Table 1. Characteristics of 2,397 clinical encounters with an ICD-9 diagnosis code for venous thromboembolism during follow-up.[a]

Characteristic	Overall, n (%) N= 2,397
VTE type based on ICD-9 code	
Pulmonary embolism with/without DVT	984 (41.1)
Lower extremity DVT without PE	976 (40.7)
Upper extremity DVT only	69 (2.9)
Other venous thrombosis only	368 (15.4)
Encounter setting	
Inpatient / Emergency Department	
VTE code in the primary position	398 (16.6)
VTE code in the secondary position	638 (26.6)
Ambulatory care setting	1361 (56.8)

Abbreviations: DVT, deep venous thrombosis; ICD-9, International Classification of Diseases, 9th edition; PE, pulmonary embolism; VTE, venous thromboembolism

[a] inpatient /emergency department encounters with an ICD-9 code in the secondary discharge position or ICD-9 codes only from outpatient encounters that had a relevant radiology procedure code present within 7 days from the diagnosis

Table 2. Positive predictive value of ICD-9 codes to identify valid recurrent venous thromboembolism events

Type of VTE	ICD-9 Codes	Positive Predictive Value for Recurrent VTE Events, % (n/N)			
		Overall	Hospital/Emergency Department N=1036		Outpatient[a]
			Primary Position	Secondary Position[a]	
		N= 2397	N= 398	N= 638	N= 1361
Any VTE	All codes below	31.1 (746/2397)	61.3 (244/398)	35.4 (226/638)	20.3 (276/1361)
Pulmonary embolism	415.x	29.9 (294/984)	67.0 (144/215)	31.1 (79/254)	13.8 (71/515)
Lower extremity DVT	451.1x, 451.2, 451.81, 453.4x, 453.5x	38.3 (374/976)	61.2 (90/147)	43.0 (116/270)	30.1 (168/559)
Upper extremity DVT	451.83, 451.84, 451.89, 453.72, 453.73, 453.74, 453.75, 453.76, 453.77, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87	37.7 (26/69)	50.0 (4/8)	40.0 (14/35)	30.8 (8/26)
Other VTE	451, 451.9, 452, 453.0, 453.1, 453.2, 453.3, 453.79, 453.8, 453.89, 453.9	14.1 (52/368)	21.4 (6/28)	21.5 (17/79)	11.1 (29/261)

Abbreviations: DVT, deep venous thrombosis; ICD-9, International Classification of Diseases, 9th edition; VTE, venous thromboembolism

Numbers in parentheses represent the number of chart confirmed recurrent VTE events (n) per number of charts reviewed with an ICD-9 code for recurrent VTE (N). Charts without available documentation for review were excluded.

[a] inpatient /emergency department encounters with an ICD-9 code in the secondary discharge position or ICD-9 codes only from outpatient encounters that had a relevant radiology procedure code present within 7 days from the diagnosis

Table 3. Positive predictive value of ICD-9 codes combined with a new prescription for anticoagulants for valid recurrent VTE event

Type of VTE	ICD-9 Codes	Positive Predictive Value for recurrent VTE events, % (n/N)			
		Overall	Hospital/Emergency Department N=286		Outpatient[a]
			Primary Position	Secondary Position[a]	
		N=596	N= 141	N= 145	N=310
Any VTE	All codes below	54.2 (323/596)	77.3 (109/141)	57.2 (83/145)	42.3 (131/310)
Pulmonary embolism	415.x	58.9 (139/236)	84.5 (71/84)	56.9 (33/58)	37.2 (35/94)
Lower extremity DVT	451.1x, 451.2, 451.81, 453.4x, 453.5x	59.9 (148/247)	69.6 (32/46)	66.1 (39/59)	54.2 (77/142)
Upper extremity DVT	451.83, 451.84, 451.89, 453.72, 453.73, 453.74, 453.75, 453.76, 453.77, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87	69.2 (9/13)	75 (3/4)	50.0 (3/6)	100 (3/3)
Other VTE	451, 451.9, 452, 453.0, 453.1, 453.2, 453.3, 453.79, 453.8, 453.89, 453.9	27.0 (27/100)	42.9 (3/7)	36.4 (8/22)	22.5 (16/71)

Abbreviations: DVT, deep venous thrombosis; ICD-9, International Classification of Diseases, 9th edition; VTE, venous thromboembolism
Numbers in parentheses represent the number of confirmed recurrent VTE events by chart review (n) per number of charts reviewed with an ICD-9 code for recurrent VTE in combination with a new anticoagulation prescription (N). Charts without available documentation for review were excluded.

