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## Barriers and facilitators to adopting high value practices and de-adopting low value practices in the Intensive Care Unit: A multi method study

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**Title:** Barriers and facilitators to adopting high value practices and de-adopting low value practices in the Intensive Care Unit: A multi method study

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## ABSTRACT

**Objective:** To compare and contrast illustrative examples of the adoption of high value practices and the de-adoption of low value practices.

**Design:** 1) Retrospective, population-based audit of low molecular weight heparin (LMWH) for venous thromboembolism (VTE) prophylaxis (high value practice) and albumin for fluid resuscitation (low value practice) and 2) Cross-sectional survey of healthcare providers.

**Setting:** Data were collected from nine adult medical-surgical ICUs in two large Canadian cities. Patients are managed in these ICUs by a group of multi-professional and multi-disciplinary healthcare providers.

**Participants:** Participants included 6946 ICU admissions and 309 healthcare providers from the same ICUs.

**Main Outcome Measures:** 1) The use of LMWH for VTE prophylaxis (percent ICU days) and albumin for fluid resuscitation (percent of patients); and 2) provider knowledge of evidence underpinning these practices, and barriers and facilitators to adopt and de-adopt these practices.

**Results:** LMWH was administered on 38.7% of ICU days, and 20.0% of patients received albumin.

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3 Most participants had knowledge of evidence underpinning VTE prophylaxis and fluid  
4 resuscitation (59.1% and 84.2%, respectively). Providers perceived these practices to  
5 be followed. The most commonly reported barrier to adoption was insufficient  
6 knowledge/understanding (32.8%), and to de-adoption was clinical leader preferences  
7 (33.2%). On-site education was the most commonly identified facilitator for adoption  
8 and de-adoption (67.8% and 68.6%, respectively).  
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19 **Conclusions:** Despite knowledge of and self-reported adherence to best practices,  
20 the audit demonstrated opportunity to improve. Provider-reported barriers and  
21 facilitators to adoption and de-adoption are broadly similar.  
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28 **KEY WORDS:** Intensive Care; Appropriateness, Under-use and Over-use; Healthcare  
29 System; Quality Improvement  
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### 34 **STRENGTHS & LIMITATIONS**

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37 • A strength of this study is the use of mixed-methods to comprehensively  
38 compare adoption of high value practices and de-adoption of low value  
39 practices in the ICU.  
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- 43  
44 • Another strength is the use of population-based data to capture current clinical  
45 practices.  
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- 48  
49 • A limitation of this study is related to the survey used to assess barriers and  
50 facilitators of the two illustrative practices; perfection was compromised to  
51 optimize the practicality of the survey.  
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- Another limitation is the comparison of two practices, which may account for some of the differences observed between adoption of the high value practice and de-adoption of the low value practice.
  - Our study provides several insights into similarities and differences between adoption of high value practices and de-adoption of low value practices.

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## INTRODUCTION

Optimizing the quality of care<sup>1</sup> is of particular importance in the intensive care unit (ICU) due to the acuity of patient illness and substantial resources required to care for these patients. However, it is estimated that practice change (adopting high value practices or de-adopting low value practices) can take up to 17 years.<sup>2</sup> To minimize the latency for change, it is important find ways to improve the implementation of evidence-based practices.

A growing body of evidence has evaluated barriers and facilitators for adopting high value practices (effective at improving outcomes).<sup>3-6</sup> Substantially less is known about the barriers and facilitators for de-adopting low value practices (ineffective at improving outcomes or harmful), and how they compare to those for adopting high value practices.<sup>7,8</sup> De-adoption is the discontinuation of a practice that has been previously adopted.<sup>9</sup> Terminology used to describe de-adoption is voluminous – over 43 terms have been identified, with little consensus on the most appropriate term.<sup>7</sup> Some have suggested that the adoption of high value practices and de-adoption of low value practices involve similar processes and common facilitators and barriers;<sup>10,11</sup> however, others suggest that the two are clearly distinct.<sup>8,12</sup> There has been limited comparative evaluation of adoption and de-adoption and this is an important knowledge gap given the growing number of initiatives aimed at de-adopting low value practices.<sup>13-16</sup>

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3 The two illustrative practices (one for adoption of a high value practice and one for de-  
4 adoption of a low value practice) used in our study were chosen by a network of  
5 medical-surgical ICUs based on published evidence and stakeholder engagement.<sup>17</sup>  
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8 The expanding evidence (randomized trials, a systematic review and meta-analysis,  
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10 and an economic evaluation)<sup>18-20</sup> suggests LMWH is a high value practice relative to  
11 unfractionated heparin (UFH) for VTE prophylaxis, which is also reflected in recent  
12 international and local clinical practice guidelines.<sup>21,22</sup> The evidence (multiple  
13  
14 randomized trials and a systematic review)<sup>23</sup> indicates that albumin is a low value  
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16 practice relative to crystalloids for fluid resuscitation. Patient and family  
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18 representatives, frontline providers and decision-makers considered the totality of the  
19  
20 evidence from a clinically grounded perspective (i.e., evaluated the evidence using a  
21  
22 patient-centred and healthcare focused perspective), and through validated  
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24 consensus methods chose low molecular weight heparin (LMWH) for venous  
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26 thromboembolism (VTE) prophylaxis and albumin for fluid resuscitation as illustrative  
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28 examples of adoption of a high value practice and de-adoption of a low value practice,  
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30 respectively.<sup>17</sup>  
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## 43 **METHODS**

### 44 **Aim**

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46 The objective of this study was to describe illustrative example practices of the  
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48 adoption of high value practices and the de-adoption of low value practices in the ICU.  
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50 The results of this study prompted a subsequent implementation study to improve  
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52 these two practices. The audit data identified important opportunities to improve  
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3 clinical care, and the perceived barriers and facilitators identified in the survey were  
4  
5 used to inform the development of interventions.  
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## 10 **Study design**

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12 This multi-method observational study included: 1) a retrospective cohort study of  
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14 patients admitted to ICUs to describe current VTE prophylaxis and fluid resuscitation  
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16 practices, and 2) a cross-sectional survey of ICU healthcare providers to examine:  
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18 knowledge of evidence underpinning these two practices, and perceived barriers and  
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20 facilitators to adopt LMWH for VTE prophylaxis and de-adopt albumin for fluid  
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22 resuscitation.  
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## 28 **Setting**

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30 All data were collected from nine adult medical-surgical ICUs in the two largest cities  
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32 in a Canadian province (population of 4.1 million). A single health services provider is  
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34 responsible for the provision of all hospital-based care in the province and uses a  
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36 single formulary across all ICUs (clinical practices may differ between cities and sites).  
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38 ICU patients are managed by a multi-disciplinary and multi-professional group of  
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40 healthcare providers, including (but not limited to): physicians, medical trainees  
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42 (clinical fellows and residents), nurse practitioners (NPs with prescribing privileges),  
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44 pharmacists, and nurses (managers, educators, bedside).  
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## 51 **Audit of current practices**

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54 Participants  
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3 We included patients admitted to nine adult medical-surgical ICUs between January 1,  
4 2014 and December 31, 2014. For analyses, patients were grouped into two cohorts.

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7 1) The adoption cohort consisted of patients without a contraindication for  
8 pharmacological VTE prophylaxis where according to international and local  
9 guidelines LMWH should be prescribed.<sup>18,21,22,24,25</sup> Contraindications to  
10 pharmacological prophylaxis included a diagnosis potentially associated with a high  
11 risk of bleeding (Supplemental Content 1), daily assessed platelet count  $<50 \times 10^9/L$ ,  
12 INR  $\geq 2$ , PTT  $\geq 55$  seconds, or receipt of therapeutic anti-coagulation.

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15 2) The de-adoption cohort consisted of patients without an indication for use of  
16 albumin for fluid resuscitation and where according to the current evidence-base  
17 albumin should not be used for fluid resuscitation.<sup>23,26-28</sup> Potential indications for  
18 albumin included documented liver disease (cirrhosis or hepatic failure), or receipt of  
19 plasma exchange.<sup>29-32</sup> The two study cohorts were drawn from the same patient  
20 population and patients satisfying both sets of clinical indications were included in  
21 both cohorts.

