

Use of Managed Care Claims Data in the Risk Assessment of Venous Thromboembolism in Outpatients

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Abstract

Background: Deep vein thrombosis (DVT) is a complication of immobilizing illness in both inpatient and outpatient settings and can lead to serious complications such as pulmonary embolism (PE). DVT and PE are collectively referred to as venous thromboembolism.

Objective: To develop DVT and PE risk assessment models that can be used in office-based practice and for population-based disease management efforts.

Methods: Data were culled from integrated medical and pharmacy claims paid by 37 health plans in the United States (the PharMetrics Integrated Outcomes Database, PharMetrics Inc., Watertown, MA), and included information on adult plan members enrolled during 1998 and 1999. Patients hospitalized for DVT or PE in 1999 were identified, and potential risk factors were assessed by reviewing claims for the entire study population in 1998 to document prior DVT or immobilizing illness. The contribution of each potential risk factor to the probability of the occurrence of DVT or PE was determined by means of multiple logistic regression analysis. A risk-scoring algorithm based on regression coefficients was then developed.

Results: Fifty-two percent of the study population of 2.8 million plan members were women. DVT or PE occurred in 1330 of those 2.8 million individuals (47 per 100,000). Logistic regression results confirmed the role of risk factors previously reported in the literature and revealed additional risk factors that have not been reported previously, including diabetes, renal failure, rheumatoid arthritis, cellulitis, use of warfarin, use of systemic corticosteroids, and use of potassium chloride. When risk scores were applied to the study population, the 1% identified as being at highest risk had a probability for the development of venous thromboembolism that was 10 times greater than that of the population average.

Conclusions: This study confirms the feasibility of using managed care claims data to develop a risk assessment tool for venous thromboembolism that can be used in office-based practice and for population-based disease management.

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Deep vein thrombosis (DVT) is a complication of immobilizing illness that occurs in both inpatient and outpatient settings in as many as 2 million Americans annually.^{1,2} Treatment usually involves a hospital stay of 6 to 7 days for anticoagulation therapy at an average cost of \$9300 per admission.¹ In most cases, an underlying coagulation defect is present, so recurrence and readmission are frequent.¹ DVT can also lead to pulmonary embolism (PE), which occurs annually in about 600,000 Americans (approximately 60,000 of whom die as a result).^{3,4} DVT and PE are collectively referred to as venous thromboembolism.

Prophylactic use of anticoagulants in high-risk patients is effective in preventing the occurrence of DVT and PE and is recommended for many patients hospitalized for major surgery or prolonged medical illness.^{1,5} However, less attention has been paid to the prevention of DVT in outpatients. To identify patients for whom DVT is a significant hazard and thereby target preventive measures effectively and efficiently, a better quantitative understanding of the risk profile of outpatients is required. For example, risk-scoring algorithms for coronary heart disease have been used for many years and have helped guide the use of therapy to prevent coronary events.⁶ A similar approach for assessing the risk of DVT and PE may also be warranted.

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The purpose of this study is to develop assessment models to determine the risk of DVT or PE that clinicians can apply to individual patients in office-based settings and that medical managers can use to profile entire populations by using administrative data from managed healthcare plans.

Methods

Data. Data for this study, which were obtained from the PharMetrics Integrated Outcomes Database, include the longitudinal, integrated, and complete medical and pharmacy claims histories of more than 22 million members of 37 health plans in the United States. Provider claims submitted to health plans for reimbursement provide information on diagnoses associated with healthcare encounters, therapeutic and diagnostic procedures performed, prescription drugs dispensed, and amounts charged and reimbursed for those services.

The study population consisted of all adult plan members (age > 18 years) who were enrolled continuously from January 1, 1998, through December 31, 1999. Members of plans that did not provide complete enrollment history records were excluded. All claims for medical and pharmacy services rendered to the selected plan enrollees during the study period were extracted from the database.

Occurrence of DVT or PE

Occurrences of DVT or PE that required patients' hospitalization during calendar

year 1999 were identified from principal diagnoses recorded on hospital claims from the study population.

