



## Transition of care for pediatric and adult patients with venous thromboembolism: A National Quality Improvement Project from the American Thrombosis and Hemostasis Network (ATHN)

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### ABSTRACT

**Background:** Transition of care (TOC) for management of anticoagulation from inpatient to outpatient setting for patients with acute venous thromboembolism (VTE) poses serious safety concerns. We implemented a national quality improvement educational initiative to address this issue.

**Methods:** Pediatric and adult patients admitted for their first VTE were prospectively enrolled at 16 centers from January 2016 to December 2018. Patient demographics, VTE diagnosis, risk factors, and treatment characteristics were collected. There were two phases: pre-intervention (PI) and quality intervention (QI). The PI phase assessed the quality and patient understanding and satisfaction of anticoagulation instructions given at hospital discharge and adherence to these instructions via a patient and/or caregiver feedback questionnaire (PFQ) and a patient knowledge questionnaire (PKQ) at 30 days. The QI phase provided patient and/or caregiver enhanced education regarding anticoagulation therapy and VTE at hospital discharge using a comprehensive discharge instruction module and a phone call follow-up at one week. Patient and/or caregiver knowledge at 7 and 30 days was assessed with the same PFQ and PKQ and compared to the PI baseline measures.

**Results:** Of the 409 study patients, 210 (51%) were adults, 218 (53%) females, and 316 (77%) White. Deep vein thrombosis (62.8%) and pulmonary embolism (47.9%) were the most common VTE in children and adults, respectively. Day 30 PFQ scores were significantly higher in the QI phase compared to the PI phase by 11% ( $p < 0.01$ ). Day 30 PKQ demonstrated enhanced teaching (93.7% vs. 83.5%,  $p$ -value 0.004) and disease recognition (89.6% vs. 84.6%  $p = 0.03$ ) in the QI phase than the PI phase.

**Conclusion:** Comprehensive VTE discharge instructions followed by a 1-week post-discharge phone call strengthen patient and caregiver knowledge, satisfaction of education given and care provided, and disease recognition.

### 1. Introduction

Transition of care (TOC) across multiple health care settings makes patients vulnerable to serious medical errors [1,2]. Discharge from the acute care hospital to an outpatient ambulatory setting is increasingly

recognized as a time of heightened vulnerability for lapses in safety and quality. Poorly executed transitions contribute to hospital readmissions, resulting in annual Medicare costs estimated at \$17 billion [3]. Medication errors are one of the most common causes of medical mistakes during transition from the inpatient to the outpatient setting [4,5].

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High quality TOC is important for patients with venous thromboembolism (VTE) treated with anticoagulation medication since these therapies are associated with significant adverse effects [6]. TOC education must include signs and symptoms of bleeding and precautions to decrease bleeding risk since major and fatal bleeding, the most serious side effect of anticoagulant therapy, occurs in 11% of patients within 30 days of hospital discharge [7]. VTE is also increasingly reported in the pediatric and adolescent population [8,9]. TOC must also incorporate proper medication administration and education about medication adherence since errors in medication administration and sub-optimal adherence may result in recurrent VTE and hospital readmission. Adult patients with VTE have a 30-day readmission rate of 17.5% [10]. The Joint Commission has mandated healthcare institutions to establish guidelines for the safe use of anticoagulants that will ensure patient safety during TOC from the inpatient to the outpatient setting [11].

Several types of anticoagulants exist for the medical management of VTE. These include unfractionated heparin, low molecular weight heparins (LMWH; typically, enoxaparin in the United States [US]), warfarin, and direct oral anticoagulants (DOACs). In adults, the availability of DOACs has changed the landscape of VTE therapy resulting in shortened length of stay as these anticoagulants are administered at a fixed dose and do not require routine laboratory monitoring [12]. Although DOACs are not approved yet for use in children, clinical trials assessing their efficacy are underway/recently completed [13,14]. The EINSTEIN Junior: Oral Rivaroxaban in Children With Venous Thrombosis trial demonstrated that children treated with rivaroxaban had a similar low risk of recurrent VTE and similar rates of bleeding than current standard anticoagulation therapy [15]. Likewise a phase 3 trial with dabigatran showed a favorable safety profile for secondary VTE prevention in children aged >3 months and < 18 years old [16].