[a] inpatient /emergency department encounters with an ICD-9 code in the secondary discharge position or ICD-9 codes only from outpatient encounters that had a relevant radiology procedure code present within 7 days from the diagnosis

Table 4. Encounters with a possible recurrent VTE event that were considered invalid after chart review (n=1036)

Encounter setting, N (%)	Reasons why encounters were considered invalid	Type of potential recurrent VTE assigned by diagnosis codes			
		Pulmonary Embolism, % (n/N) N=393	Lower Extremity DVT, % (n/N) N=357	Upper Extremity DVT, % (n/N) N=23	Other VTE, % (n/N) N=263
Hospital / Emergency Department, 366 (35.3)	No acute event, but with past history of VTE	70.2 (113/161)	64 (80/125)	46.7 (7/15)	69.2 (45/65)
	Superficial venous thrombosis, no evidence of deep venous clot	0.6 (1/161)	3.2 (4.125)	0 (0/15)	4.6 (3/65)
	Initial concern for VTE, but subsequently ruled out	21.1 (34/161)	23.2 (29/125)	6.7(1/15)	18.5 (12/65)
	No or insufficient documentation available in chart to confirm VTE event	7.5 (12/161)	9.6 (12/125)	33.3 (5/15)	3.1 (2/65)
	Other non-VTE related reasons for medical encounter	0.6 (1/161)	0 (0/125)	13.3 (2/15)	4.6 (3/65)
Outpatient, 670 (64.7)	No acute event, but with past history of VTE	60.8 (141/232)	62.5 (145/232)	37.5 (3/8)	69.2 (137/198)
	Superficial venous thrombosis, no evidence of deep venous clot	0.4 (1/232)	3.5 (8/232)	25 (2/8)	1.0 (2/198)
	Initial concern for VTE, but subsequently ruled out	27.2 (63/232)	23.3 (54/232)	25 (2/8)	16.7 (33/198)
	No or insufficient documentation available in chart to confirm VTE event	11.2 (26/232)	9.1 (21/232)	12.5 (1/8)	10.6 (21/198)
	Other non-VTE related reasons for medical encounter	0.4 (1/232)	1.7 (4/232)	0 (0/8)	2.5 (5/198)

Abbreviations: DVT, deep vein thrombosis; VTE, venous thromboembolism. This table only shows the reasons for invalid events among the 1,782 encounters with possible recurrent VTE events that have been evaluated by manual chart review and does not include the 615 encounters that have been considered invalid events by natural language processing.

Appendix Table A.1. Positive predictive value of individual ICD-9 codes for valid recurrent venous thromboembolism event

ICD-9 Code	Code Description	Positive Predictive Value % (n/N)		
		Overall N=2397	Hospital/ED N=1036	Outpatient N=1361
Pulmonary embolism				
415.1	Pulmonary embolism and infarction	0 (0/2)	0 (0/1)	0 (0/2)
415.11	Iatrogenic pulmonary embolism and infarction	31 (4/14)	66.7 (4/6)	0 (0/7)
415.19	Other pulmonary embolism and infarction	28.6 (290/968)	47.4 (219/462)	14.0 (71/506)
Lower extremity deep venous thrombosis				
451.11	Phlebitis and thrombophlebitis of femoral vein	25 (1/4)	100 (1/1)	0 (0/3)
451.19	Phlebitis and thrombophlebitis of other deep veins of lower extremities	24 (12/51)	50 (4/8)	18.6 (8/43)
451.2	Phlebitis and thrombophlebitis of lower extremities, unspecified	0 (0/9)	0 (0/3)	0 (0/6)
451.81	Phlebitis and thrombophlebitis of iliac vein	0 (0/1)	NA (n/0)	0 (0/1)
453.40	Acute venous embolism and thrombosis of unspecified deep vessels of lower extremity	37.4 (222/594)	47.2 (93/197)	32.5 (129/397)
453.41	Acute venous embolism and thrombosis of deep vessels of proximal lower extremity	53.8 (84/156)	62.5 (65/104)	36.5 (19/52)
453.42	Acute venous embolism and thrombosis of deep vessels of distal lower extremity	37.5 (33/88)	53.8 (28/52)	13.9 (5/36)
453.51	Chronic venous embolism and thrombosis of deep vessels of proximal lower extremity	30.6 (15/49)	27.3 (9/33)	37.5 (6/16)
453.52	Chronic venous embolism and thrombosis of deep vessels of distal lower extremity	29.2 (7/24)	31.6 (6/19)	20 (1/5)
Upper extremity deep venous thrombosis				
451.83	Phlebitis and thrombophlebitis of deep veins of upper extremities	33.3 (1/3)	0 (0/1)	50 (1/2)
451.84	Phlebitis and thrombophlebitis of upper extremities, unspecified	0 (0/4)	NA (n/0)	0 (0/4)
451.89	Phlebitis and thrombophlebitis of other upper extremity site	40 (2/5)	50 (2/4)	0 (0/1)
453.72	Chronic venous embolism and thrombosis of deep veins of upper extremity	11.1 (1/9)	0 (0/3)	16.7 (1/6)
453.75	Chronic venous embolism and thrombosis of subclavian veins	25 (1/4)	0 (0/1)	33.3 (1/3)
453.76	Chronic venous embolism and thrombosis of internal jugular veins	0 (0/2)	0 (0/2)	NA (n/0)
453.77	Chronic venous embolism and thrombosis of other thoracic veins	0 (0/2)	0 (0/2)	NA (n/0)
453.82	Acute venous embolism and thrombosis of deep veins of upper extremity	57.9 (11/19)	61.5 (8/13)	50 (3/6)

