**Title:** Preventing Venous Thromboembolism: Empowering Patients and Enabling Patient-Centered Care via Health Information Technology

**AUTHORS**: Elliott R. Haut MD, PhD, FACS; Brandyn D. Lau, MPH, CPH; Deborah B. Hobson, BSN, RN; Dauryne L. Shaffer, MSN, RN, CCRN; Peggy S. Kraus, PharmD, CACP; Jonathan K. Aboagye, MBBS, MPH; Norma Farrow, MD; Victor O. Popoola, MBBS, MPH, ScM; Hasan M. Shihab, MBChB, MPH; Gayane Yenokyan, MD, PhD, MPH, MHS; Jiangxia Wang, MS; Elizabeth Sugar, PhD; Joseph Canner, MS; David Bongiovanni, MS; Paul Zaruba, BA; Susan Kulik, DNP, MBA, RN; Kenneth M. Shermock, PhD, PharmD; Peter J. Pronovost, MD, PhD, FCCM; Michael B. Streiff MD, FACP

[1] Johns Hopkins Medicine, Baltimore, MD

**PCORI ID:** CE-12-11-4489
**HSRProj ID:** 20143176
**ClinicalTrials.gov ID:** NCT02402881

To cite this document, please use: Haut, E., Lau, B., Hobson, D., et al. 2018. *Preventing Venous Thromboembolism: Empowering Patients and Enabling Patient-Centered Care via Health Information Technology*. Washington, DC: Patient-Centered Outcomes Research Institute (PCORI). https://doi.org/10.25302/11.2018.CE.12114489

**Table of Contents**

**Abstract**

**Background**: Although hospital-acquired venous thromboembolism (VTE) is largely preventable with risk-appropriate prophylaxis, VTE continues to be an important cause of morbidity and mortality. Numerous interventions aimed at improving prescription, including computerized decision support, have been implemented, resulting in improved ordering of VTE prophylaxis. However, ordering prophylaxis does not ensure patients—even hospitalized patients—receive every dose. A surprisingly high proportion (12%-16%) of doses is not administered, largely due to patient refusal accounting for more than half of missed doses. Nonadministration of VTE prophylaxis is associated with VTE events. To address this problem, we hypothesize that nurse-specific and patient-centered education can reduce rates of nonadministered pharmacologic prophylaxis.

**Objectives**: We sought to engage patients and stakeholders to create educational materials for patients and nurses that could be studied to examine the effect on missed doses of VTE prophylaxis.

**Methods**: We undertook a multitier, multidisciplinary intervention at the Johns Hopkins Hospital (JHH) from March 2014 to December 2015 to improve administration of VTE pharmacologic prophylaxis. The first stage involved the development of a patient-centered VTE education bundle with input from nationally representative patient stakeholders and a local patient advocacy group using a modified Delphi method. In the second stage, we initiated a nurse education intervention, which was a cluster randomized clinical trial of 2 web-based modules (dynamic scenario-based education and linear static education) to educate nurses about the harms of VTE, benefits of VTE prophylaxis, and strategies to better communicate with patients about VTE prophylaxis. In the third stage, we implemented a patient education intervention on selected floors at JHH by using a novel real-time alert built into our electronic medical record system to notify a health educator any time a patient missed a dose of pharmacologic VTE prophylaxis. Any patient who refused a dose of VTE prophylaxis received 1 or more component of an education bundle as an intervention, which included (1) a 1:1, face-

to-face engagement with a health educator; (2) a 2-page patient education sheet; and (3) a 10-minute patient education video.

**Results**: Participants engaged in the development of the educational bundle wanted to learn about VTE symptoms, risk factors, prevention, and complications in a context that emphasized harm. Most of them preferred to receive education in the context of a doctor–patient encounter followed by video and paper educational materials. Overall, nurse education reduced the frequency of VTE prophylaxis non-administration (12.4% to 11.1%, $p = 0.002$). The patient education intervention resulted in a large, statistically significant improvement in VTE prophylaxis. The odds of VTE prophylaxis non-administration decreased by 42% (OR 0.58, 95% CI 0.50–0.68), and the odds of patient refusal decreased by 45% (OR 0.55, 95% CI 0.90–-1.09). The corresponding frequency of VTE prophylaxis non-administration changed from 9.0% to 5.6%.

**Conclusion**: Patients want to be educated on VTE, specifically to recognize the signs and symptoms of VTE, their personal risk for VTE, and the consequences of developing VTE. Educating bedside nurses and providing a targeted patient-centered education intervention bundle significantly reduces non-administration of pharmacologic VTE prophylaxis.

**Trial Registration**: clinicaltrials.gov Identifier NCT02301793 and NCT02402881

**Background**

Venous thromboembolism (VTE), comprising deep vein thrombosis (DVT) and/or pulmonary embolism (PE), is one of the most important causes of potentially preventable harm in the United States. Each year as many as 600 000 patients are affected, and more than 100 000 are killed by PE, which exceeds deaths from motor vehicle accidents, breast cancer, and AIDS combined.[1-3] In fact, it is estimated that more than 12 million hospitalized patients are at risk for VTE.[4]

Ironically, this exists within a milieu of overwhelming evidence in support of the effectiveness of VTE prophylaxis.[5-8] VTE prophylaxis could be mechanical, including sequential compression devices and graduated compression stockings, or pharmacologic, including low molecular weight heparin or unfractionated heparin given for up to 3 times daily as an injection. Guidelines recommending different VTE prophylaxis regimens for different categories of patients abound. For instance, the Ninth American College of Chest Physicians evidenced-based clinical practice guidelines recommend pharmacologic VTE prophylaxis for the majority of acutely ill hospitalized medical patients and nearly all surgical patients. Extended outpatient pharmacologic prophylaxis is recommended for some populations, such as people who have undergone major orthopedic surgery.[9] It is indisputable that many hospitalized patients do not receive optimal VTE prophylaxis, prompting the Surgeon General's "Call to Action to Prevent VTE"[2] and the Agency for Healthcare Research and Quality (AHRQ) to describe VTE prevention as a top strategy to improve patient safety in hospitals.[10,11] The American Public Health Association states that "the disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis."[3] The Center for Medicare and Medicaid Services and other patient safety stakeholders have prioritized the need for improvement in VTE prophylaxis largely as a result of the direct economic costs of VTE. It is estimated that more than 1.5 billion dollars, a largely avoidable health care expenditure, is spent on the treatment of VTE and its complications annually.[12]

Recently, major gains have been made to increase the prescription of VTE prophylaxis by providers, owing to the implementation of novel interventions. In 2005 the researchers

developed evidence-based, paper VTE prophylaxis order sets that guided ordering providers on the assessment of VTE and bleeding risks and facilitated the selection of risk-appropriate VTE prophylaxis at the Johns Hopkins Hospital. However, the paper order sets could not be made mandatory, existed outside the usual clinical workflow, and were labor- and time-intensive. Therefore, we adopted a computerized physician order entry-based clinical decision support tool to assist providers in assessing patients' VTE and bleeding risk factors and provide evidence-based risk-appropriate VTE prophylaxis. This approach has since been lauded by the AHRQ as an important patient safety initiative.[13] Our computerized clinical decisions support tool requires a clinician to select from a list of risk factors for VTE and contraindications to pharmacologic VTE prophylaxis and guides them to prescribe the optimal patient-specific prophylaxis regimen. This tool significantly improved VTE prophylaxis orders by 3-fold and significantly reduced the rate of preventable VTE in trauma patients.[14,15] However, not all prescribed doses are received by patients. Previous studies have established that only 87% of prescribed doses of unfractionated heparin and low molecular weight heparin were received, with patient refusal as the most common reason for nonadherence.[16]

Non-administration of pharmacologic VTE prophylaxis is underappreciated. At the Johns Hopkins Hospital, 12% of pharmacologic VTE prophylaxis doses are not administered, and patient refusal contributes to more than half of these.[16] This stands to derail major gains made in efforts to prevent hospital-acquired VTE, because interruption of VTE prophylaxis is associated with VTE events.[17,18] In a cohort of general surgical and trauma patients, a DVT rate of 23.5% was reported in patients who missed doses compared with 4.0% in patients who received all doses. In fact, more than half of patients diagnosed with hospital-associated VTE had errors in their medication prescriptions or administration, with more than three-quarters of the failures being patients missing doses of prescribed medications. Because dosing of a medication is tied to its half-life, missing a dose could potentially offset its benefits. There is also a rebound theory, which proposes that patients missing doses become hypercoaguable and at higher risk for VTE. A critical look at patient refusal in our hospital showed that it was influenced by myriad reasons related to patient and system characteristics. For instance, medicine patients were more likely to miss and refuse doses compared with surgical patients

(including orthopedic and nonorthopedic) and black patients were more likely to refuse doses than were Caucasian patients. There were also differences by nursing unit, both within and between services; this reveals how culture of different floors and different patient populations contributes to our findings.[19]

While patients have the right to refuse any type of care, it is the responsibility of health care providers to educate patients so they can make informed decisions. Unfortunately, we have found that some nurses unilaterally make clinical decisions regarding the appropriateness of prescribed pharmacological VTE prophylaxis or allow patients to make uninformed decisions to refuse prophylaxis without educating patients about the harms of VTE or the benefits of VTE prophylaxis.[20] Consequently, an education intervention targeting nurses, who play a vital role in the delivery of VTE pharmacologic prophylaxis, could potentially help address the missing dose phenomenon.

Partnering with and educating patients could significantly reduce preventable VTE. Patient education holds great promise in addressing patient refusal. A patient education intervention targeting all patients who were ordered VTE prophylaxis significantly improved the VTE prophylaxis administration rate; however, this required 1 hour of a pharmacist's time to counsel each patient, which would be difficult to replicate in all hospitals.[21] The importance of educating health care professionals and clinical decision support within computerized order entry systems to increase prescription of VTE prophylaxis is well recognized.[15, 22-24] It is also imperative that we educate both patients and nurses on the benefits of pharmacologic VTE prophylaxis [26]

Our previous findings indicate that it is not necessary to target every patient for an educational intervention. In our hospital, 20% of all patients account for more than 80% of all missed doses of VTE prophylaxis, a phenomenon in congruence with the Pareto principle (also known as the 80/20 rule). The majority of patients who missed medications are clustered within specific medicine floors.[16] Although some might say that targeting these floors alone is a reasonable approach, we would disagree because we would still miss patients missing doses on other floors. These data suggest a role for targeted educational efforts aimed specifically at

individually identified hospitalized patients who are most likely to miss prescribed doses of VTE prophylaxis.[18]

In view of these findings, we partnered with patients and key stakeholders to implement a multitier, multidisciplinary intervention to transform patient–nurse communication, empower patients to take an active role in prophylaxis administration, and utilize an informatics tool to ensure that hospitalized patients are well-informed regarding their VTE preventive care. First, we engaged patients and our collaborating patient organizations, which included members of the North American Thrombosis Forum (NATF), the National Blood Clot Alliance (NBCA), Clot Care, and the Johns Hopkins Hospital (JHH) Patient and Family Advisory Council, to develop our intervention strategies. Their input determined the timing and content of patient education and identified patient–clinician communication needs. We also got received from a variety of patients who developed VTE during and after hospitalization to help us produce patient-centered educational materials that take into account a variety of demographics, personal preferences and values, and social circumstances among hospitalized patients. We hypothesize that a patient-centered education intervention will improve non-administration of VTE prophylaxis and refusal rates of pharmacologic VTE prophylaxis.

