Hidden burden of venous thromboembolism after trauma: A national analysis

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BACKGROUND: Trauma patients are at increased risk for venous thromboembolism (VTE). One in four trauma readmissions occur at a different hospital. There are no national studies measuring readmissions to different hospitals with VTE after trauma. Thus, the true national burden in trauma patients readmitted with VTE is unknown and can provide a benchmark to improve quality of care.

METHODS: The Nationwide Readmission Database (2010–2014) was queried for patients ≥18 years non-electively admitted for trauma. Patients with VTE or inferior vena cava filter placement on index admission were excluded. Outcomes included 30-day and 1-year readmission to both index and different hospitals with a new diagnosis of VTE. Multivariable logistic regression identified risk factors. Results were weighted for national estimates.

RESULTS: Of the 5,151,617 patients admitted for trauma, 1.2% (n = 61,800) were readmitted within 1 year with VTE. Of those, 29.6% (n = 18,296) were readmitted to a different hospital. Risk factors for readmission to a different hospital included index admission to a for-profit hospital (OR 1.33 [1.27–1.40], $p < 0.001$), skull fracture (OR 1.20 [1.08–1.35], $p < 0.001$), Medicaid (OR 1.16 [1.06–1.26], $p < 0.001$), hospitalization >7 days (OR 1.12 [1.07–1.18], $p < 0.001$), and the lowest quartile of median household income for patient ZIP code (OR 1.13 [1.07–1.19], $p < 0.01$). The yearly cost of 1-year readmission for VTE was $256.9 million, with $90.4 million (35.2%) as a result of different hospital readmission.

CONCLUSIONS: Previously unreported, over one in three patients readmitted with VTE a year after hospitalization for trauma, accounting for over a third of the cost, present to another hospital and are not captured by current metrics. Risk factors are unique. This has significant implications for benchmarking, outcomes, prevention, and policy. (*J Trauma Acute Care Surg.* 2018;85: 899–906. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiological study, level II.

KEY WORDS: Venous thromboembolism; deep vein thrombosis; quality; trauma; readmission.

Measurement of quality after hospitalization for trauma can be accomplished with a variety of metrics. Readmission is one fundamental metric tracked by those interested in improving outcomes and reducing cost. In a recent study, nearly one in four trauma readmissions occur at a different hospital.[1] This is a population currently uncaptured by national readmission quality measures, accounting for nearly $500 million yearly in additional cost to the USA.[1]

Venous thromboembolism (VTE) is one of the most common preventable causes of hospital mortality.[2–7] Trauma is a significant risk factor for VTE, with incidence ranging from 4% to 90% depending on stratification and surveillance.[8] Further, risk of VTE after trauma persists after discharge.[9–15] Despite this, there are no national studies examining readmission with VTE after trauma that also include readmission to different hospitals. As such, the true rate of VTE after trauma is unknown.

The purpose of this study was to identify the incidence, risk factors, and costs related to readmission with VTE after trauma. We hypothesized that a significant proportion of readmissions with VTE after trauma occur at a different hospital, that risk factors for readmission differ between patients readmitted to the index hospital and patients readmitted to a different hospital, and that the cost of readmission to a different hospital was higher than the cost of readmission to the index hospital.

METHODS

A component of the Healthcare Cost and Utilization Project (HCUP), the Nationwide Readmissions Database (NRD) is composed of US hospitalizations in a nationally representative sample from 27 states, accounting for 57% of all hospitalizations. The NRD uses an identifier for each patient allowing admissions across different hospitals to be linked. Inter-hospital transfers are collapsed into one record so that transfers are not entered as readmissions.[16] The NRD cannot track patients across calendar years or state lines. Nevertheless, the NRD is the only nationally representative readmissions database in the USA.