While previous studies demonstrated that systematic TOC processes can improve patient-reported outcomes and adherence to antithrombotic therapies in adults [17], the use of TOC in children has not been systematically evaluated. We designed a prospective quality improvement study to improve the TOC from the inpatient to the outpatient setting in both adult and pediatric patients diagnosed with their first VTE.

## 2. Methods

### 2.1. Design

This study “ATHN 4: Transition of Care for Patients with Venous Thromboembolism” was a multi-center, quality improvement study conducted at 16 ATHN-affiliated centers from January 2016 through December 2018. ATHN is a nonprofit organization dedicated to improving the lives of people affected by blood disorders. ATHN supports its ATHN Affiliate Network, consisting of more than 145 ATHN-affiliated treatment centers across the US, in the execution of data projects, research and public health surveillance.

### 2.2. Study aims

The primary aims of the study were: 1. To improve the transition of care from an inpatient to an outpatient environment for patients with VTE, specifically looking at delivery and understanding of instructions regarding anticoagulant therapy at the time of discharge. 2. To evaluate patient/caregiver understanding of and adherence to anticoagulation therapy-related instructions at approximately one week after initial VTE diagnosis and prescribing of anticoagulation with LMWH, warfarin and DOACs.

### 2.3. Study population

Adult and pediatric patients with a first diagnosis of VTE who met the eligibility criteria and were receiving care from one of the 16

participating ATHN-affiliated centers during either of the active phases of the project: Pre-Intervention (PI) and Quality Intervention (QI).

### 2.4. Study procedures

For this quality improvement study, we recruited adult and pediatric patients hospitalized at participating centers with their first diagnosis of VTE, who were being discharged with an anticoagulant and willing to follow up for at least 30 days. Patients with prior history of VTE, on anticoagulation for other reasons, discharged directly from the emergency department, or not fluent in English or Spanish were excluded. For the purpose of this study we considered adult patients to be  $\geq 18$  and pediatric patients to be <18 years of age.

The study design depicted in Fig. 1 has been previously published [18]. Briefly; the study consisted of two phases:

- Pre-Intervention (PI) Phase: A first cohort of patients received anticoagulant discharge instructions per standard policy at each institution. A Patient Knowledge Questionnaire (PKQ) and Patient Feedback Questionnaire (PFQ) were developed for this project and administered at the outpatient clinic at 30-day follow-up (Supplementary Appendix).
- Quality Intervention (QI) phase: A second cohort of patients received a Comprehensive Discharge Instruction Module (CDIM) provided by trained staff. The CDIM included individualized face-to-face teaching accompanied by written specific anticoagulation instructions, followed by one-week and one-month communication via phone call or office visit. For the purposes of the CDIM, a written handout was designed for each anticoagulant describing the formulation, route of administration, frequency of dosing and instructions in what to do in case of missing a dose. It also included the patient's anticoagulant dose, reason for anticoagulant, follow-up plan, and contact number for questions. Prior to hospital discharge trained staff gave the handout to the patient and/or caregiver and explained in detail the signs and symptoms of VTE and different types of bleeding complications. This was followed by a 1-week phone call where a PKQ was administered to provide reinforcement of instructions and supplemental education. Lastly, both the PKQ and PFQ were completed at day 30 post-discharge.

An Evaluation of Provider Perceptions (EPP) survey was designed consisting of 12 questions reporting the collective perceptions of all the health care professionals involved in the project at the 16 participating centers (Supplementary Appendix).

Anticoagulation Adherence assessment: After hospital discharge, adherence with anticoagulation was measured via self-reporting through a designed questionnaire. The questionnaire asked questions to understand adherence with filling the anticoagulant prescription, adherence with taking the medication as prescribed (name of anticoagulant, dose and frequency), and adherence with follow-up visits.

### 2.5. Data collection

Clinical data collected on all eligible patients included demographics, VTE diagnosis, VTE risk factors (medical, environmental), VTE site, and VTE treatment during their hospitalization. Adverse events including VTE recurrence and side effects of anticoagulation, such as bleeding, were collected using the PKQ either at hematology appointment or by phone by staff trained within the institution regarding use of CDIM and supporting tools, questionnaires, and materials.

