

BMJ Open Assessing the appropriateness of prevention and management of venous thromboembolism in Australia: a cross-sectional study

Peter D Hibbert,^{1,2} Natalie A Hannaford,^{2,3} Tamara D Hooper,^{1,2} Diane M Hindmarsh,¹ Jeffrey Braithwaite,¹ Shanthi A Ramanathan,^{2,4} Nicholas Wickham,⁵ William B Runciman^{1,2,3}

To cite: Hibbert PD, Hannaford NA, Hooper TD, *et al.* Assessing the appropriateness of prevention and management of venous thromboembolism in Australia: a cross-sectional study. *BMJ Open* 2016;**6**: e008618. doi:10.1136/bmjopen-2015-008618

► Prepublication history for this paper is available online. To view these files please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2015-008618>).

Received 5 May 2015
Accepted 14 January 2016



CrossMark

For numbered affiliations see end of article.

Correspondence to

Peter D Hibbert;
Peter.hibbert@mq.edu.au

ABSTRACT

Objectives: The prevention and management of venous thromboembolism (VTE) is often at variance with guidelines. The CareTrack Australia (CTA) study reported that appropriate care (in line with evidence-based or consensus-based guidelines) is being provided for VTE at just over half of eligible encounters. The aim of this paper is to present and discuss the detailed CTA findings for VTE as a baseline for compliance with guidelines at a population level.

Setting: The setting was 27 hospitals in 2 states of Australia.

Participants: A sample of participants designed to be representative of the Australian population was recruited. Participants who had been admitted overnight during 2009 and/or 2010 were eligible. Of the 1154 CTA participants, 481 (42%) were admitted overnight to hospital at least once, comprising 751 admissions. There were 279 females (58%), and the mean age was 64 years.

Primary and secondary outcome measures: The primary measure was compliance with indicators of appropriate care for VTE. The indicators were extracted from Australian VTE clinical practice guidelines and ratified by experts. Participants' medical records from 2009 to 2010 were analysed for compliance with 38 VTE indicators.

Results: Of the 35 145 CTA encounters, 1078 (3%) were eligible for scoring against VTE indicators. There were 2–84 eligible encounters per indicator at 27 hospitals. Overall compliance with indicators for VTE was 51%, and ranged from 34% to 64% for aggregated sets of indicators.

Conclusions: The prevention and management of VTE was appropriate for only half of the at-risk patients in our sample; this provides a baseline for tracking progress nationally. There is a need for national and, ideally, international agreement on clinical standards, indicators and tools to guide, document and monitor care for VTE, and for measures to increase their uptake, particularly where deficiencies have been identified.

Strengths and limitations of this study

- The study is designed to be representative of the Australian population rather than a convenience-based or purposive-based sample.
- The review of medical records, while costly and difficult, allowed compliance to be measured in a real-world setting.
- Numbers of participants and/or eligible encounters are low for some indicators.
- There was a high rate of attrition of potential participants and several sources of possible bias. However, weighting using two methods and five different options made no significant difference to the compliance percentage.

INTRODUCTION

Each year in Australia about 1 in every 1000 people develop a first episode of venous thromboembolism (VTE), manifesting as deep venous thrombosis (DVT) and/or pulmonary embolism (PE).^{1 2} This amounts to about 20 000 cases, of which 80% occur during or soon after an admission to hospital.^{1 2} Including loss of productivity, total costs amount to well over \$A1 billion per year.³

There is evidence that the appropriate use of pharmacological and mechanical prophylaxis in orthopaedic, general surgical and medical patients can reduce the incidence of VTE,^{4–6} although a recent paper has questioned use of pharmacological prophylaxis in lower risk medical patients.⁷ Clinical practice guidelines (CPGs) have been developed, in Australia^{8 9} and elsewhere,^{10 11} to prevent VTE and to standardise the management of DVT and PE. Several initiatives have been undertaken to promote and facilitate their uptake, including implementation guides,¹² templates,¹³ learning modules,¹⁴ hospital

medication self-assessments¹⁵ and patient information pamphlets.¹⁶ However, despite these initiatives and the considerable harm from VTE, much of the care provided for VTE is not in line with CPGs¹⁷ in both the developed¹⁸ and developing worlds.¹⁹