#### 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 Data source

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42 All nine ICUs employ a shared integrated, prospective, clinical information system that  
43 captures and delivers multimodal patient data (demographic, clinical, outcome) in real  
44 time to the bedside (eCritical MetaVision, iMDsoft, MetaVision), and is also a  
45 repository and clinical analytics system that stores these data (eCritical TRACER) to  
46 support quality improvement and clinical research. eCritical TRACER was used to  
47 extract all data.  
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## Variables

Patient and ICU demographic variables included age, sex, comorbidities, admission type, disease severity (APACHE II score), ICU and hospital length of stay, ICU and hospital mortality. Data abstracted included: 1) type of VTE prophylaxis (mechanical included antiembolic stockings and sequential compression devices, and pharmacological included UFH and LMWH), 2) ICU day that VTE prophylaxis was administered, 3) if the patient received albumin, 4) quantity (units) of albumin, and 5) ICU day that albumin was administered. An ICU day was defined as any portion of a day between 07:00 and 06:59, recognizing that follow-up time on admission day and discharge day may be less than 24 hours.

## Data analysis

Descriptive statistics (means with standard deviations [SD], medians with interquartile ranges [IQR], frequencies with proportions) were used to describe the two cohorts. The proportion of admissions and ICU days with LMWH, UFH, and mechanical VTE prophylaxis by ICU and ICU day; and with any albumin administration by ICU and patient were calculated to describe current clinical practices.

To examine potential associations between demographic and site-level factors, and the adoption of the high value practice (LMWH) a multivariable generalized estimating equations (GEEs) logistic regression model with exchangeable correlation structure given daily measurements (clustering by patient) was used. To examine potential

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3 associations between demographic and site-level factors, and the de-adoption of the  
4 low value practice (albumin) a multivariable logistic regression model given a single  
5 measurement per patient was used.  
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## 10 11 12 **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting** 13 **albumin for fluid resuscitation** 14

### 15 16 17 Survey development 18

19 The survey was modeled after previous work on adoption of LMWH for VTE  
20 prophylaxis,<sup>33</sup> and refined to include questions regarding fluid resuscitation. Because  
21 research around barriers and facilitators of de-adopting low value practices is in its  
22 infancy<sup>34</sup> the evidence of barriers and facilitators for adopting high value practices was  
23 employed.  
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32 The survey was divided into four sections: participant demographic information,  
33 knowledge of the current evidence underpinning the best practices, and perceptions  
34 of barriers and facilitators to the use of the two illustrative examples of best practices  
35 (Supplemental Content 2).  
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44 The survey was pilot tested in two phases: Phase 1) Seven providers completed the  
45 survey and identified unnecessary, missing, or poorly worded items. The survey was  
46 modified and pilot tested with 12 additional ICU providers (1 attending physician, 2  
47 residents, 1 clinical fellow, 1 nurse practitioner, 1 nurse manager/charge nurse, 1  
48 nurse educator, 2 bedside nurses, and 3 pharmacists). Phase 2) Providers completed  
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3 the survey twice (7-10 days apart) and an additional brief questionnaire to rate the  
4 clinical sensibility of the survey. Test-retest reliability of the survey demonstrated a  
5 mean intraclass correlation coefficient (ICC) of 0.66 (SD 0.47) for continuous  
6 responses and a mean proportion of agreement of 0.86 (SD 0.10) for categorical  
7 responses. The low ICC for continuous responses is due to low variability in  
8 responses for questions relating to knowledge of best practices. The participants  
9 agreed that the survey had face validity (100%), content validity (92%), clarity (92%),  
10 utility (100%), discriminability (75%), and minimal redundancy (100%).  
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## 24 Participants

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26 Healthcare providers (as described in Setting) that cared for patients in the nine ICUs  
27 were invited by email to participate in the study. Invitations to participate were sent to  
28 healthcare providers by the principal investigators or by a local clinical leader and  
29 included a link to the electronic survey (Fluid Survey) or were provided a paper copy if  
30 requested. Weekly reminders were sent for three weeks. Providers that responded to  
31 the survey were offered entry into a draw for one of three \$20 coffee gift cards.  
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## 42 Data Analysis

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44 We used descriptive statistics to describe demographic features of participants,  
45 knowledge of best practices, perceived barriers to adopting high value practices and  
46 de-adopting low value practices, perceived facilitators to encourage adopting high  
47 value practices and de-adopting low value practices. Barriers and facilitators to the  
48 use of best practices were described overall, and by professional group. Professions  
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3 were categorized into three groups for analysis: 1) Physicians/NPs (those who  
4 prescribe), 2) Nurses (those who administer), and 3) Pharmacists (those who advise  
5 prescribers). Chi-squared tests were used to test for statistical significance between  
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10 groups.

### 11 12 13 14 15 **Ethical considerations**

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17 This study was approved by the University of Calgary Conjoint Health Research  
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19 Ethics Board (REB14-0992 and REB15-2147) and the University of Alberta Research  
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21 Ethics Board (Pro00056709 and Pro00060650).  
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## 26 **RESULTS**

### 27 28 **Audit of current practices**

#### 29 30 **Patients**

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33 There were 6,946 ICU admissions during the study period, from 6,299 unique  
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35 patients. The typical ICU admission was a 60 (IQR=46-71) year old male (58.4%),  
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37 with at least one comorbidity (44.6%), and admitted for a medical reason (59.9%).  
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39 The median ICU and hospital length of stay were 3.7 (IQR=1.8-7.7) days, and 13.3  
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41 (IQR=6.1-29.5) days, respectively. ICU and hospital mortality were 14.1% and 21.0%,  
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43 respectively (Supplemental Content 3).  
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50 The adoption cohort consisted of 4,931 admissions (71.0% of all admissions) without  
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52 a contraindication to pharmacological VTE prophylaxis, and the de-adoption cohort  
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3 consisted of 6,467 admissions (93.1%) without a potential indication for albumin  
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5 (Figure 1).  
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#### 10 VTE prophylaxis (adoption cohort)

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12 During the ICU stay LMWH was given on 38.7% of ICU days, UFH on 45.3% of ICU  
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14 days and mechanical prophylaxis (exclusive of pharmacological prophylaxis) on 7.7%  
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16 of ICU days. The type of VTE prophylaxis administered varied throughout patients'  
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18 ICU stay; administration of mechanical devices and UFH decreased over the course  
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20 of the ICU stay while administration of LMWH increased (Figure 2).  
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#### 26 Albumin for fluid resuscitation (de-adoption cohort)

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28 6,804 units of albumin were administered to 20.0% of the 6,467 admissions without  
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30 documented liver disease or receipt of plasma exchange. Among those receiving at  
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32 least 1 unit of albumin, the median number of units per patient was 3 (IQR=1.0-6.0).  
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35 Albumin was administered on 6.5% of ICU days.  
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40 When controlling for demographic and site-level factors, there were no differences in  
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42 adoption or de-adoption based on patient age, sex, or comorbidity (Supplemental  
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44 Content 4). The odds of adopting LMWH for VTE prophylaxis and de-adopting  
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46 albumin for fluid resuscitation were significantly lower for those patients with higher  
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48 severity of illness (APACHE II score). The odds of adopting LMWH for VTE  
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50 prophylaxis were significantly higher for patients with non-surgical admissions  
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52 compared to those with elective surgical admissions (odds ratio = 1.34 (95%  
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3 confidence interval 1.08-1.66); Supplemental Content 4). There were significant  
4 differences in the odds of adopting LMWH for VTE prophylaxis, and de-adopting  
5 albumin for fluid resuscitation across ICUs (Supplemental Content 4 and 5).  
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## 10 11 12 **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting** 13 **albumin for fluid resuscitation** 14

### 15 16 17 Participants

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19 83.8% (259 of 309) of participants responded; physicians/NPs (48.3%), nurses  
20 (42.5%), and pharmacists (9.3%). Participants worked in healthcare for a median of  
21 13 years (IQR=7.1-20.0) and in critical care for a median of 8 years (IQR=3.0-15.0;  
22 Supplemental Content 6).  
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### 28 29 30 31 Knowledge of evidence