### 2.6. Statistical analysis

Descriptive analysis was performed for evaluation of demographics, VTE characteristics, risk factor assessment, treatment, and adverse events. PKQs were reviewed and two-sample z-tests were used to

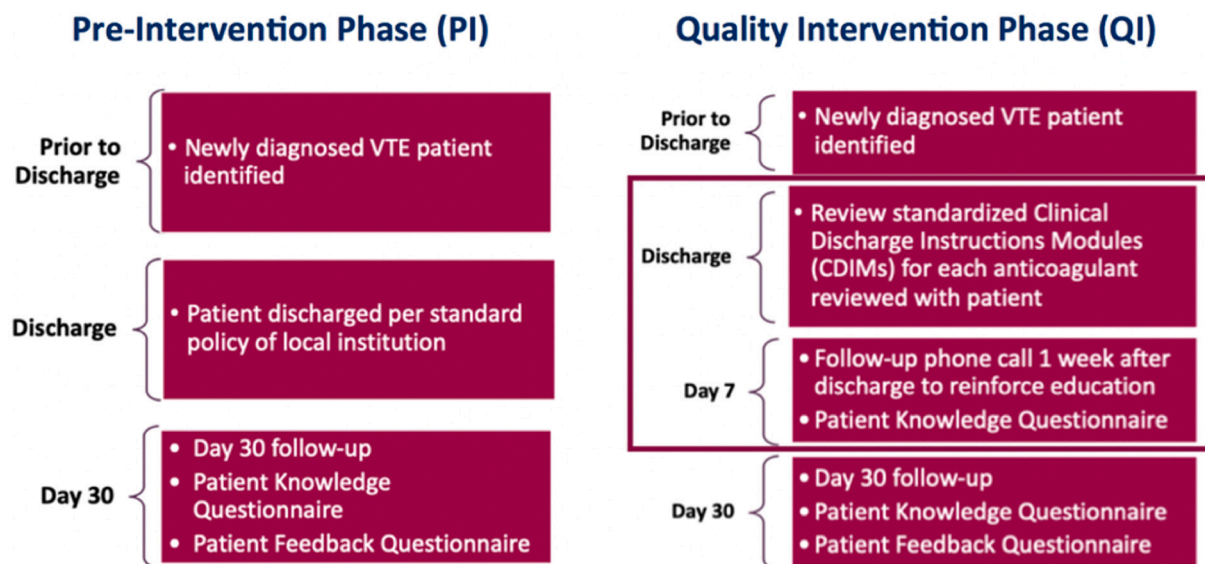


Fig. 1. Study design.

confirm whether or not TOC leads to a better understanding of VTE signs and symptoms and to higher adherence to anticoagulation therapy. A *t*-test was used to compare total scores on PFQ between two independent study cohorts (PI and QI) to determine if patients receiving the intervention demonstrated more satisfaction. A Likert scale was applied for the response to each PFQ question ranging from “Strongly Agree” to “Strongly Disagree.” To analyze all the questions on the PFQ simultaneously, a score of 0 to 100 with an increment of 25 was matched to individual Likert scale. A multivariate normal distribution was assumed for all the scores assigned to all the answers on the PFQ form.

Patient Knowledge Questionnaire 7-day follow-up was only administered to the patients in the QI group and had some correlation with PKQ 30-day measurements for those patients in the same cohort. Due to the matched design, conditional generalized linear regression was used to test whether there was any trend between the answers from the PKQ 7-day and PKQ 30-day follow-ups in the QI group. The chi-square test was used to compare responses of PKQ 30-day from the QI group and PKQ 30-day in the PI group.

There were seven TOC-related outcome measurements: follow-up appointment, hospitalization rate, recurrent thrombosis, bleeding events, compliance with anticoagulants, anticoagulant dosing recall errors, and anticoagulant dosing frequency recall errors. For each TOC outcome, we tested its association with age, sex, ethnicity, race, payer, length of hospital stay, anticoagulant at discharge, and study cohort. We performed 56 chi-square, *t*-test, or ANOVA (analysis of variance) tests. For the outcome of a follow-up appointment, we only considered those patients who had scheduled appointments.

Institutional Review Board (IRB) approval or exemption status was confirmed for the sites that were required by their local IRB to conduct the study.

### 3. Results

#### 3.1. Baseline patient characteristics, VTE risk factors, thrombosis location and treatment

A total of 456 consecutive patients were enrolled and 409 (90%) completed the study (188 in the PI and 221 in the QI phase) at all participating centers. The sex distribution was almost equal, 218 (53%) female, 210 (51%) were adults, 304 (74%) White, and 330 (81%) Non-Hispanic. The most common payer was private insurance (46%) followed by Medicaid (25.6%), Table 1. Patients most commonly

Table 1  
Baseline patient characteristics.