## Methods

### Education Bundle Development

From March 2014 to September 2014, we engaged a national sample of patients and family members on the content and approaches to delivery of information related to VTE prevention in hospitalized patients. To build consensus, we employed a modified Delphi approach, an iterative process of obtaining input from experts and working toward consensus.[27] We invited members of the NATF, the NBCA, Clot Care, and the JHH Patient and Family Advisory Council to participate. We recruited participants via email and/or social media (websites, Facebook, Twitter) through their respective organizations, and we collected their responses using an interactive, 3-phase, web-based survey tool (SurveyMonkey. Palo Alto, CA). We obtained informed consent from participants and collected email addresses to link multiple surveys.

During Phase 1, respondents were asked to self-report demographic characteristics including age, race, gender, highest education attained, health care–related training or experience, and personal or family history of VTE. In Phase 2, respondents were asked to identify broad areas of patient–clinician communication needs and approaches to delivery. For each question, a field was included for free text so that respondents could volunteer additional information they considered important. Based on feedback from Phase 2, respondents were asked to rank their top 4 educational topics (from first through fourth choice) and top 3 methods of delivery (from first through third choice). We assigned weights to reference ranks for educational topics; we assigned the highest weight of 4 to the first-choice category and the lowest weight of 1 to the fourth-choice category. Participants were required to rank all 4 educational topics. Similarly, we assigned weights to preference ranks for the approaches to delivery of VTE education from a maximum weight of 3 for the first-choice category to a weight of 1 for the third-choice category. An unranked category had a weight of 0. In addition, respondents were asked to identify the maximum amount of time they would be willing to spend reviewing educational materials as hospitalized patients.

For Phase 2, we defined consensus as a simple majority of respondents. To determine consensus in Phase 3, we employed the Borda count, a well-recognized statistical approach for aggregating rankings. This consensus-based voting system accounts for both popularity and preference.[28,29] We summed the weights associated with participants' preference selections in each category to produce the Borda count for that category. We calculated mean weights as a simple average of weights allocated to the categories by all respondents. We compared categories using the Kruskal-Wallis rank sum test. We analyzed data using Stata SE ([computer program]. Version 13.1. Stata Corp) and Microsoft Excel 2013 (Microsoft). This research study, which involves a survey procedure with minimal risk to participants, was approved by the Johns Hopkins Institutional Review Board (NA_00091152) with an exemption.

We used the information gathered from this patient engagement exercise to inform the educational approach and intervention created and implemented in later parts of the project.

## Nursing Education Intervention Trial

We conducted a double-blinded cluster randomized clinical trial of 2 web-based modules to educate nurses about the harms of VTE, benefits of VTE prophylaxis, and strategies to better communicate this information to patients at the Johns Hopkins Hospital, an academic medical center in Baltimore, Maryland. The participating nurses were blinded to the entire intervention. They knew they were completed VTE education but did not know there were 2 different educational modules of which they were assigned to only 1. We included 21 adult inpatient floors comprising internal medicine floors (*n* = 11) and surgery floors (*n* = 10). The Johns Hopkins Medicine Institutional Review Board approved the study and the trial was registered on ClinicalTrials.gov ("Educating Nurses About Venous Thromboembolism [VTE] Prevention," NCT02301793).

### Educational Interventions

In partnership with the Johns Hopkins Central Nursing Education, we built 2 web-based educational modules with the same content about VTE prevention. The VTE education materials for nurses covered topics similar to those in the patient educational materials, although at a deeper, more sophisticated level. One arm provided linear static education (static) using PowerPoint slides with voiceover to cover the concepts. The other arm provided interactive learner-centric dynamic scenario-based education (dynamic), where each scenario resulted in either positive reinforcement or corrective feedback, with an opportunity to apply knowledge to a new scenario.

### Enrollment and Randomization

We identified nurses using our centralized education directory that associates nurses with their designated departments and hospital floors. Beginning on July 23, 2014, nurses were cluster randomized by floor to receive 1 of 2 education modules about VTE prevention. Nurses were asked to complete their assigned education module by October 23, 2014. All nurses permanently associated with 1 of the 21 adult inpatient floors were eligible for enrollment in

the trial; thus, we excluded traveling and floating nurses. Because of known differences between medical and surgical floors in VTE prophylaxis administration practice and culture,[1-4] floors 17, 20, 30 and31 were stratified by department (i.e., medicine and surgery) for randomization. Within strata, a coin toss, Extended Riemann Hypothesis (ERH) was used to randomize floors into either the dynamic education arm or the static education arm.

**Data Collection**

We extracted patient demographic data from the JHH administrative database. We extracted pharmacologic VTE prophylaxis medication administration data directly from the electronic medication administration record in our computerized provider order entry system. We collected data for 1 year and divided them into 3 distinct time periods: April 1 through July 22, 2014 (baseline); July 23, 2014, through October 23, 2014 (education intervention); October 24, 2014, through March 31, 2015 (postintervention). We did not analyze the data during the education intervention. We completed all pre–post comparisons using only the baseline period and the postintervention period. Immediately following completion of the assigned education module, nurses were asked to complete a voluntary 5-question survey to assess the relevance of and satisfaction with the education module.

**Statistical Analysis**

Our primary outcome was the proportion of prescribed pharmacologic VTE prophylaxis doses not administered. Secondary outcomes included the proportion of prescribed pharmacologic VTE prophylaxis doses not administered due to patient/family member refusal versus other reasons. The primary hypothesis was that nurse education would lead to a lower proportion of missed doses, and the secondary hypothesis was that dynamic arm would have a larger effect than the linear static arm. We evaluated both hypotheses using an intention-to-treat approach accounting for clustering in the data and comparing rates of VTE prophylaxis dose nonadministration before and after the education intervention period. Patient visit-level demographic characteristics for the baseline period were described by arm.

Our biostatistician team members were blinded to the arm assignment and strata. They compared pharmacologic VTE prophylaxis administration practices between the baseline and postintervention periods for each education strategy by department, using generalized linear mixed-effects models with binomial family and a logit link, and random intercepts for floor and nurse to account for the intragroup correlation within the same floor or within the same nurse (see Figure 1). The model included indicator variables for time period (pre-intervenion/postintervention), intervention (dynamic/static), type of floor (medicine/surgery), and their interactions. We included the interaction terms to account for differences in odds ratio of missed dose by intervention, time, and type of floor.

**Figure 1. Timeline for Data Collection and Interventions in 2 Studies (Nursing Education Intervention Trial and Patient Education Intervention)**

| | Baseline Period | Intervention Period | Postintervention Period |
|---|---|---|---|
| **Nursing Education Intervention Trial** | April 1-<br>July 22, 2014 | July 23-<br>October 23, 2014 | October 24, 2014-<br>March 31, 2015 |
| **Patient Education Intervention** | October 1, 2014-<br>March 31, 2015 | n/a | April 1-<br>December 31, 2015 |

Due to the complexity of the multilevel structure of the data (i.e., multiple doses per patient across various hospitalizations, nurses, and floors), we employed multiple outputation (MO)[32] to reduce the levels of hierarchical structure to the floor level and nurse level by randomly selecting 1 dosage per patient. By reiterating the procedure 1000 times, we estimated the odds ratios (ORs) and their 95% confidence intervals conditional on the floor and nurse. MO provides a simple, elegant solution when a multilevel solution for clustered data is not practical. The reported *P* values are also derived from this procedure. We encountered very little missing data in our analyses; this was made possible by directly extracting data from the electronic health record (EHR) into our VTE database. We performed manual chart reviews to

capture data not extracted directly into our database. We analyzed responses to the follow-up survey to assess nurse perception with the education modules using a 2-sided Chi-square test. We conducted all statistical tests at 5% statistical significance. We performed statistical analyses using Stata version 14.1 MP ([computer program]. College Station, TX).

## Patient Education Intervention

### Study Setting and Design

This was a controlled before–after patient-centered education intervention to improve administration of pharmacologic VTE prophylaxis from April 2015 to December 2015 at the Johns Hopkins Hospital, a large, tertiary care, academic medical center in the United States. In this institution every patient, on admission, gets risk stratified for VTE and is suggested to receive or not receive risk-appropriate VTE prophylaxis based on risk.[13,14,22] The algorithm for risk stratification is published elsewhere. We included a total of 16 unique adult nursing units (floors) in the analysis. We conveniently selected 4 floors—2 each of surgery and medicine—to receive the intervention. We designated the remaining 12 floors—5 of surgery and 7 of medicine—as control floors. From the hospital's electronic medical record system, we collected data on ordered and administered pharmacologic VTE prophylaxis from October 1, 2014, through December 31, 2015, to evaluate temporal changes associated with the intervention (see Figure 1).

### Intervention

On intervention floors, each patient who missed a dose of VTE prophylaxis was offered the entire education bundle and received 1 or more component of the education bundle as an intervention based on his or her preference. This included (1) a 1:1, face-to-face engagement with a nurse educator; (2) a 2-page patient education paper handout; and (3) a 10-minute patient education video.[33]

We used a novel medical informatics tool built into our electronic medical record system to immediately alert our research team nurse educator via a pager and email when a patient was not administered any ordered dose of pharmacologic VTE prophylaxis. On receiving the

alert, the health educator nurse first engaged the bedside nurse to verify patient refusal, and if that was the case, subsequently engaged the patient by using any of his or her preferred components of the education bundle. If the dose was missed for a reason other than patient refusal, the health educator nurse educated the floor nurse on the need to give the dose. If a patient refused again after this initial intervention, we escalated the intervention by informing the provider (resident, nurse practitioner, or physician assistant) and/or the attending physician to engage with the patient. The health educator timed all encounters, and the median duration of health educator–patient interaction was 10 minutes (range 1-40 minutes) and the median duration of health educator–nurse interaction was 2 minutes (range 1-25 minutes). The health educators were present routinely on weekdays from 8 AM to 6 PM to administer the intervention. Patients who missed ordered doses of pharmacologic VTE prophylaxis on control floors received no intervention.

**Statistical Analysis**

The primary hypothesis was that the patient education would lead to a lower proportion of missed doses. Our primary outcome was the proportion of prescribed pharmacologic VTE prophylaxis doses administered. Secondary outcomes included the proportion prescribed pharmacologic VTE prophylaxis doses administered by nurse and by patient, which is the documented reason for pharmacologic VTE prophylaxis non-administration. We evaluated the primary hypothesis using a multilevel mixed-effects generalized linear model accounting for clustering by floor in the data and comparing rates of VTE prophylaxis dose administration before and after the patient intervention period. We stratified the analyses by department type. Patient-level and nurse-level demographic characteristics for the baseline period were described by arm. We compared pharmacologic VTE prophylaxis administration practices before the patient intervention (October 1, 2014-March 31, 2015) and after the intervention (April 1-December 31, 2015) periods using generalized linear mixed-effects models with random intercepts for floor and nurse to account for the intragroup correlation within the same floor or within the same nurse (see Figure 1). Due to the complexity of the multilevel structure of the data, we employed MO to reduce the levels of hierarchical structure to the floor level

and nurse level by randomly selecting 1 dosage per patient and reiterating the procedure 1000 times to bootstrap the *P* values for the comparisons.[32] For estimating the conditional odds ratios and their confidence intervals, we used the binomial family and a logit link in the generalized models, and for estimating the conditional proportions, we used the Poisson family and a log link. We did not encounter any missing data in our analysis. We considered a *P* value < 0.05 statistically significant. We performed statistical analyses using Stata version 14.1 MP - Parallel Edition (College Station, TX). This quality improvement intervention was approved by the Institutional Review Board of Johns Hopkins Hospital (NA_00091152) and registered on clinicaltrials.gov (NCT02402881).

