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TITLE PAGE

Why doctors bypass Clinical Decision Support: using a venous thromboembolism risk assessment tool as a case study.

Ugochi Nwulu[1], Hannah Brooks[1], Suzanna Richardson[1], Lorraine McFarland[2] and Jamie J Coleman[1,2]

[1] University Hospitals Birmingham NHS Foundation Trust, Edgbaston, Birmingham, B15 2TH, UK
[2] College of Medical and Dental Sciences, University of Birmingham, Birmingham B15 2SP, UK

Ugochi Nwulu
Senior Research Associate, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Hannah Brooks
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Suzanna Richardson
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Lorraine McFarland
Research Fellow, School of Health and Population Sciences, University of Birmingham, Birmingham, UK

Jamie J Coleman
Senior Lecturer in Clinical Pharmacology, University of Birmingham, Birmingham, UK and Honorary Consultant Physician, University Hospitals Birmingham NHS Foundation Trust, Birmingham UK

Correspondence to: Jamie J Coleman, *Queen Elizabeth Hospital/ University of Birmingham*
Email: j.j.coleman@bham.ac.uk
Telephone: 0121 371 6003, Fax: 0121 626 4587

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ABSTRACT

Background

The underutilisation of venous thromboembolism (VTE) prophylaxis is still a problem in the United Kingdom despite the emergence of national guidelines and incentives to increase the number of patients undergoing VTE risk assessments. In our hospital setting, the completion of the VTE risk assessment form introduced into the hospital-wide electronic prescribing and health records system is mandatory. Despite this feature providing active support, there is still a problem with doctors not prescribing pharmacological thromboprophylaxis once recommended by the risk assessment tool.

Objective

To examine the reasons doctors gave for not prescribing enoxaparin when recommended by an electronic VTE risk assessment alert.

Methods

We extracted data over a 7-month period in 2012 from the audit database of a hospital-wide electronic prescribing system. Free text reasons for not prescribing enoxaparin when recommended were thematically coded.

Results

A total of 1136 free text responses were collected in the time period and 1206 separate reasons were analysed and coded. 389 reasons (32.3%) for not prescribing enoxaparin were coded as being due to 'clinical judgment'; in 288 (23.9%) of the responses doctors were going to reassess the patient or prescribe enoxaparin; and in 245 responses (20.3%) the system was seen to have produced an inappropriate alert.

Conclusions

In order to increase specificity of warnings and avoid users developing alert fatigue, it is essential that an evaluation of user responses and / or end user feedback as to the appropriateness and timing of alerts is obtained.

ARTICLE SUMMARY

Strengths and Limitations of this Study

- This study addresses an important topic, as VTE prophylaxis is not always prescribed as recommended in secondary care
- The hospital in the study has its own locally-developed electronic prescribing system with embedded clinical decision support (CDS) in which alerts are specifically designed to encourage VTE prophylaxis (e.g. prescribing of enoxaparin)
- The study used data collected immediately after the implementation of a unique free-text feature within the CDS system, in which doctors can provide reasons for not prescribing enoxaparin
- The data has allowed us to highlight a number of strengths and limitations of using CDS to encourage doctors to appropriately prescribe enoxaparin in secondary care
- However, we are unable to determine whether responses that were provided were reliable and we were unable to take into account cases in which no free-text response was provided

INTRODUCTION

The early identification of patients at risk of venous thromboembolism (VTE) and prescription of prophylaxis, where appropriate, are important measures in preventing the morbidity and mortality associated with hospital-acquired Deep Vein Thrombosis (DVT) and / or Pulmonary Embolism (PE). VTE contributes to up to 10% of hospital deaths [1 2] and it is estimated that 25 000 people in the UK die each year from preventable hospital-acquired VTE [3]. In the past decade, evidence-based guidelines outlining the importance of VTE prevention have been published internationally [4-7]. In England, there has been an increased emphasis on programmes to educate clinicians and to incentivise hospital trusts to increase VTE risk assessment completion on admission. From June 2010, the Commissioning for Quality and Innovation (CQUIN) payment framework required all acute trusts in the UK to assess 90% of patients admitted for the risk of VTE in order to receive 1.5% of their funding. [8] The Care Quality Commission is responsible for monitoring NHS trusts' performance on the new Quality Standards throughout the UK and collects data each month on the number of VTE risk assessments completed. [9] Despite the increase in VTE risk assessment completion, VTE prophylaxis is still underutilised and there is some evidence of poor adherence to the published guidelines. [10-13]

In the UK, computer-based rather than paper-based Clinical Decision Support (CDS) is gaining popularity as a way of prompting or guiding clinicians in the secondary care setting to prescribe appropriately. Changes to physicians'adherence to processes of care by computer reminders have been found to be modest on the whole [14] but electronic alerts and computerized CDS have been found to increase the prescription of thromboprophylaxis in hospitalised medical patients. [15-18] While other studies have been undertaken to understand why physicians do not follow clinical guidelines [19] and VTE prophylaxis guidelines specifically, [20] few have been able to ask clinicians why prophylaxis has not been prescribed at the point of recommendation.

In this study, we were interested doctors' responses to a mandatory free text field completion when acknowledging a decision support alert specific to the circumstance when a VTE risk assessment suggests prophylaxis but no prescription was completed. Nearly every patient (99%) admitted to this hospital now has their risk of developing

VTE assessed on admission [21]. However, a trust audit in 2010 found that enoxaparin was not prescribed in 38% of cases when recommended by the electronic risk assessment. We wanted to identify cases where the system was alerting inappropriately and we wished to identify where the system could lead to user frustration and 'work-arounds' being employed to save time and ease the workload.

METHODS

This study was conducted under the umbrella of a larger research project funded by the National Institute for Health Research, for which ethical approval was gained. This study involved the use of secondary data collected in the course of normal care and had no patient identifiers or patient-sensitive information so was anonymised to the researchers at the point of access.

Setting

This study was conducted in a large NHS university hospital, which has a locally-developed electronic prescribing system known as PICS (Prescribing, Information and Communication System). PICS is in operation throughout all (approximately 1200) inpatient beds and for all prescribing. The system was first installed in the renal unit 15 years ago [22] and now covers general and specialist medical and surgical specialties. For the purpose of this study a key feature of the system is that all information about prescriptions and dose administrations are exported to a comprehensive audit database on a weekly basis.

The hospital has prioritized measures to reduce the occurrence of hospital-acquired VTE over the last few years. In June 2008 a VTE risk assessment tool was introduced into PICS with an alert issued to remind doctors if the risk assessment was not completed. From June 2010 in line with the national guidelines and data collection, the completion of the VTE risk assessment within the trust became mandatory for every admitted patient. The assessment has to be completed before the patient record and drug prescribing is enabled for that admission. Following the completion of the risk assessment, a scheduled decision support rule is run in PICS that reviews the current prescriptions for each patient and automatically generates an alert where, as indicated by the risk assessment, enoxaparin should be prescribed but is not currently prescribed. This initial alert is displayed to the first prescriber to view the patient's

medical records on PICS (this process is summarized in Figure 1) and requires a written free text response to explain why enoxaparin has not been prescribed (see Figure 2).

Data capture

Our outcome was the reason given for not prescribing enoxaparin where recommended by the VTE risk assessment. These responses were obtained from the enoxaparin free text alert shown in Figure 2. Data were extracted from the PICS audit database on all enoxaparin alerts generated between 1st June 2012 and 31st December 2012. The anonymized data were extracted into Excel for analysis.

Analysis

Four reviewers (UN, HB, SR and LMcF) independently conducted preliminary content analysis of the respondents' reasons for not prescribing enoxaparin. Themes were allowed to emerge from the data in an iterative process, with initial themes informing and contextualising subsequent themes and vice versa. The reviewers then met to discuss their analyses and sought to reach consensus where reasons were unclear. A consultant physician (JJC) provided clinical context to reasons that the reviewers found difficult to categorize. The four reviewers then independently coded the data. Whole group discussion was used to refine coding and to identify over-arching themes which helped to group subordinate themes, until consensus was reached. Representation of each theme is given as actual number of reasons observed (some responders gave more than one reason) and percentage of total reasons provided.

RESULTS

During the seven-month time period, a total of 1136 free text responses were provided in response to the enoxaparin alert. Some responses contained multiple reasons. As such, a total of 1206 reasons were recorded and coded.

Six main themes were identified from the reasons provided for not having prescribed enoxaparin. These themes and the number of reasons coded within each theme are displayed in Table 1.

Table 1 - Frequency of reasons for not prescribing enoxaparin by theme

Reasons for not prescribing enoxaparin (by theme)	Number of responses	Percentage of all responses
Clinical judgment	389	32.3%
Positive response initiated	287	23.8%
System	246	20.4%
Surgery	139	11.5%
Ambiguous	81	6.7%
Drug contraindication	64	5.3%
Total	*1206*	*100%*

The reviewers coded 23.8% of the responses provided as 'positive response initiated'. Here, doctors indicated that they would go on to prescribe enoxaparin after having read the message or that they would review the patient's VTE risk as a result of the message. Examples of responses are: *"will review"*; *"will prescribe"*; *"oversight – prescribed by myself today"*.

The most common type of reason given for not prescribing enoxaparin was due to 'clinical judgment', and represents 32.3 % of the reasons given. The 'clinical judgment' theme can be further broken down into 5 main categories: clinical reason; patient mobile; patient discharged or soon to be discharged; patient at risk of bleeding; and patient at risk of falls. The distribution of these reasons (as a percentage of all clinical judgment coded reasons) can be seen in Table 2. The category of 'clinical reason' refers to a broad range of reasons which are either:

- An explicit clinical judgment, e.g. *"not required"*, *"end of life care. no benefit from enoxaparin"* and *"consultant decision"*;
- Situation-specific such as *"liver failure"*, *"stroke"* and *"bleeding ulcer "*or
- Where further information was needed before a full assessment could be made *"clinical information still pending"*, *"awaiting blood results"* and *"low Hb ?cause"*.