Risk Factors

The presence or absence of potential risk factors for DVT or PE was assessed for calendar year 1998 (ie, prior to the occurrence of these events). Risk factors were identified from diagnoses recorded on hospital and professional claims and from the list of prescription drugs recorded on pharmacy claims.

A preliminary list of known DVT risk factors was identified from the available medical literature.^{1,7-9} Those risk factors included advancing age, prior DVT or PE, major orthopedic surgery, brain or spinal cord injury, malignancy, blood disorders, the use of hormone replacement therapy in women, varicose veins, and a range of cardiovascular, respiratory, and digestive illnesses. The list of potential risk factors was then extended by including other diagnoses (diabetes, renal failure, rheumatoid arthritis, cellulitis) and use of prescription drugs (warfarin, systemic corticosteroids, potassium chloride) observed most frequently (>0.5% for diagnoses and >1% for prescriptions) in members of the study population who developed DVT or PE.

Statistical Analyses

The contribution of each potential risk factor identified for calendar year 1998 to the probability of occurrence of DVT or PE in 1999 was estimated by means of multiple logistic regression analysis. Separate analyses were conducted for men and women. The contribution of interactive effects involving age and prior venous thromboembolism was considered in addition to the main effect of each risk factor listed above. The statistical significance of each main effect and interaction was assessed by means of Wald's chi-square statistic. The final set of risk factors was selected by backward elimination (threshold, $P < .35$). Values of regression coefficients were reported as odds ratios. All analyses were conducted by means of the Proc Logistic

Table 1. Number of Health Plan Members in the Population Studied

Age (yrs)	Women	Men
20 to 39	484,336	428,426
40 to 54	587,675	536,443
55 to 64	231,185	221,398
> 64	190,301	143,589
All adults	1,493,497	1,329,856
Total: 2,823,353		

routine in SAS System Version 8 (SAS Institute, Cary, NC).

Risk Scoring

A risk-scoring algorithm was developed from the logistic regression coefficients. A score of zero represented the reference case (a man or woman younger than 40 years of age and with no risk factors), and the probability of DVT or PE occurrence was calculated from the intercept of the regression. Older patients and those with various risk factors were assigned points according to the regression coefficient of each risk factor that was scaled to permit the use of integer values for convenience. This method of scoring is similar to that developed by the Framingham Heart Study investigators for use in assessing the risk of coronary heart disease.⁶

To assess the ways in which particular levels of risk related to the population distribution, the logistic regression models were used to estimate the probability of DVT for each study participant, and the percentiles of risk were calculated for men and women. Associated risk scores were reported for selected percentiles (range, 90th to 99.9th percentile).

Results

Study Population. A review of data indicated that 2,823,353 people in the PharMetrics Integrated Outcomes Database were continuously enrolled in that health plan during calendar years 1998 and 1999 (Table 1). Of that number of enrollees, 1330 individuals (730 women and 600 men) were hospitalized for DVT or PE during 1999. Those cases represented a crude annual incidence rate of 47 per 100,000 (49 per 100,000 for women and 45 per 100,000 for men).

The prevalence of each risk factor included in the final models is reported in Table 2 for both the overall sample and the 1330 patients

who experienced DVT or PE during calendar year 1999, respectively. As expected, the prevalence of most risk factors was greater in patients who experienced DVT or PE.

Risk Assessment

The independent contribution of each risk factor for DVT and PE, expressed as an odds ratio, is reported in Table 3 for women and men, respectively. Several risk factors (including rheumatoid arthritis, chronic obstructive pulmonary disease, renal disease, cellulitis, diabetes, and