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33 Most participants reported that LMWH was most effective at preventing deep vein  
34 thrombosis and pulmonary embolism; and that crystalloids were most effective for fluid  
35 resuscitation (Table 1). Perceptions regarding the effectiveness of VTE prophylaxis  
36 varied by professional group, as did perceptions regarding the risks of harm (Table 1).  
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38 Perceptions regarding effectiveness of albumin for fluid resuscitation and risks of  
39 harm associated with each form of fluid resuscitation did not vary by professional  
40 group but perceptions regarding the risk of fluid overload did (Table 1).  
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49 It was perceived that both best practices were being followed in the ICUs where the  
50 participants practiced (Table 1).  
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**Table 1.** Knowledge of best practices for VTE prophylaxis and fluid resuscitation

Survey question	% (N)			
	Overall N=259	Physicians/NPs 48.3% (N= 125)	Nurses 42.5% (N= 110)	Pharmacists 9.3% (N= 24)
What form(s) of prophylaxis is/are most effective at preventing deep vein thrombosis?*				
LMWH only	59.1 (153)	63.2 (79)	51.8 (57)	70.8 (17)
UFH only	4.3 (11)	2.4 (3)	7.3 (8)	0.0 (0)
LMWH & UFH	16.2 (42)	24.0 (30)	5.5 (6)	25.0 (6)
Mechanical only	1.9 (5)	0.0 (0)	4.6 (5)	0.0 (0)
(LMWH or UFH) and Mechanical	15.1 (39)	8.0 (10)	25.5 (28)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
What form(s) of prophylaxis is/are most effective at preventing pulmonary embolism? *				
LMWH only	56.8 (147)	72.0 (90)	33.6 (37)	83.3 (20)
UFH only	18.2 (47)	1.6 (2)	40.9 (45)	0.0 (0)
LMWH & UFH	12.7 (33)	20.8 (26)	3.6 (4)	12.5 (3)
Mechanical only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
(LMWH or UFH) & Mechanical	8.5 (22)	3.2 (4)	15.5 (17)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
Which form(s) of prophylaxis is/are most cost effective?*				
LMWH only	51.0 (132)	70.4 (88)	22.7 (25)	79.2 (19)
UFH only	15.4 (40)	12.8 (16)	20.0 (22)	8.3 (2)
LMWH & UFH	4.3 (11)	5.6 (7)	0.9 (1)	12.5 (3)
Mechanical only	10.0 (26)	4.8 (6)	18.2 (20)	0.0 (0)
(LMWH or UFH) & Mechanical	2.7 (7)	0.0 (0)	6.4 (7)	0.0 (0)
Unsure only	16.6 (43)	6.4 (8)	31.8 (35)	0.0 (0)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of bleeding?†				
LMWH only	57.5 (149)	47.2 (59)	69.1 (76)	58.3 (14)
UFH only	24.7 (64)	32.8 (41)	18.2 (20)	12.5 (3)
LMWH & UFH	5.0 (13)	6.4 (8)	0.0 (0)	20.8 (5)
Unsure only	12.7 (33)	13.6 (17)	12.7 (14)	8.3 (2)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of heparin induced thrombocytopenia?*				

	LMWH only	86.1 (223)	94.4 (118)	74.6 (82)	95.8 (23)
	UFH only	6.6 (17)	3.2 (4)	11.8 (13)	0.0 (0)
	LMWH & UFH	0.4 (1)	0.0 (0)	0.0 (0)	4.2 (1)
	Unsure only	7.0 (18)	2.4 (3)	13.6 (15)	0.0 (0)
To what extent do you think best practices are followed for preventing DVT/PE in your ICU? 0=never and 7=always, Median (IQR)					
		6 (5-6)	6 (5-6)	6 (6-7)	6 (5-6)
<b>Survey question</b>	<b>Overall N=259</b>	<b>Physicians/NPs 48.3% (N= 125)</b>	<b>Nurses 42.5% (N= 110)</b>	<b>Pharmacists 9.3% (N= 24)</b>	
What form(s) of IV fluids is/are most effective for fluid resuscitation? ‡					
	Albumin only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
	Crystalloids only	84.2 (218)	83.2 (104)	82.7 (91)	95.8 (23)
	Albumin & Crystalloids	8.5 (22)	9.6 (12)	9.1 (10)	0.0 (0)
	Unsure only	3.9 (10)	4.8 (6)	2.7 (3)	4.2 (1)
Which form(s) of IV resuscitation fluids are most cost effective? ‡					
	Albumin only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
	Crystalloids only	94.6 (245)	94.4 (118)	95.5 (105)	91.7 (22)
	Albumin & Crystalloids	0.4 (1)	0.8 (1)	0.0 (0)	0.0 (0)
	Unsure only	4.6 (12)	4.8 (6)	3.6 (4)	8.3 (2)
Which form(s) of IV resuscitation fluids has the lowest risk of fluid overload? *					
	Albumin only	47.1 (122)	32.8 (41)	69.1 (76)	20.8 (5)
	Crystalloids only	29.7 (77)	36.8 (46)	23.6 (26)	20.8 (5)
	Albumin & Crystalloids	1.9 (5)	3.2 (4)	0.0 (0)	4.2 (1)
	Unsure only	21.2 (55)	27.2 (34)	7.3 (8)	54.2 (13)
Which form(s) of IV resuscitation fluids has the lowest risk of infectious disease? ‡					
	Albumin only	2.7 (7)	1.6 (2)	4.6 (5)	0.0 (0)
	Crystalloids only	86.5 (224)	87.2 (109)	87.3 (96)	79.2 (19)
	Albumin & Crystalloids	0.8 (2)	0.8 (1)	0.9 (1)	0.0 (0)
	Unsure only	10.0 (26)	10.4 (13)	7.3 (8)	20.8 (5)

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To what extent do you think best practices are followed for prescribing fluid boluses in your ICU? 0=never and 7=always; Median (IQR)			
	6 (5-6)	5 (5-6)	5 (5-6)

<sup>1</sup>Evidence suggests the efficacy of LMWH for deep vein thrombosis is similar to or better than UFH.<sup>19,20,24,25</sup> Evidence suggests that LMWH is more efficacious than UFH for preventing pulmonary embolism, has a lower incidence of heparin induced thrombocytopenia, and a similar or lower risk of bleeding.<sup>19,20,24,25</sup>

<sup>2</sup>Evidence suggests that LMWH is more cost effective than UFH.<sup>18</sup>

<sup>3</sup>Evidence suggests that albumin and crystalloids are similarly effective for fluid resuscitation.<sup>21, 24, 25, 26</sup> Evidence suggests that albumin has a higher risk of infectious disease transmission than crystalloids and is less cost-effective than crystalloids.

*Abbreviations: IQR* = interquartile range (p25 - p75), **LMWH** = low molecular weight heparin, **N** = number, **NP** = nurse practitioner, **UFH** = unfractionated heparin, \* = responses varied by professional group (p<0.001), † = responses varied by professional group (p=0.01), ‡ = responses did not vary by professional group (p>0.05)

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5 Barriers to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
6 resuscitation  
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10 Barriers to adoption and de-adoption were reported by 65.2% and 64.9% of  
11 respondents, respectively. The most commonly reported perceived barriers to  
12 adopting LMWH for VTE prophylaxis were insufficient knowledge or understanding,  
13 ICU culture, and no clinical guidelines (Figure 3). The most commonly reported  
14 barriers to de-adopting albumin for fluid resuscitation were a strong clinical preference  
15 of the local clinical leaders in the ICUs, ICU culture, and insufficient knowledge or  
16 understanding (Figure 3). Reported barriers differed between professional groups for  
17 both adoption (Supplemental Content 7) and de-adoption (Supplemental Content 8).  
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31 Facilitators to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
32 resuscitation  
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35 On site education and pre-set orders were perceived to be the most commonly  
36 reported facilitator of both adoption and de-adoption (Figure 4). Verbal reminders  
37 from pharmacists to physicians was commonly reported as a perceived facilitator for  
38 adopting LMMH for VTE prophylaxis. A local leader championing the practice was  
39 commonly reported as a perceived facilitator for de-adopting albumin for fluid  
40 resuscitation (Figure 4). There was no variability by professional group.  
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## 51 **DISCUSSION**