		PI	QI
		n (%)	n (%)
Age	Pediatric	87 (46.3)	112 (50.7)
	Adult	101 (53.7)	109 (49.3)
Age (yrs.)	0–1	36 (19.1)	39 (17.6)
	2–5	7 (3.7)	7 (3.2)
	6–10	6 (3.2)	13 (5.9)
	11–14	14 (7.5)	12 (5.4)
	15–17	24 (12.8)	41 (18.6)
	18–30	14 (7.5)	32 (14.5)
	31–40	10 (5.3)	11 (5.0)
Gender	41–64	49 (26.1)	39 (17.7)
	≥ 65	28 (14.9)	27 (12.2)
Gender	Female	98 (52.1)	120 (54.3)
	Male	90 (47.9)	101 (45.7)
Ethnicity	Hispanic	22 (11.7)	29 (13.1)
	Non-Hispanic	163 (86.7)	191 (86.4)
	Unknown	3 (1.6)	1 (0.5)
Race	White	154 (81.9)	162 (73.3)
	Black	19 (10.1)	39 (17.7)
	Other	8 (4.3)	7 (3.2)
	Unknown	7 (3.7)	13 (5.9)
	Payer	Private insurance	87 (46.3)
Medicaid		40 (21.3)	66 (29.9)
Medicare		23 (12.2)	26 (11.8)
Other		27 (14.4)	23 (10.4)
Unknown/uninsured		11 (5.9)	5 (2.3)

PI = Pre-Intervention; QI = Quality Intervention.

diagnosed with VTE were between ages 41 to 64 years and 0 to 1 years in the adult and pediatric groups, respectively. The most frequent type of thrombosis was deep vein thrombosis (DVT) in children and pulmonary embolism (PE) in adults. Central venous catheters and length of hospitalization in the pediatric group and obesity and surgical interventions in adults were the major risk factors for VTE, Table 2. Enoxaparin and apixaban were the most frequently prescribed anticoagulants in pediatric and adult patients, respectively. Administration of recombinant tissue plasminogen activator was the most common interventional procedure performed. Seventy-one patients had a total of 121 invasive procedures during hospitalization Table 3. A total of 183 patients in the PI phase and 220 in the QI phase answered all nine questions on the PFQ. The day 30 PFQ revealed improved education and satisfaction in thrombosis quality of care by 7.1% (*p* < 0.01) in the QI phase compared

**Table 2**  
Venous thrombosis location and risk factors.

	Pediatric, n (%)	Adult, n (%)
<b>Venous thrombosis type</b>		
DVT <sup>a</sup>	125 (62.8)	65 (31.2)
PE	21 (10.6)	100 (47.9)
Cerebral venous thrombosis	22 (11.1)	6 (2.9)
Abdominal venous thrombosis	6 (3.0)	9 (4.3)
Superficial venous thrombosis	3 (1.5)	2 (1.0)
Other	6 (3.0)	5 (2.4)
Two types of venous thrombosis <sup>b</sup>	16 (8.4)	22 (10.5)
<b>Medical risk factors</b>		
Length of hospital stay (days)	79 (51.6)	20 (14.4)
Obesity	23 (15.0)	73 (52.5)
Congenital heart disease	29 (19.0)	4 (2.9)
Cancer	8 (5.2)	24 (17.3)
Sepsis	22 (14.4)	4 (2.9)
Autoimmune disorder	7 (4.6)	9 (6.5)
Recent trauma	9 (5.9)	7 (5.0)
Inflammatory bowel disease	5 (3.3)	6 (4.3)
Nephrotic syndrome	4 (2.6)	4 (2.9)
Pregnancy	0 (0.0)	8 (5.8)
Antiphospholipid syndrome	2 (1.3)	2 (1.4)
Inborn error of metabolism	4 (2.6)	0 (0.0)
Sickle cell disease	2 (1.3)	1 (0.7)
Liver cirrhosis	0 (0.0)	1 (0.7)
Other	28 (18.3)	27 (19.4)
<b>Environmental risk factors</b>		
Central venous catheter	98 (67.6)	18 (14.5)
Surgical intervention	40 (27.6)	39 (31.5)
Immobility	40 (27.6)	27 (21.8)
Hormonal contraception	18 (12.4)	24 (19.4)
Smoking	2 (1.4)	22 (17.7)
Steroid	16 (11.0)	8 (6.5)
Travel	3 (2.1)	19 (15.3)
Cardiac catheterization	7 (4.8)	1 (0.8)
Heparin-induced	0 (0.0)	4 (3.2)
Asparaginase	2 (1.4)	0 (0.0)
Other	6 (4.1)	5 (4.0)

<sup>a</sup> DVT = Deep vein thrombosis of lower and/or upper extremity. PE = Pulmonary embolism.