As healthcare is facing an affordability crisis, there is an urgent need to move towards being able to monitor the appropriateness of care (care in line with evidence-based or consensus-based guidelines).²⁰ The CareTrack Australia (CTA) study was designed to establish baseline estimates of the appropriateness of care delivered, at a population level, by a range of practitioners in real-world settings, and to determine what would be needed to monitor the ongoing appropriateness of care.²¹ CTA showed that adult Australians received appropriate care for 22 common conditions at 57% of eligible healthcare encounters during 2009 and 2010; VTE compliance was reported at 58%.²² The aim of this paper is to present and discuss the detailed CTA findings for VTE as a baseline for compliance with guidelines at a population level, from which to track progress resulting from future interventions.

METHODS

The CTA methods have been described in detail elsewhere.^{21 22} Some aspects of relevance to VTE are summarised here.

Development and ratification of indicators

An initial list of 15 indicators (with 54 subcriteria) was sourced from recommendations within the National Health and Medical Research Council guidelines^{8 9} and sent to three practising specialist haematologists who were Heads of Departments, asking them to comment on and rate each on a scale of 1–9 for appropriateness²³ in the Australian context during 2009 and 2010. A two-round review process was used and a formal process was employed for managing discrepancies between specialists.²¹ Opinions of other specialists were not canvassed for logistical reasons. This resulted in 39 indicators being accepted as appropriate: 31 relating to pharmacological and mechanical prophylaxis and eight to risk assessment, discharge care and management of DVT or PE (see [table 1](#)).

Recruitment of participants and healthcare providers

A sample designed to be representative of the Australian adult population was used. Households were randomly selected from a phone directory (the Telstra White Pages) from defined regions within New South Wales and South Australia and contacted using a Computer-Assisted Telephone Interview (CATI).^{21 22} One adult was randomly selected from each household and was asked to participate. Those who agreed were sent a mail package containing information about the study and a consent form to allow access to their medical records. Participants who provided consent

were called back and asked if they had been admitted overnight to a hospital or had one or more of the CTA conditions, and which healthcare providers they had seen for these in 2009 and 2010. Hospitals identified by the participants were contacted and asked to provide their consent for medical record access.²²

Review of medical records

Medical record reviews were undertaken for the 1154 consenting participants whose healthcare providers had also provided consent. Healthcare encounters were deemed eligible for scoring of VTE indicators if a participant had been admitted overnight during 2009 and/or 2010.

Experienced registered nurses were recruited and trained as surveyors to conduct the medical record reviews using a web-based tool for onsite encrypted data collection. They were provided with formal training and received a manual with detailed criteria for inclusion, exclusion and scoring of indicators.

Estimates of compliance were measured as the percentage of eligible encounters for the VTE indicators that were answered 'yes'.^{21 22} The inclusion criteria for the indicators for VTE prophylaxis were specific to particular types of surgery (eg, hip fracture surgery or abdominal surgery) or medical conditions (eg, decompensated cardiac failure or acute on chronic lung disease).^{8 9} As the CTA study was designed to measure the overall appropriateness of the healthcare delivered for 22 conditions and was not powered for significant results at indicator level, the number of eligible encounters for many indicators was low. To address this, indicators were aggregated into broader, clinically meaningful categories. For example, orthopaedic conditions with pharmacological prophylaxis (indicators 45–48) were grouped and included hip arthroplasty, hip fracture surgery, knee arthroplasty and lower limb fractures (see [table 1](#)).

Data relating to documentation of VTE risk assessment (indicator 42) was not included in the analysis reported here, as a review of surveyor practices revealed that some had assumed that a risk assessment had been carried out whenever appropriate prophylaxis had been prescribed, whether or not explicit documentation of an assessment was found. This was in breach of the criteria for this indicator, and these data were thus excluded.

