



NATIONAL INSTITUTE OF CLINICAL STUDIES

**Trends in Venous
Thromboembolism in
Western Australia
1989 - 2001**

June 2005

TURNING EVIDENCE INTO ACTION

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ISBN 0-9756964-3-2

Suggested citation

National Institute of Clinical Studies 2005. Trends in Venous Thromboembolism in Western Australia 1989 - 2001. Prepared by the School of Population Health, Unit of Clinical Epidemiology, University of Western Australia. NICS, Melbourne.

Acknowledgements

This document was prepared by the following staff at The School of Population Health, University of Western Australia:

Michael Hobbs
Steve Ridout
Louise Stewart
Eileen McKenzie
Qun Mai
Judith Finn
Matthew Knuiman

The Department of Health of Western Australia is thanked for supporting the Unit of Clinical Epidemiology (Professor M Hobbs) and for allowing access to the Western Australian Linkage System and in particular the Data Linkage Unit in the Health Information Centre for extracting the data required for the study.

The Directors of Departments of Radiology and Nuclear Medicine at Fremantle Hospital, Royal Perth Hospital and Sir Charles Gairdner Hospital for facilitating access to results of diagnostic tests for venous thromboembolism.

The staff in Medical Record Departments in participating hospitals are thanked for their assistance in providing access to medical records.

Further copies of this publication can be downloaded from the National Institute of Clinical Studies website at www.nicsl.com.au

The National Institute of Clinical Studies is Australia's national agency for improving health care by helping close important gaps between best available evidence and current clinical practice. NICS is funded by the Australian Government.

Foreword

The prevention of venous thromboembolism in hospitalised patients is one of the clinical priority areas for the National Institute of Clinical Studies (NICS) because deep vein thrombosis and pulmonary embolism are largely preventable complications of hospitalisation, yet there is a substantial gap between current practice in Australia and evidence-based best practice.

The National Institute of Clinical Studies aims to improve the prevention of VTE in all hospitalised patients in Australia. The Western Australian Venous Thromboembolism Study was funded to inform the process of developing an effective intervention program to reduce the mortality associated with pulmonary embolism and morbidity associated with long-term complications of deep vein thrombosis in Australian hospitals.

Specifically we sought information on:

- The overall magnitude of the problem of VTE in hospital practice and how cases are distributed among surgical and medical specialties (see NICS 2005 *Trends in the Incidence of venous thromboembolism in hospitals in Western Australia 1999-2001*)
- the prevalence of chemoprophylaxis in high risk patients (see NICS 2005 *The Prevalence of Chemoprophylaxis in Surgical and Medical Cases at High Risk of Venous Thromboembolism*); and
- Trends in the incidence of VTE in hospitalised patients (this report)

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1. INTRODUCTION

Venous thromboembolism (VTE), consisting of pulmonary embolism (PE) and deep vein thrombosis (DVT), is an infrequent but serious complication of complex surgery and prolonged hospitalization. In a previous study of VTE in Western Australia we found that surgical procedures and medical hospital admissions each accounted for about 40% of hospital cases of VTE, with Primary VTE accounting for the remaining 20%. (1) Of the secondary cases just over half occurred as readmissions within 90 days of a previous hospital admission for a surgical procedures or medical condition (Admission or Readmission VTE) while in the remainder VTE occurred as a complication of an admission for another condition (Index case VTE). Cases of PE, the more serious condition, contributed approximately half of secondary cases but nearly two thirds of readmission cases and 30% of index cases.

Clinical trials in selected high-risk conditions suggest that substantial reductions in the prevalence of VTE in hospital admissions can be achieved with chemoprophylaxis or physical measures such as graduated elastic stockings (GES) or intermittent pneumatic compression (IPC). (2, 3) Guidelines for prevention of VTE in high-risk cases have been developed by authoritative bodies and promulgated widely. (2, 3) Information on the extent to which guidelines have been systematically implemented in hospital practice is sparse but a recent review in Australia suggests that this is sub-optimal.(4) Information on present levels of chemoprophylaxis in Australian hospitals is also lacking but a recent study of chemoprophylaxis in selected high-risk cases in hospitals in Perth conducted as part of the present study, suggests that compliance is reasonably high in lower-limb joint procedures and colorectal surgery for cancer. (5) If this is generally the case, it is reasonable to assume that chemoprophylaxis against VTE in hospital practice has increased over the past decade and could be expected to eventually have some impact on trends in population rates of VTE. Such information would therefore be of considerable interest and could provide a guide to the effectiveness of preventive programs. In this report we examine trends in VTE in Western Australia over the period 1989-2001.

2. SUBJECTS AND METHODS

The study population includes all residents of Western Australia who were admitted to hospital suffering from a DVT or PE (as defined below) during the period 1989 to 2001. People who were not admitted to hospital, including those who died or were treated for DVT either by their own GP or from outpatient clinics were not included. The methods used in this and associated studies have been described in detail elsewhere. (1) In brief we selected a subset of records of cases admitted to hospital with coded diagnoses of PE or DVT in any diagnostic field from a linked file of records of hospital admissions and deaths of all persons ever admitted to hospital for cardiovascular disease in Western Australia in the period 1980 – 2001 (The Linked Vascular File). Cases with a diagnosis of PE in any diagnostic field were classified as PE irrespective of whether there was also a code for DVT in the record. Cases of VTE were those with a code of either DVT OR PE in any diagnostic field. Using record linkage to create 90-day episodes, cases of VTE were further classified into broad aetiological classes as follows:

Surgical VTE: a diagnosis of VTE recorded during the same admission or in a readmission within three months of an admission for a surgical procedure.