<sup>b</sup> Two types of venous thrombosis referred to DVT plus PE, DVT plus abdominal venous thrombosis and DVT plus superficial venous thrombosis.

**Table 3**  
Anticoagulant, interventional procedures, and treatment form questionnaire.

	Pediatric, n (%)	Adult, n (%)	Total, n (%)
<b>Anticoagulant</b>			
Enoxaparin	166 (83.4)	50 (23.9)	216 (52.9)
Apixaban	3 (1.5)	52 (24.9)	55 (13.5)
Warfarin	5 (2.5)	42 (20.1)	47 (11.5)
Rivaroxaban	4 (2.0)	38 (18.2)	42 (10.3)
Fondaparinux	15 (7.5)	7 (3.4)	22 (5.4)
Dabigatran	3 (1.5)	5 (2.4)	8 (2.0)
Unfractionated Heparin	0 (0.0)	1 (0.5)	1 (0.2)
Two anticoagulants	3 (1.5)	14 (6.7)	17 (4.2)
<b>Procedures</b>			
r-TPA administration	29 (47.5)	28 (46.7)	57 (47.1)
Thrombectomy	12 (19.7)	10 (16.7)	22 (18.2)
Angioplasty	10 (16.4)	6 (10.0)	16 (13.2)
IVC filter placement	2 (3.3)	12 (20.0)	14 (11.6)
Stent placement	8 (13.1)	4 (6.7)	12 (9.9)

Recombinant-Tissue Plasminogen Activator = t-PA; Inferior Vena Cava = IVC.

to the PI phase (Table 4) and by 8.6% in the adult cohort compared to the pediatric cohort.

### 3.2. Patient Knowledge Questionnaire (PKQ) Day 30

The PKQ at day 30 demonstrated that patients in the QI phase had a better recall of symptoms to watch for (93.7% vs. 83.5%,  $p$ -value 0.004)

**Table 4**  
Estimated differences between QI and PI groups.

This table shows the differences between adult and pediatric groups for nine questions surveyed on day 30 PFQ and PKQ comparing PI with QI groups.

PFQ question	Estimator of (QI – PI)	Estimator of (A – P)
Taught about blood clot	9.4	8
Pleased with blood clot education	10	10.3
Taught about anticoagulation medicine	7.2	8.3
Pleased with anticoagulation medicine education	10	8.4
Pleased with blood clot quality care	12.9	14.8
Returned calls within 1 day	3	8.2
Questions answered to satisfaction	3	8.2
Information given in a language understood	3.7	5.9
Health care professional responsive to needs	4.4	5.2

PKQ question		PI (%)	QI (%)
Told about blood clot	Yes	184 (97.9)	216 (97.7)
	No	1 (0.5)	4 (1.8)
	Unknown	3 (1.6)	1 (0.5)
Return to hospital/clinic	Readmitted	12 (6.4)	10 (4.5)
	Go to ED	10 (5.3)	5 (2.3)
	Physician follow-up	83 (44.2)	106 (48.0)
Taught watch symptoms	No	83 (44.2)	100 (45.3)
	Yes	157 (83.5)*	207 (93.7)*
	No	21 (11.2)	11 (5.0)
Watch bleeding symptom	Unknown	10 (5.3)	3 (1.4)
	Yes	15 (8.0)	18 (8.1)
	No	170 (90.4)	201 (91.0)
	Unknown	3 (1.6)	2 (0.9)

Quality Intervention = QI; Pre-intervention = PI; Patient Knowledge Questionnaire = PKQ.

Adult = A; Pediatric = P; Patient Knowledge Questionnaire = PKQ; Emergency Department = ED.

\*  $p = 0.004$ .

and accurately recalled symptoms (89.6% vs. 84.6%,  $p = 0.029$ ) compared to those in the PI phase (Table 4). There was no significant difference regarding timing of anticoagulant prescription or following correct dosing instructions between both cohorts.