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3 The present study identified opportunities to improve the adoption of an illustrative  
4 high value practice (LMWH for VTE prophylaxis) and de-adoption of an illustrative low  
5 value practice (albumin for fluid resuscitation). Our audit data demonstrated that  
6 practices do not reflect providers' understanding of the evidence for these practices.  
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8 Both adoption and de-adoption of the illustrative example practices were less likely for  
9 patients with greater severity of illness and varied across institutions. The perceived  
10 barriers and facilitators to adoption and de-adoption were broadly similar.  
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21 Are de-adoption and adoption just the flip-side of the same coin? There is substantial  
22 literature describing the adoption of high value practices, but much less is known  
23 about de-adoption of low value practices; such that even consistent terminology to  
24 describe the process has yet to be agreed upon.<sup>7</sup> Science can inform clinical practice  
25 through discovery resulting in adoption of a new practice, replacement resulting in a  
26 practice update, and reversal resulting in de-adoption of an existing practice. It is only  
27 recently that the last concept, de-adopting low value practices, has been debated in  
28 journals and by professional societies.<sup>13,14,16</sup> The practical implication is that there is  
29 limited evidence to inform whether the barriers and facilitators for adoption and de-  
30 adoption are similar or sufficiently distinct to warrant different approaches.<sup>8,10-12</sup> Our  
31 study adds to the limited evidence base by suggesting that culture or organizational  
32 factors, provider characteristics, and patient characteristics are perceived to be  
33 important barriers and facilitators that may play broadly similar roles in adoption and  
34 de-adoption.<sup>10,11</sup>  
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3 Knowledge translation (KT) interventions; strategies to improve the synthesis,  
4 dissemination, exchange, and application of evidence to improve health,<sup>4</sup> tailored to  
5 the specific barriers and facilitators of an innovation and the local context are more  
6 likely to effect change.<sup>4,5</sup> Our study provides insight into the perceived barriers and  
7 facilitators of adopting high value practices (LMWH for VTE prophylaxis) and de-  
8 adopting low value practices (albumin for fluid resuscitation) within ICUs, which should  
9 be taken into consideration when designing KT interventions. Interestingly, despite  
10 knowledge of the evidence underlying the illustrative example practices, providers  
11 perceived insufficient knowledge or understanding to be a barrier and perceived  
12 education to be a facilitator to both adopting high value practices and de-adopting low  
13 value practices. These barriers and facilitators are consistent with a systematic review  
14 that suggests the most effective KT interventions in the ICU employ a combination of  
15 education and protocols.<sup>35</sup> While consistent with previous KT studies, this finding is  
16 paradoxical. It is possible that while knowledgeable, providers' confidence in applying  
17 their knowledge clinically was low and they believed education to be the intervention  
18 needed to improve their confidence in applying their knowledge. Furthermore,  
19 confidence in applying new evidence in clinical practice may be particularly  
20 challenging in the care of severely ill patients. This hypothesis is supported by two of  
21 our findings: 1) adoption of LMWH for VTE prophylaxis and de-adoption of albumin for  
22 fluid resuscitation was inversely associated with severity of patient illness and 2)  
23 adoption of LMWH and de-adoption of albumin increased as the patient became more  
24 stable (over ICU stay). Both observations suggest that clinicians may employ  
25 conservative decision-making when caring for sicker patients. The implications are

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3 that KT interventions should consider clinician heuristics that are likely to be  
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5 influenced by the nature and severity of patient illness.  
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10 Our study suggests that factors other than knowledge may contribute to the  
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12 successful adoption of high value practices and de-adoption of low value practices,  
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14 which includes culture, providers, and the innovation. These factors have previously  
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16 been identified within the context of the ICU.<sup>36-42</sup> ICU culture and local clinical leader  
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18 preferences were among the most commonly endorsed barriers to adopting high  
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20 value practices and de-adopting low value practices in this study and in our study as  
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22 highlighted by the variation in the adoption of LMWH between sites. Interestingly, this  
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24 finding was less pronounced for de-adoption, which has been previously reported.<sup>8</sup>  
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27 Culture, also referred to as organizational context, is a frequently cited barrier to  
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29 evidence-based medicine and can have a profound effect on clinical practice.<sup>6,43</sup>  
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32 However, few studies have systematically evaluated the effect of culture on adopting  
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34 high value practices and de-adopting low value practices, and implementation studies  
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36 infrequently account for the effect of culture on their practice change interventions.<sup>44</sup>  
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39 Similarly, the professional role of the provider is not often contextualized but may be  
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41 important (e.g., should pharmacists and nurses be targeted in KT interventions  
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43 designed to change the prescribing patterns of physicians and if so how?).<sup>45</sup> This may  
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45 be especially relevant as healthcare delivery becomes increasingly multi-professional  
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47 and team-based as illustrated in our setting (ICU).  
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3 The characteristics of innovations themselves may influence change in clinical  
4 practice. Evidence suggests that if the innovation being adopted is congruent with  
5 clinical practice beliefs it can facilitate adoption.<sup>6</sup> Furthermore, the quality, quantity,  
6 and stability of available evidence to support the adoption or de-adoption of an  
7 innovation is likely important.<sup>46</sup> Although most providers in our study were aware of  
8 the evidence to support the adoption of LMWH for VTE prophylaxis and de-adoption  
9 of albumin for fluid resuscitation, they may not have perceived the evidence to be  
10 sufficient to warrant practice change. A growing awareness of challenges with  
11 reproducing scientific evidence and clinician experience with practice reversals<sup>42</sup> may  
12 result in more conservative provider behavior and slower practice change in response  
13 to new evidence. The suboptimal prescribing practices observed in our study likely  
14 represent a combination of all these factors.

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33 One limitation of this study is the use of an electronic medical record as the data  
34 source, which provides population-based data, but may not capture all possible  
35 indications for the failure to adopt high value practices and the use of low value  
36 practices (i.e., patient, provider, and organizational factors). Secondly, the survey  
37 used in this study is imperfect. The results of the self-reported survey reflect  
38 perceived modifiers of practice among providers who had knowledge of the evidence  
39 underpinning these two illustrative example practices, rather than factors shown to  
40 influence practice patterns as identified in observational studies.<sup>47</sup> The survey was  
41 purposefully designed to be simple and accessible to garner a representative  
42 perspective from all provider professions and therefore lacks granularity.



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3 Nevertheless, the survey has been successfully used for a similar purpose by  
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5 others;<sup>33</sup> was reliable and reported to have good clinical sensibility. Thirdly, while this  
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7 study was a provincial and multi-site it was constrained to ICUs, which should be  
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9 taken into consideration when interpreting our findings beyond this setting.  
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15 In conclusion, our study provides several insights into similarities and differences  
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17 between adoption of high value practices and de-adoption of low value practices. Both  
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19 adoption and de-adoption of the illustrative practices did not reflect healthcare  
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21 providers' knowledge of the evidence. Both adoption and de-adoption of the were  
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23 less likely for patients with greater severity of illness and varied across institutions. We  
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25 found that perceived barriers and facilitators are more similar than different between  
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27 adoption and de-adoption, which suggests existing behavior change frameworks for  
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29 adopting high value practices may also be applicable for de-adopting low value  
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31 practices.  
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## **DISCLOSURE OF CONFLICT OF INTERESTS**

The authors declare that they have no competing interests.