Table 2 - Frequency of reasons for not prescribing enoxaparin within the theme 'clinical judgment'

Clinical judgment reasons for not prescribing enoxaparin	Number of responses	Percentage of all responses
Clinical reason	120	30.8%
Patient mobile	111	28.5%
Discharge*	84	21.6%
Risk of bleeding**	64	16.5%
Falls risk	10	2.6%
Total	*389*	*100%*

* Patient about to be discharged or had been discharged by time of alert

**Patient under investigation for bleeding risk or known condition

One in five reasons were coded as 'system' and reflect those alerts deemed as being generated inappropriately or caused by a system error which led to the production of the alert. Responses coded as 'system' often reflected cases where enoxaparin had been prescribed after the alert had been generated on day 1, but before a reason had been given. If the rules-based alert is ignored or closed, it will continue to appear to subsequent prescribers logging in to the patient record. Currently the rules-base alert is not cancelled by the system automatically if an appropriate prescription is made in the interim. Examples of free text responses include *"already prescribed"*, *"it is"*, *"has been"* and *"enoxaparin prescribed"*. In some cases the free text reason was indicative of users' frustrations with these persistent alerts. For example, this was demonstrated by the use of multiple exclamation marks in 29 out of 246 (11.8%) 'system' reasons. Furthermore, some users overtly stated their frustration with the alert, for example, *"It's been prescribed so this message is something of a frustration* "and *"It is prescribed - PICS giving false warning x 3"*.

The theme 'surgery' (11.5% of reasons given) refers to the patient being in the peri-operative period or undergoing a specific surgical procedure where it was thought that prescribing enoxaparin was not appropriate. For example, free text responses included

"not meant to have until enox 23 hours post surgery - according to protocol", "post operative – for review" and *"on theatre list today"*. Additionally, some reasons alluded to inappropriate prescribing of enoxaparin as a result of the patient's postoperative condition: *"late operation yesterday with post-op haematoma"* and *"Post neurosurgery. Bleeding around EVD site"*.

The theme 'ambiguous' (6.7% of responses) refers to cases which did not relate to a clinical indication or process such as *"not yet reviewed"* or *"patient not known to me"* or simply *"don't know"*. Finally, 5.3% of the reasons were coded as 'drug contraindication' as the patient had (since the VTE risk assessment) been prescribed a drug with a similar action, such as warfarin or heparin. The rules-base does not check for such prescriptions, as the risk assessment is specific in recommending enoxaparin.

DISCUSSION

The system succeeded in prompting either a repeat review of the patient or prescription of enoxaparin where it had been overlooked or delayed in a quarter of cases. In these cases the alert produced the positive response that was intended by its implementation.

The main reasons for not prescribing enoxaparin when recommended were due to 'clinical judgment'. As the use of any such tool is not intended to replace clinical judgment, we would have expected that clinicians would delay or avoid prescribing VTE prophylaxis until the patient has been fully assessed. The tool is, however, designed to provide decision support deemed appropriate for the majority of cases. It may be prudent to wait until test results return and a more complete picture emerges of the patient's condition. Clearly complete compliance with the recommendations before all information is assessed would be just as dangerous as poor compliance.

Where the system or process does not seem to work as well is when it produces a seemingly inappropriate alert. Of concern were the responses (20.4%) that indicated doctors felt there had been a system error which had led to inappropriate or inaccurate alert generation. A lack of specificity in the alerting process can result in doctors unnecessarily being alerted when, for example, a patient has already been prescribed a

lower than recommended dose of enoxaparin as per their therapeutic needs or where enoxaparin is not prescribed as the patient is to undergo surgery.

Despite the risk assessment algorithm incorporating details of the surgery the patient was about to have (alongside the likely duration and likelihood of decreased mobility) 11% of the reasons for not prescribing were due to the timing of the surgery and the type of surgery. Surgical VTE risk assessments require a complex algorithm to capture the types of surgery, the patient's condition and risks of bleeding therein. The electronic risk assessment is completed within the first few hours of admission and it would seem from the responses that the delay or avoidance in prescribing enoxaparin stems from perceived risk of major bleeding linked with certain surgical procedures and with the timing of the alert. When alerts are produced preoperatively there may be an expectation that VTE prophylaxis will be given in theatre after surgery or in cases where the alert is read postoperatively the patient has returned to the ward after having been administered a VTE prophylaxis as per protocol or indeed may have postoperative complications that rule out pharmacological prophylaxis. An established parallel system exists for surgical patients outside of the ward area and the timing of the free text and daily reminder alerts produced will not be sensitive to timing issues (e.g. delayed theatre list) or changes in a patient's risk of bleeding (e.g. postoperative complications).

This lack of specificity of the alerts produced by the VTE risk assessment leads to the question of whether is it better to have irrelevant alerts rather than no alerts. Specificity could be increased by including a check for prescriptions of warfarin or heparin as contraindications to prescribing enoxaparin or preventing the generation of the alert no matter what dosage of enoxaparin is prescribed. This would reduce the number of alerts produced where an alternative anticoagulant is already prescribed or where enoxaparin is prescribed at a different dosage, thereby reducing inappropriate alerting. It is noteworthy that a prescription of warfarin or patient being already given anticoagulants is part of the VTE risk assessment process - and the presence of this would contraindicate enoxaparin and suppress subsequent alerts.

Timing of the alert can be an issue, for example when clinicians are presented with the free text alert even when an enoxaparin prescription is visible on the system. To the clinician the alert has been generated inappropriately, but this does not provide a

full picture. To note, the system only cross-checks for an enoxaparin prescription once per day at 07:30AM. Therefore, when the free text alert (Figure 2) is bypassed on day 1 (so called 'third-party ignore'), it will be shown again on day 1 to other (or the same) clinicians who next access the patient's record regardless of whether enoxaparin has since been prescribed. For example, if an enoxaparin prescription has been written during the morning ward round and no response entered to the free text alert, the alert will still be shown the next time the patient's record is accessed. As long as no free-text response is entered that day and enoxaparin has not been prescribed, the daily reminder (Figure 3) and the free text alert will reappear on day 2 when the system cross-checks the prescription data. Despite causing some frustration, allowing third-party dismissal of alerts means that it can still be visible to clinicians directly responsible for the patient's care. This frustration may be unavoidable in some cases as the alert is presented to anyone with authorisation to prescribe. In the case of bank /locum doctors or those who are not familiar with the patient, they may be unaware of the reason that enoxaparin has not been prescribed and therefore may not respond appropriately (e.g. they may just be logging onto PICS to familiarise themselves with the patient prior to meeting them). The only way to truly avoid this is to change the system to check for a prescription prior to each presentation of the alert.

What is of concern is the likelihood of fatigue due to excessive alerts and workarounds especially when the mechanisms behind the alert generation are not understood. We found 4 examples in the data of clinicians entering full stops in the free text field to make the alert recede (3 by the same clinician). Frustration is often secondary to inappropriate use of the system, for example, failure to acknowledge alerts even when doing the correct thing or not noting options in the risk assessment which would suppress future alerts.

Limitations

In this research we have obtained information regarding the real time reasons and feedback from responses left during the workflow about user experiences and how the VTE alerts within our CPOE system are understood. What is particularly useful is that we have examined data regarding the free text alerts for the first 7 months after its initial implementation, meaning that our findings will allow us to feedback and make

changes to the system if and where appropriate. This evaluation of our own system may lead to improvements which we can then share with other system providers.

Nonetheless, in this study we are unable to take into account those cases in which no free text response was provided at all. Furthermore, from our data we are unable to determine whether the responses that are provided by doctors are reliable (i.e. honest) or if there are more complex reasons behind not having prescribed enoxaparin. For example, some responses are written in capital letters and it is not possible to tell whether this is done due to frustration or whether it is a default by the keyboard that the doctor is using. Other incomplete responses meant that we were not provided with information that we could utilise in our analysis.

To follow on from this research, it would be useful to organise discussion groups or forums in which doctors can verbally discuss their perceptions of the VTE alerts (and perhaps decision support warnings more generally) and provide some more context to their responses. Alternatively, it may be interesting to shadow doctors on the ward and observe their response as they use the system and as alerts are generated. Furthermore, it might be useful to investigate the process of VTE assessment and appropriate anticoagulant prescription for surgical patients in more detail. This might help to establish whether it may be necessary to design a parallel system for these patients, which may lead to the prescription being made/decision not to prescribe due to the time of surgery. Finally, it might be interesting to utilize stealth alerts/ stealth processes [23] through a third party in order to alert the patient's regular doctor/consultant to a lack of VTE prophylaxis or, for example, alert a pharmacist to check the dose where an enoxaparin prescription is present but the dose is not what would normally be recommended.

CONCLUSION

This study examined the free text reasons given by doctors when they have not yet prescribed the prophylaxis suggested by the VTE risk assessment tool. The analysis shows that doctors bypass the recommendations because they are rationalizing the VTE risk and use of prophylaxis on the emerging picture of the patient's condition on one hand and they become frustrated with the system because of lack of training on

the other. Understanding why doctors use work-arounds will enable healthcare providers to modify systems or training programmes to reduce alert fatigue whilst optimising the appropriateness of CDS alerts.

Contributorship Statement

All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. UN was involved in the study conception and design and the data coding and analysis. UN was also involved in the drafting and revision of the manuscript. HB was involved in the study conception and design and the data coding and analysis. HB was also involved in the drafting and revision of the manuscript. SR was involved in the study conception and design and the data coding and analysis. SR was also involved in the drafting and revision of the manuscript. LM was involved in the study conception and design and the data coding and analysis. LM was also involved in the drafting and revision of the manuscript. JC was involved in the study conception and design, and the data analysis. JC was also involved in the drafting and revision of the manuscript. All authors contributed to the writing of the manuscript, the interpretation of data, and approved the final version.

Data Sharing Statement

Additional data relating to the free text responses and the coding process is available by emailing Dr. Jamie Coleman.