Statistical analysis

Mean compliance and associated 95% CIs (using a modified version of the Clopper-Pearson (exact) method) were obtained using the SURVEYFREQ procedure in SAS V.9.3 for Windows (SAS Institute, Cary, North Carolina, USA). To address biases arising from the study design (including adjustment for non-response), two different weighting options and five versions of weights (three based on approaches used in the similar US study²³) were used to generate weighted estimates of compliances. These were not significantly different to

Table 1 CTA indicators (and aggregated sets of indicators) by compliance

Indicator number	Indicator and sets of indicators	Eligible encounters (N)	Compliant encounters (N)	Compliance* (%)	95% confidence limits† (%)
45–48	Patients undergoing certain orthopaedic procedures or care received appropriate pharmacological anticoagulant therapy	55	34	62	48–75
45	Patients who had a hip arthroplasty have received anticoagulant therapy for up to 35 days‡	22	12	Insufficient data to report	
46	Patients who had hip fracture surgery have received anticoagulant therapies for up to 35 days§	2	2	Insufficient data to report	
47	Patients who had a knee arthroplasty received anticoagulant therapies for up to 28 days¶	24	16	Insufficient data to report	
48	Patients who had a lower limb fracture received anticoagulant therapies for at least 5 days or until fully mobile§	7	4	Insufficient data to report	
62, 68–70, 73–75	Patients undergoing certain orthopaedic procedures or care received appropriate mechanical anticoagulant therapy	104	49	47	37–57
62	Patients having a total hip replacement have been prescribed graduation compression stockings	20	19	Insufficient data to report	
68	Patients having a total hip replacement have been prescribed an intermittent pneumatic compression device	18	11	Insufficient data to report	
69	Patients having hip fracture surgery have been prescribed an intermittent pneumatic compression device	3	1	Insufficient data to report	
70	Patients having a total knee replacement have been prescribed an intermittent pneumatic compression device	21	15	Insufficient data to report	
73	Patients having a total hip replacement have been prescribed a foot pump	18	1	Insufficient data to report	
74	Patients having a total knee replacement have been prescribed a foot pump	22	2	Insufficient data to report	
75	Patients having hip fracture surgery have been prescribed a foot pump	2	0	Insufficient data to report	
49–54	Patients undergoing non-orthopaedic surgical procedures (general, gynaecological, abdominal, cardiac, thoracic or vascular, trauma or spinal surgery) or who had cancer and underwent surgery received appropriate pharmacological anticoagulant therapy	226	76	34	27–41
49	Patients who had a general surgical procedure received anticoagulant therapies (unless contraindicated) until hospital discharge or fully mobile**	55	19	35	22–49
50	Patients who had gynaecological surgery received anticoagulant therapies (unless contraindicated) until hospital discharge or fully mobile**	26	5	Insufficient data to report	
51	Patients who had abdominal surgery received anticoagulant therapies (unless contraindicated) until hospital discharge or fully mobile**	61	29	48	18–78
52	Patients who had cardiac, thoracic or vascular surgery received anticoagulant therapies (unless contraindicated) until hospital discharge or fully mobile**	31	12	39	16–66
53	Patients who had trauma or spinal surgery received anticoagulant therapies started after primary haemostasis was established (unless contraindicated) until hospital discharge or fully mobile**	18	0	Insufficient data to report	

Continued

Table 1 Continued

Indicator number	Indicator and sets of indicators	Eligible encounters (N)	Compliant encounters (N)	Compliance* (%)	95% confidence limits† (%)
54	Patients who have cancer that underwent surgery received one of the following anticoagulant therapies (unless contraindicated) until hospital discharge or fully mobile**	35	11	31	5–74
63–67, 71–72	Patients undergoing non-orthopaedic surgical procedures received appropriate mechanical anticoagulant therapy	294	176	60	52–67
63	Patients having general surgery have been prescribed graduated compression stockings	72	63	88	78–94
64	Patients having gynaecological surgery have been prescribed graduation compression stockings	28	21	Insufficient data to report	
65	Patients having abdominal surgery have been prescribed graduation compression stockings	66	48	73	46–91
66	Patients having cardiac, thoracic or vascular surgery have been prescribed graduation compression stockings	52	17	33	2–85
67	Patients having neurosurgery have been prescribed graduation compression stockings	13	11	Insufficient data to report	
71	Patients having cardiac, thoracic or vascular surgery have been prescribed an intermittent pneumatic compression device	50	7	14	2–41
72	Patients having neurosurgery have been prescribed an intermittent pneumatic compression devices	13	9	Insufficient data to report	
55–61	Medical patients admitted to hospital with certain conditions received appropriate pharmacological anticoagulant therapy	167	77	46	36–57
55	Medical patients admitted to hospital with ischaemic stroke received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	5	1	Insufficient data to report	
56	Medical patients admitted to hospital with myocardial infarct (where full anticoagulant is not in use) received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	15	6	Insufficient data to report	
57	General medical patients admitted to hospital assessed as being at risk of VTE received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	84	43	51	40–62
58	Medical patients admitted to hospital with active cancer received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	23	8	Insufficient data to report	
59	Medical patients admitted to hospital with decompensated cardiac failure received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	7	3	Insufficient data to report	
60	Medical patients admitted to hospital with acute on chronic lung disease received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	31	15	48	30–67
61	Medical patients admitted to hospital with acute on chronic inflammatory disease received anticoagulant therapies until resolution of the acute medical illness or until hospital discharge††	2	1	Insufficient data to report	