Compared to the PI phase, the cohort of patients in the QI phase had fewer hospital readmissions or clinic visits due to bleeding [0.85% vs. 3.9%  $p = 0.126$ , 95% CI (–0.9%–7%)] or recurrent thrombosis [5% vs. 8.7%  $p = 0.268$ , 95% CI (–3%–10%)], although this did not reach statistical significance.

Recurrent thrombosis was more prevalent in the adult than in the pediatric population [5.2% vs 1.5%,  $p = 0.024$ ]. Interestingly, patients discharged on warfarin or two concomitant anticoagulants had a higher risk of recurrent thrombosis compared to patients discharged on DOACs or parenteral anticoagulants alone (10.6% vs. 3.8% vs. 1.68%,  $p = 0.008$ ). White patients had a higher adherence rate with their prescribed anticoagulants (93.3%) compared to Blacks (84.5%) or other /unknown races (88.6%,  $p = 0.012$ ). The accuracy of recalling the anticoagulant dosing frequency correctly was higher in the adult population compared to the pediatric (92% vs. 85.4%,  $p = 0.038$ ).

Patients with commercial insurance were less likely to require hospital readmission compared to patients with Medicare/Medicaid and other or unknown insurance (4.8% vs. 5.8% vs. 7.6%  $p < 0.001$ ).

### 3.3. Patient Knowledge Questionnaire Day 7 Follow-Up

During the PKQ administered at day 7, 212 of 220 (96.4%) patients in the QI phase recalled receiving VTE education at the time of hospital discharge, 187 (85%) followed correct anticoagulant dosing instructions, and 213 (97%) were taking the medication on time, Table 5.

Patients were similarly aware of their VTE diagnosis at day 30 in the

**Table 5**

Response comparison of 7-Day PKQ (n = 220) and 30-Day PKQ in the quality intervention group (n = 221).

PKQ question	Category	PKQ 7-day (%)	PKQ 30-day (%)	p-Value
Received VTE education	Yes	212 (96.4)	216 (97.7)	0.357
	No	5 (2.3)	4 (1.8)	
	Unknown	3 (1.4)	1 (0.5)	
Return to hospital/clinic	Readmitted	9 (3.6)	10 (4.5)	<0.001
	Go to ED	8 (4.1)	5 (2.3)	
	Physician follow-up	73 (33.2)	106 (48.0)	
	No	130 (59.1)	100 (45.3)	
Taught watch symptoms	Yes	200 (90.9)	207 (93.7)	0.141
	No	14 (6.4)	11 (5.0)	
	Unknown	6 (2.7)	3 (1.4)	
Follow dosing instructions	Strongly agree	187 (85.0)	197 (89.1)	0.054
	Agree	30 (13.6)	22 (10.0)	
	Neutral	3 (1.4)	1 (0.5)	
	Disagree	0 (0.0)	1 (0.5)	
Percent of time taking medication	100%	213 (96.8)	203 (91.9)	<0.001
	75%	7 (3.2)	17 (7.7)	
	0%	0 (0.0)	1 (0.5)	
Has appointment for follow-up testing	Yes	167 (75.9)	186 (84.2)	0.003
	No	47 (21.4)	32 (14.5)	
	Unknown	6 (2.7)	3 (1.4)	
Able to recall symptoms	Yes	190 (86.4)	198 (89.6)	0.564
	No	22 (10.0)	21 (9.5)	
	N/A	8 (3.6)	2 (0.9)	
Able to recall medications	Yes	209 (95.0)	217 (98.2)	0.01
	No	11 (5.0)	4 (1.8)	

PI group and at day 7 in the QI group. There was improvement in recollection of symptoms to watch for in the QI group at day 7 than in the PI group at day 30 (200 [91%] vs 157 [83.5%]). The majority of patients were taking the medications correctly in the QI phase at day 7 than at day 30 in the PI phase (213 [97%] vs 172 [91.5%]), [Table 6](#).

**3.4. Treatment characteristics**

Treatment forms were collected for a total of 409 patients. There was no difference regarding recurrent VTE, bleeding, repeat diagnostic imaging, change on anticoagulation therapy, reversal of anticoagulation, or taking the anticoagulants as instructed at time of discharge between the PI and QI cohorts, [Table 7](#).

**3.5. Evaluation of provider perceptions**

Fourteen providers (87.5%) recommended the implementation of the QI to other institutions based on the following parameters: feasibility of implementing the CDIM, implementing the day-7 questionnaire via phone call, value of the transition of care, and the periodic learning exchange.