Medical VTE: a diagnosis of VTE coded as a complication or co-morbidity in non-surgical admissions or as the principal diagnosis in a readmission within ninety days of a non-surgical admission.

Primary (or Idiopathic) VTE: all remaining cases with a Principal diagnosis of VTE

Statistical analysis

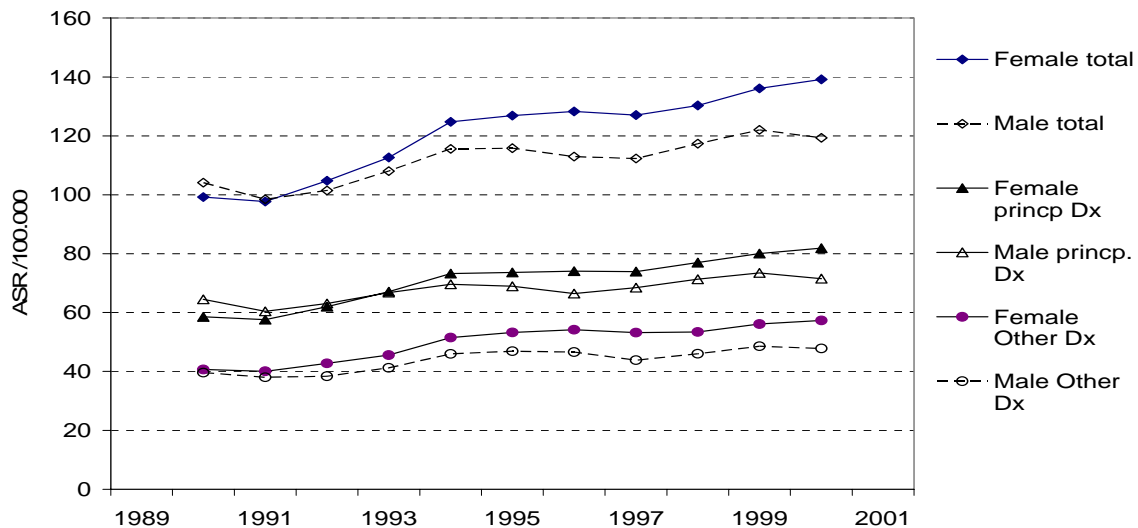
The results of males and females were analysed separately. Trends in age standardized rates (ASR) of VTE, DVT and PE were estimated using direct standardization. Each of the above was further disaggregated into rates based on cases in which the diagnosis was coded in the principal diagnosis or in secondary diagnostic fields. Trends in each outcome were also estimated separately for surgical, medical and primary cases. Poisson regression was used to determine changes in relative risk of the outcome variables in three-year calendar periods after adjustment for age.

3. RESULTS

3.1 Trends in VTE

Figure 1 shows trends in age standardised rates (three-year moving averages) of 90-day episodes of VTE in males and females. The upper trend lines are for total VTE (a diagnosis of VTE in any diagnostic field including the principal diagnosis). The middle trend lines are for rates based on the principal diagnosis and the lower trend-lines for rates based on diagnoses in secondary diagnostic fields. Rates of total VTE were stable from 1989 to 1992, but then rose steeply to 1994 in both males and females. Thereafter, rates rose only slightly in males but continued to rise in females but at a slower rate, to be nearly 20% higher than rates in males by the end of the period. Similar patterns occurred in rates based on principal or secondary diagnoses that contribute equally to the overall increase in rates, although in relative terms rates based on secondary diagnoses increased more than rates based on principal diagnoses.

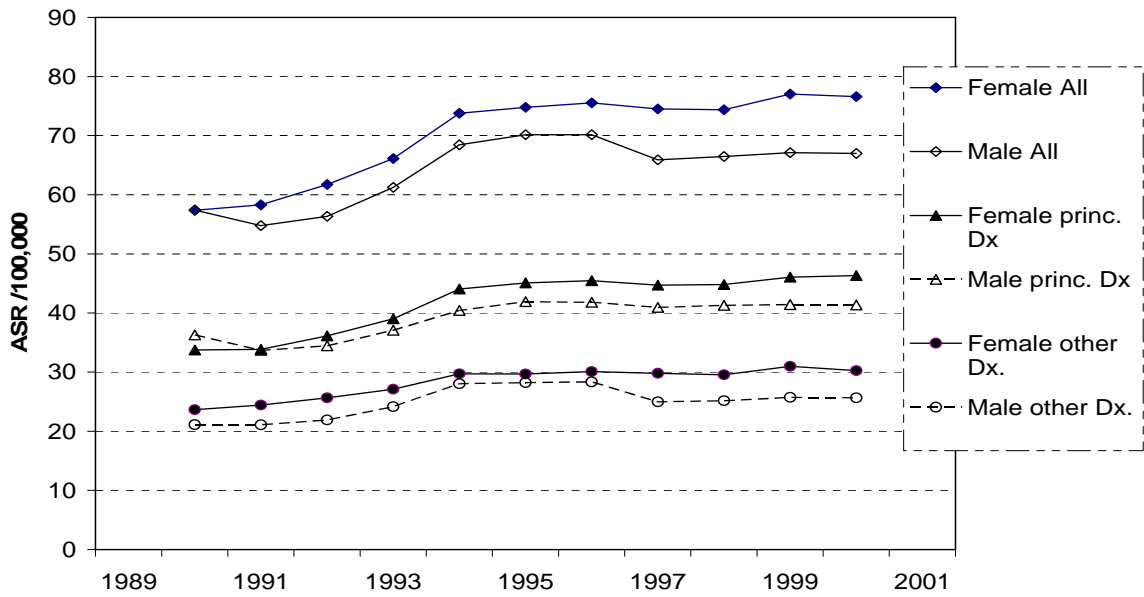
Figure 1. Trends in VTE by principal and secondary diagnoses in males and females