Continued

Table 1 Continued

Indicator number	Indicator and sets of indicators	Eligible encounters (N)	Compliant encounters (N)	Compliance* (%)	95% confidence limits† (%)
76–80	Patients with suspected PE/DVT were managed with appropriate investigations, or had anticoagulant therapy started as soon as clinically suspected; or if PE/DVT confirmed, were managed appropriately	89	57	64	51–76
76	Patients with a suspected DVT had a venous duplex ultrasound performed	12	10	Insufficient data to report	
77	Patients with a suspected PE had investigations performed‡‡	21	17	Insufficient data to report	
78	Patients with a suspected DVT or PE where ultrasound was delayed, had anticoagulant therapy started (unless contraindicated) as soon as clinically suspected	10	8	Insufficient data to report	
79	Patients with a confirmed DVT/PE received anticoagulant therapies§§	6	3	Insufficient data to report	
80	Patients who were administered heparin therapy had it continued until the INR had been therapeutic for 48 h (INR range 2.0–3.0)	40	19	48	26–70
	Patients discharged on anticoagulant therapy have an appropriate documented care plan including details on the intended duration of treatment AND a review date¶¶	70	32	46	31–61
43	Patients who are discharged on anticoagulant therapy have a documented care plan that includes details on the intended duration of treatment	73	43	59	46–71
44	Patients who are discharged on anticoagulant therapy have a documented care plan that includes a review date	70	35	50	29–71

Bold typeface indicates the aggregated indicators.

*Percentage compliance calculated as the number of compliant encounters/number of eligible encounters ×100.

†Compliance and per cent of compliance were not calculated for <30 encounters.

‡Enoxaparin 40 mg/day; dalteparin 5000 U/day; LDUH 5000 u three times a day; fondaparinux 2.5 mg/day (started 6–8 h postoperatively); rivaroxaban (orally); dabigatran (orally).

§Enoxaparin 40 mg/day; dalteparin 5000 U/day; LDUH 5000 u three times a day; fondaparinux 2.5 mg/day (started 6–8 h postoperatively).

¶Enoxaparin 40 mg/day; dalteparin 5000 U/day; LDUH 5000 u three times a day; fondaparinux 2.5 mg/day (started 6–8 h postoperatively); rivaroxaban (orally); dabigatran (orally).

**Enoxaparin 20 mg/day; dalteparin 2500 U/day.

††Enoxaparin 40 mg/day; dalteparin 5000 U/day; LDUH 5000 U two times or three times a day; assumed implicit and explicit risk assessments included.

‡‡One of: ventilation perfusion scan; CT angiography; pulmonary angiography.

§§Heparin administered together with warfarin for at least 5 days; unfractionated heparin intravenous (APTT) or subcutaneous (dose/kg); LMWH subcutaneously at least once daily.

¶¶Compliance for this aggregated indicator was both indicators 43 and 44 were compliant for a participant in an episode of hospitalisation. In other aggregated indicators, compliance was measured by adding each individual encounter as each episode of hospitalisation was an independent event.