**4. Discussion**

Our study demonstrated that a systematic implementation of a quality improvement process to improve TOC for hospitalized pediatric and adult patients after a first episode of VTE improved anticoagulation-related knowledge and quality of TOC and recollection of symptoms and medications in adult and pediatric patients. To our knowledge this is the first TOC quality improvement project involving pediatric and adult patients with VTE that has been conducted in the US. Since the study was conducted across 16 diverse centers across the US, we believe that our results are applicable to the US population. The primary intervention consisted of providing patient and caregiver enhanced education about anticoagulation therapy and VTE at the time of hospital discharge. These objectives were achieved through individualized face-to-face teaching accompanied by written specific anticoagulation instructions and

**Table 6**

Responses of 7-Day PKQ (n = 220) quality intervention and 3-Day PKQ in the pre-intervention group (n = 188).

PKQ question	Category	PKQ 7-day (%)	PKQ 30-day PI group (%)	p-Value
Told about blood clot	Yes	212 (96.4)	184 (97.9)	0.614
	No	5 (2.3)	1 (0.5)	
	Unknown	3 (1.4)	3 (1.6)	
Return to hospital/clinic	Readmitted	9 (3.6)	12 (6.4)	<0.001
	Go to ED	8 (4.1)	10 (5.3)	
	Physician follow-up	73 (33.2)	83 (44.2)	
	No	130 (59.1)	83 (44.2)	
Taught watch symptoms	Yes	200 (90.9)	157 (83.5)	0.078
	No	14 (6.4)	21 (11.2)	
	Unknown	6 (2.7)	10 (5.3)	
Follow dosing instructions	Strongly agree	187 (85.0)	158 (84.0)	0.571
	Agree	30 (13.6)	28 (14.9)	
	Neutral	3 (1.4)	1 (0.5)	
	Disagree	0 (0.0)	1 (0.5)	
%time taking medication	100%	213 (96.8)	172 (91.5)	0.035
	75%	7 (3.2)	13 (6.9)	
	50%	0 (0.0)	3 (1.6)	
Appointment for follow-up testing	Yes	167 (75.9)	166 (88.3)	0.005
	No	47 (21.4)	20 (10.6)	
	Unknown	6 (2.7)	2 (1.1)	
Accurately recall symptoms	Yes	190 (86.4)	159 (84.6)	0.708
	No	22 (10.0)	19 (10.1)	
	N/A	8 (3.6)	10 (5.3)	
Accurately recall medications	Yes	209 (95.0)	185 (98.4)	0.06
	No	11 (5.0)	3 (1.6)	

**Table 7**

Treatment form questionnaire.

Treatment form question	Category	PI	QI
		n (%)	n (%)
n		188 (100%)	221 (100%)
Diagnosed with other VTE	Yes	7 (3.7)	6 (2.7)
	No	181 (96.3)	215 (97.3)
Bleed since discharge	Yes	20 (10.6)	19 (8.6)
	No	168 (89.4)	202 (91.4)
Have interventional procedure	Yes	1 (0.5)	2 (0.9)
	No	187 (99.5)	219 (99.1)
Repeat imaging since diagnosis	Yes	66 (35.1)	83 (37.6)
	No	122 (64.9)	138 (62.4)
Switch anticoagulant	Yes	13 (6.9)	24 (10.9)
	No	175 (93.1)	197 (89.1)
Require reversal anticoagulation	Yes	1 (0.5)	0 (0.0)
	No	187 (99.5)	221 (100.0)
Take prescribed medication	Yes	184 (97.9)	216 (97.7)
	No	4 (2.1)	5 (2.3)

followed by one-week and one-month communication via phone call or office visit. During these interactions, patient and/or caregiver knowledge were assessed with a structured questionnaire and compared the improved TOC to the current baseline. In addition, we used questionnaires to assess patients' knowledge at 30 days for both the PI and the QI phase allowing us to compare both groups. The key observations are as follows.

**4.1. VTE characteristics and treatment with DOACs**

PE was the main type of VTE in our adult patients. This is not

surprising given that the majority of adult patients who present with DVT are not hospitalized due to the availability of DOACs [19]. The most frequent anticoagulant prescribed for the treatment of VTE in our adult patients was apixaban. This reflects the recommendations provided in the 2016 American College of Chest Physicians Guideline on Antithrombotic Therapy [20]. This study demonstrates the effectiveness of our standardized discharge instructions in adult patients receiving DOACs, which previously has not been demonstrated.