3.2 Trends in deep vein thrombosis (DVT)

Trends in DVT are shown in Figure 2. As in the case of VTE, rates did not change until 1992 but then rose steeply until 1995 in both men and women, before leveling-out in females and falling slightly in males. In women, rates of DVT increased by 35% over the study period compared with 17% in men. The pattern of trends in rates based on principal diagnoses and secondary diagnoses were similar to those for All DVT.

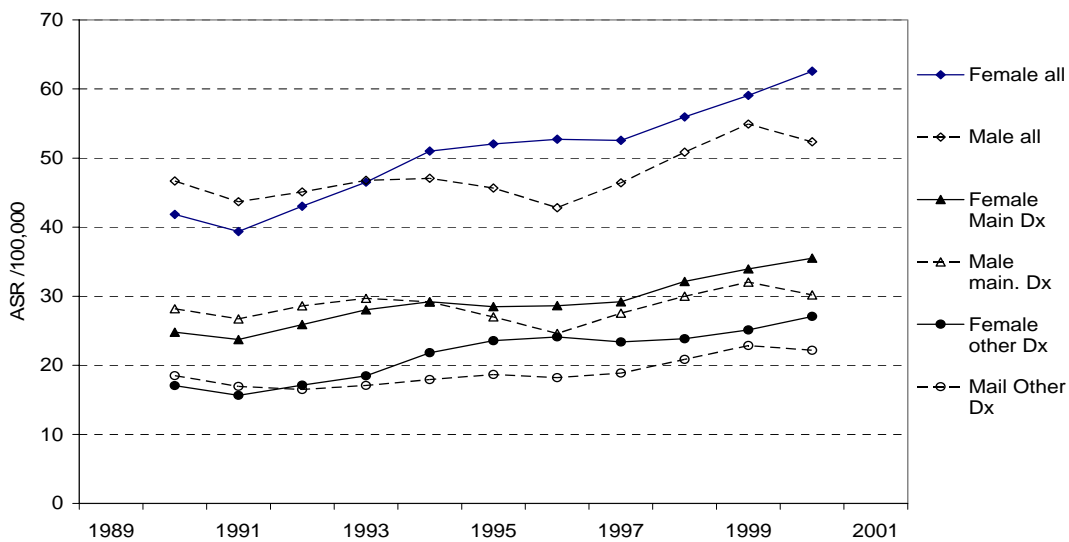
Figure 2. Trends in DVT by principal and secondary diagnoses in males and females



3.3 Trends in pulmonary embolism (PE)

Trends in PE are shown in Figure 3. The most striking feature is the rapid rise in rates of total PE in women which increased by 50% in the study period. Rates rose steeply from 1991 to 1994, less rapidly until 1997, then again increased rapidly until 2000. In men total rates of PE rose by 12%, with the greatest increase occurring from 1996 to 2000 from 1991 to 1994. The pattern of trends in rates based on principal diagnoses or secondary diagnoses was similar to that for All PE

Figure 3. Trends in PE by principal and secondary diagnoses in males and females (three year moving averages)



3.4 Changes in relative risk of PE and DVT by calendar period

Because of the potential importance of the apparent increases in rate of PE in women we examined changes in risk of PE and DVT by calendar period using Poisson regression to adjust for age.

Table 1 shows the estimate of changes in relative risk of 90-day episodes of PE by calendar period relative to 1999-2001. In women the risk of PE in 1999-2001 was nearly 20% greater than in 1993-95 and 1996-98, and 35% greater than in 1988-92. The results indicate a large increase over the study period in cases coded as having PE that is not due to chance. Significant but smaller increases in risk in 1999-2001 compared with the other calendar periods are also seen in men, but the differences are less than in women.

Table 1. Risk of PE per calendar period after adjustment for age

Calendar period	Odds Ratio*	Lower 95% CI	Upper 95% CI
Females			
1988-92	0.65	0.60	0.70
1993-95	0.81	0.74	0.88
1996-98	0.82	0.76	0.89
1999-2001	1.00	1.00	1.00
Males			
1988-92	0.86	0.79	0.94
1993-95	0.88	0.81	0.97
1996-98	0.89	0.81	0.97
1999-2001	1.00	1.00	1.00

*Odds ratio estimated by Poisson regression.

Table 2 shows the estimate of changes in relative risk of 90-day episodes of DVT by calendar period relative to 1999-2001. The risk of DVT is significantly lower in 1988-92 (by 30% in women and 20% in men) but there is no difference in risk of DVT between 1999-2001 and the remaining calendar periods.