## Results

### Education Bundle Development

During the Phase 1 assessment we collected information on participant demographics; we recruited 421 individuals through our 3 national partnering stakeholder organizations and the local patient advisory committee. Of the 421 respondents, 251 (59.6%) were recruited from the NBCA, 156 (37.0%) from Clot Care, and 7 (1.7%) each from the NATF and JHH Patient and Family Advisory Council. Respondents were disproportionately female (331/421, 78.6%) and white (376/421, 89.3%) (see Table 1). The median age of respondents was 47 years (range: 17-82). The majority of respondents lived in the United States (354/421, 84.1%) and had earned at least a college degree (373/421, 88.6%). One-third (139/421, 33.0%) of respondents had some form of medical or health care training. Most respondents had a personal history of VTE (330/421, 78.4%), and more than one-third (169/421, 40.1%) had a family history of VTE. The majority (137/169, 81.1%) of respondents who had a family history of VTE also had a personal history of VTE.

In the Phase 2 survey we asked respondents about broad areas of patient–clinician communication needs and approaches to delivery. Of the 227 respondents in the Phase 2 survey, 186 (81.9%) wanted to talk to a physician, 145 (63.9%) wanted to receive information about VTE on a piece of paper, 105 (46.3%) wanted to talk to a nurse, and 41 (18.1%) wanted to talk to a pharmacist. Of respondents, 99 (43.6%) wanted to watch a video on a smartphone or television. Asked separately whether they would be willing to read a piece of paper if this was the only available medium, 88.1% (200/227) responded affirmatively. On their preferred route of administration, 178 (78.4%) preferred pills, 31 (13.7%) preferred shots, and 18 (7.9%) had no preference (see Table 2). Nearly half of all respondents (107/227, 47.1%) wanted information that would emphasize the danger of VTE, especially relative to other common conditions. Less than a third (66/227, 29.1%) wanted information that emphasized the preventable nature of VTE.

During Phase 3 we asked respondents to rank their top 4 educational topics and top 3 modes of delivery of information. Out of the 215 respondents in this phase of the survey, 181 (84.2%) preferred to receive education about VTE by talking to a physician; 140 (65.1%) wanted

to watch an educational video on a TV, tablet, or smartphone; 136 (63.3%) wanted to read from a piece of paper; 118 (54.9%) preferred to receive education by talking to a nurse; and 43 (20%) wanted to talk to a pharmacist. Most patients (141, 65.6%) selected the option for talking to a physician as their most preferred method of receiving education on VTE; only 32 (14.9%) selected a video as their most preferred method, while 29 (13.5%) wanted to learn about VTE by reading a piece of paper. Only 6 (2.8%) respondents selected talking to a nurse or talking to a pharmacist as their most preferred method.

The most chosen methods for receiving education about VTE (Borda counts, mean weights) were talking with a doctor (491, 2.3); watching a video on a TV, tablet, or smartphone (255, 1.2); reading from a piece of paper (232, 1.1); and talking with a nurse (209, 1.0). There was a statistically significant difference between the ranks allocated to those methods ($p < 0.0001$) (see Figure 2A).

**Table 1. Demographic Characteristics of Respondents**

| Characteristics | Frequency **(%)** ***N* = 421** |
|---|---|
| **Gender** | |
| *Female* | 331 (78.6) |
| *Male* | 88 (20.9) |
| *Prefer not to answer* | 2 (0.5) |
| **Race** | |
| *American Indian or Alaska Native* | 2 (0.5) |
| *Asian* | 8 (1.9) |
| *Black or African American* | 17 (4.0) |
| *White* | 376 (89.3) |
| *Other (please specify)* | 13 (3.1) |
| *Prefer not to answer* | 5 (1.2) |
| **Level of education** | |
| *College degree or higher* | 323 (76.7) |

| | |
|---|---|
| *No college degree* | 94 (22.3) |
| *Prefer not to answer* | 4 (1.0) |
| **Health care training** | |
| *Yes* | 139 (33.0) |
| *No* | 281 (66.7) |
| *Prefer not to answer* | 1 (0.2) |

Respondents were asked to rank methods of receiving VTE education in order of preference. Preference categories first, second, and third were assigned weights of 3, 2, and 1, respectively, and an unranked category was assigned a weight of 0.

When asked what they would prefer to learn the most about VTE, nearly half the respondents (100/212, 47.2%) were most interested in learning how to recognize signs and symptoms, and of the remaining 112 respondents, 58 (51.8%) selected this as their second-most-preferred topic of interest. Of respondents, 39 (18.4%) were most interested in learning how to prevent VTE, 38 (17.9%) were most interested in learning their risk for having a blood clot, and 35 (16.5%) were most interested in learning the possible consequences of a blood clot. Overall, there was a statistically significant difference between the ranks allocated to the various topics ($p < 0.0001$). The item receiving the highest Borda count was "symptoms" (Borda Count = 668, mean weight = 3.2). The other 3 items ("prevention," "consequences," and "risk") were very similar, with Borda counts (mean weights) of 498 (2.3), 486 (2.3), and 468 (2.2), respectively ($p = 0.3$) (see Figure 2B).

**Table 2. Preferred Route of Administration of Pharmacologic VTE Prophylaxis**

| **Preferred Route of VTE Prophylaxis Administration** | **Frequency (%)**<br>***N* = 227** |
|---|---|
| Pill | 178 (78.4) |
| Shot | 12 (5.3) |
| No preference | 31 (13.7) |
| No response | 6 (2.6) |

**Figure 2A. Respondents' Preferences for Receiving VTE Education (Methods).**

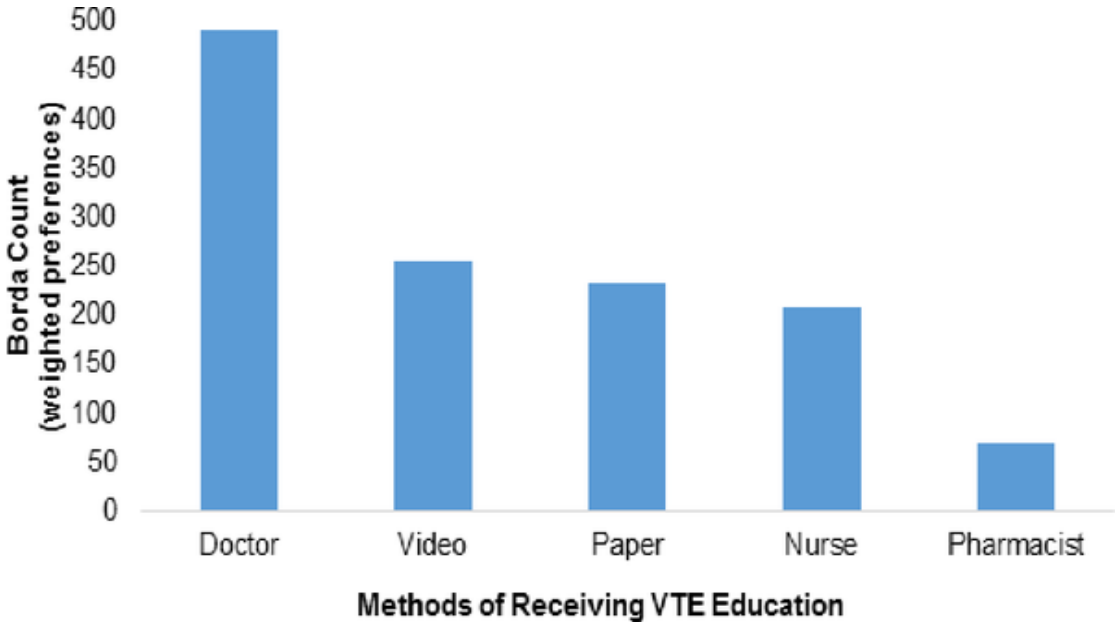
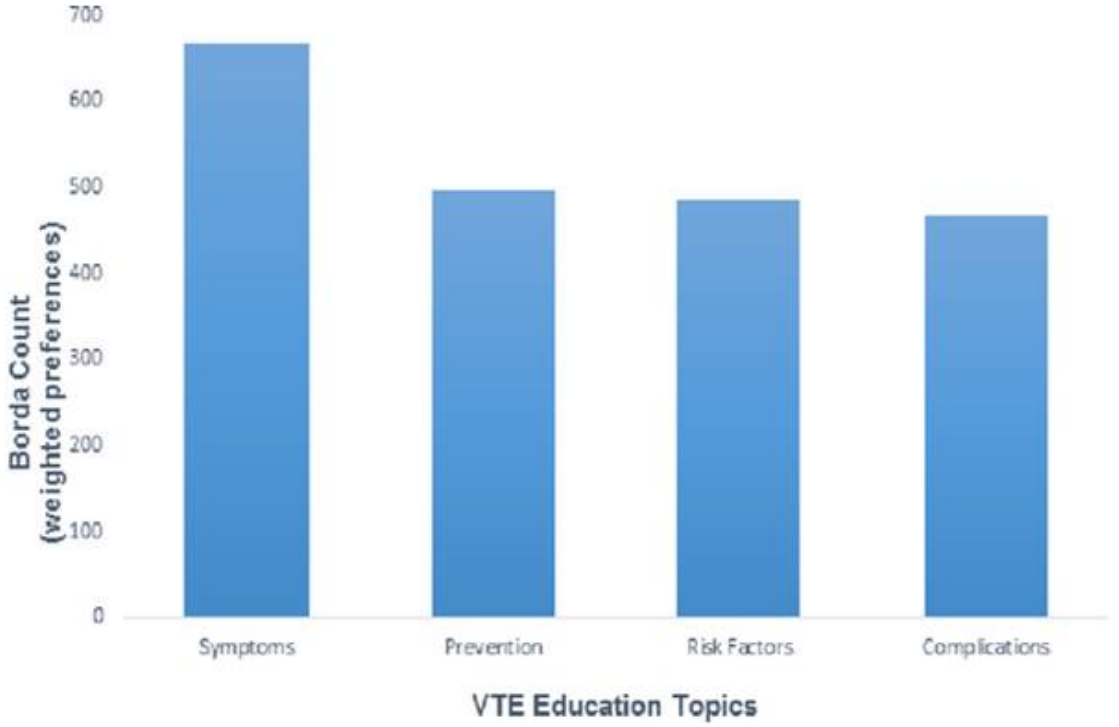



**Figure 2B. Respondents' Preferences for Receiving VTE Education (Topics).**



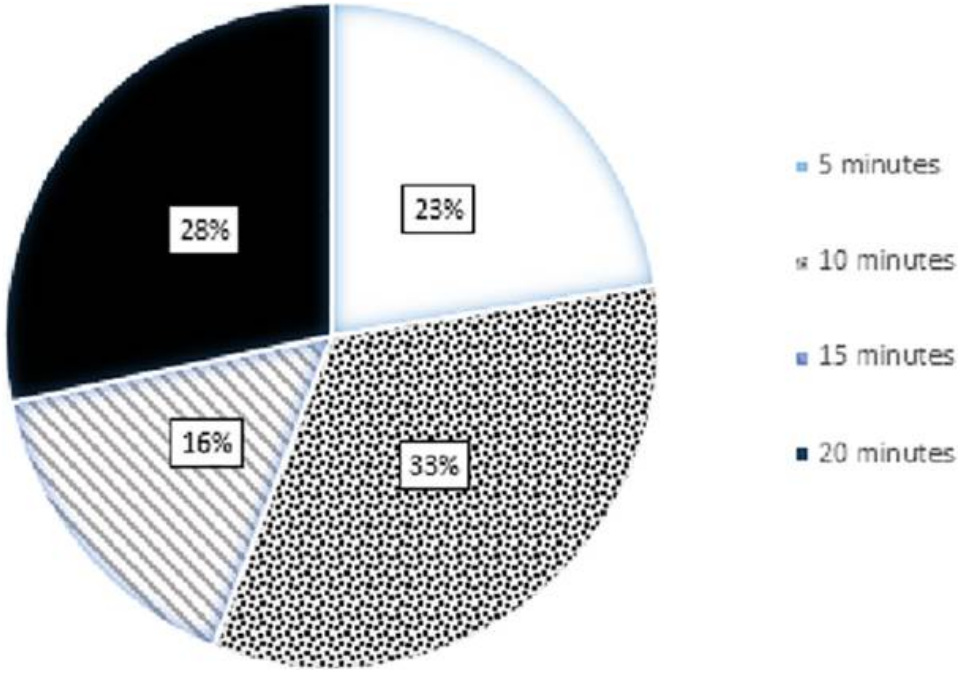

The vast majority of respondents were willing to read a 1-page (199, 93.9%) or 2-page (197, 92.9%) piece of paper with information on VTE risks and prevention. Fewer were willing to read a 3-page

handout (*n* = 156, 73.6%) or guidelines from national clinical organizations (*n* = 153, 72.2%) with the similar information.