## **AUTHORS' CONTRIBUTIONS**

Dr. Sauro contributed to the design and conceptualization of the study; analysis and interpretation of the data, drafting and revising the manuscript and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Bagshaw contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Niven contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

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7 conflicts of interest to declare.  
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16 conflicts of interest to declare.  
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43 version of the manuscript. No conflicts of interest to declare.  
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4 **Figure 1.** The flow of patients into the ICU and into the adoption and de-adoption  
5 cohorts.  
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8 *Abbreviations:* ICU: intensive care unit; VTE: venous thromboembolism; LMWH:  
9 low molecular weight heparin  
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3 **Figure 2.** The proportion of patients receiving mechanical, unfractionated, and  
4 low molecular weight heparin for venous thromboembolism prophylaxis over time  
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8 (by intensive care unit patient day).  
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For peer review only



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3 **Figure 3.** Barriers to the adoption of high value practices (low molecular weight  
4 heparin for venous thromboembolism prophylaxis) and de-adoption of low value  
5 practices (albumin for fluid resuscitation)  
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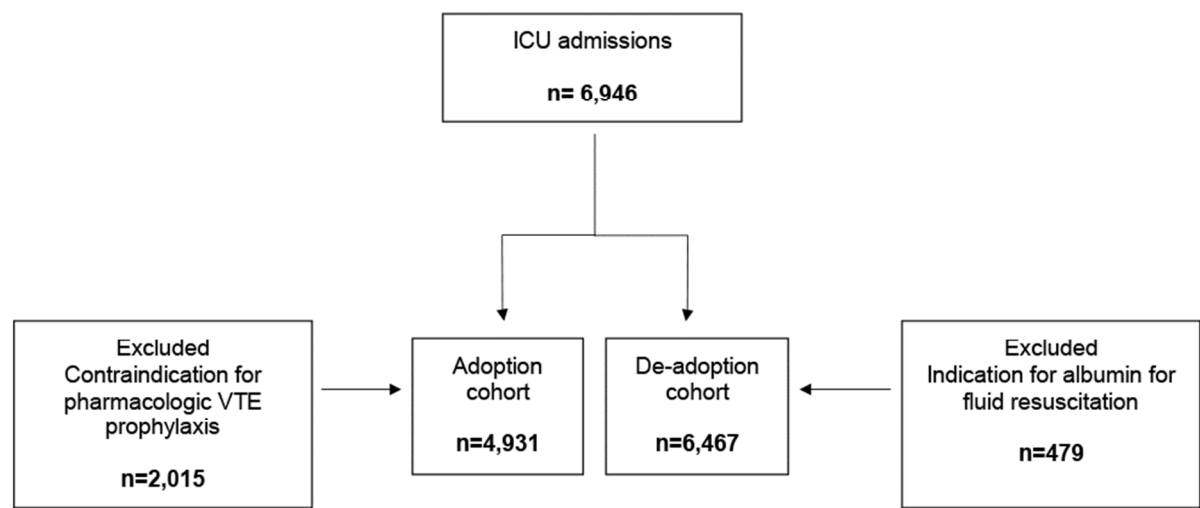
For peer review only

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3 **Figure 4.** Facilitators to the adoption of high value practices (low molecular  
4 weight heparin for venous thromboembolism prophylaxis) and de-adoption of low  
5 value practices (albumin for fluid resuscitation).  
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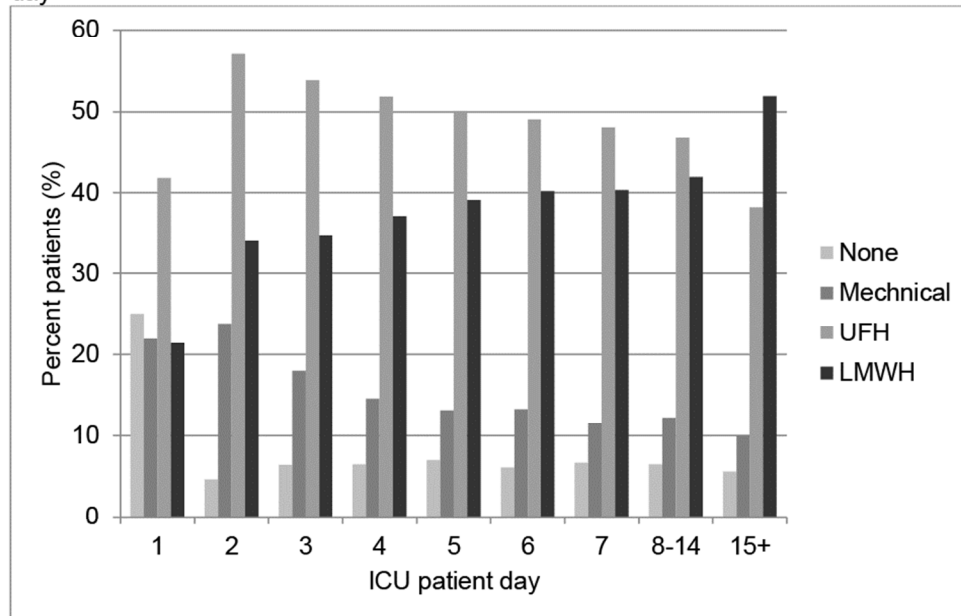
**Figure 1. Flow of patients**



*Footnote:* Adoption cohort = Recommended to receive LMWH for VTE prophylaxis; de-adoption cohort = Recommended to NOT receive albumin for fluid resuscitation

For review only

**Figure 1.** Venous thromboembolism prophylaxis by intensive care unit patient day



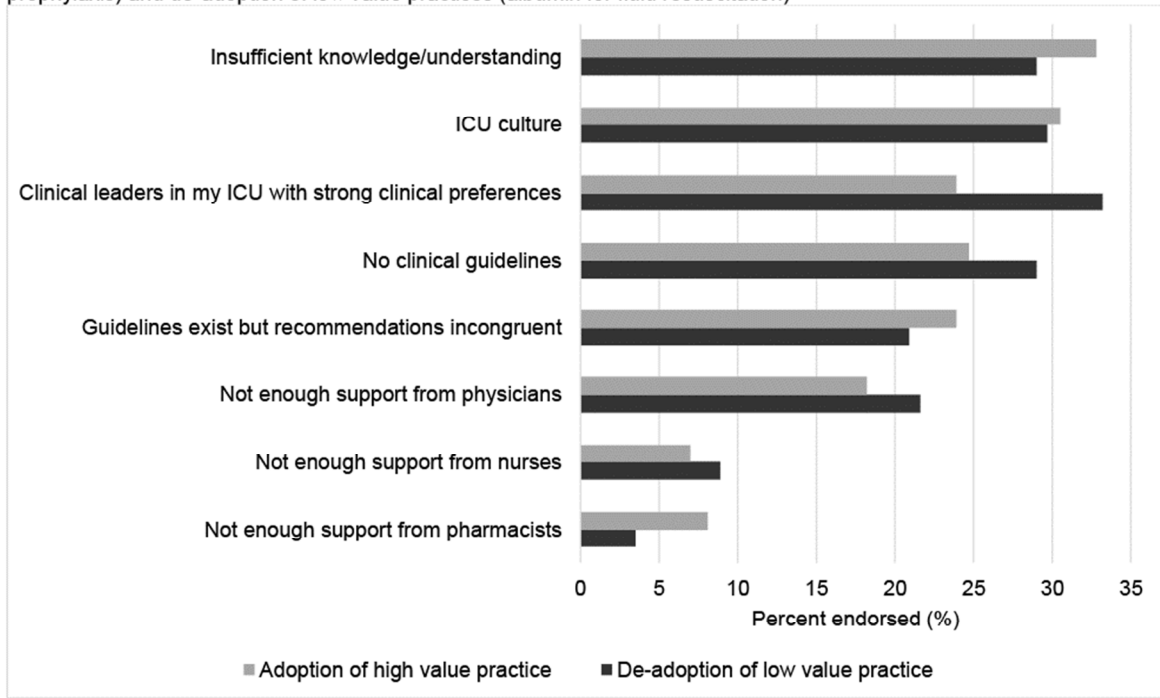
*Footnote:* Percent of patients may add to greater than 100% because patients may have received more than one form of venous thromboembolism prophylaxis on a given patient day.