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Competing Interest Statement

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) (JJC) (1) Financial support for the submitted work was obtained from the National Institute of Health Research CLAHRC for the West Midlands and Black Country. (2) JJC works within the University Hospital Birmingham NHS Foundation Trust which is collaborating with CSE Healthcare Systems to commercialise the PICS system in the UK. All other authors report no

financial relationships with commercial entities that might have an interest in the submitted work; (3) No spouses, partners, or children of the authors have relationships with commercial entities that might have an interest in the submitted work; (4) None of the authors have non-financial interests that may be relevant to the submitted work

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Figure 1 - Flow diagram of VTE alert production

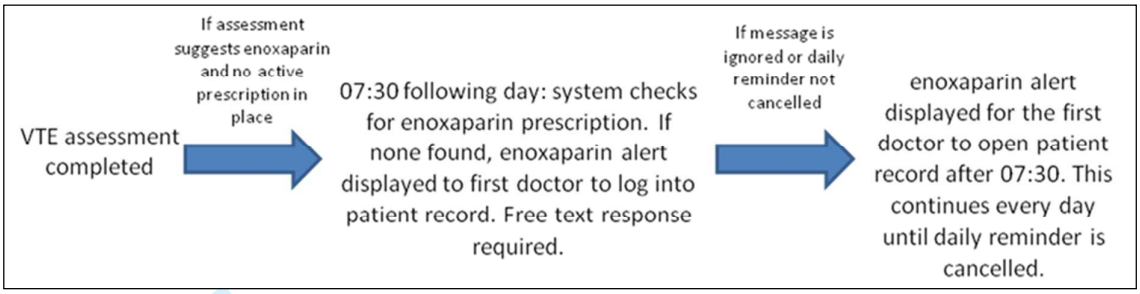


Figure 2 - Initial enoxaparin alert (free text alert)

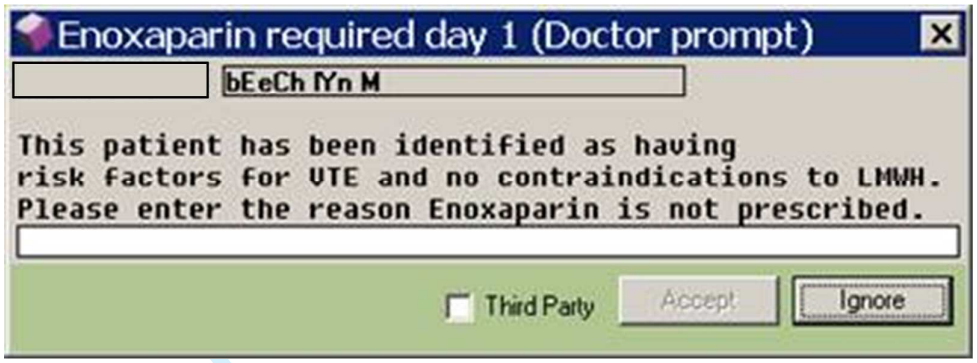
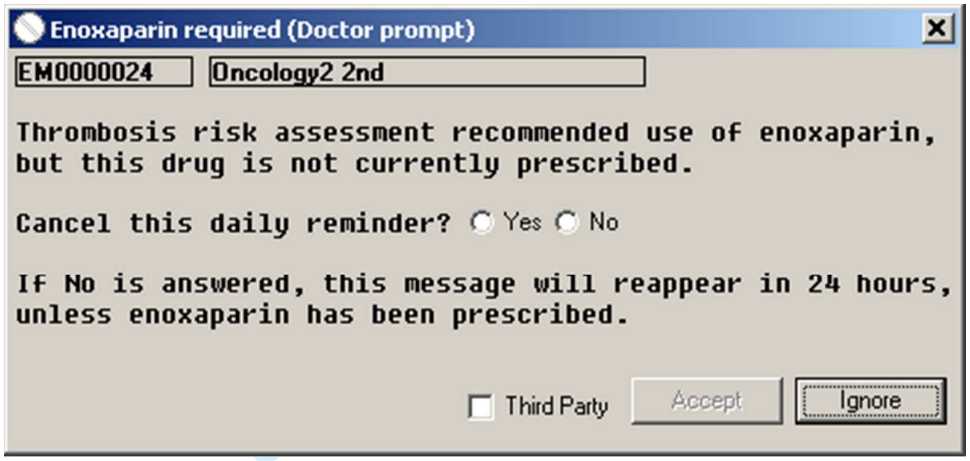


Figure 3 -Subsequent enoxaparin alert



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Electronic risk assessment for venous thromboembolism: investigating physicians' rationale for bypassing clinical decision support recommendations

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TITLE PAGE

Electronic risk assessment for venous thromboembolism: investigating physicians' rationale for bypassing clinical decision support recommendations

Ugochi Nwulu[1], Hannah Brooks[1], Suzanna Richardson[1], Lorraine McFarland[2] and Jamie J Coleman[1,2]

[1] University Hospitals Birmingham NHS Foundation Trust, Edgbaston, Birmingham, B15 2TH, UK
[2] College of Medical and Dental Sciences, University of Birmingham, Birmingham B15 2SP, UK

Ugochi Nwulu
Senior Research Associate, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Hannah Brooks
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Suzanna Richardson
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Lorraine McFarland
Research Fellow, School of Health and Population Sciences, University of Birmingham, Birmingham, UK

Jamie J Coleman
Senior Lecturer in Clinical Pharmacology, University of Birmingham, Birmingham, UK and Honorary Consultant Physician, University Hospitals Birmingham NHS Foundation Trust, Birmingham UK

Correspondence to: Jamie J Coleman, *Queen Elizabeth Hospital/ University of Birmingham*
Email: j.j.coleman@bham.ac.uk
Telephone: 0121 371 6003, Fax: 0121 626 4587

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ABSTRACT

Objective

The underutilisation of venous thromboembolism (VTE) prophylaxis is still a problem in the United Kingdom despite the emergence of national guidelines and incentives to increase the number of patients undergoing VTE risk assessments. Our objective was to examine the reasons doctors gave for not prescribing enoxaparin when recommended by an electronic VTE risk assessment alert.

Design

We used a qualitative research design to conduct a thematic analysis of free text entered into an electronic prescribing system.

Setting

The study took place in a large University teaching hospital, which has a locally-developed electronic prescribing system known as PICS (Prescribing, Information and Communication System).

Participants

We extracted prescription data from all inpatient admissions over a 7-month period in 2012 using the audit database of PICS.

Intervention

The completion of the VTE risk assessment form introduced into the hospital-wide electronic prescribing and health records system is mandatory. Where doctors do not prescribe VTE prophylaxis when recommended they are asked to provide a reason for this decision. The free text field was introduced in May 2012.

Primary and secondary outcome measures

Free text reasons for not prescribing enoxaparin when recommended were thematically coded.

Results

A total of 1136 free text responses from 259 doctors were collected in the time period and 1206 separate reasons were analysed and coded. 389 reasons (32.3%) for not prescribing enoxaparin were coded as being due to 'clinical judgment'; in 288 (23.9%) of the responses doctors were going to reassess the patient or prescribe enoxaparin; and in 245 responses (20.3%) the system was seen to have produced an inappropriate alert.

Conclusions

In order to increase specificity of warnings and avoid users developing alert fatigue, it is essential that an evaluation of user responses and / or end user feedback as to the appropriateness and timing of alerts is obtained.

ARTICLE SUMMARY

Strengths and Limitations of this Study

- This study addresses an important topic, as VTE prophylaxis is not always prescribed as recommended in secondary care
- The hospital in the study has its own locally-developed electronic prescribing system with embedded clinical decision support (CDS) in which alerts are specifically designed to encourage VTE prophylaxis (e.g. prescribing of enoxaparin)
- The study used data collected immediately after the implementation of a unique free-text feature within the CDS system, in which doctors can provide reasons for not prescribing enoxaparin
- The data has allowed us to highlight a number of strengths and limitations of using CDS to encourage doctors to appropriately prescribe enoxaparin in secondary care
- However, we are unable to determine whether responses that were provided were reliable and we were unable to take into account cases in which no free-text response was provided

INTRODUCTION

The early identification of patients at risk of venous thromboembolism (VTE) and prescription of prophylaxis, where appropriate, are important measures in preventing the morbidity and mortality associated with hospital-acquired Deep Vein Thrombosis (DVT) and / or Pulmonary Embolism (PE). VTE contributes to up to 10% of hospital deaths [1 2] and it is estimated that 25 000 people in the UK die each year from preventable hospital-acquired VTE. [3] In the past decade, evidence-based guidelines outlining the importance of VTE prevention have been published internationally [4-7]. In England, there has been an increased emphasis on programmes to educate clinicians and to incentivise hospital trusts to increase VTE risk assessment completion on admission. From June 2010, the Commissioning for Quality and Innovation (CQUIN) payment framework required all acute trusts in the UK to assess 90% of patients admitted for the risk of VTE in order to receive 1.5% of their funding. [8] The Care Quality Commission is responsible for monitoring NHS trusts' performance on the new Quality Standards throughout the UK and collects data each month on the number of VTE risk assessments completed. [9] Despite the increase in VTE risk assessment completion, VTE prophylaxis is still underutilised and there is some evidence of poor adherence to the published guidelines. [10-13]

In the UK, computer-based rather than paper-based Clinical Decision Support (CDS) is gaining popularity as a way of prompting or guiding clinicians in the secondary care setting to prescribe appropriately. Changes to physicians'adherence to processes of care by computer reminders have been found to be modest on the whole [14] but electronic alerts and computerized CDS have been found to increase the prescription of thromboprophylaxis in hospitalised medical patients. [15-18] While other studies have been undertaken to understand why physicians do not follow clinical guidelines [19] and VTE prophylaxis guidelines specifically, [20] few have been able to ask clinicians why prophylaxis has not been prescribed at the point of recommendation.

In this study, we were interested doctors' responses to a mandatory free text field completion when acknowledging a decision support alert specific to the circumstance when a VTE risk assessment suggests prophylaxis but no prescription was completed. Nearly every patient (99%) admitted to this hospital now has their risk of developing

VTE assessed on admission. [21] However, the trust quality report from 2012-13 identified that enoxaparin was not prescribed in 34.1% of cases when recommended by the electronic risk assessment. [22] We wanted to identify cases where the system was alerting inappropriately and we wished to identify where the system could lead to user frustration and 'work-arounds' being employed to save time and ease the workload.