The 2010–2014 NRD was queried for patients ≥18 years non-electively admitted with a primary diagnosis of trauma (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9] diagnosis code 800.0–959.9), excluding late effects of injury (905.0–909.0), foreign body (930.0–939.0), burns (940.0–949.0), and early complications (958.0).[17] Patients were excluded if they were missing data or if they developed VTE or had an inferior vena cava filter (IVCF) placed during index hospitalization. Admissions involving VTE were identified using ICD-9 diagnosis codes for deep vein thrombosis (DVT) (451.0, 451.1x, 451.2, 451.81, 451.9, 453.4x, 453.8, 453.9) or pulmonary embolus (PE) (415.x).[18] Patients with IVCF placement were identified by ICD-9 procedure code 387.[18] Patients who expired during index hospitalization were excluded from readmission analyses. Results were weighted for national estimates.

Outcomes included 30-day and 1-year incidences of readmission with VTE. Readmission within 30 days was selected because it is recognized by Centers for Medicare and Medicaid Services (CMS) and the Hospital Quality Alliance, among others, as a quality metric.[19] Readmission within 1 year was selected because there is an increasing number of studies suggesting that injury confers risk for VTE beyond 30 days but that incidence returns to general population risk between 12 and 15 months after injury.[9–13,20] In addition to our readmission analyses at 1 year, we measured the VTE readmission rate in non-injured patients in the NRD and compared them with the 1-year VTE readmission rate in our study population to determine if incidence in our study population was actually higher at 1 year.

Cost was calculated by using HCUP cost-to-charge ratios to convert recorded charges in the NRD. These ratios are based on CMS account reports.[21] They are necessary because charges demonstrate a wide, unexplained variability between hospitals, preventing meaningful comparison.[22] This methodology provided by HCUP to estimate cost allows for standardized appraisal of relative cost between hospitals.

Categorical variables were compared with the χ^2 test. Continuous variables were presented as median [interquartile range] and compared with the Mann–Whitney U test. Univariable logistic regression using the 49 demographic, clinical, and hospital variables included in the NRD was performed for 30-day and

1-year readmission with significance set at $p < 0.05$. This was done to ensure no potential variables were excluded from our analysis to reduce bias. However, only significant variables were then used in a multivariable logistic regression for the same outcomes to determine risk factors for readmission with VTE. This methodology mirrors previous VTE and trauma studies using the NRD.[23–26] The Injury Severity Score (ISS) and Charlson Comorbidity Index were created using the ICDPIC version 3.0 software package in Stata/SE version 12.0 for Mac (StataCorp, College Station, Texas).[27] Results were weighted for national estimates according to HCUP guidelines.[16] IBM SPSS Statistics version 24 (International Business Machines Corp, Armonk, New York) was used for statistical analyses.

As the NRD is a publicly available, deidentified database, its use is not considered human subjects research, and as such, it is exempt from Institutional Review Board approval.

RESULTS

There were 5,862,239 patients admitted for trauma during the study period, of which 5,151,617 patients met inclusion criteria. Patients were excluded because of collapsed records between two hospitals preventing identification of index hospital (n = 379,504), mortality during initial admission (n = 158,767), missing data (n = 121,503), or transfer to a short-term hospital (n = 80,889). Patients were excluded from readmission analyses if they had a DVT (n = 47,647), PE (n = 31,195), or IVCF (n = 60,025) during initial admission.

The all-cause 30-day readmission rate for trauma patients was 10.3% (n = 531,643) to any hospital with 24.5% (n = 130,401) of those readmitted to a different hospital. The 30-day readmission rate with VTE for trauma patients was 0.6% (n = 28,224) to any hospital with 26.6% (n = 7,498) of those readmitted to a different hospital. The 1-year readmission rate with VTE for trauma patients was 1.2% (n = 61,800) to any hospital with 29.6% (n = 18,296) of those readmitted to a different hospital. The VTE readmission rate was higher in patients admitted with a primary diagnosis of trauma (i.e., this study population) compared with the remainder of patients in the NRD (i.e., patients admitted with a primary diagnosis other than trauma) at both 30 days (0.6% vs. 0.3%, $p < 0.001$) and 1 year (1.2% vs. 0.8%, $p < 0.001$).