APTT, activated partial thromboplastin time; DVT, deep venous thrombosis; INR, international normalised ratio; LDUH, low-dose unfractionated heparin; LMWH, low molecular weight heparin; PE, pulmonary embolism; VTE, venous thromboembolism.

unweighted compliances overall or for any condition (including VTE). Hence, unweighted compliances were used for this analysis.²² Appendix 2 of the CTA study outlines the detailed methodology and overall results.²²

RESULTS

Of the 1154 CTA participants, 481 (42%) were admitted overnight to hospital at least once, with a total of 751 admissions eligible for assessment against the VTE indicators. There were 279 females (58%), and the mean

age was 64 years (6% were aged 18–39, 17% 40–54, 56% 55–74 and 21% were over 70 years of age).

Of the 35 145 CTA encounters (with duplicates and the risk indicator removed), 1078 (3%) were eligible for scoring against VTE indicators; the number of eligible encounters per indicator ranged from 2 to 84. Records were reviewed at 33 hospitals, with 27 having eligible encounters. Eight of the hospitals had 50 or more eligible encounters.

Overall compliance with the VTE indicators was 51% (95% CI 47% to 54%), with results for aggregated sets

of indicators ranging from 34% to 64% (table 1). Omission of the risk assessment indicator from the overall score reduced compliance from the 58% reported originally²² to the 51% reported here. For the eight hospitals with 50 or more eligible encounters, compliance ranged from 45% to 70%.

DISCUSSION

Our analysis of CTA data has shown that a sample of 481 Australian adults in 27 hospitals received appropriate care for VTE during 2009 and 2010 at only 51% of eligible healthcare encounters, in spite of considerable efforts to promote and facilitate the uptake of CPGs in Australia.^{12–16} Thus, despite the prevalence, cost, morbidity and mortality associated with VTE and PE, prophylaxis and treatment are still in line with CPGs only half the time. This continues to be a problem in both the developed and developing worlds.^{17–19}

CTA patients who had surgery received appropriate pharmacological or mechanical anticoagulant therapy on only 39% and 57% of occasions, respectively (aggregations from table 1). The ENDORSE study, a multinational cross-sectional survey, also examined the proportion of at-risk patients who received effective prophylaxis.¹⁷ It found, for 804 patients from eight Australian hospitals studied in 2006–2007, that 82% of at-risk surgical patients received appropriate prophylaxis. This study did not separate pharmacological and mechanical prophylaxis.¹⁷ Baseline (preintervention) compliances for surgical patients were also higher than CTA compliances in two single hospital studies (65% and 74% for pharmacological prophylaxis and 89% and 64% for mechanical prophylaxis).^{24–25} Possible reasons for the lower CTA compliances are that CTA was a population-based study at 27 hospitals which were effectively randomly selected, while ENDORSE mainly collected data from prominent teaching hospitals, and the two single hospital studies were about to start an intervention for VTE prophylaxis, and had possibly raised awareness of the problem.

In contrast, the CTA compliance for at-risk medical patients at 46% (aggregations from table 1) was similar to those in the eight Australian ENDORSE hospitals and a regional hospital (51% and 64%, respectively).^{17–25} Lower compliances for medical than surgical patients in the ENDORSE study and the regional hospital are consistent with the more complex indications in medical patients, and have been noted elsewhere.²⁶ No equivalent Australian studies could be found for indicators associated with management of suspected or confirmed DVT or PE (CTA compliance 64%), or patients with a documented discharge plan and a date for cessation of treatment (CTA compliance 46%), but it would seem reasonable to conclude that both of these areas of practice also require attention.

The risk assessment indicator was studied in two Australian single-hospital studies which both found 0%

compliance at the preintervention stage, with modest postintervention compliances of 28% and 36%.^{24–27}

The poor compliances with VTE indicators in Australia are consistent with the lack of a system-wide approach. Compliance measures or outcomes are not publicly reported at hospital level,²⁸ VTE is not included in national standards,²⁹ nor is it a national healthcare goal.³⁰ Australian clinicians have identified that setting agreement on clinical guidelines and standards (agreement on risk categories, risk assessment tools, mandatory actions and protocols, provision of summaries), decision-support tools, and reporting results are enablers to delivering appropriate VTE care.^{31–32} The fact that compliance ranged from 45% to 70% between hospitals suggests that some facilities are faring better than others at managing VTE appropriately.