When asked what they would like to see in a video if that was the method of education, the overwhelming majority (181, 85.4%) preferred to see both patients and clinicians talking about VTE. All 212 respondents were willing to watch an educational video. The respondents had varying preferences for video duration: 110 (51.9%) were willing to watch 10 minutes or less of video while about half (102, 48.1%) were willing to watch a longer video of 15 to 20 minutes (see Figure 2C).

In summary, patients want to learn about a variety of VTE education topics, including signs and symptoms of VTE, prevention options, and their risk of getting VTE. Patients would prefer to learn directly from their physician supplemented by a variety of approaches, including watching videos, talking with a nurse, and reading written materials. These preferences suggest that patients' perceptions of clinicians' roles, whether correct or incorrect, may influence patient health behavior.

**Figure 2C. Respondents' Preferences for the Length of Educational Material (Video)**




**<u>Nursing Education Intervention Trial</u>**

In the nurse education trial to test 2 web-based modules to educate nurses about the harms of VTE, benefits of VTE prophylaxis, and strategies to better communicate this information to patients, we included 21 hospital floors at the Johns Hopkins Hospital. We randomized 11 floors (6 medicine and 5

surgery) to the dynamic arm and 10 floors (5 medicine and 5 surgery) to the static arm. The dynamic arm received VTE information via scenario-based education, in which each scenario resulted in either positive reinforcement or corrective feedback with an opportunity to apply knowledge to a new scenario. The static arm received VTE information through PowerPoint slides with voiceover to cover the concepts. Out of 977 nurses identified as being potentially eligible for inclusion, using our centralized education directory, 933 (95.5%) were determined to be actively employed by JHH and associated with the study floors (Figure 3). By the end of the education trial period, 396/445 (89.0%) nurses who were assigned had completed the static module and 405/488 (83.0%) nurses who were assigned had completed the dynamic module. We ascertained these figures through our online learning platform and not from self-report. During the entire study period, 214 478 doses of pharmacologic VTE prophylaxis were prescribed to patients on the 21 hospital floors. During the baseline period, 2722 unique patient admissions were in the dynamic arm and 2603 unique patient admissions were in the static arm. Table 3 lists the baseline patient demographics.

**Table 3. Patient Education Intervention Patient Demographics at Baseline**

| | Intervention | | Control* | |
|---|---|---|---|---|
| | Preintervention (*n* = 2313) | Postintervention (*n* = 3225) | Preintervention (*n* = 5821) | Postintervention (*n* = 8903) |
| Unique patients | 1903 | 2607 | 4836 | 7097 |
| Unique nurses | 259 | 296 | 741 | 826 |
| Mean age (SD), years | 54.0 (17.3) | 54.7 (17.6) | 56.3 (16.9) | 55.8 (16.9) |
| Sex, *n* (%) | | | | |
| Male | 1116 (48.3%) | 1636 (50.7%) | 3044 (52.3%) | 4184 (47.0%) |
| Female | 1196 (51.7%) | 1589 (49.3%) | 2777 (47.7%) | 4716 (53.0%) |
| Race, *n* (%) | | | | |
| Black | 976 (42.2%) | 1359 (42.1%) | 2408 (41.4%) | 3586 (40.3%) |
| White | 1135 (49.1%) | 1581 (49.0%) | 2897 (49.8%) | 4538 (51.0%) |
| Asian | 45 (2.0%) | 77 (2.4%) | 120 (2.1%) | 173 (1.9%) |
| Native American | 9 (0.4%) | 4 (0.1%) | 12 (0.2%) | 14 (0.2%) |
| Other | 148 (6.4%) | 204 (6.3%) | 384 (6.6%) | 592 (6.7%) |
| Median number of prescribed doses per patient visit (Q1-Q3) | 7 (3-14) | 7 (3-14) | 8 (4-15) | 8 (4-15) |

| | | | | |
|---|---|---|---|---|
| Median number of prescribed doses per nurse (Q1-Q3) | 64 (5-166) | 51.5 (3-240) | 62 (5-152) | 83 (6-200) |
| Median length of stay, days (Q1-Q3) | 4 (2-7) | 4 (2-7) | 4 (2-8) | 5 (2-8) |

*Two patients on control floor were on fondaparinux.

**Figure 3. Flow of Participants Through Trial, Comparing Dynamic Education With Static Education Among Nurses for Venous Thromboembolism Prevention (Nursing Education Intervention Trial)**

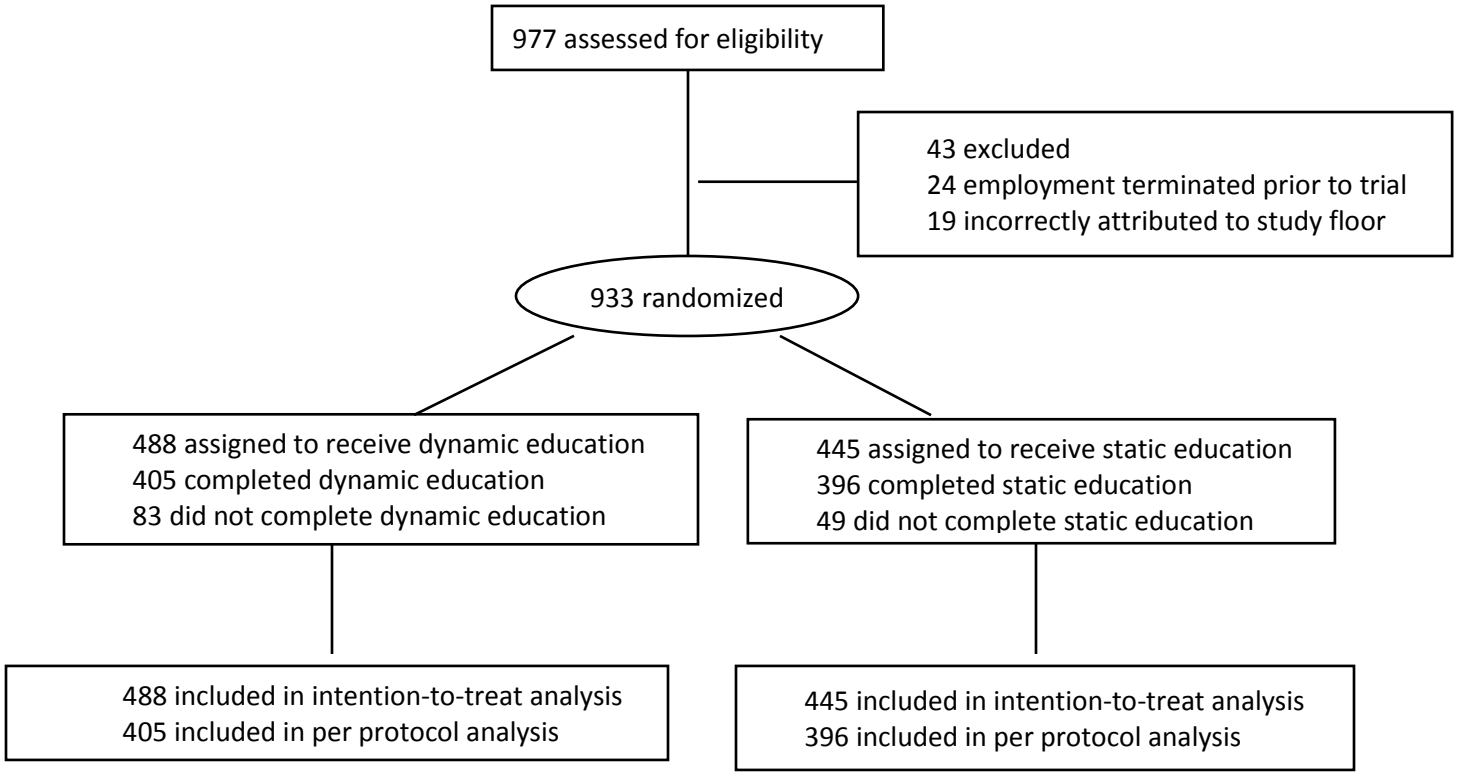



**Table 4A. Nursing Education Intervention Trial Comparison of the Pattern of Administration of Prescribed Venous Thromboembolim Prophylaxis Medication Doses Over Time for the Dynamic and Static Education Interventions.** The pre–nurse education and post–nurse education periods are defined either based on the overall training period (i.e., excluding all visits within the training period regardless of the individual nurse's training with a common pre- and post- period) or based on the individual nurse's training (i.e., includes all visits within the pre- and post- period for each individual nurse).

| | Pre-education % (95% CI) | Post-Education % (95% CI) | Odds Ratio: Post/Pre (95% CI) | Ratio of Odds Ratios: Static/Dynamic (95% CI) | *P* Value |
|---|---|---|---|---|---|
| *Intention to Treat*: Period Based on Overall Training* | | | | | |
| **Overall** | 12.4% (9.6%, 15.9%) | 11.1% (8.6%, 14.2%) | 0.87 (0.80, 0.95) | | 0.002§ |
| **Dynamic education** | 10.8% (7.7%, 15.0%) | 9.2% (6.6%, 12.8%) | 0.83 (0.72, 0.95) | | |
| **Static education** | 14.5% (10.2%, 20.4%) | 13.5% (9.6%, 19.1%) | 0.92 (0.81, 1.03) | 1.11 (0.92, 1.33) | 0.26‡ |
| *Per Protocol†: Period Based on Overall Training* | | | | | |
| **Overall** | 12.3% (9.6%, 15.7%) | 11.2% (8.8%, 14.3%) | 0.89 (0.81, 0.95) | | 0.012§ |
| **Dynamic education** | 10.6% (7.7%, 14.7%) | 9.4% (6.8%, 13.0%) | 0.86 (0.75, 0.99) | | |
| **Static education** | 14.4% (10.3%, 20.2%) | 13.5% (9.7%, 19.0%) | 0.92 (0.82, 1.04) | 1.07 (0.89, 1.30) | 0.438‡ |
| *Per Protocol†: Period Based on Individual Nurse's Training* | | | | | |
| **Overall** | 12.1% (9.5%, 15.5%) | 10.9% (8.5%, 13.9%) | 0.88 (0.81, 0.95) | | 0.001§ |
| **Dynamic education** | 10.6% (7.6%, 14.7%) | 9.3% (6.7%, 12.9%) | 0.86 (0.76, 0.96) | | |
| **Static education** | 14.1% (10.0%, 19.8%) | 13.0% (9.2%, 18.3%) | 0.90 (0.81, 1.01) | 1.06 (0.90, 1.24) | 0.516‡ |

*The intention-to-treat cohort includes all visits with all nurses regardless of whether training was completed.
†The per-protocol analysis includes only those visits overseen by nurses who received training.
§The *P* value compares whether the overall change in the odds of non-administration differs between pre-education and post-education, regardless of arm assignment.
‡The *P* value compares whether the change in the odds of missing an administration differs by arm (i.e., a test of interaction between period and arm).
CI = confidence interval.