METHODS

This study was conducted under the umbrella of a larger research project funded by the National Institute for Health Research, for which ethical approval was gained. This study involved the use of secondary data collected in the course of normal care and had no patient identifiers or patient-sensitive information so was anonymised to the researchers at the point of access.

Setting

This study was conducted in a large NHS university hospital, which has a locally-developed electronic prescribing system known as PICS (Prescribing, Information and Communication System). PICS is in operation throughout all (approximately 1200) inpatient beds and for all prescribing. The system was first installed in the renal unit 15 years ago [23] and now covers general and specialist medical and surgical specialties. For the purpose of this study a key feature of the system is that all information about prescriptions and dose administrations are exported to a comprehensive audit database on a weekly basis.

The hospital has prioritized measures to reduce the occurrence of hospital-acquired VTE over the last few years. In June 2008 a VTE risk assessment tool was introduced into PICS with an alert issued to remind doctors if the risk assessment was not completed. From June 2010 in line with the national guidelines and data collection, the completion of the VTE risk assessment within the trust became mandatory for every admitted patient. The assessment has to be completed before the patient record and drug prescribing is enabled for that admission. Following the completion of the risk assessment, a scheduled decision support rule is run in PICS that reviews the current prescriptions for each patient and automatically generates an alert where, as indicated by the risk assessment, enoxaparin should be prescribed but is not currently

prescribed. This initial alert is displayed to the first prescriber to view the patient's medical records on PICS (this process is summarized in Figure 1) and requires a written free text response to explain why enoxaparin has not been prescribed (see Figure 2). Further details about the electronic VTE risk assessment process are provided in Appendix A.

Data capture

Our outcome was the reason given for not prescribing enoxaparin where recommended by the VTE risk assessment. These responses were obtained from the enoxaparin free text alert shown in Figure 2. Data were extracted from the PICS audit database on all enoxaparin alerts generated between 1st June 2012 and 31st December 2012. The anonymized data were extracted into Excel for analysis.

Analysis

Four reviewers (UN, HB, SR and LMcF) independently conducted preliminary content analysis of the respondents' reasons for not prescribing enoxaparin. Themes were allowed to emerge from the data in an iterative process, with initial themes informing and contextualising subsequent themes and vice versa. The reviewers then met to discuss their analyses and sought to reach consensus where reasons were unclear. A consultant physician (JJC) provided clinical context to reasons that the reviewers found difficult to categorize. The four reviewers then independently coded the data. Whole group discussion was used to refine coding and to identify over-arching themes which helped to group subordinate themes, until consensus was reached. Representation of each theme is given as actual number of reasons observed (some responders gave more than one reason) and percentage of total reasons provided.

RESULTS

During the seven-month time period there were 37,737 admissions to the hospital. Based on figures from the Trust quality account, approximately 37,340 (99%) would have received a VTE risk assessment. A total of 1136 free text responses were provided from 259 doctors in response to the enoxaparin alert, which equates to 9% of the approximately 12,740 (34.1%) who were not prescribed enoxaparin when

recommended. Some responses contained multiple reasons. As such, a total of 1206 reasons were recorded and coded.

Six main themes were identified from the reasons provided for not having prescribed enoxaparin. These themes and the number of reasons coded within each theme are displayed in Table 1.

Table 1 - Frequency of reasons for not prescribing enoxaparin by theme

Reasons for not prescribing enoxaparin (by theme)	Number of responses	Percentage of all responses
Clinical judgment	389	32.3%
Positive response initiated	287	23.8%
System	246	20.4%
Surgery	139	11.5%
Ambiguous	81	6.7%
Drug contraindication	64	5.3%
Total	*1206*	*100%*

The reviewers coded 23.8% of the responses provided as 'positive response initiated'. Here, doctors indicated that they would go on to prescribe enoxaparin after having read the message or that they would review the patient's VTE risk as a result of the message. Examples of responses are: *"will review"*; *"will prescribe"*; *"oversight – prescribed by myself today"*.

The most common type of reason given for not prescribing enoxaparin was due to 'clinical judgment', and represents 32.3 % of the reasons given. The 'clinical judgment' theme can be further broken down into 5 main categories: clinical reason; patient mobile; patient discharged or soon to be discharged; patient at risk of bleeding; and patient at risk of falls. The distribution of these reasons (as a percentage of all clinical judgment coded reasons) can be seen in Table 2. The category of 'clinical reason' refers to a broad range of reasons which are either:

- An explicit clinical judgment, e.g. *"not required"*, *"end of life care. no benefit from enoxaparin"* and *"consultant decision"*;

- Situation-specific such as *"liver failure"*, *"stroke"* and *"bleeding ulcer "*or
- Where further information was needed before a full assessment could be made *"clinical information still pending"*, *"awaiting blood results"* and *"low Hb ?cause"*.

Table 2 - Frequency of reasons for not prescribing enoxaparin within the theme 'clinical judgment'

Clinical judgment reasons for not prescribing enoxaparin	Number of responses	Percentage of all responses
Clinical reason	120	30.8%
Patient mobile	111	28.5%
Discharge*	84	21.6%
Risk of bleeding**	64	16.5%
Falls risk	10	2.6%
Total	*389*	*100%*

* Patient about to be discharged or had been discharged by time of alert

**Patient under investigation for bleeding risk or known condition

One in five reasons were coded as 'system' and reflect those alerts deemed as being generated inappropriately or caused by a system error which led to the production of the alert. Responses coded as 'system' often reflected cases where enoxaparin had been prescribed after the alert had been generated on day 1, but before a reason had been given. If the rules-based alert is ignored or closed, it will continue to appear to subsequent prescribers logging in to the patient record. Currently the rules-base alert is not cancelled by the system automatically if an appropriate prescription is made in the interim. Examples of free text responses include *"already prescribed"*, *"it is"*, *"has been"* and *"enoxaparin prescribed"*. In some cases the free text reason was indicative of users' frustrations with these persistent alerts. For example, this was demonstrated by the use of multiple exclamation marks in 29 out of 246 (11.8%) 'system' reasons. Furthermore, some users overtly stated their frustration with the

alert, for example, *"It's been prescribed so this message is something of a frustration* "and *"It is prescribed - PICS giving false warning x 3"*.

The theme 'surgery' (11.5% of reasons given) refers to the patient being in the peri-operative period or undergoing a specific surgical procedure where it was thought that prescribing enoxaparin was not appropriate. For example, free text responses included *"not meant to have until enox 23 hours post surgery - according to protocol", "post operative – for review"* and *"on theatre list today".* Additionally, some reasons alluded to inappropriate prescribing of enoxaparin as a result of the patient's postoperative condition: *"late operation yesterday with post-op haematoma"* and *"Post neurosurgery. Bleeding around EVD site"*.

The theme 'ambiguous' (6.7% of responses) refers to cases which did not relate to a clinical indication or process such as *"not yet reviewed"* or *"patient not known to me"* or simply *"don't know"*. Finally, 5.3% of the reasons were coded as 'drug contraindication' as the patient had (since the VTE risk assessment) been prescribed a drug with a similar action, such as warfarin or heparin. The rules-base does not check for such prescriptions, as the risk assessment is specific in recommending enoxaparin.

DISCUSSIONIn a quarter of cases where a free text response was provided the system succeeded in prompting either a repeat review of the patient or prescription of enoxaparin where it had been overlooked or delayed. In these cases the alert produced the positive response that was intended by its implementation.

The main reasons for not prescribing enoxaparin when recommended were due to 'clinical judgment'. As the use of any such tool is not intended to replace clinical judgment, we would have expected that clinicians would delay or avoid prescribing VTE prophylaxis until the patient has been fully assessed. The tool is, however, designed to provide decision support deemed appropriate for the majority of cases. It may be prudent to wait until test results return and a more complete picture emerges of the patient's condition. Clearly complete compliance with the recommendations before all information is assessed would be just as dangerous as poor compliance.

Where the system or process does not seem to work as well is when it produces a seemingly inappropriate alert. Of concern were the responses (20.4%) that indicated

doctors felt there had been a system error which had led to inappropriate or inaccurate alert generation. A lack of specificity in the alerting process can result in doctors unnecessarily being alerted when, for example, a patient has already been prescribed a lower than recommended dose of enoxaparin as per their therapeutic needs or where enoxaparin is not prescribed as the patient is to undergo surgery.

Despite the risk assessment algorithm incorporating details of the surgery the patient was about to have (alongside the likely duration and likelihood of decreased mobility) 11% of the reasons for not prescribing were due to the timing of the surgery and the type of surgery. Surgical VTE risk assessments require a complex algorithm to capture the types of surgery, the patient's condition and risks of bleeding therein. The electronic risk assessment is completed within the first few hours of admission and it would seem from the responses that the delay or avoidance in prescribing enoxaparin stems from perceived risk of major bleeding linked with certain surgical procedures and with the timing of the alert. When alerts are produced preoperatively there may be an expectation that VTE prophylaxis will be given in theatre after surgery or in cases where the alert is read postoperatively the patient has returned to the ward after having been administered a VTE prophylaxis as per protocol or indeed may have postoperative complications that rule out pharmacological prophylaxis. An established parallel system exists for surgical patients outside of the ward area and the timing of the free text and daily reminder alerts produced will not be sensitive to timing issues (e.g. delayed theatre list) or changes in a patient's risk of bleeding (e.g. postoperative complications).

This lack of specificity of the alerts produced by the VTE risk assessment leads to the question of whether is it better to have irrelevant alerts rather than no alerts. Specificity could be increased by including a check for prescriptions of warfarin or heparin as contraindications to prescribing enoxaparin or preventing the generation of the alert no matter what dosage of enoxaparin is prescribed. This would reduce the number of alerts produced where an alternative anticoagulant is already prescribed or where enoxaparin is prescribed at a different dosage, thereby reducing inappropriate alerting. It is noteworthy that a prescription of warfarin or patient being already given anticoagulants is part of the VTE risk assessment process - and the presence of this would contraindicate enoxaparin and suppress subsequent alerts.