Table 2. Prevalence of Risk Factors in the Study Population and in DVT Cases

Risk Factors for Venous Thromboembolism in 1998	Population (%) (n = 2,823,353)	DVT Cases (%) (n = 1330)
Mean age (yrs)	47.2	57.5
DVT and/or PE	1.0	25.9
Major orthopedic procedure	2.2	7.7
Ischemic heart disease	3.1	10.9
Diabetes mellitus	4.3	12.5
Abnormal respiration	2.3	9.8
Other heart disease	3.8	14.1
Brain and/or spinal cord injury	1.5	2.9
Anemia	1.2	5.9
Other blood disorder (except anemia)	1.1	3.9
Irritable bowel syndrome	1.4	3.1
Pregnancy	2.3	0.8
Pneumonia	1.2	5.3
Chronic obstructive pulmonary disease	1.2	4.7
Primary neoplasm, nonlymphatic	2.7	10.5
Primary neoplasm, lymphatic	0.3	2.1
Secondary neoplasm	0.2	3.2
Neoplasm, uncertain behavior	1.8	4.8
Varicose veins	0.4	4.2
Cellulitis	0.3	3.3
Renal failure	0.2	1.6
Rheumatoid arthritis	0.5	2.1
Use of warfarin	0.7	7.4
Use of corticosteroids	1.0	5.8
Use of hormone replacement therapy in women	3.5	7.2
Use of potassium chloride	0.9	4.9

DVT = deep vein thrombosis; PE = pulmonary embolism.

Table 3. Odds Ratios for DVT Risk Factors

Risk Factor in 1998	Women		Men	
	Odds Ratio	P	Odds Ratio	P
Age 40 to 54 yrs	1.896	.0001	1.993	.0001
Age 55 to 64 yrs	3.736	.0001	3.806	.0001
Age > 64 yrs	3.875	.0001	4.554	.0001
Prior DVT and/or PE and:				
Secondary neoplasm	0.946	.0011	—	—
Renal failure	3.993	.1371	0.200	.0507
Major orthopedic procedure	5.926	.0115	0.158	.0008
Cellulitis	6.274	.1001	0.645	.3213
Congestive heart failure	6.733	.0668	0.327	.0234
Varicose veins	7.276	.2053	0.352	.0671
Primary neoplasm	9.167	.2422	0.335	.0141
Diabetes mellitus	9.418	.1973	0.558	.0981
Pregnancy	36.141	.1902	—	—
None of the above	13.911	.0001	20.802	.0001
Major orthopedic procedure	2.370	.0001	2.729	.0001
Ischemic heart disease	1.152	.3428	1.256	.0932
Diabetes mellitus	1.798	.0001	1.295	.0769
Abnormal respiration	1.750	.0001	1.303	.1213
Other heart disease, age < 40 yrs	6.220	.0001	—	—
Other heart disease, age 40 to 54 yrs	1.599	.001	—	—
Other heart disease, age 55 to 64 yrs	0.858	.0001	—	—
Other heart disease, age > 64 yrs	1.014	.0001	—	—
Brain and/or spinal cord injury	1.674	.0183	1.663	.0475
Blood disorder (except anemia), age < 55 yrs	1.535	.1364	1.614	.2761
Blood disorder (except anemia), age 55 to 64 yrs	0.481	.0407	1.614	.2761
Blood disorder (except anemia), age > 64 yrs	0.757	.1068	0.338	.0981
Anemia, age < 55 yrs	1.539	.1519	—	—
Anemia, age 55 to 64 yrs	2.165	.0117	—	—
Anemia, age > 64 yrs	2.120	.0021	—	—
Irritable bowel syndrome	1.518	.0265	—	—
Pregnancy	0.503	.1009	—	—
Pneumonia	1.196	.3449	1.837	.0015
Chronic obstructive pulmonary disease, age < 65 yrs	1.452	.1725	1.425	.2085
Chronic obstructive pulmonary disease, age > 65 yrs	0.951	.2473	0.429	.0367
Primary neoplasm, nonlymphatic	1.676	.001	1.617	.0056
Primary neoplasm, lymphatic	2.024	.0133	2.191	.0067
Secondary neoplasm, age < 55 yrs	13.696	.0001	10.482	.0001
Secondary neoplasm, age 55 to 64 yrs	5.903	.0536	0.149	.0274
Secondary neoplasm, age > 64 yrs	3.314	.005	0.375	.123
Neoplasm, uncertain behavior	1.441	.0376	—	—
Varicose veins	1.793	.1973	3.348	.0177
Cellulitis	3.625	.0001	4.049	.0001
Renal failure, age < 40 yrs	16.672	.0001	8.105	.0529
Renal failure, age 40 to 54 yrs	2.217	.0378	8.105	.0529
Renal failure, age 55 to 64 yrs	3.068	.0431	8.105	.0529
Renal failure, age > 64 yrs	0.400	.0019	0.211	.2049
Rheumatoid arthritis	1.439	.1284	1.722	.1408
Use of warfarin	1.546	.0133	1.676	.0029
Use of corticosteroids	2.188	.0001	2.082	.0007
Use of hormone replacement therapy in women	1.269	.0355	—	—
Use of potassium chloride	1.407	.0436	1.283	.3074

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use of warfarin, corticosteroids, or potassium chloride) not previously reported in the medical literature were found to be significant independent predictors of venous thromboembolism.