### Intention-to-Treat Analysis

By floor, non-administration ranged from 3.2% to 32.7% before the trial began and ranged from 3.7% to 35.2% after the trial ended. Overall, the primary hypothesis was confirmed. Non-administration improved significantly following the nurse education in the trial (12.4% versus 11.1%, conditional odds ratio [cOR]: 0.87, 95% CI: 0.80-0.95, $p = 0.002$; see Table 4A). Using the intention-to-treat analysis, the magnitude of the reduction in non-administration was slightly greater in the dynamic arm following education (10.8% versus 9.2%, cOR: 0.83, 95% CI: 0.72-0.95) compared with the static arm (14.5% versus 13.5%, cOR: 0.92, 95% CI: 0.81-1.03),

although the difference between intervention arms was not statistically significant ($p$ = 0.26). These findings were similar when performing a per-protocol analysis (limiting the analyses to nurses who completed the education).

There was no change in the proportion of prescribed doses that were documented as refused by patients or family members overall (cOR: 0.91, 95% CI: 0.81, 1.02, $p$ = 0.113; see Table 4B) or in either the dynamic arm (5.6% versus 5.1%, cOR: 0.89, 95% CI: 0.75-1.04) or the static arm (7.3% versus 7.0% cOR: 0.94, 95% CI: 0.81-1.10). Overall, non-administration for other reasons (e.g., patient off the floor, dose held for planned invasive procedure) was significantly lower after the education trial (4.1% versus 3.4%, cOR: 0.82, 95% CI: 0.73-0.92, $p$ < 0.001). The magnitude of the reduction in non-administration for other reasons was slightly greater in the dynamic arm (3.4% versus 2.6%, cOR: 0.73, 95% CI: 0.60-0.88) compared with in the static arm (5.0% versus 4.4%, cOR: 0.89, 95% CI: 0.76-1.04; see Table 4B), although the difference between intervention arms was not statistically significant ($p$ = 0.151).

**Table 4B. Nursing Education Intervention Trial comparison of the Reason for Non-administration of Prescribed Venous Thromboembolism Prophylaxis Medication Doses Over Time for the Dynamic and Static Education Interventions.** The pre-education and post-education periods are defined based on the overall training period (i.e., excluding all visits within the training period regardless of the individual nurse's training with a common pre- and post- period).

| | **Pre-education % (95% CI)** | **Post-education % (95% CI)** | **Odds Ratio: Post/Pre (95% CI)** | **Ratio of Odds Ratios: Static/Dynamic (95% CI)** | ***P* Value** |
|---|---|---|---|---|---|
| *Reason for Non-administration: Patient or Family Member Refusal* | | | | | |
| **Overall** | 6.4% (4.2%, 9.7%) | 5.9% (3.9%, 9.0%) | 0.91 (0.81, 1.02) | | 0.113§ |
| **Dynamic education** | 5.6% (3.1%, 10.0%) | 5.1% (2.8%, 9.0%) | 0.89 (0.75, 1.04) | | |
| **Static education** | 7.3% (4.0%, 13.2%) | 7.0% (3.8%, 12.6%) | 0.94 (0.81, 1.10) | 1.06 (0.85, 1.33) | 0.584‡ |
| *Reason for Nonadministration: Other* | | | | | |
| **Overall** | 4.1% (3.3%, 5.0%) | 3.4% (2.8%, 4.2%) | 0.82 (0.73, 0.92) | | < 0.001§ |
| **Dynamic education** | 3.4% (2.6%, 4.5%) | 2.6% (2.0%, 3.3%) | 0.73 (0.60, 0.88) | | |
| **Static education** | 5.0% (3.8%, 6.4%) | 4.4% (3.4%, 5.7%) | 0.89 (0.76, 1.04) | 1.22 (0.93, 1.60) | 0.151‡ |

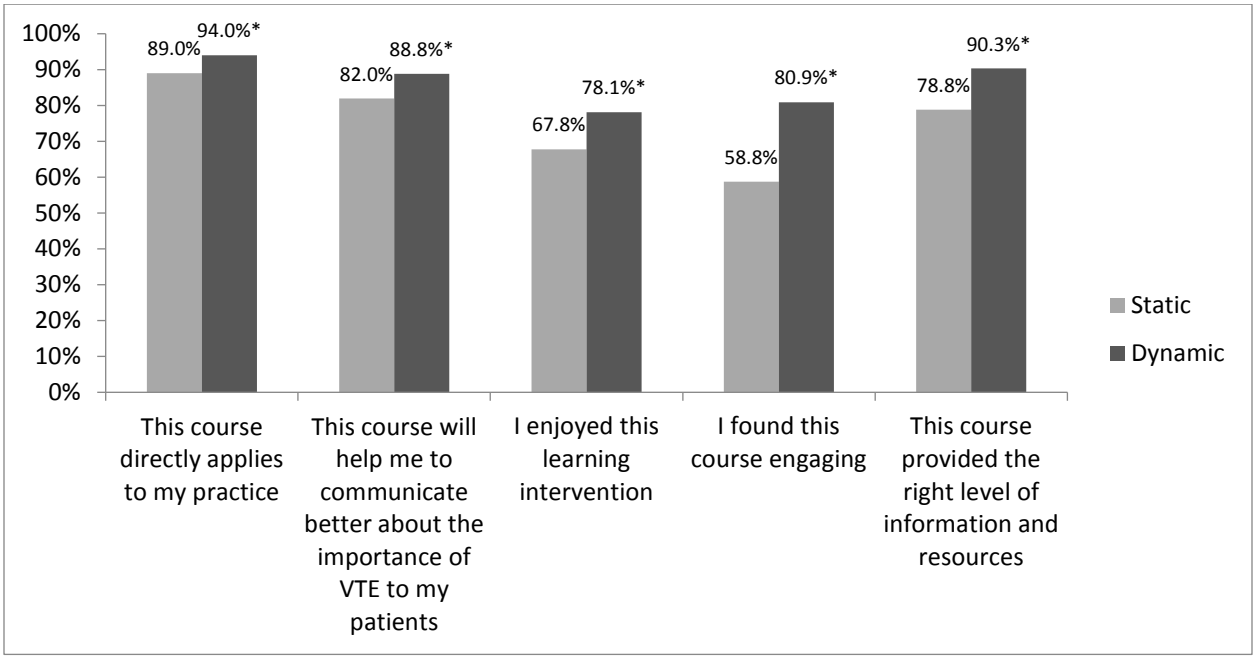
§The *P* value compares whether the overall change in the odds of reason for non-administration differs between pre-education and post-education, regardless of arm assignment.
‡The *P* value compares whether the change in the odds of missing an administration differs by arm (i.e., a test of interaction between period and arm).
CI = confidence interval.

**Nurse Perceptions Survey**

Overall, 580/801 (72.4%) nurses, including 245/396 (61.9%) who completed the static module and 335/405 (82.7%) who completed the dynamic module, responded to the voluntary follow-up survey. Scores were significantly higher in the dynamic arm for all questions asked. Compared with nurses who completed the static module, significantly more nurses reported that the dynamic module was engaging (80.9% versus 58.8%, $p = 0.005$), was enjoyable (78.1% versus 67.8%, $p = 0.005$), helped to better communicate the importance of VTE to patients (88.8% versus 82.0%, $p = 0.020$), provided the right level of information and resources (90.3%

versus 78.8%, $p < 0.001$), and directly applied to their clinical practice (94.0% versus 89.0%, $p = 0.028$; see Figure 4).

**Figure 4. Nurse-reported Satisfaction With and Perception of Each Education Module, by Arm (Nursing Education Intervention Trial)**




*$P$ value < 0.05 comparing dynamic with static education.

## Patient Education Intervention

We included in the analysis a total of 20 262 unique hospitalizations by 16 443 unique patients associated with an order of at least a single dose of risk-appropriate VTE pharmacologic prophylaxis during the study period. Of these, 5538 (27.3%) and 14 724 (72.75%) were admitted to the intervention and control floors, respectively. On intervention floors, 2313 (41.8%) and 3225 (58.2%) hospitalizations were in the preintervention and postintervention periods, respectively. On control floors, 5821 (39.5%) and 8903 (60.5%) hospitalizations were in the preintervention and postintervention periods, respectively. In all, 345 unique hospitalizations received an intervention, 68 (19.7%) receiving a nurse-only intervention and

277 (80.3%) receiving a nurse-plus-patient intervention. Of the 277 patients who received an intervention, 165 (59.6%) and 64 (23.1%) selected paper-based and video-based education, respectively. Close to a quarter of patients requested both means of intervention delivery. We were unable to offer the educational bundle to 503 patients (58.8%) on the intervention floor. Of these, 135 (26.8%) were discharged before an intervention, 129 (25.6%) had an order to discontinue the dose because they were bleeding or had a bleeding risk and therefore an intervention would not be appropriate, 60 (11.9%) had technical errors associated with the order, and 54 (10.7%) were off the floor when the health educator visited.

The mean age for hospitalizations on intervention floors was similar between the preintervention and postintervention groups. (54.0 ± 17.3 versus 54.7 ± 17.6) On control floors, the mean age for hospitalizations for preinterventions and postinterventions was 56.3 ± 16.9 years and 55.8 ± 16.9 years, respectively. On intervention floors, males accounted for 48.3% and 50.7% of hospitalizations in the preintervention and postintervention periods, respectively, and on control floors 52.3% and 47.0%, respectively. By race, whites accounted for a large proportion of the sample on both control and intervention floors. On intervention floors, the median number of prescribed VTE doses per hospitalization was similar in the preintervention and postintervention periods. Similarly, the median number of prescribed doses per hospitalization was 8 for both the preintervention and postintervention period on control floors. The median length of stay on intervention floors in both the preintervention and postintervention periods was 4 days. On control floors, the median length of stay was 4 days in the preintervention and 5 days in the postintervention periods (see Table 3).

The odds of non-administration of a dose of pharmacologic VTE prophylaxis from the preintervention period to postintervention period decreased by 12% (OR 0.88, 95% CI 0.82-0.95). On intervention floors, the odds of non-administration of VTE prophylaxis dropped by 42% after the intervention (OR 0.58, 95% CI 0.50-0.68), but was unchanged on control floors (13.5% versus 13.2%, OR 0.98, 95% CI 0.91-1.07). The difference in the refusal of non-administered doses on intervention floors was statistically significantly different from that on control floors (OR 1.68, 95% CI 1.41-2.01) (see Table 5A).

The odds of refusing a dose overall declined by 12% (OR 0.88, 95% CI 0.80-0.96) during the intervention period compared with the preintervention period. On intervention floors, the odds of refusing a dose decreased by 45% from the preintervention to postintervention period (OR 0.55, 95% CI 0.45-0.66). We observed no change in the odds of refusing a dose on control floors from preintervention to postintervention (OR 0.99, 95% CI 0.90-1.09). The difference in the rate of refused doses on intervention floors was statistically significantly different from that on control floors (OR 1.82, 95% CI 1.46-2.26) (see Table 5A).