Characteristics of patients readmitted within 30 days with VTE, including to a different hospital, are reported in Table 1. Patients with a skeletal injury accounted for 70.4% (n = 3,574,867) of patients. Of those with fractures, 68.7% (n = 2,454,940) had a long bone fracture, accounting for 48.4% of all patients included in the study. For-profit hospitals had higher rates of readmission to a different hospital compared with not-for-profit hospitals (30.6% vs. 24.9%, $p < 0.001$). Medicaid patients had higher rates of readmission to a different hospital compared with privately insured patients (32.5% vs. 28.3%, $p < 0.001$). Finally, leaving against medical advice had higher rates of readmission to a different hospital compared with routine discharge (61.0% vs. 30.2%, $p < 0.001$).

The results of multivariable logistics regressions to identify risk factors for 30-day readmission with VTE are presented in Table 2. Whereas undergoing a major operating room procedure decreased the risk of readmission to a different hospital (OR 0.73 [95% CI 0.69–0.77], $p < 0.001$), initial hospitalization

TABLE 1. Characteristics of Study Population and 30-day Readmission Subpopulations with Venous Thromboembolism

	Total		Readmission		Different Hospital Readmission		
	n	%	n	%	n	%	p
Total	5,075,338	100.0	28,224	0.6	7,498	26.6	
Age, y							<0.001
18–44	1,180,703	23.3	3,046	0.3	847	27.8	
45–64	1,172,730	23.1	5,489	0.5	1,566	28.5	
≥65	2,721,904	53.6	19,690	0.7	5,084	25.8	
Female	2,700,749	53.2	15,990	0.6	4,091	25.6	
Fracture							<0.001
No fracture	1,500,462	29.56	6,688	0.5	2,064	30.9	
Skull	275,776	5.43	739	0.3	246	33.3	
Spine/trunk	844,160	16.63	4,288	0.5	1,307	30.5	
Upper limb	459,334	9.05	1,797	0.4	465	25.9	
Lower limb	1,995,606	39.32	14,712	0.7	3,415	23.2	
Venous injury	10,864	0.2	187	1.7	39	20.9	
Penetrating injury	235,795	4.6	776	0.3	187	24.1	
ISS > 15	841,628	16.6	5,315	0.6	1,477	27.8	
LOS > 7 days	736,925	14.5	6,871	0.9	1,941	28.2	
CCI ≥ 1	2,192,045	43.2	15,188	0.7	3,945	26.0	
Major operation	2,751,984	54.2	17,800	0.6	4,341	24.4	
Hospital ownership							<0.001
Not-for-profit	3,555,824	70.1	20,064	0.6	4,996	24.9	
Public	770,160	15.2	3,637	0.5	1,118	30.7	
Investor-owned	749,353	14.8	4,523	0.6	1,383	30.6	
Hospital bed size							<0.001
Large	3,415,231	67.3	18,826	0.6	4,710	25.0	
Medium	1,154,530	22.7	6,594	0.6	1,879	28.5	
Small	505,577	10.0	2,804	0.6	909	32.4	
Hospital teaching status							0.04
Metropolitan non-teaching	1,773,093	34.9	10,384	0.6	2,832	27.3	
Metropolitan teaching	2,832,643	55.8	15,541	0.5	4,095	26.3	
Non-metropolitan	469,602	9.3	2,299	0.5	571	24.8	
Insurance							<0.001
Private	1,170,515	23.1	5,024	0.4	1,423	28.3	
Medicare	2,699,743	53.2	19,206	0.7	4,879	25.4	
Medicaid	399,575	7.9	1,580	0.4	513	32.5	
Self-pay	418,280	8.2	1,063	0.3	246	23.1	
No charge	38,812	0.8	99	0.3	35	35.4	
Other	348,413	6.9	1,251	0.4	402	32.1	
Income quartile							0.26
4th	1,107,627	21.8	6,413	0.6	1,706	26.6	
3rd	1,220,417	24.0	6,856	0.6	1,821	26.6	
2nd	1,292,690	25.5	7,101	0.5	1,832	25.8	
1st	1,454,604	28.7	7,853	0.5	2,140	27.3	
Disposition							<0.001
Routine	2,281,275	44.9	7,230	0.3	2,184	30.2	
Skilled nursing	2,137,873	42.1	17,460	0.8	4,443	25.4	
Home health care	612,568	12.1	3,429	0.6	807	23.5	
Against medical advice	43,622	0.9	105	0.2	64	61.0	