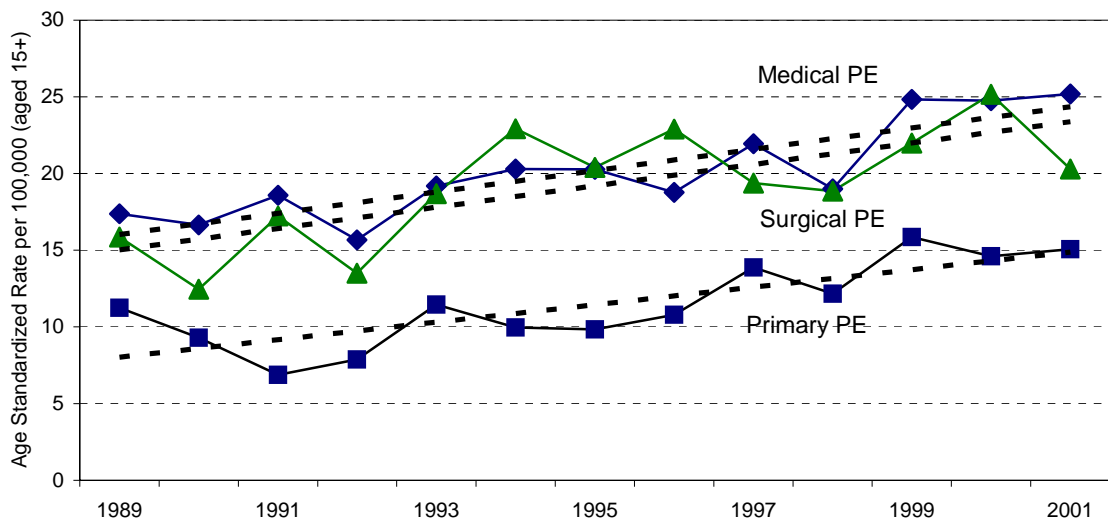
Table 2. Risk of PE per calendar period after adjustment for age

Calendar period	Odds Ratio*	Lower 95% CI	Upper 95% CI
Females			
1988-92	0.76	0.70	0.81
1993-95	0.97	0.90	1.04
1996-98	0.98	0.92	1.05
1999-2001	1.00	1.00	1.00
Males			
1988-92	0.85	0.79	0.92
1993-95	1.01	0.93	1.09
1996-98	0.99	0.92	1.07
1999-2001	1.00	1.00	1.00

3.5 Trends in PE and DVT by aetiological class

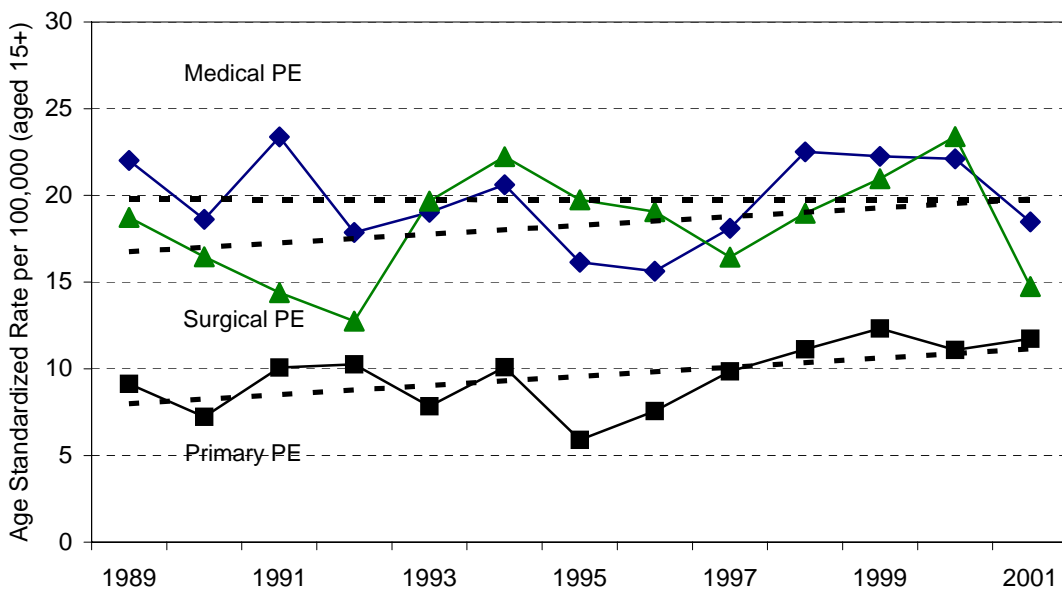
In order to identify factors that may underlie the observed changes in rates of PE and DVT we examined trends of each in three broad aetiological classes. Trends in PE by aetiological class are shown for females in Figure 4. Rates of PE increased in all classes, but there was no appreciable difference between classes in the rate of increase in medical and surgical cases. In relative terms, rates of primary PE increased more than those for medical and surgical cases.