The proportion of doses not administered as a result of reasons other than patient refusal in the preintervention was 3.1% compared with 2.8% in the postintervention period (OR 0.9,2 95% CI 0.83-1.03). On intervention floors, this proportion decreased from 2.3% in preintervention to 1.7% postintervention (OR 0.74, 95% CI 0.58-0.96). On control floors, this proportion was unchanged after the intervention (3.4% versus 3.3%, OR 95%, CI 0.86-1.09). The odds of non-administration of VTE prophylaxis for a reason other than patient refusal that did not differ by intervention floor from preintervention to postintervention (OR 1.30, 95% CI 0.98-2.72) (see Table 5C).

**Table 5A. Patient Education Intervention Proportion of Doses Missed and Stratified by Refused and Other Reasons of Missed Dose Comparisons Between Preintervention Versus Postintervention and Different Arms**

| Period | Intervention | Control | *P* Value |
|---|---|---|---|
| *Any Missed Dose* | | | |
| Preintervention % (95% CI) | 9.1% (5.2%, 16.2%) | 13.6% (9.8%, 18.7%) | 0.238 |
| Postintervention % (95% CI) | 5.6% (3.1%, 9.9%) | 13.3% (9.6%, 18.5%) | 0.010 |
| Odds ratio Post/pre (95% CI) | 0.57 (0.48, 0.67) | 0.98 (0.91, 1.07) | < 0.001[§] |
| *Refused Dose* | | | |
| Preintervention % (95% CI) | 5.9% (2.6%, 13.6%) | 8.7% (5.4%, 14.0%) | 0.441 |
| Postintervention % (95% CI) | 3.4% (1.5%, 7.8%) | 8.5% (5.3%, 13.8%) | 0.057 |
| Odds ratio Post/pre (95% CI) | 0.53 (0.43, 0.65) | 0.98 (0.89, 1.08) | < 0.001[§] |
| *Other Reason for Missed Dose (Not Refused)* | | | |
| Preintervention | 2.3% (1.5%, 3.4%) | 3.4% (2.7%, 4.4%) | 0.087 |
| Postintervention | 1.7% (1.1%, 2.6%) | 3.3% (2.6%, 4.2%) | 0.005 |
| Odds ratio post/pre (95% CI) *P* value | 0.74 (0.58, 0.94) $p = 0.014$ | 0.98 (0.87, 1.10) $p = 0.692$ | 0.047[§] |

[§]The *P* value compares whether the odds of non-administration differ by treatment group (i.e., a test of interaction between period and treatment).
CI = confidence interval.

A subgroup analysis by admitting service revealed that on medical floors, the odds of non-administration of VTE prophylaxis decreased only on intervention floors (OR 0.60, 95% CI 0.49-0.74) and was unchanged on control floors (OR 1.07, 95% CI 0.97-1.18). On surgical floors, there was a large decline in the odds of non-administration of VTE prophylaxis on intervention floors (OR 0.54, 95% 0.41-0.69) and a smaller, but still significant, drop on control floors (OR 0.84, 95% CI 0.74-0.95) (see Table 5B). The proportion of refused doses out of all doses prescribed decreased after the intervention on both intervention (3.2 % versus 1.2%, $p < 0.001$) and control (7.0% versus 5.3%, $p = 0.006$) surgical floors. On medical floors, the proportion of doses refused decreased only on intervention floors (14.6% versus

9.0%, $p < 0.001$) and was unchanged on control floors (16.6% versus 17.3%, $p = 0.27$). The proportion of doses not administered for reasons other than patient refusal decreased from 2.1% to 1.2% ($p = 0.002$) on intervention floors associated with the surgical service. No significant reduction in the proportion of doses not administered (out of all doses prescribed) for other reasons was observed on surgery control (3.8% versus 3.3%, $p = 0.19$), medicine intervention (2.2 versus 1.6%, $p = 0.76$), and control (2.8% versus 2.7%, $p = 0.61$) floors after the intervention.

**Table 5B. Patient Education Intervention Proportion of Prescribed Venous Thromboembolism Prophylaxis Medication Doses Not Administered, Before and After Patient Intervention by All Nurses on Study Floors, by Reason and Arm**

| **Surgery** | | | |
|---|---|---|---|
| **Period** | **Intervention** | **Control** | ***P* Value** |
| *Any Missed Dose* | | | |
| Preintervention % (95% CI) | 5.1%<br>(3.1%, 8.3%) | 9.3%<br>(6.8%, 12.6%) | |
| Postintervention % (95% CI) | 2.8%<br>(1.7%, 4.6%) | 7.9%<br>(5.8%, 10.8%) | |
| Odds ratio Post/pre (95% CI) | 0.54<br>(0.41, 0.69)<br>$p < 0.001$ | 0.84<br>(0.74, 0.95)<br>$p = 0.004$ | 0.002 |
| *Patient Refused Dose* | | | |
| Preintervention % (95% CI) | 2.5%<br>(1.3%, 4.9%) | 4.6%<br>(3.0%, 6.8%) | |
| Postintervention % (95% CI) | 1.3%<br>(0.6%, 2.6%) | 3.6%<br>(2.4%, 5.4%) | |
| Odds ratio Post/pre (95% CI) | 0.49<br>(0.33, 0.74)<br>$p < 0.001$ | 0.78<br>(0.65, 0.93)<br>$p = 0.006$ | 0.041 |
| *Other Reason for Missed Dose (Excluding Patient Refusal)* | | | |
| Preintervention | 2.3%<br>(1.3%, 4.0%) | 3.9%<br>(2.7%, 5.5%) | |
| Postintervention | 1.4%<br>(0.8%, 2.4%) | 3.5%<br>(2.5%, 5.0%) | |
| Odds ratio Post/pre (95% CI) *P* value | 0.59<br>(0.42, 0.83)<br>$p = 0.002$ | 0.91<br>(0.78, 1.05)<br>$p = 0.196$ | 0.022 |

| Medicine | | | |
|---|---|---|---|
| **Period** | **Intervention** | **Control** | ***P* Value** |
| *Any Missed Dose* | | | |
| Preintervention % (95% CI) | 16.3% (10.0%, 26.4%) | 18.1% (13.9%, 23.5%) | |
| Postintervention % (95% CI) | 10.7% (6.6%, 17.3%) | 19.0% (14.6%, 24.5%) | |
| Odds ratio Post/pre (95% CI) | 0.60 (0.49, 0.74) $p < .001$ | 1.07 (0.97, 1.18) $p = 0.195$ | < .001 |
| *Patient Refused Dose* | | | |
| Preintervention % (95% CI) | 13.6% (7.3%, 25.5%) | 14.3% (10.2%, 20.1%) | |
| Postintervention % (95% CI) | 8.2% (4.4%, 15.4%) | 15.0% (10.8%, 20.0%) | |
| Odds ratio Post/pre (95% CI) | 0.56 (0.45, 0.70) $p < .001$ | 1.07 (0.95, 1.20) $p = 0.273$ | < .001 |
| *Other Reason for Missed Dose (Excluding Patient Refusal)* | | | |
| Preintervention | 2.3% (1.3%, 4.0%) | 3.1% (2.2%, 4.2%) | |
| Postintervention | 2.1% (1.2%, 3.8%) | 3.2% (2.4%, 4.3%) | |
| Odds ratio Post/pre (95% CI) *P* value | 0.95 (0.66, 1.36) $p = 0.761$ | 1.05 (0.87, 1.26) $p = 0.613$ | 0.624 |

## Discussion

In this single-center study we show the effectiveness of a patient-centered multitier approach to improve VTE prophylaxis nonadministration among hospitalized patients. We found that most patients want to learn about a variety of VTE education topics from their physician, supplemented by a variety of approaches that include watching videos, talking with a nurse, and reading written materials. Nurse education reduced the frequency of VTE prophylaxis nonadministration. The targeted patient-centered education intervention resulted in a reduction in the odds of patient refusal and improvement in nonadministered doses of pharmacologic VTE prophylaxis. The staggering patient refusal and nonadministration rates of pharmacologic VTE prophylaxis reemphasizes the American Public Health Association's

assertion that “the disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis.”[3] This statement deserves mention against the backdrop that VTE is an important cause of mortality and morbidity in hospitalized patients and that nonadministration of VTE pharmacologic prophylaxis in at-risk patients is associated with adverse VTE events.[17,19] Although patient education may show some promise in curbing patient refusal and VTE events, developing the right educational tool that can address concerns and be delivered efficiently can be daunting.[21] Consequently, to empower and engage patients in shared decision making on VTE prophylaxis and address the downstream costs of non-administered doses, we developed an educational bundle in collaboration with patients, families, clinicians, and other stakeholders for trial in our institution.

Educating patients has been shown to improve understanding of the necessity of medication, reduce perception of harm from treatment, and potentially prevent adverse clinical outcomes.[35] However, little has been written about the process by which the target audience is included in the planning and creation of health care educational materials. One strategy to improve compliance is to engage patients to make informed decisions about their preventive care by improving the quality of communication between health care workers and patients.[34,36] Most patients wanted to learn about VTE in a context of harm. This is not surprising, as the perceived threat of a health condition is known to be an important determinant of patients’ health behavior.[37] However, previous studies of health behavior have found that while patients sometimes expect to be afraid when presented with their risk, most tend to demonstrate an “optimistic bias” or an “illusion of invulnerability” regarding their personal risk.[38,39] Hence, greater emphasis on risk in patient education may not necessarily result in a higher likelihood of adherence. In our study, more than 80% of respondents that had a family history of VTE also had a history of VTE. This suggests a significant gap in targeted VTE prevention efforts even among such high-risk patients.

Although not the primary objective of this project, it is important to remember that clinicians may not always know, and should ask specifically, patient preferences for treatment and for education. There are only a few patient populations in which oral regimens for VTE prophylaxis are indicated. This group is growing with the assumption that ALL patients prefer an

oral agent over an injectable medication. While it is true that three-quarters of patients (78.4%) have this stated preference, some patients preferred shots (13.7%) or had no preference (7.9%). These numbers from the current national survey are similar to a previously published sample of inpatients at our hospital with a different demographic breakdown that found only 60% of patients preferred an oral medication.[30]

A systematic review of interventions to improve VTE prevention practices reported that education strategies alone are not sufficient to drive and sustain change.[40] However, although not sufficient alone, education is a necessary component of any successful intervention. Interventions to improve prescription of appropriate VTE prophylaxis in hospitals have been wildly successful at doing just that[13,24,25,41] and are promoted by AHRQ as 1 of the top 10 most important patient safety practices. However, improving prescription is only 1 step in a multistep process to ensure defect-free VTE prevention; prescribed medication doses must be administered. In this study, nurses found the interactive dynamic module to be more engaging, more enjoyable, and better for patient engagement. While we are unable to demonstrate a statistically significantly greater reduction in dose non-administration, the magnitude of improvement was slightly greater for the dynamic module. These findings indicate that interactive, learner-centric education might be most appropriate to change practice and should be adopted more widely and further applied to other domains of clinical education.

This study reveals the role of nursing in improving VTE prophylaxis in hospitalized patients, and the findings are not unique. A previous study implemented a 3-step approach to improve VTE prophylaxis administration that included a standardized nurses' response to patient refusal of VTE prophylaxis, integration of daily assessment of VTE prophylaxis into a multidisciplinary rounds checklist, and frequent audit and feedback of unit performance. Studies focused on giving individual physicians feedback about their prescribing habits have shown marked improvement in practice.[42-44] It is reasonable to believe that providing nurses with feedback about their administration practices would have a similar improvement on practice habits. This is the first study to specifically identify individual nurse data for medication administration, the first step toward providing individualized feedback to nurses.