Code	Description			
453.83	Acute venous embolism and thrombosis of upper extremity, unspecified	33.3 (3/9)	25 (2/8)	100 (1/1)
453.85	Acute venous embolism and thrombosis of subclavian veins	50 (3/6)	50 (3/6)	NA (n/0)
453.86	Acute venous embolism and thrombosis of internal jugular veins	60 (3/5)	100 (2/2)	33.3 (1/3)
453.87	Acute venous embolism and thrombosis of other thoracic veins	100 (1/1)	100 (1/1)	NA (n/0)
Other venous thrombosis				
451.9	Phlebitis and thrombophlebitis of unspecified site	23.3 (7/30)	16.7 (1/6)	25.0 (6/24)
452	Portal vein thrombosis	10 (3/30)	13.3 (2/15)	6.7 (1/15)
453	Hepatic vein thrombosis	0 (0/3)	0 (0/2)	0 (0/1)
453.1	Thrombophlebitis migrans	0 (0/1)	0 (0/1)	NA (n/0)
453.2	Thrombosis of inferior vena cava	22.2 (2/9)	28.6 (2/7)	0 (0/2)
453.3	Thrombosis of renal vein	0 (0/2)	0 (0/1)	0 (0/1)
453.79	Chronic venous embolism and thrombosis of other specified veins	100 (1/1)	NA%(n/0)	100 (1/1)
453.8	Acute venous embolism and thrombosis of other specified veins	13.6 (25/184)	21.4 (12/56)	10.2 (13/128)
453.89	Acute venous embolism and thrombosis of other specified veins	29 (2/7)	40 (2/5)	0 (0/2)
453.9	Other venous embolism and thrombosis of unspecified site	11.9 (12/101)	28.6 (4/14)	9.2 (8/87)

Abbreviations: ED, emergency department: ICD-9, International Classification of Diseases, 9th edition

Numbers in parentheses represent the number of chart confirmed recurrent VTE events (n) per number of charts reviewed with an ICD-9 code for recurrent VTE (N). Charts without available documentation for review were excluded.

Appendix Table A.2. Current procedural terminology (CPT) codes to diagnose venous thromboembolism

CPT Code	Description of Examination
Ultrasound of the veins of extremities, inferior vena cava, or pelvic vessels	
93965	Noninvasive physiologic studies of extremity veins, complete bilateral study (e.g., Doppler waveform analysis with responses)
93970	Duplex scan of extremity veins including responses to compression and other maneuvers; complete bilateral study
93971	Duplex scan of extremity veins including responses to compression and other maneuvers; unilateral or limited study
93975	Duplex scan of arterial inflow and venous outflow of abdominal, pelvic, scrotal contents and/or retroperitoneal organs; complete study
93976	Duplex scan of arterial inflow and venous outflow of abdominal, pelvic, scrotal contents and/or retroperitoneal organs; limited study
93978	Duplex scan of aorta, inferior vena cava, iliac vasculature, or bypass grafts; complete study
93979	Duplex scan of aorta, inferior vena cava, iliac vasculature, or bypass grafts; unilateral or limited study
Ventilation-perfusion scan of the lung	
78580	Pulmonary perfusion imaging, particulate
78584	Pulmonary perfusion imaging, particulate, with ventilation; single breath
78585	Pulmonary perfusion imaging, particulate, with ventilation; rebreathing and washout, with or without single breath
78586	Pulmonary ventilation imaging, aerosol; single projection
78587	Pulmonary ventilation imaging, aerosol; multiple projections (e.g., anterior, posterior, lateral views)
78588	Pulmonary perfusion imaging, particulate, with ventilation imaging, aerosol, 1 or multiple projections
78591	Pulmonary ventilation imaging, gaseous, single breath, single projection
78593	Pulmonary ventilation imaging, gaseous, with rebreathing and washout with or without single breath; single projection
78594	Pulmonary ventilation imaging, gaseous, with rebreathing and washout with or without single breath; multiple projections
78596	Pulmonary quantitative differential function (ventilation/perfusion) study
Computed tomography of the chest with contrast	
71260	Computed tomography, thorax; with contrast material(s)
71270	Computed tomography, thorax; without contrast material, followed by contrast material(s) and further sections
71275	Computed tomographic angiography, chest (non-coronary), with contrast material(s), including non-contrast images, if performed
72193	Computed tomography, pelvis; with contrast material(s)
72194	Computed tomography, pelvis; without contrast material, followed by contrast material(s) and further sections