Timing of the alert can be an issue, for example when clinicians are presented with the free text alert even when an enoxaparin prescription is visible on the system. To the clinician the alert has been generated inappropriately, but this does not provide a full picture. To note, the system only cross-checks for an enoxaparin prescription once per day at 07:30AM. Therefore, when the free text alert (Figure 2) is bypassed on day 1 (so called 'third-party ignore'), it will be shown again on day 1 to other (or the same) clinicians who next access the patient's record regardless of whether enoxaparin has since been prescribed. For example, if an enoxaparin prescription has been written during the morning ward round and no response entered to the free text alert, the alert will still be shown the next time the patient's record is accessed. As long as no free-text response is entered that day and enoxaparin has not been prescribed, the daily reminder (Figure 3) and the free text alert will reappear on day 2 when the system cross-checks the prescription data. Despite causing some frustration, allowing third-party dismissal of alerts means that it can still be visible to clinicians directly responsible for the patient's care. This frustration may be unavoidable in some cases as the alert is presented to anyone with authorisation to prescribe. In the case of bank /locum doctors or those who are not familiar with the patient, they may be unaware of the reason that enoxaparin has not been prescribed and therefore may not respond appropriately (e.g. they may just be logging onto PICS to familiarise themselves with the patient prior to meeting them). The only way to truly avoid this is to change the system to check for a prescription prior to each presentation of the alert.

What is of concern is the likelihood of fatigue due to excessive alerts and workarounds especially when the mechanisms behind the alert generation are not understood. We found 4 examples in the data of clinicians entering full stops in the free text field to make the alert recede (3 by the same clinician). Frustration is often secondary to inappropriate use of the system, for example, failure to acknowledge alerts even when doing the correct thing or not noting options in the risk assessment which would suppress future alerts.

Limitations

In this research we have obtained information regarding the real time reasons and feedback from responses left during the workflow about user experiences and how the VTE alerts within our CPOE system are understood. What is particularly useful is that

we have examined data regarding the free text alerts for the first 7 months after its initial implementation, meaning that our findings will allow us to feedback and make changes to the system if and where appropriate. This evaluation of our own system may lead to improvements which we can then share with other system providers.

Nonetheless, in this study we are unable to take into account those cases in which no free text response was provided at all. The system was effective in prompting doctors to provide a reason for not prescribing enoxaparin in 1,136 cases. In the remaining approximately 11,600 cases where no free text response was obtained, this may be attributed to patients being discharged prior to the free text alert being triggered, Furthermore, from our data we are unable to determine whether the responses that are provided by doctors are reliable (i.e. honest) or if there are more complex reasons behind not having prescribed enoxaparin. For example, some responses are written in capital letters and it is not possible to tell whether this is done due to frustration or whether it is a default by the keyboard that the doctor is using. Other incomplete responses meant that we were not provided with information that we could utilise in our analysis. We are also unable to determine whether a prescription was actioned even when a positive response to the free text alert was given. Finally, the single site nature of the study further limits the generalisability of the findings.

To follow on from this research, it would be useful to organise discussion groups or forums in which doctors can verbally discuss their perceptions of the VTE alerts (and perhaps decision support warnings more generally) and provide some more context to their responses. Alternatively, it may be interesting to shadow doctors on the ward and observe their response as they use the system and as alerts are generated. Furthermore, it might be useful to investigate the process of VTE assessment and appropriate anticoagulant prescription for surgical patients in more detail. This might help to establish whether it may be necessary to design a parallel system for these patients, which may lead to the prescription being made/decision not to prescribe due to the time of surgery. It might be interesting to utilize stealth alerts/ stealth processes [24] through a third party in order to alert the patient's regular doctor/consultant to a lack of VTE prophylaxis or, for example, alert a pharmacist to check the dose where an enoxaparin prescription is present but the dose is not what would normally be recommended.

The ultimate aim of using the CPOE system is to improve patient safety by receiving appropriate VTE risk assessment and treatment. Since this study was conducted, the system has been updated so that doctors are now automatically taken to a blank prescription page if enoxaparin is recommended following the VTE risk assessment. System improvements such as this are required to support the assessment processes, prescriber engagement, and education to take the appropriate action.

CONCLUSION

This study examined the free text reasons given by doctors when they have not yet prescribed the prophylaxis suggested by the VTE risk assessment tool. The analysis shows that doctors bypass the recommendations because they are rationalizing the VTE risk and use of prophylaxis on the emerging picture of the patient's condition on one hand and they become frustrated with the system because of lack of training on the other. Understanding why doctors use workarounds will enable healthcare providers to modify systems or training programmes to reduce alert fatigue whilst optimising the appropriateness of CDS alerts.

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Contributorship Statement

All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. UN was involved in the study conception and design and the data coding and analysis. UN was also involved in the drafting and revision of the manuscript. HB was involved in the study conception and design and the data coding and analysis. HB was also involved in the drafting and revision of the manuscript. SR was involved in the study conception and design and the data coding and analysis. SR was also involved in the drafting and revision of the manuscript. LM was involved in the study conception and design and the data coding and analysis. LM was also involved in the drafting and revision of the manuscript. JC was involved in the study conception and design, and the data analysis. JC was also involved in the drafting and revision of the manuscript. All authors contributed to the writing of the manuscript, the interpretation of data, and approved the final version.

Competing Interest Statement

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) (JJC) (1) Financial support for the submitted work was obtained from the National Institute of Health Research CLAHRC for the West Midlands and Black Country. (2) JJC works within the University Hospital Birmingham NHS Foundation Trust which is collaborating with CSE Healthcare Systems to commercialise the PICS system in the UK. All other authors report no financial relationships with commercial entities that might have an interest in the submitted work; (3) No spouses, partners, or children of the authors have relationships with commercial entities that might have an interest in the submitted work; (4) None of the authors have non-financial interests that may be relevant to the submitted work

Data Sharing Statement

Original data containing the free text responses and codes are available from the corresponding author, Dr. Jamie Coleman (j.j.coleman@bham.ac.uk).

Figure Legends

Figure 1: Flow diagram of VTE alert production

Figure 2: Initial enoxaparin alert (free text alert)

Figure 3: Subsequent enoxaparin alert

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TITLE PAGE

Electronic risk assessment for venous thromboembolism: investigating physicians' rationale for bypassing clinical decision support recommendations

~~Why doctors bypass Clinical Decision Support: using a venous thromboembolism risk assessment tool as a case study.~~

Ugochi Nwulu[1], Hannah Brooks[1], Suzanna Richardson[1], Lorraine McFarland[2] and Jamie J Coleman[1,2]

[1] University Hospitals Birmingham NHS Foundation Trust, Edgbaston, Birmingham, B15 2TH, UK
[2] College of Medical and Dental Sciences, University of Birmingham, Birmingham B15 2SP, UK

Ugochi Nwulu
Senior Research Associate, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Hannah Brooks
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Suzanna Richardson
Research Assistant, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

Lorraine McFarland
Research Fellow, School of Health and Population Sciences, University of Birmingham, Birmingham, UK

Jamie J Coleman
Senior Lecturer in Clinical Pharmacology, University of Birmingham, Birmingham, UK and Honorary Consultant Physician, University Hospitals Birmingham NHS Foundation Trust, Birmingham UK

Correspondence to: Jamie J Coleman, *Queen Elizabeth Hospital/ University of Birmingham*
Email: j.j.coleman@bham.ac.uk
Telephone: 0121 371 6003, Fax: 0121 626 4587

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ABSTRACT

Objective

The underutilisation of venous thromboembolism (VTE) prophylaxis is still a problem in the United Kingdom despite the emergence of national guidelines and incentives to increase the number of patients undergoing VTE risk assessments. Our objective was to examine the reasons doctors gave for not prescribing enoxaparin when recommended by an electronic VTE risk assessment alert.

Design

We used a qualitative research design to conduct a thematic analysis of free text entered into an electronic prescribing system.

Setting

The study took place in a large University teaching hospital, which has a locally-developed electronic prescribing system known as PICS (Prescribing, Information and Communication System).

Participants

We extracted prescription data from all inpatient admissions over a 7-month period in 2012 using the audit database of PICS.

Intervention

The completion of the VTE risk assessment form introduced into the hospital-wide electronic prescribing and health records system is mandatory. Where doctors do not prescribe VTE prophylaxis when recommended they are asked to provide a reason for this decision. The free text field was introduced in May 2012.

Primary and secondary outcome measures

Free text reasons for not prescribing enoxaparin when recommended were thematically coded.

Results

A total of 1136 free text responses from 259 doctors were collected in the time period and 1206 separate reasons were analysed and coded. 389 reasons (32.3%) for not prescribing enoxaparin were coded as being due to 'clinical judgment'; in 288 (23.9%) of the responses doctors were going to reassess the patient or prescribe enoxaparin; and in 245 responses (20.3%) the system was seen to have produced an inappropriate alert.

Conclusions

In order to increase specificity of warnings and avoid users developing alert fatigue, it is essential that an evaluation of user responses and / or end user feedback as to the appropriateness and timing of alerts is obtained.