*Abbreviation:* ICU=intensive care unit, LMWH=low molecular weight heparin, UFH=unfractionated heparin

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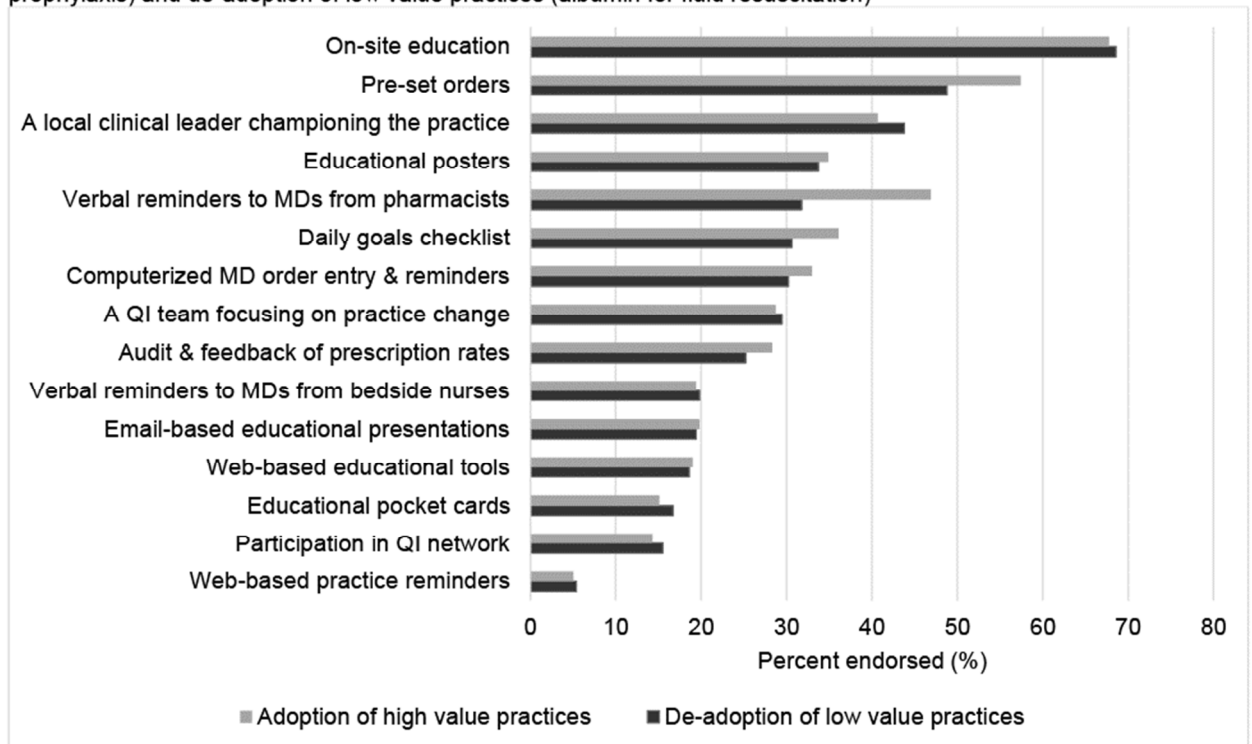
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**Figure 3.** Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)



Review only

**Figure 4.** Facilitators to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)

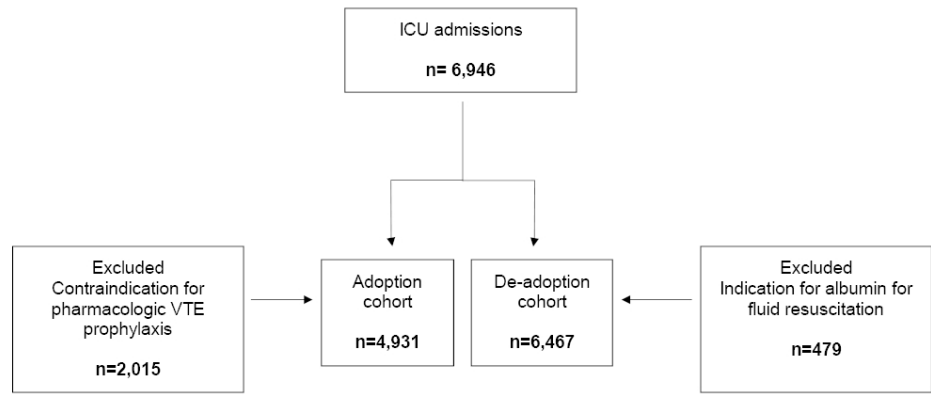


Abbreviation: MD=medical doctor, QI=quality improvement

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Figure 1. Flow of patients

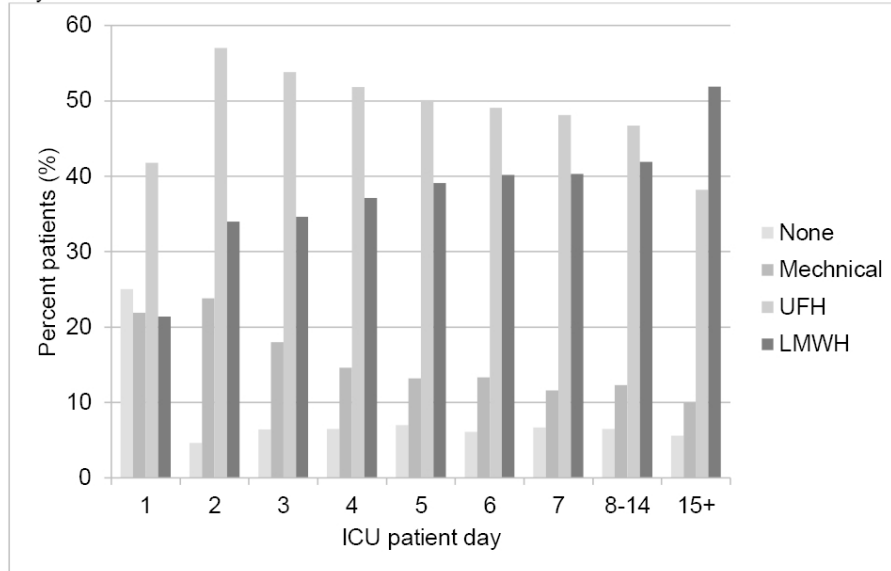


Footnote: Adoption cohort = Recommended to receive LMWH for VTE prophylaxis; de-adoption cohort = Recommended to NOT receive albumin for fluid resuscitation

Figure 1. The flow of patients into the ICU and into the adoption and de-adoption cohorts. Abbreviations: ICU: intensive care unit; VTE: venous thromboembolism; LMWH: low molecular weight heparin

90x50mm (300 x 300 DPI)

**Figure 1.** Venous thromboembolism prophylaxis by intensive care unit patient day



*Footnote:* Percent of patients may add to greater than 100% because patients may have received more than one form of venous thromboembolism prophylaxis on a given patient day.

*Abbreviation:* ICU=intensive care unit, LMWH=low molecular weight heparin, UFH=unfractionated heparin

**Figure 2.** The proportion of patients receiving mechanical, unfractionated, and low molecular weight heparin for venous thromboembolism prophylaxis over time (by intensive care unit patient day).

90x80mm (300 x 300 DPI)