Strengths and weaknesses

The key strength of the CTA study is that it is designed to be representative of the Australian population to minimise selection bias, rather than a convenience-based or purposive-based sample. However, an unavoidable consequence of this strategy, coupled with finite research funds, is that the numbers of participants and/or eligible encounters are low for some indicators; 25 of 38 had insufficient data to report. Findings for these must be disregarded or interpreted with caution. The review of medical records, while costly and difficult, allowed compliance to be measured in a real-world setting and avoided the limitations inherent in asking healthcare providers to respond to clinical vignettes^{33–34} or questionnaires.³⁵ Errors arising from measurement (information bias) were within acceptable limits for implicit review.^{36–38} Accordingly CTA provides some baseline estimates for compliance against which progress on the provision of appropriate care for VTE could be compared and tracked.

The approach used was associated with a high rate of attrition of potential participants and several other sources of possible bias. Although it was not logistically feasible to design sampling so as to eliminate all possible confounders (confusion bias) or have the sample characteristics to exactly match the Australian population, weighting using two methods and five different options made no significant difference to the overall compliance percentage, or that for VTE;²² this is consistent with providers not altering their clinical practices for patients of different ages, gender, or socioeconomic or health literacy status.

Commentators have raised issues with respect to the levels of evidence for and choice of indicators, effects of comorbidities, inter-rater reliability and the possibility of care having been provided but not recorded.^{36–37} These have all been addressed:^{22–38} compliance was shown to be no different for consensus-based and evidence-based recommendations; the CTA indicators were designed to be clinically relevant but not affected by comorbidities;

inter-rater reliability was moderate, but was in line with other studies using implicit medical record review;³⁸ and the effect on overall compliance of care received but not documented is thought to be no more than 10%.^{23 39 40}

CONCLUSION

Our analysis of the VTE indicators from the CTA study show that compliance is modest at 51%, despite resources and guidelines being available, and the high associated cost and burden of disease. This is consistent with the lack of a system-wide focus on VTE in Australia as is the case in most of the rest of the world. In line with recommendations arising from the overall CTA study and feedback from clinicians, the challenge is to now move towards agreement on national clinical standards and on the development of indicators and tools to guide, document and monitor the appropriateness of care for VTE. An inclusive, national wiki-based process for achieving this has been proposed.²⁰ VTE data could then be monitored at hospital level and the data aggregated at national and, potentially at international levels to track progress and inform policy.

Author affiliations

¹Australian Institute of Health Innovation, Macquarie University, Sydney, New South Wales, Australia

²Centre for Population Health Research, University of South Australia, Adelaide, South Australia, Australia

³Australian Patient Safety Foundation, Adelaide, South Australia, Australia

⁴Hunter Valley Research Foundation, Newcastle, New South Wales, Australia

⁵Adelaide Cancer Centre, Kurralta Park, South Australia, Australia

Acknowledgements The authors thank the participants, healthcare providers, practice managers, medical records staff and expert reviewers who generously gave their time and expertise.

Contributors The authors have contributed substantially to the conception and design of the study, or acquisition of data or analysis and interpretation of the finding. All have also been actively involved in either the drafting of the manuscript or revising it critically for important intellectual content; and have given approval for this version to be published. PDH was Program Manager for the NHMRC Program Grant and also assisted with the analysis and interpretation of findings and made a substantial contribution to reviewing the literature, synthesising results and findings from other relevant studies, and drafting the manuscript. NAH was responsible for the selection, development and ratification of all the indicators used in the study and assisted TDH with surveyor recruitment and training. She also contributed to the revision of the manuscript. TDH was the Project Manager for CareTrack and coordinated the data collection for the entire study including the extraction of patient medical records. She also coordinated all the necessary approvals and managed the training and performance of surveyors and contributed to the revision of the manuscript. DMH was the main Statistician for CareTrack and undertook analysis of the CareTrack data. She also contributed to the interpretation of the statistical information included in the manuscript. JB was involved in the design and conception of CareTrack Australia as the Chief Investigator-A of the NHMRC Program Grant, and extensive editing and revision of the manuscript. SAR developed the initial sampling plan for CareTrack Australia; provided advice for the process of recruiting participants and organised and managed telephone recruiters. NW was involved as a CareTrack Australia clinical expert, assisted in the ratification of the VTE indicators and provided clinical input into the editing and revision of the manuscript. WBR was the primary instigator of CareTrack and responsible for its conception and design. He was also involved in all aspects of the project from data collection to

analysis and interpretation of findings. He has been heavily involved in the editing and revision of the manuscript providing invaluable advice and guidance to the corresponding author.