Figure 4. Trends in pulmonary embolism by aetiological class - Females



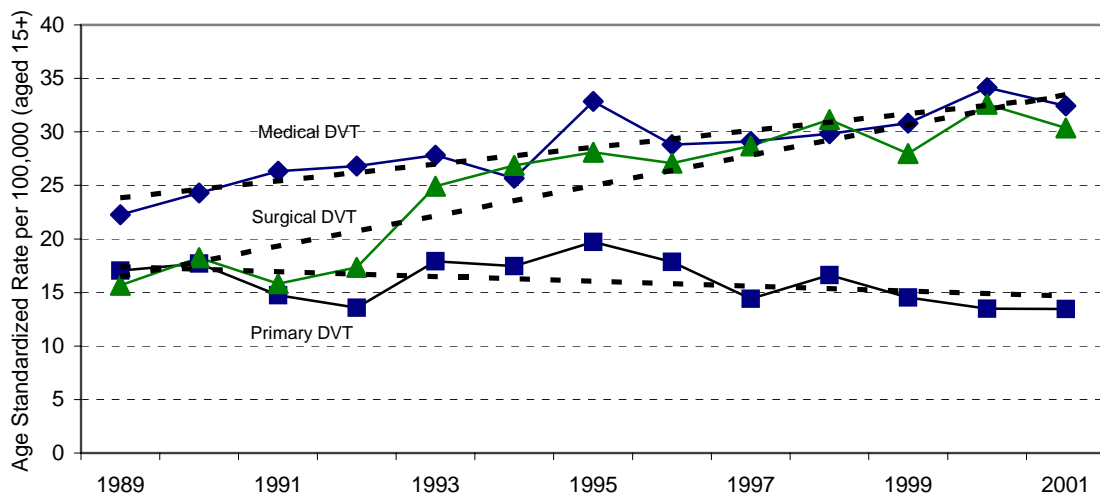
In males (Figure 5), rates of PE did not change in medical cases, but slight and approximately equal rises in rates occurred in surgical and primary cases.

Figure 5. Trends in pulmonary embolism by aetiological class - Males



Rates of DVT in females are shown by aetiological class in Figure 6. Rates rose in both medical and surgical cases, particularly in the latter, and declined in primary cases. The increase in rates in surgical cases was particularly marked between 1992 and 1993. Thereafter rates in medical and surgical cases increased equally.

Figure 6. Trends in deep vein thrombosis by aetiological class – Females



Rates of DVT in men are shown by aetiological class in Figure 7. Rates increased in both medical and surgical cases but particularly in the latter. As in women, rates of primary DVT fell consistently over the study period.

Figure 7. Trends in deep vein thrombosis by aetiological class - Males

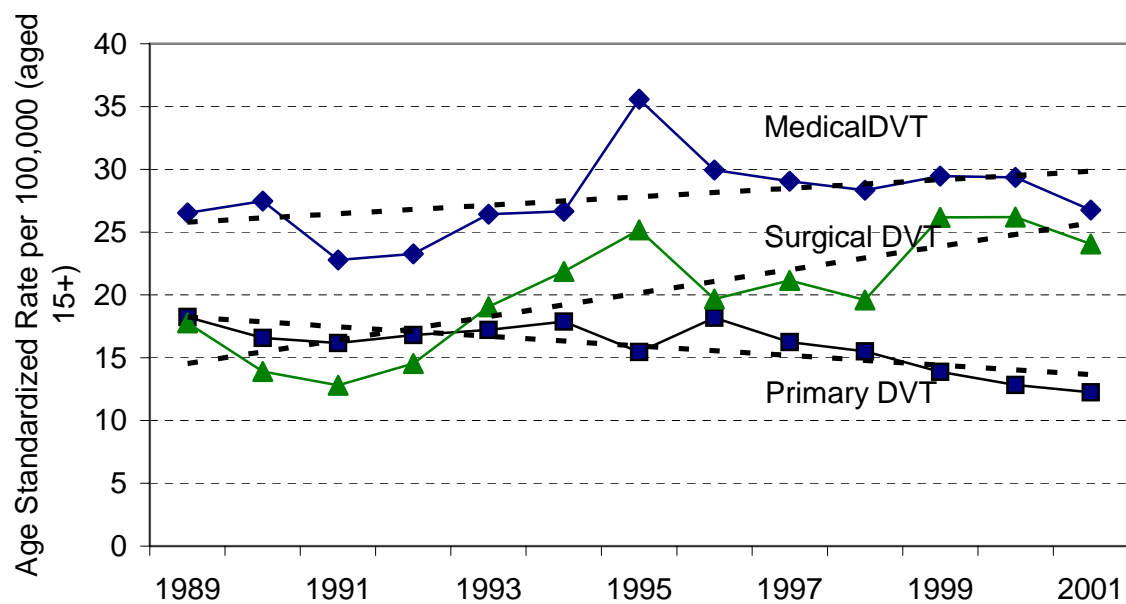
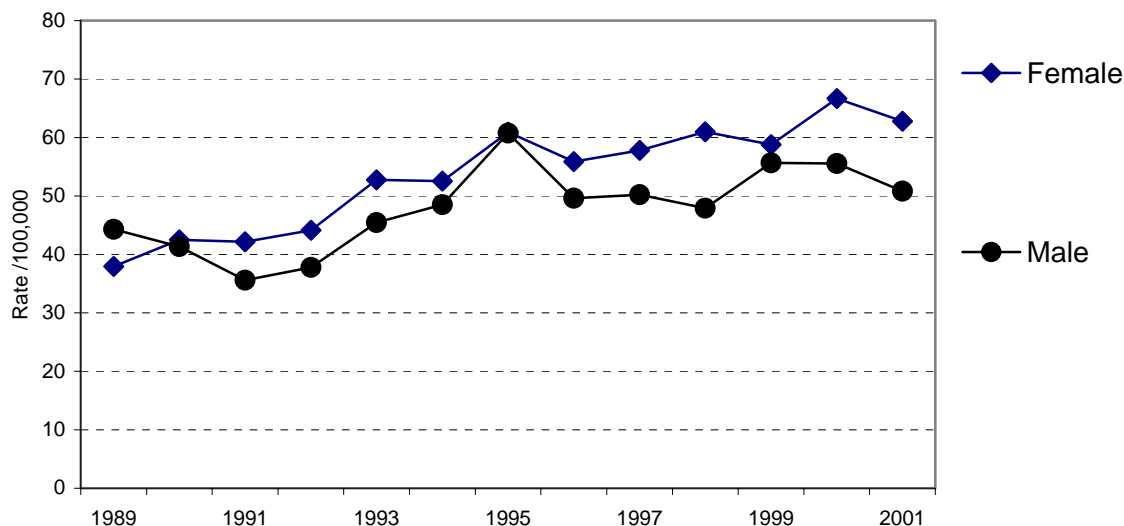