**Figure 3.** Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)

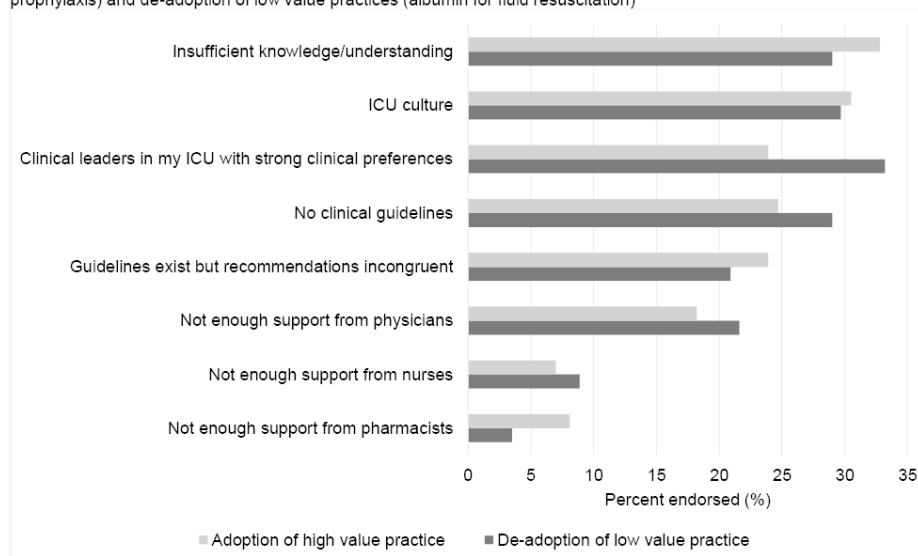
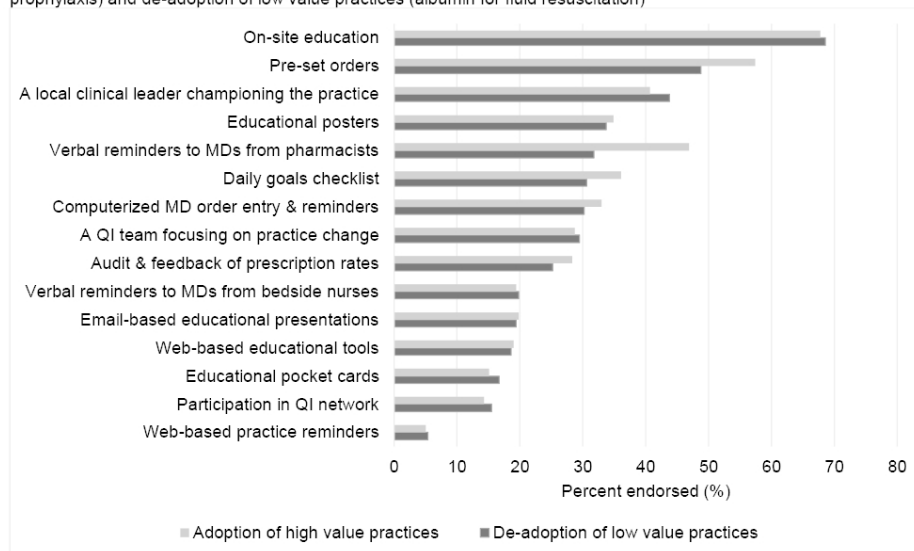


Figure 3. Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)

90x60mm (300 x 300 DPI)

**Figure 4.** Facilitators to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)



Abbreviation: MD=medical doctor, QI=quality improvement

Figure 4. Facilitators to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation).

90x63mm (300 x 300 DPI)

**Supplemental Digital Content 1.** List of diagnoses with a potential contraindication to receive pharmacological venous thromboembolism prophylaxis or indication for therapeutic anticoagulation\*

Arteriovenous malformation, surgery for
Embolus, pulmonary
GI Vascular insufficiency
Grafts, removal of infected vascular
Neoplasm, neurologic
Neoplasm-cranial, surgery for (excluding transphenoidal)
Neoplasm-spinal cord surgery or other related procedures
Neurologic surgery, other
Subarachnoid hemorrhage/intracranial aneurysm
Subarachnoid hemorrhage/intracranial aneurysm, surgery for
Thrombosis, vascular (deep vein)
Transphenoidal surgery
Ulcer disease, peptic
Abdomen only trauma
Abdomen only trauma, surgery for
Abdomen/extremity trauma
Abdomen/extremity trauma, surgery for
Abdomen/face trauma
Abdomen/face trauma, surgery for
Abdomen/multiple trauma
Abdomen/multiple trauma, surgery for
Abdomen/pelvis trauma, surgery for
Abscess/infection-cranial, surgery for
Anastomosis, vascular
Aneurysm, abdominal aortic
Aneurysm, abdominal aortic; with dissection
Aneurysm, abdominal aortic; with rupture
Aneurysm, dissecting aortic
Aneurysm, thoracic aortic
Aneurysm, thoracic aortic; with dissection
Aneurysm, thoracic aortic; with rupture
Aneurysm/pseudoaneurysm, other
Aneurysms, repair of other (except ventricular)
Biopsy, brain
Bleeding, GI from esophageal varices/portal hypertension
Bleeding, GI-location unknown
Bleeding, lower GI
Bleeding, upper GI
Bleeding-lower GI, surgery for
Bleeding-other GI, surgery for
Bleeding-upper GI, surgery for

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3	Burr hole placement
4	CABG alone, coronary artery bypass grafting
5	CVA, cerebrovascular accident/stroke
6	Chest/abdomen trauma
7	Chest/abdomen trauma, surgery for
8	Chest/extremity trauma
9	Chest/extremity trauma, surgery for
10	Chest/face trauma
11	Chest/face trauma, surgery for
12	Chest/multiple trauma
13	Chest/multiple trauma, surgery for
14	Chest/pelvis trauma
15	Chest/pelvis trauma, surgery for
16	Chest/spinal trauma
17	Chest/spinal trauma, surgery for
18	Chest/thorax only trauma
19	Chest/thorax only trauma, surgery for
20	Coagulopathy
21	Complications of prev. peripheral vasc. surgery, surgery for (i.e.ligation of bleeder, exploration and evacuation of hematoma, debridement, pseudoaneurysms, clots, fistula, etc.)
22	Complications of previous GI surgery; surgery for (anastomotic leak, bleeding, abscess, infection, dehiscence, etc.)
23	Complications of previous spinal cord surgery, surgery for
24	Cranioplasty and complications from previous craniotomies
25	Head (CNS) only trauma
26	Head (CNS) only trauma, surgery for
27	Head/abdomen trauma
28	Head/abdomen trauma, surgery for
29	Head/chest trauma
30	Head/chest trauma, surgery for
31	Head/extremity trauma
32	Head/extremity trauma, surgery for
33	Head/face trauma
34	Head/face trauma, surgery for
35	Head/multiple trauma
36	Head/multiple trauma, surgery for
37	Head/pelvis trauma
38	Head/pelvis trauma, surgery for
39	Head/spinal trauma
40	Head/spinal trauma, surgery for
41	Hematoma, epidural
42	Hematoma, epidural, surgery for
43	Hematoma, subdural
44	Hematoma, subdural, surgery for
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3	Hematomas
4	Hemorrhage (for gastrointestinal bleeding GI-see GI system) (for trauma see
5	Trauma)
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7	Hemorrhage, intra/retroperitoneal
8	Hemorrhage, postpartum (female only)
9	Hemorrhage/hematoma, intracranial
10	Hemorrhage/hematoma-intracranial, surgery for
11	Hemorrhage/hemoptysis, pulmonary
12	
13	Hemothorax
14	Pelvis/extremity trauma
15	Pelvis/extremity trauma, surgery for
16	Pelvis/face trauma
17	Pelvis/hip only trauma, surgery for
18	Pelvis/multiple trauma, surgery for
19	
20	Pelvis/spinal trauma
21	Pericardial effusion/tamponade
22	Renal bleeding
23	Spinal cord only trauma, surgery for
24	Spinal cord surgery, other
25	
26	Stereotactic procedure
27	Subarachnoid hemorrhage/arteriovenous malformation
28	Tamponade, pericardial

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*\*Footnote:* The primary diagnoses were reviewed independently by two ICU physicians (HTS, DJN). The two ICU physicians provided their judgment to establish a conservative list of primary diagnoses in order to exclude patients that may have a contraindication for pharmacological VTE prophylaxis based on bleeding risk and an indication for therapeutic anticoagulation. Discrepancies were resolved by discussion.



## Adopting Best Practices in DVT/PE Prophylaxis and Fluid Resuscitation in Critical Care

[http://fluidsurveys.com/s/ECG\\_facilitators\\_barriers\\_survey/](http://fluidsurveys.com/s/ECG_facilitators_barriers_survey/)

### **Informed Consent**

This survey is to identify and evaluate barriers to, and facilitators of, best practices in:

1. Deep Vein Thrombosis (DVT) / Pulmonary Embolism (PE) prophylaxis for medical-surgical ICU patients, and
2. Fluid Resuscitation for medical-surgical ICU patients *without* liver disease, bacterial peritonitis, hepatorenal syndrome or therapeutic paracentesis.

**This survey is not about trauma, neurosurgery or cardiac surgery patients.** Survey responses will be used to develop interventions to facilitate the adoption of best practices in Alberta ICUs.