Funding This study was funded by National Health and Medical Research Council (NHMRC) Program Grant No. 568612.

Competing interests None declared.

Ethics approval Hunter New England Local Health District Human Research Ethics Committee (HREC).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

REFERENCES

1. Heit JA. The epidemiology of venous thromboembolism in the community: implications for prevention and management. *J Thromb Thrombolysis* 2006;21:23–9.
2. University of Western Australia. *The incidence and risk factors for venous thromboembolism in hospitals in Western Australia 1999–2001*. National Institute of Clinical Studies, 2005.
3. Access Economics. *The burden of venous thromboembolism in Australia*. Report for the Australia and New Zealand Working Party on the Management and Prevention of Venous Thromboembolism. 2008.
4. Palmer AJ, Kopenhagen K, Kirchhof B, *et al*. Efficacy and safety of low molecular weight heparin, unfractionated heparin and warfarin for thrombo-embolism prophylaxis in orthopaedic surgery: a meta-analysis of randomised clinical trials. *Haemostasis* 1997;27:75–84.
5. Palmer AJ, Schramm W, Kirchhof B, *et al*. Low molecular weight heparin and unfractionated heparin for prevention of thrombo-embolism in general surgery: a meta-analysis of randomised clinical trials. *Haemostasis* 1997;27:65–74.
6. Kanaan AO, Silva MA, Donovan JL, *et al*. Meta-analysis of venous thromboembolism prophylaxis in medically ill patients. *Clin Ther* 2007;29:2395–405.
7. Flanders SA, Greene M, Grant P, *et al*. Hospital performance for pharmacologic venous thromboembolism prophylaxis and rate of venous thromboembolism: a cohort study. *JAMA Intern Med* 2014;174:1577–84.
8. The Australian and New Zealand Working Party on the Management and Prevention of Venous Thromboembolism. *Best practice guidelines for Australia and New Zealand health education and management innovations*. 4th edn. 2007.
9. National Health and Medical Research Council. *Clinical practice guideline for the prevention of venous thromboembolism (deep vein thrombosis and pulmonary embolism) in patients admitted to Australian hospitals*. Melbourne: National Health and Medical Research Council, 2009.
10. National Institute for Clinical Excellence. *CG92 Venous thromboembolism—reducing the risk: full guideline*. NICE, 2010.
11. Hirsh J, Guyatt G, GW, *et al*. Antithrombotic and thrombolytic therapy*: American college of chest physicians evidence-based clinical practice guidelines (8th edition). *Chest* 2008;133(6 suppl): 110S–12S.
12. National Health and Medical Research Council. *Stop the clot: integrating VTE prevention guideline recommendations into routine hospital care*. Melbourne: National Health and Medical Research Council, 2011.
13. Australian Commission on Safety and Quality in Health Care. *Template for hospital venous thromboembolism prophylaxis policy*. Sydney: ACSQHC, 2011.
14. National Prescribing Service. QUM for health professional students learning objectives 2013 (cited 6 May 2013). <http://www.nps.org.au/health-professionals/professional-development/online-learning/qum-for-health-professional-students-learning-objectives>
15. Clinical Excellence Commission. *Medication safety SELF ASSESSMENT for antithrombotic therapy in Australian hospitals*. Sydney: New South Wales Therapeutic Advisory Group, 2007.