Scoring algorithms for assessing a patient's 1-year risk of DVT and/or PE according to demographic and risk factor profiles are provided for women and men, respectively, in Tables 4 and 5. High-risk patients can be identified by comparing their scores to the values associated with selected population percentiles of risk reported in Table 6.

Discussion

This study demonstrates the feasibility of using administrative claims data from

managed healthcare plans to assess individuals' risk of venous thromboembolism. In this study, the rate of incidence of DVT and PE in an adult managed care population was approximately 1 per 2000 plan members. However, increasing age, prior history of DVT, and a wide range of chronic illnesses were associated with risks several-fold higher than the average. The application of the risk-scoring algorithm to the study population revealed that the 0.1% of patients at highest risk in managed care have an annual probability of experiencing DVT or PE that is approximately 30 times the population average.

The high level of DVT risk associated with multiple chronic illnesses is illustrated by the following examples. A 59-year-

Table 4. Algorithm for Assessing the 1-Year Risk of Venous Thromboembolism in Women

Age (yrs)	Points	Risk Factor	Age			
			< 40 yrs	40 to 54 yrs	55 to 64 yrs	> 64 yrs
< 40	0	Anemia	0	3	5	5
40 to 54	5	Blood disorder, except anemia	3	3	-5	-2
55 to 64	9	Chronic obstructive pulmonary disease	3	3	3	0
> 64	10	Other heart disease (except coronary heart disease or congestive heart failure)	13	3	-1	0
		Secondary neoplasm	18	18	12	8
		Renal failure	20	6	8	-6

Risk Factor	Points	Risk Factor	Points
Abnormal respiration	4	DVT and/or PE in past year	19
Brain and/or spinal cord injury	4	<i>Add or subtract if also present in past year</i>	
Cellulitis	9	Cellulitis	-6
Diabetes mellitus	4	Congestive heart failure	-5
Irritable bowel syndrome	3	Diabetes mellitus	-3
Ischemic heart disease	1	Major orthopedic procedure	-6
Major orthopedic procedure	6	Pregnancy	7
Neoplasm, uncertain behavior	3	Primary neoplasm	-3
Pneumonia	1	Renal failure	-9
Pregnancy	-5	Secondary neoplasm	-19
Primary neoplasm, lymphatic	5	Varicose veins	-5
Primary neoplasm, nonlymphatic	4		
Rheumatoid arthritis	3		
Use of corticosteroids	6		
Use of hormone replacement therapy	2		
Use of potassium chloride	2		
Use of warfarin	3		

DVT = deep vein thrombosis; PE = pulmonary embolism.

old woman with diabetes has approximately a 0.1% annual risk of DVT, which places her above the 90th percentile of risk. If she also has rheumatoid arthritis for which she takes a corticosteroid, her risk triples to 0.3%, which is just below the 99th percentile. If she also has a history of DVT, her risk is 2.8%, which is well above the 99.9th percentile. A 67-year-old man with metastatic prostate cancer has a risk of DVT of 0.4%, which is above the 99th percentile. If he also has cellulitis of the leg, his risk increases to 1.6%, which is above the 99.9th percentile. If he also has a history of DVT, his risk is 7.1%, or a 1-in-14 chance of experiencing DVT in the coming year.