Figure 8 shows trends in Secondary DVT (Medical and Surgical VTE combined) by sex. Rates in females increased by nearly 70% over the whole study period, and by nearly 20% after 1994. In males rates increased by approximately 40% over the whole period but did not increase after 1994.

Figure 8. Trends in Secondary DVT by sex.



3.6 Reasons for sex differences in rates of VTE in 1999-2001

Determination of the reasons for sex differences in trends requires an understanding of the extent to which these are related to differences in the prevalence of the underlying conditions that are responsible for VTE in hospital practice or to differences in risks of VTE in men and women. It would not be possible to answer these questions without information on total hospital admissions relating to the underlying causes. This is beyond the scope of the present study. An understanding of the reasons for the higher rates of VTE in women in the period 1999-2001 may however provide direction for further research into this subject.

Table 3. Age specific and age standardised rates of VTE by sex in Western Australia in 1999-2001

Age Group	No. of Cases		Rates per 100,000		Rate ratio (F/M)
	Male	Female	Male	Female	
15-54	840	1063	56	72	1.29
55-64	493	496	149	159	1.07
65-74	544	641	271	319	1.18
75++	647	946	357	388	1.09
All Ages	2524	3146	113	141	1.25
Age Standardised Rates per 100,000			117	137	1.17

Table 3 shows age specific and age standardised rates in VTE by gender. The age standardised rates in women is 17% higher than in men. Higher rates are seen in women in all age groups with the greatest difference in those aged 15-54. There is however no consistent trend for rate ratios to decrease with age.

Table 4 shows differences in number of VTE cases by gender in broad aetiological groups.

Table 4. The distribution of cases of VTE by Aetiology and sex. WA 1999-2001

AETIOLOGY	Male	Female	Female less male	Ratio F/M	% of net difference
Primary	679	796	117	1.17	18.8%
Secondary					
Gender specific					
<i>Pregnancy</i>	NA	133	133		
<i>Cancer breast and female genital</i>	NA	58	58		
<i>Cancer male genital</i>	35	NA	-35		
<i>Other Female Genital system</i>	NA	83	83		
<i>Other Male Genital system</i>	24	NA	-24		
All gender specific	59	274	215	4.64	34.6%
All non-gender specific	1790	2076	286	1.16	46.0%
Total VTE	2524	3146	622	1.25	100.0%

Of a total number of 5680 cases of VTE, there were 622 more cases in women in than in men. The ratio of female to male cases (1.25) is consistent with the differences in age-standardised rates in Table 3. An excess of VTE is also seen in both primary and secondary cases and, among the latter cases, between gender specific and non gender specific causes of VTE. Just under 20% of the total excess of female cases of VTE occurs in primary cases, 35% in gender-specific secondary conditions and the remaining 46% in non-gender-specific secondary conditions.

Table 5. Differences in the number of cases and risk of VTE by gender and disease condition (body system)

Disease Condition (body system)	Cases of VTE		F - M	% of net difference	F/M cases	Relative risk (F/M)#
	Males	Females				
Female > male						
Musculoskeletal	305	395	90	31.5%	1.30	1.34
Injury and poisoning	264	310	46	16.1%	1.17	1.53
Respiratory system	111	150	39	13.6%	1.35	1.34
Symptoms and ill-defined	62	95	33	11.5%	1.53	1.20
Digestive system	155	187	32	11.2%	1.21	1.11
Other health contacts	40	69	29	10.1%	1.73	1.64
Endocrine, nutritional, etc	33	53	20	7.0%	1.61	1.26
Sense organs	25	37	12	4.2%	1.48	1.15
Skin, subcutaneous	46	58	12	4.2%	1.26	1.37
Other neoplasms	36	46	10	3.5%	1.28	0.82
Infections, parasitic	17	25	8	2.8%	1.47	1.33
Mental disorders	30	38	8	2.8%	1.27	1.10
Blood forming organs	20	27	7	2.4%	1.35	1.05
Central nervous system	17	21	4	1.4%	1.24	1.09
Congenital anomalies	2	3	1	0.3%	1.50	0.99
Sub-total female > male	1163	1514	351	122.7%	1.30	1.22
Male > Female						
Periph. Nervous system	9	4	-5	-1.7%	0.44	0.35
Urinary system	41	30	-11	-3.8%	0.73	0.31
Cardiovascular	280	261	-19	-6.6%	0.93	1.24
Malignant neoplasms	297	267	-30	-10.5%	0.90	1.35
Sub-total male > Female	627	562	-65	-22.7%	0.90	0.85
All conditions	1790	2076	286	100.0%	1.16	1.09

Relative risk = Female prevalence VTE per 1000 admissions / Male prevalence VTE per 1000.

