-acquired complication specifications [12]. Codes used in international literature from the United Kingdom [3,7], Sweden [14], Australia [13] and AHRQ indicators [11] were also referred to.

We included codes I26.0 (Pulmonary embolism with mention of acute cor pulmonale), I26.9 (Pulmonary embolism without mention of acute cor pulmonale), I80.1 (Phlebitis and thrombophlebitis of femoral vein), I80.2 (Phlebitis and thrombophlebitis of other deep vessels of lower extremities), I80.8 (Phlebitis and thrombophlebitis of other sites) in line with NHS Outcomes Framework [16], OECD [10] and Australian [12] indicators. The HSE included the codes I80.3 (Phlebitis and thrombophlebitis of lower extremities, unspecified) and I80.9 (Phlebitis and thrombophlebitis of unspecified site). These are included in NHS and OECD indicators, but not Australian indicators. The HSE team felt these were core codes used to classify deep venous thrombosis.

We elected to exclude the codes I80.0 (phlebitis/thrombophlebitis superficial vessels lower extremities) and I82.1 (thrombophlebitis migrans), which are included in the UK NHS Outcomes Framework but are not included in OECD and Australian indicators. HIPE stakeholders estimated that the inclusion of these terms would reduce the PPV of the HA-VTE term without improving sensitivity. We felt that miscoding of DVT as either of these terms would be unlikely, while the numerator would be likely to be inflated by the inclusion of superficial vein thrombosis, which is not a true HA-VTE event.

I82.2 (Embolism and thrombosis of vena cava) and I82.9 (Embolism and thrombosis of unspecified vein) were included, in line with NHS but not OECD or Australian indicators. I82.8 (Embolism and thrombosis of other specified veins) was included, in line with the NHS and OECD but not Australian indicators. All were considered to represent HA-VTE.

I82.3 (Embolism and thrombosis of renal vein) was excluded because the working group did not agree that a renal vein thrombosis represented a HA-VTE (in that it is not *both* provoked by hospitalization and theoretically preventable by appropriate administration of thromboprophylaxis).

O08.2 (Embolism following abortion and ectopic and molar pregnancy) *was* included as the team argued that these events *are* procedural/hospitalization-related (the numerator of the HSE KPI would require only those procedures resulting in a hospitalization of at least two days to be included).

O22.3 (Deep phlebothrombosis in pregnancy) was excluded as the overwhelming majority of these cases are not hospital-acquired thrombosis events but rather pregnancy-associated.

O22.9 (Venous complication in pregnancy) was excluded as it was felt to lack specificity and have the potential to reduce the PPV of the HA-VTE KPI.

O87.0 (Superficial thrombophlebitis in the puerperium), O87.1 (Deep phlebothrombosis in the puerperium), and O87.9 (Venous complications in the puerperium, unspecified) were excluded given the far greater likelihood that a woman admitted in the puerperium is admitted solely because of her postpartum state[36]. A VTE occurring in this scenario would be pregnancy/postpartum-provoked rather than a HA-VTE, which is in the scope of a separate project.

O88.2 (Obstetric blood clot embolism) was included as its exclusion was predicted to reduce the sensitivity of the HSE KPI (due to the high predicted likelihood of sole coding of a HA-VTE event occurring in a women who is admitted with a medical condition but is pregnant as this code).