~~**Background**~~

~~The underutilisation of venous thromboembolism (VTE) prophylaxis is still a problem in the United Kingdom despite the emergence of national guidelines and incentives to increase the number of patients undergoing VTE risk assessments. In our hospital setting, the completion of the VTE risk assessment form introduced into the hospital-wide electronic prescribing and health records system is mandatory. Despite this feature providing active support, there is still a problem with doctors not prescribing pharmacological thromboprophylaxis once recommended by the risk assessment tool.~~

~~**Objective**~~

~~To examine the reasons doctors gave for not prescribing enoxaparin when recommended by an electronic VTE risk assessment alert.~~

~~**Methods**~~

~~We extracted data over a 7-month period in 2012 from the audit database of a hospital-wide electronic prescribing system. Free text reasons for not prescribing enoxaparin when recommended were thematically coded.~~

~~**Results**~~

~~A total of 1136 free text responses were collected in the time period and 1206 separate reasons were analysed and coded. 389 reasons (32.3%) for not prescribing enoxaparin were coded as being due to 'clinical judgment'; in 288 (23.9%) of the~~

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~~In order to increase specificity of warnings and avoid users developing alert fatigue, it is essential that an evaluation of user responses and / or end user feedback as to the appropriateness and timing of alerts is obtained.~~

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Strengths and Limitations of this Study

- This study addresses an important topic, as VTE prophylaxis is not always prescribed as recommended in secondary care
- The hospital in the study has its own locally-developed electronic prescribing system with embedded clinical decision support (CDS) in which alerts are specifically designed to encourage VTE prophylaxis (e.g. prescribing of enoxaparin)
- The study used data collected immediately after the implementation of a unique free-text feature within the CDS system, in which doctors can provide reasons for not prescribing enoxaparin
- The data has allowed us to highlight a number of strengths and limitations of using CDS to encourage doctors to appropriately prescribe enoxaparin in secondary care
- However, we are unable to determine whether responses that were provided were reliable and we were unable to take into account cases in which no free-text response was provided

INTRODUCTION

The early identification of patients at risk of venous thromboembolism (VTE) and prescription of prophylaxis, where appropriate, are important measures in preventing the morbidity and mortality associated with hospital-acquired Deep Vein Thrombosis (DVT) and / or Pulmonary Embolism (PE). VTE contributes to up to 10% of hospital deaths [1 2] and it is estimated that 25 000 people in the UK die each year from preventable hospital-acquired VTE. [3] In the past decade, evidence-based guidelines outlining the importance of VTE prevention have been published internationally [4-7]. In England, there has been an increased emphasis on programmes to educate clinicians and to incentivise hospital trusts to increase VTE risk assessment completion on admission. From June 2010, the Commissioning for Quality and Innovation (CQUIN) payment framework required all acute trusts in the UK to assess 90% of patients admitted for the risk of VTE in order to receive 1.5% of their funding. [8] The Care Quality Commission is responsible for monitoring NHS trusts' performance on the new Quality Standards throughout the UK and collects data each month on the number of VTE risk assessments completed. [9] Despite the increase in VTE risk assessment completion, VTE prophylaxis is still underutilised and there is some evidence of poor adherence to the published guidelines. [10-13]

In the UK, computer-based rather than paper-based Clinical Decision Support (CDS) is gaining popularity as a way of prompting or guiding clinicians in the secondary care setting to prescribe appropriately. Changes to physicians'adherence to processes of care by computer reminders have been found to be modest on the whole [14] but electronic alerts and computerized CDS have been found to increase the prescription of thromboprophylaxis in hospitalised medical patients. [15-18] While other studies have been undertaken to understand why physicians do not follow clinical guidelines [19] and VTE prophylaxis guidelines specifically, [20] few have been able to ask clinicians why prophylaxis has not been prescribed at the point of recommendation.

In this study, we were interested doctors' responses to a mandatory free text field completion when acknowledging a decision support alert specific to the circumstance when a VTE risk assessment suggests prophylaxis but no prescription was completed. Nearly every patient (99%) admitted to this hospital now has their risk of developing

VTE assessed on admission. [21]. However, a trust audit in 2010the trust quality report from 2012-13 found identified that enoxaparin was not prescribed in 3834.1% of cases when recommended by the electronic risk assessment. [22]. We wanted to identify cases where the system was alerting inappropriately and we wished to identify where the system could lead to user frustration and 'work-arounds' being employed to save time and ease the workload.

METHODS

This study was conducted under the umbrella of a larger research project funded by the National Institute for Health Research, for which ethical approval was gained. This study involved the use of secondary data collected in the course of normal care and had no patient identifiers or patient-sensitive information so was anonymised to the researchers at the point of access.

Setting

This study was conducted in a large NHS university hospital, which has a locally-developed electronic prescribing system known as PICS (Prescribing, Information and Communication System). PICS is in operation throughout all (approximately 1200) inpatient beds and for all prescribing. The system was first installed in the renal unit 15 years ago [23] and now covers general and specialist medical and surgical specialties. For the purpose of this study a key feature of the system is that all information about prescriptions and dose administrations are exported to a comprehensive audit database on a weekly basis.

The hospital has prioritized measures to reduce the occurrence of hospital-acquired VTE over the last few years. In June 2008 a VTE risk assessment tool was introduced into PICS with an alert issued to remind doctors if the risk assessment was not completed. From June 2010 in line with the national guidelines and data collection, the completion of the VTE risk assessment within the trust became mandatory for every admitted patient. The assessment has to be completed before the patient record and drug prescribing is enabled for that admission. Following the completion of the risk assessment, a scheduled decision support rule is run in PICS that reviews the current prescriptions for each patient and automatically generates an alert where, as indicated by the risk assessment, enoxaparin should be prescribed but is not currently

prescribed. -This initial alert is displayed to the first prescriber to view the patient's medical records on PICS (this process is summarized in Figure 1) and requires a written free text response to explain why enoxaparin has not been prescribed (see Figure 2). Further details about the electronic VTE risk assessment process are provided in Appendix A.

Data capture

Our outcome was the reason given for not prescribing enoxaparin where recommended by the VTE risk assessment. These responses were obtained from the enoxaparin free text alert shown in Figure 2. Data were extracted from the PICS audit database on all enoxaparin alerts generated between 1st June 2012 and 31st December 2012. The anonymized data were extracted into Excel for analysis.

Analysis

Four reviewers (UN, HB, SR and LMcF) independently conducted preliminary content analysis of the respondents' reasons for not prescribing enoxaparin. Themes were allowed to emerge from the data in an iterative process, with initial themes informing and contextualising subsequent themes and vice versa. The reviewers then met to discuss their analyses and sought to reach consensus where reasons were unclear. A consultant physician (JJC) provided clinical context to reasons that the reviewers found difficult to categorize. The four reviewers then independently coded the data. Whole group discussion was used to refine coding and to identify over-arching themes which helped to group subordinate themes, until consensus was reached. Representation of each theme is given as actual number of reasons observed (some responders gave more than one reason) and percentage of total reasons provided.

RESULTS

During the seven-month time period there were 37,737 admissions to the hospital. Based on figures from the Trust quality account, approximately 37,340 (99%) would have received a VTE risk assessment. ~~a~~A total of 1136 free text responses were provided from 259 doctors in response to the enoxaparin alert, which equates to 9% of the approximately 12,740 (34.1%) who were not prescribed enoxaparin when

recommended. -Some responses contained multiple reasons. As such, a total of 1206 reasons were recorded and coded.

Six main themes were identified from the reasons provided for not having prescribed enoxaparin. These themes and the number of reasons coded within each theme are displayed in Table 1.

Table 1 - Frequency of reasons for not prescribing enoxaparin by theme

Reasons for not prescribing enoxaparin (by theme)	Number of responses	Percentage of all responses
Clinical judgment	389	32.3%
Positive response initiated	287	23.8%
System	246	20.4%
Surgery	139	11.5%
Ambiguous	81	6.7%
Drug contraindication	64	5.3%
Total	*1206*	*100%*

The reviewers coded 23.8% of the responses provided as 'positive response initiated'. Here, doctors indicated that they would go on to prescribe enoxaparin after having read the message or that they would review the patient's VTE risk as a result of the message. Examples of responses are: *"will review"*; *"will prescribe"*; *"oversight – prescribed by myself today"*.

The most common type of reason given for not prescribing enoxaparin was due to 'clinical judgment', and represents 32.3 % of the reasons given. The 'clinical judgment' theme can be further broken down into 5 main categories: clinical reason; patient mobile; patient discharged or soon to be discharged; patient at risk of bleeding; and patient at risk of falls. The distribution of these reasons (as a percentage of all clinical judgment coded reasons) can be seen in Table 2. The category of 'clinical reason' refers to a broad range of reasons which are either:

- An explicit clinical judgment, e.g. *"not required"*, *"end of life care. no benefit from enoxaparin"* and *"consultant decision"*;

- Situation-specific such as *"liver failure"*, *"stroke"* and *"bleeding ulcer "*or
- Where further information was needed before a full assessment could be made *"clinical information still pending"*, *"awaiting blood results"* and *"low Hb ?cause"*.

Table 2 - Frequency of reasons for not prescribing enoxaparin within the theme 'clinical judgment'

Clinical judgment reasons for not prescribing enoxaparin	Number of responses	Percentage of all responses
Clinical reason	120	30.8%
Patient mobile	111	28.5%
Discharge*	84	21.6%
Risk of bleeding**	64	16.5%
Falls risk	10	2.6%
Total	*389*	*100%*

* Patient about to be discharged or had been discharged by time of alert

**Patient under investigation for bleeding risk or known condition

One in five reasons were coded as 'system' and reflect those alerts deemed as being generated inappropriately or caused by a system error which led to the production of the alert. Responses coded as 'system' often reflected cases where enoxaparin had been prescribed after the alert had been generated on day 1, but before a reason had been given. If the rules-based alert is ignored or closed, it will continue to appear to subsequent prescribers logging in to the patient record. Currently the rules-base alert is not cancelled by the system automatically if an appropriate prescription is made in the interim. Examples of free text responses include *"already prescribed"*, *"it is"*, *"has been"* and *"enoxaparin prescribed"*. In some cases the free text reason was indicative of users' frustrations with these persistent alerts. For example, this was demonstrated by the use of multiple exclamation marks in 29 out of 246 (11.8%) 'system' reasons. Furthermore, some users overtly stated their frustration with the

alert, for example, *"It's been prescribed so this message is something of a frustration* "and *"It is prescribed - PICS giving false warning x 3"*.

The theme 'surgery' (11.5% of reasons given) refers to the patient being in the peri-operative period or undergoing a specific surgical procedure where it was thought that prescribing enoxaparin was not appropriate. For example, free text responses included *"not meant to have until enox 23 hours post surgery - according to protocol", "post operative – for review"* and *"on theatre list today"*. Additionally, some reasons alluded to inappropriate prescribing of enoxaparin as a result of the patient's postoperative condition: *"late operation yesterday with post-op haematoma"* and *"Post neurosurgery. Bleeding around EVD site"*.