Most pediatric patients had DVT and were managed with enoxaparin, which reflects current epidemiology and clinical practice [8]. DOACs were prescribed to 3.5% of children with no major difference in off-label use of DOACs and showed that education was also effective in this group with no major adverse events. Prescription of DOACs is likely to increase as data are published from pediatric clinical trials and pediatric indications are approved. This should be considered as pediatric thrombosis programs develop and implement TOC programs.

The ultimate goal for TOC is to ensure patient safety and optimize anticoagulation efficacy through reduction in bleeding complications, recurrent VTE, hospital readmission, and mortality. In our study, there was a trend towards fewer hospital readmissions for either bleeding or recurrent thrombosis in the QI group. In a study that analyzed patients >18 years old with hospitalizations associated with acute VTE over a period of 4 years using the Nationwide Readmissions Database, the 30-day readmission rate was 17.5%. The main predictors and causes of readmissions were related to patient characteristics such as underlying malignancy and Medicaid insurance, as well as complications from comorbid conditions while healthcare quality had only a moderate impact on readmission risk [10]. A concordance with our study was that patients with Medicaid and Medicare also had more frequent hospital readmissions compared to patients with commercial insurance. This finding indicates that patients with commercial insurance may have easier access to follow-up appointments after hospital discharge compared to Medicaid and Medicare carriers. We found that VTE recurrence was higher in adults than in children, which may be related to the differences in the etiology of VTE between adult and pediatric population. Unlike adults, majority of VTE in pediatrics were caused by transient risk factors such as CVL while adult population had age related morbidity. However, given the lack of studies comparing directly the risk of VTE recurrence between pediatric and adults, accurate conclusions cannot be drawn. In a study by Heit et al., one of the independent predictors of VTE recurrence was increasing patient age [21]. Interestingly, the risk of recurrent VTE was lower with parenteral anticoagulation and DOACs compared to warfarin. This observation suggests that patients on DOACs or parenteral anticoagulants have a simpler transition from the inpatient to the outpatient setting. Since these anticoagulants do not require routine monitoring, medication adherence may be improved. White patients had better compliance with anticoagulants compared to patients of other races and the accuracy of recall was higher in the adults than in the pediatric patient population. Predictors of non-adherence are predominantly clinical and socio-demographic in nature. In a cross-sectional study of patients on oral anticoagulants predictors of anticoagulation adherence were age, female sex, use of other oral medications, and retired status. In this study the adherence rate was similar for patients on DOACs and VKAs at 55% [22]. In contrast, in our study, the rate of adherence was much higher ranging from 84% to 93% which likely reflects the careful monitoring of our patients.

#### 4.2. Patient satisfaction

The QI phase of our study resulted in improved education and satisfaction in thrombosis quality of care by 7.1% compared to PI phase. This finding underscores the importance of education, specifically spending time with the patient at the time of hospital discharge to ascertain adequate comprehension of medication adherence and awareness of signs and symptoms of VTE and bleeding. Our QI is in

agreement with a recent proposed inter-professional guideline that delineates the important targets for improving the care around anticoagulation: “INR-monitoring,” “Transfer of care between health care settings,” “Adherence to medication,” “Patient communication and engagement,” and “Medication reconciliation and medication review.” [23].

The majority of the participating providers agreed that implementation of a quality improvement tool to improve TOC should be recommended to other institutions to improve the care of patients with new diagnosis of VTE and minimize complications. In fact, several of the centers participating in this quality improvement project have adopted the CDIM as part of the discharge procedures.

While our study showed the feasibility of implementing a national quality improvement study in both pediatric and adult populations, there are a few limitations that deserve discussion. First, there was lack of consistent follow-up in all patients after administration of the PKQ at day 30 after the VTE diagnosis. Second, selection bias is possible since not all patients who were approached participated in the study, and there was lack of follow-up of some patients. Third, despite attempts by the authors to streamline the questions in the patient surveys, the questionnaires have not been validated.

In conclusion, our study showed that systematic implementation of quality improvement process enhances knowledge on recognition of symptoms of thrombosis and quality of TOC in adults and recollection of symptoms in adults and pediatric patients. We propose a nation-wide execution of a well-designed transition of care educational module from the inpatient to the outpatient setting for patients with new diagnosis of VTE who will be discharged on anticoagulation medication.

#### Declaration of competing interest

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#### Appendix A. Supplementary data

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