Appendix Table A.3. Positive Predictive Value of ICD-9 to identify valid recurrent VTE, restricting to the first encounter of potential recurrent VTE

Type of VTE	ICD-9 Codes	Positive Predictive Value for Recurrent VTE Events, % (n/N)			
		Overall	Hospital/Emergency Department N=711		Outpatient[a]
			Primary Position N= 272	Secondary Position[a] N= 439	
		N=1592			N=881
Any VTE	All codes below	33.7% (536/1592)	62.9% (171/272)	38.3% (168/439)	22.4% (197/881)
Pulmonary embolism	415.x	31.7% (221/696)	69.3% (104/150)	32.4% (60/185)	15.8% (57/361)
Lower extremity DVT	451.1x, 451.2, 451.81, 453.4x, 453.5x	42.6% (264/619)	63.2% (60/95)	49.4% (86/174)	33.7% (118/350)
Upper extremity DVT	451.83, 451.84, 451.89, 453.72, 453.73, 453.74, 453.75, 453.76, 453.77, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87	38.5% (15/39)	50.0% (3/6)	45.0% (9/20)	23.1% (3/13)
Other VTE	451, 451.9, 452, 453.0, 453.1, 453.2, 453.3, 453.79, 453.8, 453.89, 453.9	15.1% (36/238)	19.0%(4/21)	21.7% (13/60)	12.1% (19/157)

Abbreviations: DVT, deep venous thrombosis; ICD-9, International Classification of Diseases, 9th edition; VTE, venous thromboembolism
Numbers in parentheses represent the number of confirmed recurrent VTE events by chart review (n) per number of charts reviewed with an ICD-9 code for recurrent VTE (N) restricted to the first encounter of potential VTE. Charts without available documentation for review were excluded.

[a] inpatient /emergency department encounters with an ICD-9 code in the secondary discharge position or ICD-9 codes only from outpatient encounters that had a relevant radiology procedure code present within 7 days from the diagnosis

Appendix Table A.4. Positive Predictive Value of ICD-9 to identify valid recurrent VTE excluding potential recurrent VTE events occurring within 7 days of the incident event

Type of VTE	ICD-9 Codes	Positive Predictive Value for Recurrent VTE Events, % (n/N)			
		Overall	Hospital/Emergency Department N=1036		Outpatient[a]
			Primary Position	Secondary Position[a]	
		N=2323	N= 391	N= 627	N=1305
Any VTE	All codes below	31.5% (732/2323)	62.1% (243/391)	35.4% (222/627)	20.4% (267/1305)
Pulmonary embolism	415.x	30.4% (289/950)	67.8% (143/211)	31.2% (77/247)	14.0% (69/492)
Lower extremity DVT	451.1x, 451.2, 451.81, 453.4x, 453.5x	38.9% (370/950)	62.5% (90/144)	42.9% (115/268)	30.7% (165/538)
Upper extremity DVT	451.83, 451.84, 451.89, 453.72, 453.73, 453.74, 453.75, 453.76, 453.77, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87	37.7% (26/69)	50.0% (4/8)	40.0% (14/35)	30.8% (8/26)
Other VTE	451, 451.9, 452, 453.0, 453.1, 453.2, 453.3, 453.79, 453.8, 453.89, 453.9	13.3% (47/354)	21.4% (6/28)	20.8% (16/77)	10.0% (25/249)

Abbreviations: DVT, deep venous thrombosis; ICD-9, International Classification of Diseases, 9th edition; VTE, venous thromboembolism
Numbers in parentheses represent the number of confirmed recurrent VTE events by chart review (n) per number of charts reviewed with an ICD-9 code for recurrent VTE (N) excluding potential recurrent VTE events occurring within 7 days of the incident event. Charts without available documentation for review were excluded.

[a] inpatient /emergency department encounters with an ICD-9 code in the secondary discharge position or ICD-9 codes only from outpatient encounters that had a relevant radiology procedure code present within 7 days from the diagnosis