Our patient intervention study reveals important points worthy of discussion. First, patient education improves adherence to pharmacologic VTE prophylaxis in hospitalized patients. Our finding is consistent with a single-center study of a pharmacist-led individualized patient program that resulted in a significantly improved adherence to pharmacologic VTE prophylaxis in hospitalized patients.[21] Unlike this study, our intervention is health educator–led, is strengthened by using an education bundle with content developed by patient representatives and stakeholders, and gives patients an opportunity to choose which component is ideal. This is important as patient-centered approaches in health care are garnering support, spearheaded by the Institute of Medicine's "Crossing the Quality Chasm" report.[45] Health care systems that enable patients and their families to make informed decisions about their treatment result in enormous benefits, as demonstrated by our intervention and others.[46,47]

Furthermore, this study emphasizes that a targeted education intervention, harnessing health information technology to target the patients in most need of education based on the alert that they had missed a dose of VTE prophylaxis, rather than a blanket education approach, may hold the key to addressing non-administration of VTE prophylaxis. Our real-time alert allows us to efficiently target a relatively small group of patients for intervention, because only 20% of all patients account for more than 80% of all missed doses of VTE prophylaxis, a phenomenon in congruence with the Pareto principle.[17] Perhaps this offsets the enormous resources and time that would be required to educate all patients, which would be beyond the means of most institutions.

As already noted, patient education is recognized to improve adherence to various therapies,[48,49] and an intervention like this is desperately needed given the prevailing enormous knowledge gap about VTE among patients.[26] In view of this, various education strategies, such as nurse-driven, paper-based, or video-based ones, have been used or advocated to help improve patient awareness of VTE.[50,51] A randomized trial to evaluate the effectiveness of video-based education showed improved patient satisfaction and knowledge on VTE.[52] More than half of the patients in our cohort preferred a paper-based education strategy; about one-quarter expressed their willingness to watch a video. In a national sample of patients, 64%

preferred to receive VTE education by reading from a piece of paper.[33] Our study also demonstrates further evidence that matching patient learning preferences to an education strategy is efficacious, as described previously.[53]

We show that this intervention is effective regardless of service of admission (medicine/surgery), as demonstrated by a decrease in the odds of non-administration rate by 40% and 46% on medical and surgical floors, respectively. The corresponding absolute reductions were 2.3% and 5.6% of all doses, respectively. In the same period, the odds of a patient refusing a dose of VTE prophylaxis on medical and surgical floors that had an intervention improved by 43% and 49%, respectively. However, while the refusal rate showed no improvement on control floors associated with the medicine service, we saw a 22% improvement in their surgery counterparts. This can be explained by the "halo effect" or unintended consequence of this quality improvement intervention, which has previously been described.[54] In this institution, while internal medicine residents complete all their training primarily on a single floor without coming into contact with patients on other floors, surgical residents take care of patients across many different floors. Therefore, nurses and/or patients on control surgical floors may have been exposed to surgical residents aware of this initiative, and that may have influenced their practices and actions.

**Implications**

Education of health care professionals and clinical decision support within computerized provider order entry systems have been shown to result in improvements in VTE prophylaxis prescribing practices.[15,23,24,42,43] However, it is not enough to educate providers and improve their prescription behaviors regarding appropriate VTE prophylaxis regimen.[43] We must also educate patients and their families on the importance and health benefits of adequate VTE prophylaxis and ensure better communication between clinicians and patients so that patients can make the most informed decision regarding their care. All phases of VTE prevention are important in order to provide high-quality care. The acceptance of the medication by the patients is a critical step along the way. We hope that by educating patients, we can decrease the rate of refusal of these medications and prevent more VTE.

This study highlights significant gaps in educating and engaging patients. Although there is significant effort to leverage nonphysician providers to educate patients, patients overwhelmingly prefer to receive education from their physicians. Although patients prefer to receive supplemental education through a variety of mechanisms, including videos, text, and other types of clinicians, patient education is increasingly being linked to the electronic medical record that offers 1 mode of education.

Based on the results of this work, we have created the specific educational materials that patients and their families have asked for. We created a 2-page educational handout that is now the standard first-line educational material on VTE for all patients admitted to the Johns Hopkins Hospital. This material has been translated into multiple languages (including Spanish, Arabic, Chinese, Korean, Portuguese, Russian, and Nepali) and is available to all patients, their families, and the public via the Johns Hopkins VTE Collaborative website (http://www.hopkinsmedicine.org/armstrong_institute/improvement_projects/VTE/patients.html). We also produced a 10-minute patient-centered, educational video with segments of 4 clinicians and 6 patients discussing the topics that the survey respondents requested: signs and symptoms, prevention, risk factors, and consequences. This video is also being used at our hospital and can be viewed by the public as well (http://www.hopkinsmedicine.org/armstrong_institute/improvement_projects/VTE/patients.html, https://www.youtube.com/watch?v=0o3yadu4DFw).

This study highlights the usefulness of a computer/informatics-based approach in addressing one of the challenges encountered in the prescription, delivery, and acceptance of pharmacologic VTE prophylaxis. Alerting health educators and providers in real time when a patient misses a dose of pharmacologic VTE prophylaxis enables them to intervene in a timely fashion by engaging patients and providing them with their preferred education components. This gives the patient the opportunity to make an informed decision, an important tenet of the patient-centered approach in health care.[54] Widescale adoption of electronic health technology, fueled by the meaningful use incentive program of the Centers for Medicaid and Medicare Services, offers many centers the opportunity to embrace this intervention.

This project is suitable for dissemination to other health care settings owing to its success. As stated earlier, non-administration of VTE prophylaxis is endemic to not only our hospital and efforts must be made to disseminate this intervention beyond our facility. In this regard, we have already shared our nurse educational materials and platform that is currently in use with the Illinois Surgical Quality Improvement Collaborative. Moreover, to be able to implement the patient intervention, hospitals would require an electronic health record system and the requisite technical support infrastructure capable of integrating clinical decision support tools. However, implementation of EHR systems capable of clinical decision support integration is a national priority.

We identified many barriers to full implementation, which included some patients missing the intervention because they missed their doses over a weekend or at night when the health educator was unavailable. This has prompted us to encourage nursing units to own the product, with the charge nurse taking over as the primary person undertaking the intervention. By including this in the workflow of the charge nurse or nurse champion on the floor, we believe that this intervention can be implemented without hiring the services of a health educator. This proposed modification has been decided based on discussion with key stakeholders (e.g., physicians, nurses, pharmacists, patients) to allow scalability in a cost-effective manner.

**Limitations**

Our findings from our survey should be interpreted with the following limitations in mind. In the development of the education bundle, there is potential selection bias: The majority of participants were female and white and most had college degrees, so our results may not be generalizable to other demographic strata. Furthermore, only half the participants responded to the Phase 2 and Phase 3 surveys, a common phenomenon in serial survey studies. Also, nearly 80% of respondents had a personal and/or family history of VTE. It is possible that preferences among patients who have never had a blood clot may be different than those surveyed. However, input from patients and family members who had direct experience with VTE may be considered a strength by imparting the knowledge they wish they had, with the

benefit of hindsight. We also did not stratify our results by patient characteristics, such as education, race, ethnicity, or primary language, and some types of patients' preferences may differ from our findings.

Although we desired to intervene on all patients who missed a dose of a pharmacologic VTE prophylaxis, a proportion of these patients did not receive an intervention because they either were discharged before we could intervene or missed a dose when a nurse educator was off duty (factored into study protocol), the patient was off the floor when the health educator visited, etc. Nevertheless, we demonstrate a significant reduction in non-administration rate of VTE pharmacologic prophylaxis after this intervention. Perhaps if we had been able to intervene on all these patients, we would have seen greater effect of this intervention.

Our study is a single-center study and may not be representative of all medical centers, limiting the generalizability of our findings. The entire program is not directly applicable to medical centers without an electronic medical record system designed to collect data on this process. The electronic alert would not be possible, but the nurse education and patient education materials are still viable options. The patient intervention is applicable to only patients who are willing and able to participate. Also, because our institution typically uses unfractionated heparin, which is administered twice or thrice daily, our results may not be exactly the same at centers that typically use low molecular weight heparin dosed once daily. While we are unable to confirm the association between medication type/dosing, it is possible that patients receiving daily dosing may be less likely to refuse VTE prophylaxis.

**Conclusion**

In conclusion, the results of this study suggest that patients want to be educated primarily by their physician, supplemented with a variety of educational methods (in-person, video, paper) about VTE prevention. They want to understand how to recognize the signs and symptoms of VTE, their personal risk for VTE, and the consequences of developing VTE. We completed a randomized clinical trial that compared clinical process measures (missed doses of VTE prophylaxis), showing the benefit of direct education for bedside nurses. We show that a targeted patient-centered education intervention bundle deployed in a timely fashion to

patients who miss a dose of pharmacologic VTE prophylaxis significantly reduces non-administration of pharmacologic VTE prophylaxis. The hallmark of patient-centered care is that patients should be enabled to make informed decisions regarding their care. To do so, patients and their families must be educated and engaged. Hence, efforts at improving VTE prophylaxis and decreasing preventable harm from VTE should not be limited to health care workers but should target a variety of stakeholders, including patients and their families. Clinicians can use this study's findings to help educate and engage patients about VTE. Moving forward, we should solicit and use explicit patient preferences when creating educational materials geared toward patients and their families. In the era of rapidly advancing technology, quality improvement specialists should harness the power of this technology and use advanced analytics to drive change. Although the studies are not without limitations (i.e. small numbers of participants and its single-center nature), the approaches show promise to improve care.

Overall, this group of quality improvement interventions improves patient awareness, engagement, and willingness to accept VTE prophylaxis and has a multiplier effect, since refusing 1 or more doses is associated with refusing subsequent doses. The rationale and concepts behind this intervention are promising above and beyond the delivery and adherence to VTE prophylaxis. The intervention presents an opportunity to improve the efficiency of patient-centered health care delivery by identifying and targeting points of failure in real time.

Meanwhile, efforts to improve nurse–patient communication regarding VTE prophylaxis should focus on interactive leaner-centric education. Education of nurses can bridge the nurse–patient communication gap regarding VTE prevention.

## References


1. Stein PD, Matta F. Epidemiology and incidence: The scope of the problem and risk factors for development of venous thromboembolism. *Clin Chest Med*. 2010;31(4):611-628.

2. Office of the Surgeon General (US); National Heart, Lung, and Blood Institute (US). The Surgeon General's Call to Action to Prevent Deep Vein Thrombosis and Pulmonary Embolism. Rockville (MD): Office of the Surgeon General (US); 2008. Available from: https://www.ncbi.nlm.nih.gov/books/NBK44178/pdf/Bookshelf_NBK44178.pdf. Accessed August 30, 2011.

3. Deep-Vein Thrombosis: Advancing Awareness to Protect Patient Lives. American Public Health Association website. http://www.apha.org/NR/rdonlyres/A209F84A-7C0E-4761-9ECF-61D22E1E11F7/0/DVT_White_Paper.pdf. Published 2003. Accessed January 29, 2008.

4. Anderson FA Jr, Spencer FA. Risk factors for venous thromboembolism. *Circulation*. 2003;107(23) (suppl 1): I9-I16.

5. Mismetti P, Laporte-Simitsidis S, Tardy B, et al. Prevention of venous thromboembolism in internal medicine with unfractionated or low-molecular-weight heparins: a meta-analysis of randomised clinical trials. *Thromb Haemost*. 2000;83(1):14-19.