ISS, Injury Severity Score; LOS, length of stay; CCI, Charlson Comorbidity Index.

TABLE 2. Risk Factors for 30-Day Readmission with Venous Thromboembolism

	Readmission		Different Hospital Readmission	
	OR (95% CI)	p	OR (95% CI)	p
Age, y				
18–44	—	—	—	—
45–64	1.59 (1.51–1.66)	<0.001	1.13 (1.02–1.26)	0.02
≥65	1.86 (1.75–1.97)	<0.001	1.27 (1.12–1.44)	<0.001
Female	0.83 (0.81–0.85)	<0.001	0.98 (0.93–1.04)	0.54
Fracture				
No fracture	—	—	—	—
Skull	0.70 (0.65–0.76)	<0.001	1.07 (0.91–1.26)	0.43
Spine/trunk	1.00 (0.96–1.04)	1.00	0.96 (0.88–1.05)	0.34
Upper limb	0.89 (0.84–0.94)	<0.001	0.79 (0.70–0.90)	<0.001
Lower limb	1.28 (1.23–1.33)	<0.001	0.72 (0.66–0.79)	<0.001
Venous injury	3.89 (3.35–4.53)	<0.001	—	
Penetrating injury	1.00 (0.92–1.08)	0.26	—	
ISS > 15	1.33 (1.28–1.37)	<0.001	0.88 (0.81–0.95)	<0.001
LOS > 7 days	1.49 (1.45–1.54)	<0.001	1.18 (1.10–1.26)	<0.001
CCI ≥ 1	1.01 (0.97–1.05)	0.41	0.98 (0.92–1.05)	0.59
Major operation	1.10 (1.06–1.14)	<0.001	0.87 (0.81–0.93)	<0.001
Hospital ownership				
Not-for-profit	—	—	—	—
Public	0.95 (0.92–0.99)	<0.001	1.31 (1.21–1.42)	<0.001
Investor-owned	1.11 (1.07–1.14)	<0.001	1.27 (1.17–1.36)	<0.001
Hospital bed size				
Large	—	—	—	—
Medium	0.96 (0.94–0.99)	0.06	1.21 (1.13–1.29)	<0.001
Small	0.92 (0.88–0.95)	<0.001	1.50 (1.37–1.64)	<0.001
Hospital teaching status				
Metropolitan non-teaching	—	—	—	—
Metropolitan teaching	1.07 (1.04–1.10)	<0.001	0.92 (0.87–0.98)	0.02
Non-metropolitan	0.83 (0.79–0.87)	<0.001	0.87 (0.78–0.97)	0.01
Insurance				
Private	—	—	—	—
Medicare	1.02 (0.97–1.06)	0.40	0.85 (0.77–0.93)	<0.001
Medicaid	1.02 (0.96–1.08)	0.54	1.12 (0.99–1.28)	0.07
Self-pay	0.81 (0.76–0.87)	<0.001	0.76 (0.65–0.89)	<0.001
No charge	0.78 (0.64–0.96)	0.02	1.23 (0.81–1.88)	0.33
Other	0.90 (0.85–0.96)	<0.001	1.13 (0.99–1.30)	0.08
Income quartile				
4th	—	—	—	—
3rd	1.00 (0.97–1.04)	0.97	—	—
2nd	0.99 (0.96–1.03)	0.72	—	—
1st	1.04 (1.01–1.08)	0.02	—	—
Disposition				
Routine	—	—	—	—
Skilled nursing	1.61 (1.55–1.67)	<0.001	0.89 (0.82–0.96)	<0.001
Home health care	1.28 (1.23–1.34)	<0.001	0.74 (0.67–0.81)	<0.001
Against medical advice	0.90 (0.74–1.09)	0.32	3.11 (2.08–4.66)	<0.001