16. National Health and Medical Research Council. *Blood clots: reducing your risk*. NHMRC, 2010.
17. Cohen AT, Tapson VF, Bergmann JF, *et al*. Venous thromboembolism risk and prophylaxis in the acute hospital care setting (ENDORSE study): a multinational cross-sectional study. *Lancet* 2008;371:387–94.
18. Golian M, Moussa M, White C, *et al*. Venous thromboembolism prophylaxis on a cardiology in-patient unit: a surprising result? *Can J Cardiol* 2016;32:256–8.
19. Atmakusuma TD, Tambunan KL, Sukrisman L, *et al*. Underutilization of anticoagulant for venous thromboembolism prophylaxis in three hospitals in Jakarta. *Acta Med Indones* 2015;47:136–45.
20. Runciman WB, Coiera EW, Day RO, *et al*. Towards the delivery of appropriate health care in Australia. *Med J Aust* 2012;197:78–81.
21. Hunt TD, Ramanathan SA, Hannaford NA, *et al*. CareTrack Australia: assessing the appropriateness of adult healthcare: protocol for a retrospective medical record review. *BMJ Open* 2012;18:e000665.
22. Runciman WB, Hunt TD, Hannaford NA, *et al*. CareTrack: assessing the appropriateness of health care delivery in Australia. *Med J Aust* 2012;197:100–5.
23. McGlynn EA, Asch SM, Adams J, *et al*. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;348:2635–45.
24. Duff J, Walker K, Omari A. Translating venous thromboembolism (VTE) prevention evidence into practice: a multidisciplinary evidence implementation project. *Worldviews Evid Based Nurs* 2011;8:30–9.
25. Liu DS, Lee MM, Spelman T, *et al*. Medication chart intervention improves inpatient thromboembolism prophylaxis. *Chest* 2012;141:632–41.
26. Pow RE, Vale PR. Thromboprophylaxis in patients undergoing total hip and knee arthroplasty: a review of current practices in an Australian teaching hospital. *Intern Med J* 2015;45:293–9.
27. Li F, Walker K, McInnes E, *et al*. Testing the effect of a targeted intervention on nurses' compliance with "best practice" mechanical venous thromboembolism prevention. *J Vasc Nurs* 2010;28:92–6.
28. National Health Performance Authority. My Hospitals 2013 (cited 15 August 2013). <http://www.myhospitals.gov.au/>
29. Australian Commission on Safety and Quality in Health Care. *National Safety and Quality Health Service Standards*. Sydney: ACSQHC, 2011.
30. Australian Commission on Safety and Quality in Health Care. *Overview of the Australian Safety and Quality Goals for Health Care*. Sydney: ACSQHC, 2011.
31. National Health and Medical Research Council. *Venous thromboembolism prevention policy summit May 2010: summary report*. Melbourne: National Health and Medical Research Council, 2011.
32. National Health and Medical Research Council. *Preventing venous thromboembolism in hospitalised patients. Summary of NHMRC Activity 2003–2010*. NHMRC, 2011.
33. Johnson MJD, Sheard LD, Maraveyas AD, *et al*. Diagnosis and management of people with venous thromboembolism and advanced cancer: how do doctors decide? A qualitative study. *BMC Med Inform Decis Mak* 2012;12:75.
34. Bikkdeli B, Sharif-Kashani B, Raeissi S, *et al*. Chest physicians' knowledge of appropriate thromboprophylaxis: insights from the PROMOTE study. *Blood Coagul Fibrinolysis* 2011;22:667–72.
35. de Franciscis S, Agus GB, Bisacci R, *et al*. Guidelines for venous thromboembolism and clinical practice in Italy: a nationwide survey. *Ann Vasc Surg* 2008;22:319–27.
36. Ackermann E. Barriers to "appropriate care" in general practice. *Med J Aust* 2012;197:76.
37. Scott IA, Del Mar CB. A dog walking on its hind legs? Implications of the CareTrack study. *Med J Aust* 2012;197:67–8.
38. Runciman WB, Hunt TD, Hannaford NA, *et al*. CareTrack: assessing the appropriateness of health care delivery in Australia. *Med J Aust* 2012;197:549–50.
39. Dresselhaus TR, Luck J, Peabody JW. The ethical problem of false positives: a prospective evaluation of physician reporting in the medical record. *J Med Ethics* 2002;28:291–4.
40. Luck J, Peabody JW. Using standardised patients to measure physicians' practice: validation study using audio recordings. *BMJ* 2002;325:679.