The theme 'ambiguous' (6.7% of responses) refers to cases which did not relate to a clinical indication or process such as *"not yet reviewed"* or *"patient not known to me"* or simply *"don't know"*. Finally, 5.3% of the reasons were coded as 'drug contraindication' as the patient had (since the VTE risk assessment) been prescribed a drug with a similar action, such as warfarin or heparin. The rules-base does not check for such prescriptions, as the risk assessment is specific in recommending enoxaparin.

DISCUSSION

In a quarter of cases where a free text response was provided ~~T~~the system succeeded in prompting either a repeat review of the patient or prescription of enoxaparin where it had been overlooked or delayed ~~in a quarter of cases~~. In these cases the alert produced the positive response that was intended by its implementation.

The main reasons for not prescribing enoxaparin when recommended were due to 'clinical judgment'. As the use of any such tool is not intended to replace clinical judgment, we would have expected that clinicians would delay or avoid prescribing VTE prophylaxis until the patient has been fully assessed. The tool is, however, designed to provide decision support deemed appropriate for the majority of cases. It may be prudent to wait until test results return and a more complete picture emerges of the patient's condition. Clearly complete compliance with the recommendations before all information is assessed would be just as dangerous as poor compliance.

Where the system or process does not seem to work as well is when it produces a seemingly inappropriate alert. Of concern were the responses (20.4%) that indicated doctors felt there had been a system error which had led to inappropriate or inaccurate alert generation. A lack of specificity in the alerting process can result in doctors unnecessarily being alerted when, for example, a patient has already been prescribed a lower than recommended dose of enoxaparin as per their therapeutic needs or where enoxaparin is not prescribed as the patient is to undergo surgery.

Despite the risk assessment algorithm incorporating details of the surgery the patient was about to have (alongside the likely duration and likelihood of decreased mobility) 11% of the reasons for not prescribing were due to the timing of the surgery and the type of surgery. Surgical VTE risk assessments require a complex algorithm to capture the types of surgery, the patient's condition and risks of bleeding therein. The electronic risk assessment is completed within the first few hours of admission and it would seem from the responses that the delay or avoidance in prescribing enoxaparin stems from perceived risk of major bleeding linked with certain surgical procedures and with the timing of the alert. When alerts are produced preoperatively there may be an expectation that VTE prophylaxis will be given in theatre after surgery or in cases where the alert is read postoperatively the patient has returned to the ward after having been administered a VTE prophylaxis as per protocol or indeed may have postoperative complications that rule out pharmacological prophylaxis. An established parallel system exists for surgical patients outside of the ward area and the timing of the free text and daily reminder alerts produced will not be sensitive to timing issues (e.g. delayed theatre list) or changes in a patient's risk of bleeding (e.g. postoperative complications).

This lack of specificity of the alerts produced by the VTE risk assessment leads to the question of whether is it better to have irrelevant alerts rather than no alerts. Specificity could be increased by including a check for prescriptions of warfarin or heparin as contraindications to prescribing enoxaparin or preventing the generation of the alert no matter what dosage of enoxaparin is prescribed. This would reduce the number of alerts produced where an alternative anticoagulant is already prescribed or where enoxaparin is prescribed at a different dosage, thereby reducing inappropriate alerting. It is noteworthy that a prescription of warfarin or patient being already given

anticoagulants is part of the VTE risk assessment process - and the presence of this would contraindicate enoxaparin and suppress subsequent alerts.

Timing of the alert can be an issue, for example when clinicians are presented with the free text alert even when an enoxaparin prescription is visible on the system. To the clinician the alert has been generated inappropriately, but this does not provide a full picture. To note, the system only cross-checks for an enoxaparin prescription once per day at 07:30AM. Therefore, when the free text alert (Figure 2) is bypassed on day 1 (so called 'third-party ignore'), it will be shown again on day 1 to other (or the same) clinicians who next access the patient's record regardless of whether enoxaparin has since been prescribed. For example, if an enoxaparin prescription has been written during the morning ward round and no response entered to the free text alert, the alert will still be shown the next time the patient's record is accessed. As long as no free-text response is entered that day and enoxaparin has not been prescribed, the daily reminder (Figure 3) and the free text alert will reappear on day 2 when the system cross-checks the prescription data. Despite causing some frustration, allowing third-party dismissal of alerts means that it can still be visible to clinicians directly responsible for the patient's care. This frustration may be unavoidable in some cases as the alert is presented to anyone with authorisation to prescribe. In the case of bank /locum doctors or those who are not familiar with the patient, they may be unaware of the reason that enoxaparin has not been prescribed and therefore may not respond appropriately (e.g. they may just be logging onto PICS to familiarise themselves with the patient prior to meeting them). The only way to truly avoid this is to change the system to check for a prescription prior to each presentation of the alert.

What is of concern is the likelihood of fatigue due to excessive alerts and workarounds especially when the mechanisms behind the alert generation are not understood. We found 4 examples in the data of clinicians entering full stops in the free text field to make the alert recede (3 by the same clinician). Frustration is often secondary to inappropriate use of the system, for example, failure to acknowledge alerts even when doing the correct thing or not noting options in the risk assessment which would suppress future alerts.

Limitations

In this research we have obtained information regarding the real time reasons and feedback from responses left during the workflow about user experiences and how the VTE alerts within our CPOE system are understood. What is particularly useful is that we have examined data regarding the free text alerts for the first 7 months after its initial implementation, meaning that our findings will allow us to feedback and make changes to the system if and where appropriate. This evaluation of our own system may lead to improvements which we can then share with other system providers.

Nonetheless, in this study we are unable to take into account those cases in which no free text response was provided at all. The system was effective in prompting doctors to provide a reason for not prescribing enoxaparin in 1,136 cases. In the remaining approximately 11,600 cases where no free text response was obtained, this may be attributed to patients being discharged prior to the free text alert being triggered.~~,~~ Furthermore, from our data we are unable to determine whether the responses that are provided by doctors are reliable (i.e. honest) or if there are more complex reasons behind not having prescribed enoxaparin. For example, some responses are written in capital letters and it is not possible to tell whether this is done due to frustration or whether it is a default by the keyboard that the doctor is using. Other incomplete responses meant that we were not provided with information that we could utilise in our analysis. We are also unable to determine whether a prescription was actioned even when a positive response to the free text alert was given. Finally, the single site nature of the study further limits the generalisability of the findings.

To follow on from this research, it would be useful to organise discussion groups or forums in which doctors can verbally discuss their perceptions of the VTE alerts (and perhaps decision support warnings more generally) and provide some more context to their responses. Alternatively, it may be interesting to shadow doctors on the ward and observe their response as they use the system and as alerts are generated. Furthermore, it might be useful to investigate the process of VTE assessment and appropriate anticoagulant prescription for surgical patients in more detail. This might help to establish whether it may be necessary to design a parallel system for these patients, which may lead to the prescription being made/decision not to prescribe due to the time of surgery. ~~Finally, it~~It might be interesting to utilize stealth alerts/ stealth processes [24] through a third party in order to alert the patient's regular doctor/consultant to a lack of VTE prophylaxis or, for example, alert a pharmacist to

check the dose where an enoxaparin prescription is present but the dose is not what would normally be recommended.

The ultimate aim of using the CPOE system is to improve patient safety by receiving appropriate VTE risk assessment and treatment. Since this study was conducted, the system has been updated so that doctors are now automatically taken to a blank prescription page if enoxaparin is recommended following the VTE risk assessment. System improvements such as this are required to support the assessment processes, prescriber engagement, and education to take the appropriate action.

CONCLUSION

This study examined the free text reasons given by doctors when they have not yet prescribed the prophylaxis suggested by the VTE risk assessment tool. The analysis shows that doctors bypass the recommendations because they are rationalizing the VTE risk and use of prophylaxis on the emerging picture of the patient's condition on one hand and they become frustrated with the system because of lack of training on the other. Understanding why doctors use workarounds will enable healthcare providers to modify systems or training programmes to reduce alert fatigue whilst optimising the appropriateness of CDS alerts.

Contributorship Statement

All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. UN was involved in the study conception and design and the data coding and analysis. UN was also involved in the drafting and revision of the manuscript. HB was involved in the study conception and design and the data coding and analysis. HB was also involved in the drafting and revision of the manuscript. SR was involved in the study conception and design and the data coding and analysis. SR was also involved in the drafting and revision of the manuscript. LM was involved in the study conception and design and the data coding and analysis. LM was also involved in the drafting and revision of the manuscript. JC was involved in the study conception and design, and the data analysis. JC was also involved in the drafting and revision of the manuscript. All authors contributed to the writing of the manuscript, the interpretation of data, and approved the final version.

Data Sharing Statement

~~Additional data relating to the free text responses and the coding process is available by emailing~~Original data containing the free text responses and codes are available from the corresponding author, -Dr. Jamie Coleman (j.j.coleman@bham.ac.uk).