Empty cells represent variables that were not significant ($p < 0.05$) on univariate logistic regression and thus were not included in the multivariate logistic regression.

ISS, Injury Severity Score; LOS, length of stay; CCI, Charlson Comorbidity Index.

over 7 days increased the risk of readmission to a different hospital (OR 1.22 [95% CI 1.14–1.30], $p < 0.001$). Presence of a lower extremity fracture was also an independent predictor of 30-day readmission with VTE (OR 1.28 [95% CI 1.23–1.33], $p < 0.001$), though it reduced the risk of readmission to a different hospital (OR 0.72 [95% CI 0.66–0.79], $p < 0.001$). When controlling for other factors and compared with patients initially admitted to a not-for-profit hospital, initial admission to a for-profit hospital remained a significant risk factor for readmission with VTE (OR 1.10 [95% CI 1.06–1.14], $p < 0.001$) as well as a readmission to a different hospital with VTE (OR 1.28 [95% CI 1.19–1.38], $p < 0.001$). Discharges that included post-discharge services, such as home health care (OR 0.73 [95% CI 0.66–0.80], $p < 0.001$) or a stay at a skilled nursing facility (OR 0.85 [95% CI 0.78–0.92], $p < 0.001$), were less likely to be readmitted to a different hospital with VTE compared with patients discharged home without any services. This is despite the fact that both discharge to a skilled nursing facility (OR 1.72 [95% CI 1.66–1.78], $p < 0.001$) or discharge with home health care (OR 1.33 [95% CI 1.27–1.39], $p < 0.001$) increased the risk of readmission with VTE overall.

The results of multivariate logistics regressions to identify risk factors for 1-year readmission with VTE are presented in Table 3. Presence of a lower extremity fracture remained an independent predictor (OR 1.14 [95% CI 1.11–1.17], $p < 0.001$) for readmission with a VTE though it also remained a protective factor against readmission with a VTE to a different hospital (OR 0.75 [95% CI 0.71–0.80], $p < 0.001$). Initial admission to a for-profit hospital remained a significant risk factor for readmission to a different hospital with VTE (OR 1.34 [95% CI 1.27–1.41], $p < 0.001$), as did leaving against medical advice (OR 1.69 [95% CI 1.32–2.16], $p < 0.001$) and length of stay (LOS) >7 days (OR 1.16 [95% CI 1.11–1.21], $p < 0.001$). Undergoing a major operating room procedure (OR 0.74 [95% CI 0.71–0.76], $p < 0.001$) or discharge with services such as home health care (OR 0.82 [95% CI 0.76–0.87], $p < 0.001$) or a skilled nursing facility (OR 0.86 [95% CI 0.82–0.91], $p < 0.001$) remained protective. Compared with private insurance, patients with Medicaid had a higher risk of readmission to a different hospital (OR 1.17 [95% CI 1.07–1.27], $p < 0.001$). Compared with the highest quartile of median household income by patient's ZIP code, those in the lowest quartile had an increased risk of readmission to a different hospital with VTE (OR 1.13 [95% CI 1.07–1.19], $p < 0.001$).