6. Dentali F, Douketis JD, Gianni M, Lim W, Crowther MA. Meta-analysis: anticoagulant prophylaxis to prevent symptomatic venous thromboembolism in hospitalized medical patients. *Ann Intern Med.* 2007;146(4):278-288.

7. Geerts WH, Bergqvist D, Pineo GF, et al. Prevention of venous thromboembolism: American College of Chest Physicians evidence based clinical practice guidelines (8th edition). *Chest*. 2008;133(suppl 6):381S-453S.

8. Rogers FB, Cipolle MD, Velmahos G, Rozycki G, Luchette FA. Practice management guidelines for the prevention of venous thromboembolism in trauma patients: the EAST practice management guidelines work group. *J Trauma*. 2002;53(1):142-164.

9. Maynard G, Stein J. *Preventing Hospital-acquired Venous Thromboembolism: A Guide for Effective Quality Improvement*. Rockville, MD: Agency for Healthcare Research and Quality; 2008. AHRQ publication 08-0075.

10. Shojania KG, Duncan BW, McDonald KM, et al. *Making Health Care Safer: A Critical Analysis of Patient Safety Practices (Evidence Reports/Technology Assessments, No. 43)*. Rockville, MD: Agency for Healthcare Research and Quality; 2001.

11. Spyropoulos AC, Hurley JS, Ciesla GN, et al. Management of acute proximal deep vein thrombosis: pharmacoeconomic evaluation of outpatient treatment with enoxaparin vs inpatient treatment with unfractionated heparin. *Chest*. 2002;122(1):108-114.

12. Haut ER, Lau BD. Prevention of venous thromboembolism: brief update review. In: *In Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Practices*. Rockville, MD: Agency for Healthcare Research and Quality; 2013.

13. Haut ER, Lau BD, Kraenzlin FS, et al. Improved prophylaxis and decreased preventable harm with a mandatory computerized clinical decision support tool for venous thromboembolism (VTE) prophylaxis in trauma patients. *Arch Surg*. 2012;10(147):901-907.

14. Lau BD, Lau BD, Hobson DB, et al. The Johns Hopkins VTE Collaborative. *J Hosp Med*. 2016;(2):S8-S14.

15. Fanikos J, Stevens LA, Labreche M, et al. Adherence to pharmacological thromboprophylaxis orders in hospitalized patients. *Am J Med*. 2010;123(6):536-541

16. Shermock KM, Lau BD, Haut ER, et al. Patterns of non-administration of ordered doses of venous thromboembolism prophylaxis: implications for novel intervention strategies. *PLoS One*. 2013;8(6):e66311. https://doi.org/10.1371/journal.pone.0066311

17. Louis SG, Sato M, Geraci T, et al. Correlation of missed doses of enoxaparin with increased incidence of deep vein thrombosis in trauma and general surgery patients. *JAMA Surg*. 2014;149(4):365-370.

18. Haut ER, Lau BD, Kraus PS, et al. Preventability of hospital-acquired venous thromboembolism. *JAMA Surg*. 2015;150(9):912-915.

19. Elder S, Hobson DB, Rand CS, et al. Hidden barriers to delivery of pharmacological venous thromboembolism prophylaxis: the role of nursing beliefs and practices. *J Patient Saf*. 2016;12(2):63-68.

20. Piazza G, Nguyen TN, Morrison R, et al. Patient education program for venous thromboembolism prevention in hospitalized patients. *Am J Med*. 2012;125(3):258-264.

21. Durieux P, Nizard R, Ravaud P, Mounier N, Lepage E. A clinical decision support system for prevention of venous thromboembolism effect on physician behavior. *JAMA*. 2000;283(21):2816-2821.

22. Streiff MB, Carolan H, Hobson DB, et al. Lessons from the John Hopkins multi-disciplinary venous thromboembolism (VTE) prevention collaborative. *BMJ*. 2012;(344):e3935. DOI: https://doi.org/10.1136/bmj.e3935

23. Zeidan AM, Streiff MB, Lau BD, et al. Impact of a venous thromboembolism prophylaxis "smart order set": improved compliance, fewer events. *Am J Hematol*. 2013;88(7):545-549.

24. Aboagye JK, Lau BD, Schneider EB, Streiff MB, Haut ER. Linking processes and outcomes: a key strategy to prevent and report harm from venous thromboembolism in surgical patients. *JAMA Surg*. 2013;148(3):299-300.

25. Maynard GA, Varga EA, Friedman RJ, et al. Deep vein thrombosis and pulmonary embolism: awareness and prophylaxis practices reported by recently hospitalized patients. Paper presented at 2011 Society of Hospital Medicine Annual Meeting in Grapevine, Texas. Available at: https://www.shmabstracts.com/abstract/deep-vein-thrombosis-and-pulmonary-embolism-awareness-and-prophylaxis-practices-reported-by-recently-hospitalized-patients/

26. Geist MR. Using the delphi method to engage stakeholders: a comparison of two studies. *Eval Program Plann*. 2010;(33):147-154

27. Marden JI. *Analyzing and Modeling Rank Data*. New York, NY; Chapman & Hall; 1995.

28. Lee MD, Steyvers M, Miller B. A cognitive model for aggregating people's rankings. *PLoS One*. 2014;(9):e96431.DOI: https://doi.org/10.1371/journal.pone.0096431

29. Wong A, Kraus PS, Lau BD, et al. Patient performances regarding pharmacologic venous thromboembolism prophylaxis. *J Hosp Med*. 2015;10(2):108-111.

30. Newman MJ, Kraus PS, Shermock KM, et al. Nonadministration of thromboprophylaxis in hospitalized patients with HIV: a missed opportunity for prevention? *J Hosp Med*. 2014;9(4):215-220. doi:10.1002/jhm.2156; 10.1002/jhm.2156.

31. Follmann D, Proschan M, Leifer E. Multiple outputation: inference for complex clustered data by averaging analyses from independent data. *Biometrics*. 2003;59(2):420-429.

32. Popoola VO, Lau BD, Shihab HM, et al. Patient Preferences for receiving education on venous thromboembolism prevention—A survey of stakeholder organizations. *PLoS One*. 2016;11(3): https://doi.org/10.1371/journal.pone.0152084

33. Clarkesmith DE, Pattison HM, Lip GY, Lane DA. Educational intervention improves anticoagulation control in atrial fibrillation patients: the treat randomised trial. *PLoS One*. 2013;(8):e74037.DOI: https://doi.org/10.1371/journal.pone.0074037

34. Ratanawongsa N, Karter AJ, Parker MM, et al. Communication and medication refill adherence: the diabetes study of northern California. *JAMA Intern Med*. 2013;(173):210-218.

35. Improving Patient-Nurse Communication to Prevent a Life-Threatening Complication. Patient-Centered Outcomes Research Institute (PCORI) website. http://www.pcori.org/research-in-action/improving-patient-nurse-communication-prevent-life-threatening-complication. Accessed June 2, 2015.

36. Blackwell B. Compliance. *Psychother Psychosom*. 1992;(58):161-169.

37. Farrimond H, Saukko PM, Qureshi N, Evans PH. Making sense of being at "high risk" of coronary heart disease within primary prevention. *Psychol Health*. 2010;(25):289-304.

38. Weinstein ND. Why it won't happen to me: perceptions of risk factors and susceptibility. *Health Psychol*. 1984;(3):431-457.

39. Tooher R, Middleton P, Pham C, et al. A systematic review of strategies to improve prophylaxis for venous thromboembolism in hospitals. *Ann Surg*. 2005;241(3):397-415.

40. Monn MF, Haut ER, Lau BD, et al. Is venous thromboembolism in colorectal surgery patients preventable or inevitable: one institution's experience. *J Am Coll Surg*. 2013;216(3):395-401.

41. Lau BD, Arnaoutakis GA, Streiff MB, et al. Individualized performance feedback to surgical residents improves appropriate venous thromboembolism (VTE) prophylaxis prescription and reduces potentially preventable VTE: a prospective cohort study. *Ann Surg*. In press.

42. Lau BD, Streiff MB, Pronovost PJ, Haider AH, Efron DT, Haut ER. Attending physician performance measure scores and resident physicians' ordering practices. *JAMA Surg*. 2015;150(8):813-814. PubMed PMID: 26083420.

43. Michtalik HJ, Carolan HT, Haut ER, et al. Use of provider-level dashboards and pay-for-performance in venous thromboembolism prophylaxis. *J Hosp Med*. 2015;10(3):172-178. PubMed PMID: 25545690. Pubmed Central PMCID: 4351181.

44. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001.

45. Brown JB, Stewart M, McWilliam CL. Using the patient-centered method to achieve excellence in care for women with breast cancer. *Patient Educ Couns*. 1999;38(2):121-129.

46. Stewart M, Brown JB, Donner A, et al. The impact of patient-centered care on outcomes. *J Fam Pract*. 2000;49(9):796-804.

47. Smith DH, Kramer JM, Perrin N, et al. A randomized trial of direct-to-patient communication to enhance adherence to beta-blocker therapy following myocardial infarction. *Arch Intern Med*. 2008;(168):477-483, discussion 483, quiz 447.

48. Lee JK, Grace KA, Taylor AJ. Effect of a pharmacy care program on medication adherence and persistence, blood pressure, and low-density lipoprotein cholesterol: a randomized controlled trial. *JAMA*. 2006;(296):2563-2571.

49. Colorado: The Foundation. Vascular Disease Foundation website. http://www.vdf.org/. Accessed November 20, 2008.

50. Le Sage S, McGee M, Emed JD. Knowledge of venous thromboembolism (VTE) prevention among hospitalized patients. *J Vasc Nurs*. 2008;26(4):109-117.

51. Marini BL, Funk K, Kraft MD, et al. The effects of an informational video on patient knowledge, satisfaction and compliance with venous thromboembolism prophylaxis: a pilot study. *Patient Educ Couns*. 2014;96(2):264-267.

52. Gottlieb LN, Rowat K. The McGill model of nursing: a practice-derived model. a perspective on health, family, learning and collaborative nursing McGill University School of Nursing, Montreal, Canada (2001) p. 253-63

53. Lau BD, Streiff MB, Hobson DB, et al. Beneficial “halo effects” of surgical resident performance feedback. *J Surg Res*. 2016;205(1):179-185

54. Institute of Medicine. *Envisioning the National Health Care Quality Report*. Washington, DC: National Academies Press; 2001.

**Appendix**

**Table 6. Baseline Demographic Characteristics of Patient Visits, by Arm**

| | **Dynamic Arm** (*n* = 2722) | **Static Arm** (*n* = 2603) |
|---|---|---|
| Unique patients | 1925 | 2021 |
| Mean age (SD), years | 55.6 (16.9) | 56.3 (17.3) |
| Sex, *n* (%) | | |
| Male | 1435 (52.7) | 1186 (45.6) |
| Female | 1287 (47.3) | 1417 (54.4) |
| Race, *n* (%) | | |
| Black | 1106 (40.6) | 980 (37.7) |
| White | 1367 (50.2) | 1396 (53.6) |
| Asian | 46 (1.7) | 50 (1.9) |
| Native American | 4 (0.2) | 7 (0.3) |
| Other | 199 (7.3) | 170 (6.5) |
| Median number of doses per patient (IQR) | 7 (3, 13) | 7 (3, 13) |
| Median length of stay, days (IQR) | 4 (2, 8) | 5 (2, 8) |

*Acknowledgement:*

*Research reported in this report was [partially] funded through a Patient-Centered Outcomes Research Institute® (PCORI®) Award (CE-12-11-4489). Further information available at:* https://www.pcori.org/research-results/2016/preventing-venous-thromboembolism-vte-engaging-patients-reduce-preventable