Table 5 shows the distribution of *non-gender specific* cases of VTE by principal disease conditions or body systems in males and females. The table has been sorted in descending order of the difference between numbers of cases of VTE in females and males (Column 3). The upper block consists of conditions in which there is an excess of female cases, the lower block conditions in which male cases exceed females cases. The second last column shows the ratio of numbers of female to male cases and the last column (Relative risk) shows the ratio of the prevalence of VTE per 1000 admissions in females to the prevalence in males.

Over all conditions there were 286 more cases of VTE in women than in men (ratio 1.16) with women having a 9% greater risk of VTE. Female cases of VTE exceeded male cases in the majority of conditions, the exceptions being in diseases of the cardiovascular system, malignant neoplasms, and diseases of the peripheral nervous and urinary systems. The relative risk of VTE is also greater in females in the majority of conditions including cardiovascular disease and malignant neoplasms despite the excess of male over female cases in these two groups. As might be expected, the greatest differences in numbers of VTE, irrespective of the direction of the difference, tend to occur in the conditions with the largest aggregate

numbers of VTE including Musculoskeletal conditions, Injuries and poisoning, Digestive system disorders, Malignant neoplasms, Cardiovascular disease and Respiratory disease.

4. DISCUSSION

The present study has demonstrated marked increases in age standardised rates of VTE, and each of its components, PE and DVT, in hospital admissions over the period 1989-2001. In all instances rates increased more in females than males, to the extent that a slight preponderance of males in the first four years of the study was progressively reversed. In the final three years (1999-2001) age standardised rates of VTE were nearly 20% higher in women than men (22% in the case of PE; 14% in the case of DVT). Further examination of cross-sectional differences between men and women in VTE in 1999-2001 demonstrated that the excess of VTE in women in this period occurred in all age groups and was distributed over broad aetiological groups (Primary VTE, gender specific causes of VTE and other secondary cases of VTE) and within the latter, between diseases of different body systems.

Despite the general increase in rates in the components of VTE, marked differences were observed in the patterns of trends in PE and DVT. While rates of both conditions initially increased rapidly (to 1994 or 1995), rates of DVT then stabilised (or fell in the cases of males), but rates of PE continued to rise, particularly in the last four years of the study period. When examined by aetiological class, we found that rates of Primary DVT fell after 1995 in both females and males, offsetting continuing rises in Medical and Surgical DVT. The increase in rates of DVT was particularly marked in Surgical cases. When trends in rates of Secondary DVT (Medical and Surgical combined) were examined, rates increased by nearly 20% in women but did not rise further in men. Anecdotal reports suggest that changes in hospital admission policies may have resulted in a greater proportion of cases of DVT being treated as outpatients in later years of the study. It is thus clear that trends of VTE based on the combination of PE and DVT are likely to be misleading.

The extent to which various forms of bias could have contributed to an apparent increase in rates of VTE is discussed below. It is however difficult to see how any of these could explain the more rapid and sustained increase in rates of PE and secondary DVT in women compared with men. We therefore believe that in women at least, the increase in rates of PE is likely to be real. As rates of PE in women increased equally in all aetiological classes (medical, surgical and primary) the reasons behind this increase are likely to be complex and not due simply to increased rates of admission for specific surgical procedures or medical conditions.

It should also be noted that the increase in rates of VTE has occurred despite probable increases in the use of chemoprophylaxis against VTE. For example, a study of the prevalence of chemoprophylaxis against VTE in high-risk cases in Perth in 2002 indicated relatively high levels of use in surgical procedures identified in clinical guidelines as being at high-risk.(5) While we do not have information about chemoprophylaxis at the beginning of the study period, it is reasonable to assume that this has increased, particularly in surgical cases, over the study period.

4.1 Possible sources of bias

As with all studies based on administrative data, the significance of our results is crucially dependent on the accuracy of diagnostic coding in the Western Australian hospital morbidity data system (HMDS). The accuracy of disease coding may vary over time and between individual hospitals for many reasons, including the uptake of new diagnostic procedures, clarity and completeness of clinical information in the hospital medical record, periodic changes in disease classifications, the number of diagnostic fields used for recording complications and co-morbidity, changes to instructions to coders regarding assignment and ordering of codes, and the experience and availability of trained coders. The findings of our study therefore need to be carefully assessed against the possibility of bias from several sources.