When calculating total costs, only patients missing cost data (n = 96,319) were excluded. The total yearly cost of 30-day readmission with VTE was $114.4 million. Of that, 31.3% ($35.8 million) was a result of readmission to a different hospital. The total yearly cost of 1-year readmission with VTE was $256.9 million. Of that, 35.2% ($90.4 million) was a result of readmission to a different hospital. The median cost of readmission with VTE was higher when the readmission occurred at a different hospital at both 30 days ($11,209 [$6,277–$21,896] vs. $10,099 [$5,749–$19,085], $p < 0.001$) and at 1 year ($11,447 [$6,379–$22,543] vs. $10,507 [$5,922–$20,059], $p < 0.001$).

DISCUSSION

We described the hidden national burden of readmission to a different hospital with VTE after trauma. We further calculated

TABLE 3. Risk Factors for 1-Year Readmission with Venous Thromboembolism

	Readmission		Different Hospital Readmission	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Age, y				
18–44	—	—	—	—
45–64	1.71 (1.65–1.77)	<0.001	1.05 (0.97–1.13)	0.25
≥65	2.05 (1.96–2.14)	<0.001	1.00 (0.92–1.09)	0.96
Female	0.93 (0.91–0.94)	<0.001	0.97 (0.94–1.01)	0.19
Fracture				
No fracture				
Skull	0.68 (0.64–0.72)	<0.001	1.20 (1.08–1.35)	<0.001
Spine/trunk	1.00 (0.98–1.03)	0.89	0.94 (0.89–0.99)	0.03
Upper limb	0.82 (0.79–0.85)	<0.001	0.97 (0.89–1.05)	0.4
Lower limb	1.14 (1.11–1.17)	<0.001	0.75 (0.71–0.80)	<0.001
Venous injury	3.63 (3.20–4.11)	<0.001	—	—
Penetrating injury	0.85 (0.80–0.90)	<0.001	—	—
ISS > 15	1.15 (1.12–1.18)	<0.001	1.04 (0.99–1.10)	0.12
LOS > 7 days	1.38 (1.35–1.41)	<0.001	1.12 (1.07–1.18)	<0.001
CCI ≥ 1	1.07 (1.05–1.10)	<0.001	0.96 (0.92–1.01)	0.14
Major operation	1.06 (1.03–1.08)	<0.001	0.86 (0.82–0.90)	<0.001
Hospital ownership				
Not-for-profit	—	—	—	—
Public	0.98 (0.96–1.01)	0.16	1.32 (1.25–1.39)	<0.001
Investor-owned	1.12 (1.09–1.15)	<0.001	1.33 (1.27–1.40)	<0.001
Hospital bed size				
Large	—	—	—	—
Medium	0.95 (0.93–0.97)	<0.001	1.08 (1.03–1.12)	<0.001
Small	0.91 (0.88–0.93)	<0.001	1.44 (1.36–1.52)	<0.001
Hospital teaching status				
Metropolitan non-teaching	—	—	—	—
Metropolitan teaching	1.02 (1.00–1.04)	0.07	1.00 (0.97–1.05)	0.82
Non-metropolitan	0.82 (0.80–0.85)	<0.001	0.84 (0.79–0.90)	<0.001
Insurance				
Private	—	—	—	—
Medicare	1.17 (1.14–1.21)	<0.001	0.92 (0.86–0.98)	0.02
Medicaid	1.19 (1.14–1.24)	<0.001	1.16 (1.06–1.26)	<0.001
Self-pay	0.77 (0.73–0.81)	<0.001	0.78 (0.69–0.87)	<0.001
No charge	1.02 (0.89–1.17)	0.76	0.91 (0.68–1.22)	0.54
Other	0.91 (0.87–0.96)	<0.001	1.15 (1.04–1.27)	<0.001
Income quartile				
4th	—	—	—	—
3rd	0.99 (0.97–1.02)	0.58	0.99 (0.94–1.04)	0.59
2nd	1.03 (1.01–1.06)	<0.001	1.00 (0.95–1.05)	0.97
1st	1.10 (1.07–1.12)	<0.001	1.13 (1.07–1.19)	<0.001
Disposition				
Routine	—	—	—	—
Skilled nursing	1.70 (1.66–1.74)	<0.001	0.90 (0.86–0.95)	<0.001
Home health care	1.35 (1.31–1.39)	<0.001	0.82 (0.77–0.88)	<0.001
Against medical advice	1.13 (1.00–1.28)	0.05	1.67 (1.30–2.13)	<0.001