The combined DVT and PE incidence rate of 47 per 100,000 observed in this study is lower than published rates for the US population.¹ Several factors may account for that difference. First, the focus of the analysis in this study was outpatients who experienced DVT and who were admitted to the hospital to treat that

condition. Therefore, the rate reported here does not include cases of DVT or PE that developed in hospitalized patients. Second, because the PharMetrics Integrated Outcomes Database is derived from commercial and not-for-profit health plans, the elderly Medicare-eligible US population is underrepresented. Because increasing age is a risk factor for DVT, it is likely that the incidence rate in the Medicare population is higher than that reported here. Finally, only the first DVT event experienced by each patient in 1999 was counted, regardless of recurrences during that year. As a result, the incidence rate reflects numbers of unique patients rather than all hospitalizations for DVT in the population studied.

In addition to confirming the role of risk factors previously identified in the medical literature, this investigation revealed a number of risk factors that have not previously been reported, such as rheumatoid arthritis, chronic obstructive pulmonary disease, renal disease, celluli-

Table 5. Algorithm for Assessing the 1-Year Risk of Venous Thromboembolism in Men

Age (yrs)	Points	Risk Factor	Age			
			< 40 yrs	40 to 54 yrs	55 to 64 yrs	> 64 yrs
< 40	0	Blood disorder, except anemia	2	2	2	-3
40 to 54	3	Chronic obstructive pulmonary disease	2	2	2	-2
55 to 64	6	Secondary neoplasm	10	10	2	6
> 64	7	Renal failure	9	9	9	2

Risk Factor	Points	Risk Factor	Points
Abnormal respiration	1	DVT and/or PE in past year	13
Brain and/or spinal cord injury	2	<i>Add or subtract if also present in past year</i>	
Cellulitis	6	Cellulitis	-2
Diabetes mellitus	1	Congestive heart failure	-5
Ischemic heart disease	1	Diabetes mellitus	-3
Major orthopedic procedure	4	Major orthopedic procedure	-8
Pneumonia	3	Primary neoplasm	-5
Primary neoplasm, lymphatic	3	Renal failure	-7
Primary neoplasm, nonlymphatic	2	Varicose veins	-5
Rheumatoid arthritis	2		
Use of corticosteroids	3		
Use of potassium chloride	1		
Use of warfarin	2		

DVT = deep vein thrombosis; PE = pulmonary embolism.

tis, diabetes, and use of warfarin, corticosteroids, or potassium chloride. Those risk factors compound the known role of immobility in the development of DVT. Of particular interest is the role of prescription drugs as markers of immobilizing illness. In a managed care setting in which medical managers may rely on claims data to screen their population, physicians treating patients who have multiple chronic illnesses may record only a single diagnosis on any given claim. Hence, pharmacy claims for drugs used to treat those conditions may provide important evidence that supplements diagnostic information supplied on medical claims. As previously stated, the role of potassium chloride as a risk factor for DVT probably relates to its use in the treatment of cardiovascular disease, and corticosteroid therapy is used to treat various chronic illnesses that are known risk factors for DVT, such as chronic lung diseases and rheumatoid arthritis.

This study shares the limitations of all retrospective, claims-based investigations. Because the data reflect clinical practice in the community rather than a clinical research protocol, there may have been less-than-complete documentation of DVT cases and risk factors. For example, patients treated for DVT without admission to the hospital were not counted as cases because it was not possible to distinguish reliably between acute DVT and follow-up care for patients with a history of DVT. Similarly, as noted above, because physicians are required to record only a single diagnosis to be reimbursed by health plans, the diagnosis of DVT and/or PE as well as risk factors for those events may be underreported for patients with multiple illnesses.

Despite those limitations, this study has demonstrated the feasibility of developing a practical risk assessment tool for screening outpatients most likely to experience DVT or PE. The risk-scoring algorithm reported here can be used by

Table 6. Risk Percentiles for DVT and/or PE and Associated Risk Scores for Women and Men

Risk Percentile	Women		Men	
	Risk of DVT and/or PE	Risk Score	Risk of DVT and/or PE	Risk Score
99.9	0.0145	32	0.0141	21
99.5	0.0067	27	0.0048	16
99	0.0035	23	0.00237	13
98	0.00196	19	0.00141	11
95	0.00112	15	0.00089	9
90	0.00077	13	0.00065	8

DVT = deep vein thrombosis; PE = pulmonary embolism.

clinicians in office-based practice or by medical managers concerned with population-based disease management to target interventions that will reduce the burden of those important diseases.

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