The striking rise in rates of VTE overall and DVT and PE separately from 1992 to 1994 is strongly suggestive of diagnostic artifact. This pattern is similar to trends observed in Western Australian Hospital admission data for other disease conditions including diabetes and congestive cardiac failure, in which there was also a marked increase in cases coded as complications or co-morbidity in secondary diagnostic fields. (6) We believe that this is part of a general effect due to increases in the number of trained coders in Western Australian hospital that occurred in the early 1990s in preparation for the introduction of DRG coding and partial case-mix funding (It should be noted that DRG weights are in some conditions increased by case complexity that is in turn dependent on complete coding of complications and co-morbid conditions).

This does not however explain rapid increases that also occurred in cases admitted with a principal diagnosis of VTE nor does it explain the differences between males and females. With the introduction of ICD 9-CM in Western Australia, coders were given more explicit instructions relating to the assignment of principal diagnoses to reflect the true reason for admission to hospital. While this may have been a factor leading to increased coding of VTE, we would not have expected its effect to be delayed to 1992. The changes in coding practice outlined above are also unlikely to explain the continued increase in rates in PE after 1994, especially the more rapid increase in rates in the last four years of the study.

A further possible source of bias is that of increased clinical awareness of the dangers of VTE associated with the dissemination and adoption of clinical guidelines for the prevention of VTE. Increased clinical awareness of VTE as a potential complication of hospitalization could for example result in the recognition of less obvious cases of DVT during index admissions for surgical procedures. This could partly explain the initial increase in prevalence of DVT in the present study. This is however less likely to be a factor in the increased admission rates for PE, although the development of Emergency Medicine as a specialty could have led to greater consideration of PE in the differential diagnosis of cases presenting to emergency departments with non-specific respiratory symptoms.

Changes in the accuracy and availability of diagnostic procedures may affect the prevalence of VTE in hospital morbidity data, although the direction of the changes may not always be predictable. For example, the introduction of a relatively non-specific screening test for venous thrombosis such as d-dimer could be expected to increase the prevalence of diagnosed VTE, whereas increased use of more specific imaging procedures for the diagnosis of DVT or PE should generally lead to a reduction in prevalence. In the only population study of the incidence of VTE conducted in Olmsted County in the United States over the period 1966-1990, the incidence of PE, which initially exceeded DVT fell rapidly over the period 1966-1980 to just less than the incidence of DVT in the period 1980-1990. (7) The authors suggested that this change was due to improved methods and greater availability of diagnostic procedures for PE. We believe that it is therefore unlikely that the apparent increase in rates of PE in the present study would be due to improved methods of diagnosis.

4.2 Directions for further research

The finding that rates of VTE in women may be increasing requires further elucidation, firstly to exclude statistical artifact but more importantly to identify the underlying causes that may be amenable to more effective preventive measures.

A true increase in rates of VTE could be related to increases in the prevalence of chronic diseases or hospital admissions for surgical and medical cases associated with a high risk of VTE, or to increased individual risk due to more general factors such as obesity or widespread use of pharmaceutical agents including chemotherapy or oestrogen use in hormone replacement therapy (HRT). While the cross-sectional differences between males and females in number of cases and risk of VTE in 1999-2001 (Tables 4 and 5) help to identify the conditions from which excess of females cases of VTE mainly arise, they do not necessarily indicate the conditions that may have contributed most to increasing rates. It is nevertheless logical to assume that substantial increases in numbers of cases of VTE are more likely to have arisen from conditions that generate the greatest number of cases of VTE such as gender specific causes of VTE (Table 4), musculoskeletal conditions, injuries, cardiovascular disease and malignant neoplasms.

In the first instance, further research should therefore examine trends in both hospital admission rates in these broad condition groups as well as possible changes in prevalence of VTE within each, to determine whether possible increases in VTE are related to increased volumes of admissions of high-risk cases or to changing risks of VTE within condition groups. From this overview, it should be possible to focus on the possible contributions to rising trends from high-risk specific disease conditions or procedures, including specific types of malignant disease, femoral neck fractures, lower-limb joint replacement procedures and cardiovascular procedures. This will require selection of much larger data sets than employed in the present study. If increases in rates appear to be due to changes in individual risk rather than increases in admissions rates of high-risk conditions, more detailed case-control or case-cohort studies should be undertaken to clarify the role of other risk factors.

5. CONCLUSIONS

- Over the period 1989-2001, rates of VTE and its components PE and DVT increased by over 50% in women and 20% in men. Initially rates of VTE were slightly higher in men than women but by the end of the study period, rates in women were nearly 20% greater than in men.
- Changes in rates were not consistent over the study period, with particularly rapid increases in the period 1992 and 1994, suggesting artifact possibly related to changes in coding practices and the coding environment in hospitals.
- After 1994 rates of both PE and Secondary DVT continued to rise in women but changed little in men. The fact that further increases after 1994 was restricted to women suggests that the increases in this period are real and not due to bias.
- After 1994, admissions for Primary DVT declined in both men and women, suggesting changes in admission policies relating to DVT.
- In women the increase in PE occurred in all aetiological groups (Surgical, Medical and Primary), suggesting that the increase in rates of PE is unlikely to be due to any single cause. This was confirmed by a cross-sectional study of gender differences in VTE in 1999-2001 which found that the excess number of cases of VTE in females was present in all age groups and widely spread over diseases in different body systems.
- Further research to determine the factors underlying increases in rates of VTE will need to focus on trends in admission rates of high-risk medical and surgical conditions as well as changes in the prevalence of VTE within each of these.

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