Empty cells represent variables that were not significant ($p < 0.05$) on univariate logistic regression and thus were not included in the multivariate logistic regression.
ISS, Injury Severity Score; LOS, length of stay; CCI, Charlson Comorbidity Index.

risk factors and costs associated with readmission with VTE after trauma. Previously unreported, more than one in four trauma readmissions within 30 days with a newly diagnosed VTE occur at a different hospital. By 1 year, nearly one in three trauma readmissions with newly diagnosed VTE occur at a different hospital. This incidence remains 150% higher than the general population. These readmissions are not currently captured by national quality metrics. They also result in a cost that is 1.5 times higher than previously calculated when including only same hospital readmission and tops a quarter billion dollars yearly. Given that nearly 7 out of 8 admissions, 30-day readmissions, and 1-year readmissions occur at a not-for-profit or public hospital and 8 out of 10 readmitted patients in this dataset are publicly insured or uninsured, US taxpayers bear the brunt of this hidden burden.

Accurate assessment of quality as it relates to VTE rates is critical. The US Surgeon General has declared VTE prevention a major quality improvement opportunity and the Joint Commission measures VTE prevention quality through their Surgical Care Improvement Program.[28] Clinical efforts to mitigate risk factors are fundamentally hampered when efforts to measure VTE are significantly inaccurate, as this research suggests. Beyond improving outcomes, quality benchmarking is also affected. For example, CMS, through the Hospital Readmissions Reduction Program, penalizes hospitals with excess readmissions.[19] However, excess readmissions are determined by benchmarking gleaned from and applied to hospitals nationwide. This study demonstrates that not only is benchmarking based only on same hospital admission inaccurate, there are significant variations in rates of readmission to a different hospital among hospital types. In other words, hospitals with higher rates of readmission to other hospitals, such as for-profit hospitals, have more of their readmissions hidden, thus falsely lowering their readmission rate in the eyes of CMS and other institutions monitoring quality. The result is that benchmarking bends toward the falsely low results of for-profit hospitals, unfairly penalizing public and not-for-profit hospitals, the major safety net caring for this vulnerable population.

The general public ought to take particular interest in such inaccuracies and their effect. The fraction of publicly insured or uninsured trauma patients—cost borne by taxpayers—is over 80% and grows yearly.[29,30] In this population, 85% of trauma patients are initially admitted to a public or not-for-profit hospital. Public insurance tended to increase risk of readmission with VTE in the short and long term. Meanwhile, patients initially admitted to for-profit hospitals are more likely to be readmitted to another hospital with VTE.

This burden is not trivial. Readmissions with VTE at different hospitals are costlier, likely caused by lack of continuity of care creating redundancy. Fragmentation of care increases cost both in individual cases and overall.[1,31,32] In this study, there is over $110 million yearly of extra cost not previously described.

Risk factors for readmission overall did not always predict risk factors for readmission to a different hospital in either the short or long term. In other words, risk factors for readmission to a different hospital are distinct. Thus, readmission reduction programs developed based only on same hospital readmission patterns are likely to miss the unique population at risk for readmission to a different hospital. Some findings are reassuring. Proxies for complex injuries, such as lower extremity fracture, ISS >15, and undergoing a major operation during the index admission, reduce the risk of readmission to a different hospital. Thus, these complicated cases are more likely to have continuity of care. However, other findings are not necessarily intuitive. Some trauma surgeons may find that patients who are treated at a public hospital often are vulnerable enough that they do not readily have access to care at other hospitals. However, this study finds that public hospital patients are actually at increased risk for readmission to a different hospital despite having a lower readmission risk overall. This may create an inaccurate sense of quality of care, where public hospitals and their staff feel that if their patients do not have access to care elsewhere nor are returning to their center for readmission, must by default not be experiencing complications. This can lead to a dangerously false sense of security and impede development of robust quality and readmission prevention programs. This study builds on previous readmission studies examining populations readmitted to different hospitals by again underlining the fact that vulnerable populations, such as the elderly, the poor, the publicly insured, or those with more severe injuries or more complex and longer hospital courses, are at higher risk for readmission to a different hospital.[1,31–33] Such fragmentation of care increases morbidity and mortality.[34–38]