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Competing Interest Statement

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) (JJC) (1) Financial support for the submitted work was obtained from the National Institute of Health Research CLAHRC for the West Midlands and Black Country. (2) JJC works within the University Hospital Birmingham NHS Foundation Trust which is collaborating with CSE

Healthcare Systems to commercialise the PICS system in the UK. All other authors report no financial relationships with commercial entities that might have an interest in the submitted work; (3) No spouses, partners, or children of the authors have relationships with commercial entities that might have an interest in the submitted work; (4) None of the authors have non-financial interests that may be relevant to the submitted work

Figure Legends

Figure 1: Flow diagram of VTE alert production

Figure 2: Initial enoxaparin alert (free text alert)

Figure 3: Subsequent enoxaparin alert

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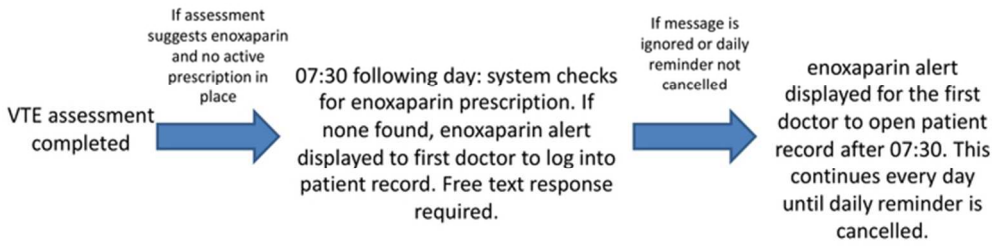

Flow diagram of VTE alert production
61x15mm (300 x 300 DPI)

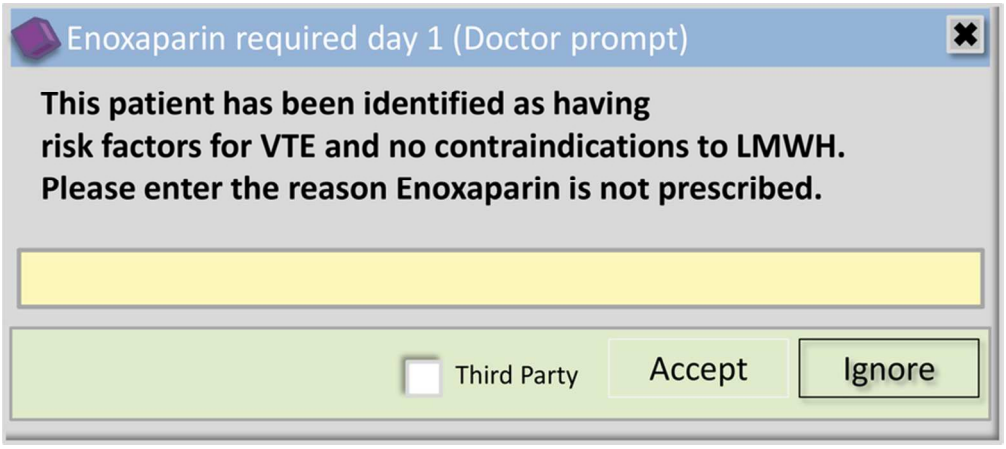

Figure 2: Initial enoxaparin alert (free text alert)
78x34mm (300 x 300 DPI)

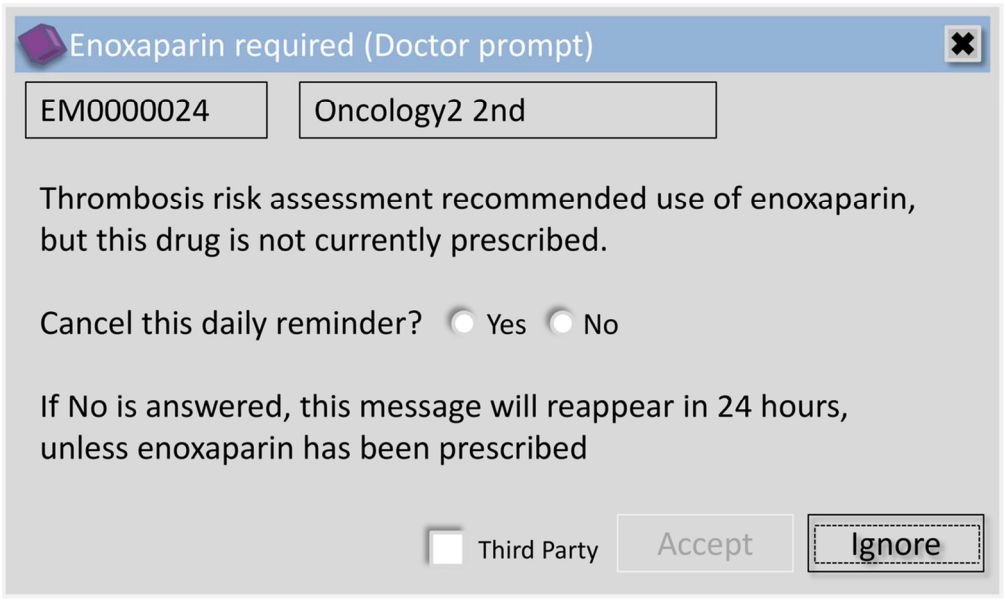

Figure 3: Subsequent enoxaparin alert
108x64mm (300 x 300 DPI)

Appendix A: Details of the VTE Electronic Risk Assessment

Upon all patients' first admission to the study site hospital, it is mandatory for doctors to perform a venous thromboembolism (VTE) risk assessment within 24 hours of admission. An initial question asks the doctor to specify the type of patient or identify that the assessment will be postponed or is not required (Figure A1). It is possible for doctors to initially postpone the assessment; however a reminder is displayed to ensure that the assessment within 24 hours. It is also possible for doctors to select an option stating that the VTE risk assessment is not required; however a reason must be provided for using this option via a free text field.

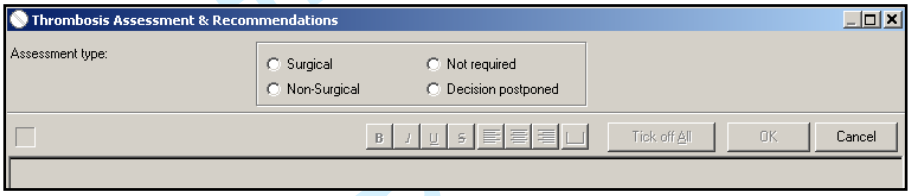

Figure A1: Initial answer fields for electronic VTE assessment

If the Surgical or Non-Surgical answer fields are selected the doctor will be presented with further assessment questions. There are different questions dependent on whether the patient is surgical (Figure A2) or non-surgical (Figure A3).

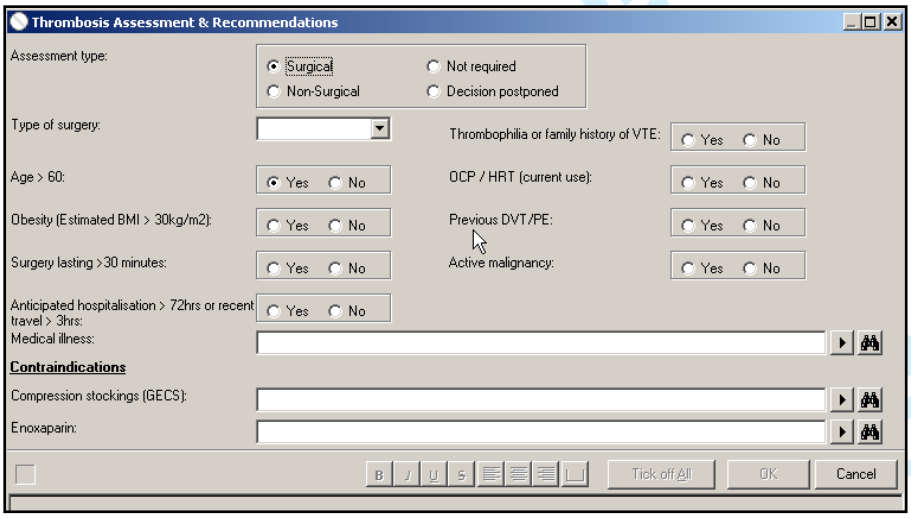

Figure A2: Further risk assessment questions for surgical patients

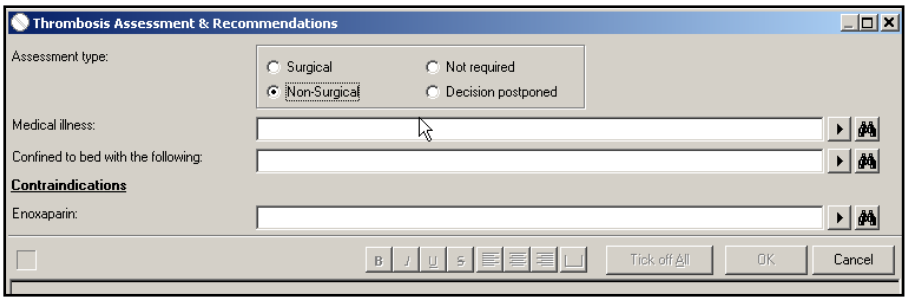

Figure A3: Further risk assessment questions for non-surgical patients

Based on the answer fields that are selected, the system may prompt the doctor to prescribe enoxaparin where VTE prophylaxis is required (Figure A4).

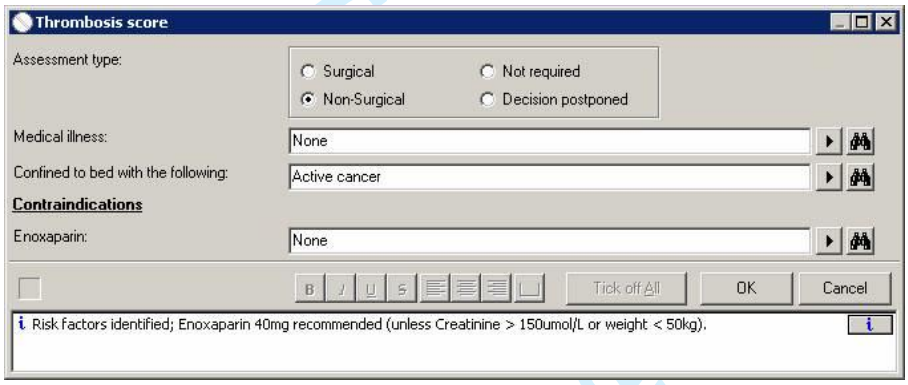

Figure A4: Example of system prompt recommending VTE prophylaxis for non-surgical patient

Where VTE prophylaxis is recommended, doctors can then use the electronic prescribing system to complete a prescription for enoxaparin at the recommended dose. However, if the doctor chooses not to complete the prescription immediately, the next time that the patient's record is opened the user (regardless of whether it was they who completed the risk assessment) will receive an alert prompting them to explain the reason why enoxaparin has not yet been prescribed (see Figure 2 in the main text). It is from these free text fields the data for our study were collected.