There are several limitations to this study. First, the dataset is administrative and is subject to data entry errors and possible discrepancies between clinical conditions and claims data. This also prevents us from determining admitting diagnosis or identifying the timing of VTE. Because of the limitations of the NRD, we can only surmise that patients were initially discharged without a diagnosis of VTE but were discharged from their readmission with a diagnosis of VTE. Related to this, a significant number of post-discharge VTE may be diagnosed or treated on an outpatient basis and thus not captured by the NRD.[39,40] In other words, the findings here likely underestimate the true burden of post-discharge VTE, especially in trauma populations who have difficulty accessing hospital care. Second, as a database based on discharge documentation, it is lacking important clinical parameters known to affect outcomes. Third, some relevant non-clinical parameters, such as race and distance to hospital, are also missing. Fourth, cost calculations, although using previous accepted methodology recommended by HCUP, are far from ideal as they are based on hospital charges, which vary widely in an unexplained manner. Finally, the NRD only captures intrastate readmissions. Although the rate of interstate hospitalization for trauma is unknown, previous studies of the NRD have estimated any effect on overall readmission rates to be minimal, on the order of tenths of a percent.[1,31–33]

This is a topic ripe for further research. First, a more complete risk factor analysis that includes clinical parameters needs to be undertaken to better understand readmission patterns. Ideally, a national database that captures demographic, hospital, and clinical parameters across different hospitals would be developed. In addition to studying readmission in a more granular way, such a robust database would be able to better examine whether the risk factors identified in this study may also have an effect on VTE development itself. Given the discrepancy between rates of readmission with VTE between hospital types, further study is warranted. For example, although the statistical analysis performed in this study suggests a correlation between for-profit hospitals and readmission with VTE, limitations of the NRD prevent further elucidation. Injury pattern may be different, with for-profit hospitals treating more elderly patients with long-bone fractures who are at high risk for VTE. Emphasis on reducing LOS without programs in place to continue chemoprophylaxis post-discharge may result in fewer days with VTE prophylaxis. With the increasing interest in improving outcomes and reducing cost, this should be of interest to policy-makers, insurers, clinicians, researchers, and patients alike. Second, with a more granular understanding of causes of readmission and high-risk groups, programs aiming to reduce readmissions can be developed and evaluated. There are data demonstrating that targeted programs even after discharge are effective.[41] Given that this and other studies have found that discharge care plans that maintain a connection to the index institution reduce readmission to a different hospital, it is likely that future studies will support expanding such outpatient efforts.[1,31–33,41] Third, a better understanding of the true cost of post-traumatic VTE would include emergency room visits that did not result in hospitalization, urgent care visits, and the socioeconomic cost related to loss of productivity and time away from family.

The national burden of VTE after trauma is higher than previously thought, with nearly a third of readmissions with VTE occurring at a different hospital. This fragmentation of care increases cost. Over one third of the cost of readmission for newly diagnosed VTE is attributable to this previously hidden fraction. Current metrics used to create benchmarking are inaccurate. More robust quality tracking and refined policies are required.

AUTHORSHIP

R.R. and J.P. were involved in all aspects of the study. S.A.E., J.G., A.D., T.L.Z., D.D.Y., E.G., and N.N. were involved with data analysis, data interpretation, writing, and critical revision.

DISCLOSURE

The authors declare no conflicts of interest.

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