You are being asked to take part in this survey because you are a healthcare professional working in adult critical care in Alberta. Our survey can be answered in approximately **5 minutes**. There are no direct benefits and/or risks to your participation.

Survey respondents can choose to have their name entered into a draw for *\$20 Starbucks gift cards* (one name will be drawn per week; non-winners will remain in the draw each week).

Your participation in this survey is voluntary and you are free to stop at any time. Your responses will be kept confidential. Your de-identified data will be stored in a password-protected database, and responses will only be presented in aggregate. The survey has peer-reviewed funding and has received ethics approval from the University of Calgary. **Your decision to complete and submit this survey will indicate your consent to participate.** Should you decide to withdraw your participation before submitting the survey, your data will be deleted.

If you have questions about this survey or your participation, please contact:

Rebecca Brundin-Mather, Research Coordinator, at [brundin@ucalgary.ca](mailto:brundin@ucalgary.ca).

If you have questions about your rights as a participant, you may contact the University of Calgary Conjoint Research Ethics Board at (403) 220-7990. This office is not affiliated with the study team.

Thank you in advance for taking the time to complete the survey!

Kind regards,

Tom Stelfox, MD, PhD, FRCPC

Intensive Care Physician

Scientific Director, AHS, Critical Care Strategic Clinical Network

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I agree to participate in this survey       I do **NOT** wish to participate in this survey (online-version)

## Demographics

### 1. What is your professional group?

- ICU physician       Nurse Clinician       Pharmacist  
 ICU resident       Nurse Educator       Other: \_\_\_\_\_  
 ICU fellow       Bedside Nurse

### 2. Approximately how many years have you worked in:

Health care       Critical care

### 3. In which hospital(s) do you primarily work? (Select all that apply)

- Chinook Regional Hospital  
 Foothills Medical Centre  
 Grand Prairie QE II Hospital  
 Grey Nuns Hospital  
 Medicine Hat Regional Hospital  
 Misericordia Hospital  
 Northern Lights Regional Health Centre  
 Peter Lougheed Centre  
 Red Deer Regional Hospital  
 Rockyview General Hospital  
 Royal Alexander Hospital  
 South Health Campus  
 Sturgeon Community Hospital  
 University of Alberta Hospital

**DVT/PE Prevention**

We are interested in your perceptions of the different forms of prophylaxes commonly used to prevent Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE) in medical-surgical ICU patients (not trauma, neurosurgery or cardiac surgery patients). Common prophylaxes include:

- Low molecular weight heparin (**LMWH** e.g., Enoxaparin, Dalteparin, Tinzaparin)
- Unfractionated heparin (**UFH**, regular Heparin)
- **Mechanical** prophylaxis (i.e., sequential compression devices)

We appreciate that practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

4. Which form(s) of prophylaxis is/are most effective at preventing:

	LMWH	UFH	Mechanical	Unsure
Deep Vein Thrombosis (DVT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pulmonary Embolism (PE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Which form(s) of prophylaxis is/are most cost-effective?

LMWH	UFH	Mechanical	Unsure
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Which form(s) of *pharmacological* prophylaxis has/have the lowest risk of:

	LMWH	UFH	Unsure
Bleeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heparin Induced Thrombocytopenia (HIT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. To what extent do you think best practices for preventing DVT/PE are followed in your ICU (i.e., the patient receives the right prophylaxis with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>	<b>Sometimes</b>			<b>Always</b>			



## **Intravenous Fluid Resuscitation**

We are now interested in your perceptions of the different types of intravenous fluids commonly used for fluid resuscitation (i.e., fluid boluses) in the ICU for medical-surgical patients, **excluding** patients with liver disease, bacterial peritonitis, or undergoing therapeutic paracentesis as they may have different fluid needs. Common resuscitation fluids include:

- **Human Albumin** (Albumin 5% or Albumin 25%)
- **Crystalloid solutions** (e.g., normal saline, ringers lactate, and plasma-lyte)

Again, we appreciate that clinical practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

8. Which form(s) of IV resuscitation fluid is/are most effective for resuscitation?

Albumin                       Crystalloids                       Unsure

9. Which form(s) of IV resuscitation fluid(s) is/are most cost-effective?

Albumin                       Crystalloids                       Unsure

10. Which form(s) of IV resuscitation fluid(s) has/have the lowest risk of:

	Albumin	Crystalloids	Unsure
Fluid overload (peripheral / pulmonary)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Contracting an infectious disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. To what extent do you think *best practices* for prescribing fluid boluses are followed **in your ICU** (i.e., the patient receives the right fluid with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>			<b>Sometimes</b>			<b>Always</b>	

**Barriers to Best Practices**

A number of ICU or ‘systems’ factors have been identified as potential barriers to best practices. We are interested in what you think are barriers **in your ICU** to prescribing:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

12. Which of the following factors are current barriers in your ICU to prescribing...

	LMWH over UFH		Crystalloids over Albumin	
	Current Barrier	Unsure	Current Barrier	Unsure
An ICU culture with an unclear or slow process for practice change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from physicians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from nurses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from pharmacists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clinical leaders in my ICU with strong clinical preferences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No clinical guidelines or orders sets in my ICU to guide the practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guidelines exist in my ICU, but they do not recommend LMWH over UFH / crystalloids over albumin	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Insufficient knowledge/understanding the evidence base for the practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>None</b> of the above factors are current barriers in my ICU to prescribing....	<input type="radio"/>		<input type="radio"/>	
Please note any other factors that may be barriers to prescribing LMWH over UFH and/or crystalloids over albumin. Specify below.				

### **Strategies to Encourage Best Practices**

A number of strategies have been identified as potential facilitators to changing clinical practice. We are interested in your perceptions of different strategies that have been used to encourage:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

13. Which of the following strategies are currently used in your ICU to encourage...

	<b>LMWH over UFH</b>	<b>Crystalloids over Albumin</b>
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="radio"/>	<input type="radio"/>
2. Educational posters (in the unit)	<input type="radio"/>	<input type="radio"/>
3. Educational pocket cards	<input type="radio"/>	<input type="radio"/>
4. Email-based educational presentations	<input type="radio"/>	<input type="radio"/>
5. Web-based educational tools	<input type="radio"/>	<input type="radio"/>
6. Verbal reminders to physicians from pharmacists	<input type="radio"/>	<input type="radio"/>
7. Verbal reminders to physicians from bedside nurses	<input type="radio"/>	<input type="radio"/>
8. Pre-set orders	<input type="radio"/>	<input type="radio"/>
9. Computerized physician order entry & reminders	<input type="radio"/>	<input type="radio"/>
10. Web-based practice reminders	<input type="radio"/>	<input type="radio"/>
11. Daily goals checklist	<input type="radio"/>	<input type="radio"/>
12. Audit & feedback of prescription rates	<input type="radio"/>	<input type="radio"/>
13. A quality improvement team focusing on practice change	<input type="radio"/>	<input type="radio"/>
14. Participation in a quality improvement network	<input type="radio"/>	<input type="radio"/>
15. A local clinical leader championing the practice	<input type="radio"/>	<input type="radio"/>
16. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
17. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
<b>NO</b> strategies are currently being used in my ICU encourage this practice:	<input type="radio"/>	<input type="radio"/>

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14. From the same list of strategies, please select the **5 best strategies** that you believe would work **in your ICU** to encourage:

(1) LMWH over UFH for DVT/PE prophylaxis

(2) Crystalloid solutions over Albumin for fluid resuscitation

(Select up to 5 strategies, regardless whether the strategy is used in your ICU or not)

**Select up to 5 in each column**

Strategy to change clinical practice	LMWH over UFH	Crystalloids over Albumin
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="checkbox"/>	<input type="checkbox"/>
2. Educational posters (in the unit)	<input type="checkbox"/>	<input type="checkbox"/>
3. Educational pocket cards	<input type="checkbox"/>	<input type="checkbox"/>
4. Email-based educational presentations	<input type="checkbox"/>	<input type="checkbox"/>
5. Web-based educational tools	<input type="checkbox"/>	<input type="checkbox"/>
6. Verbal reminders to physicians from pharmacists	<input type="checkbox"/>	<input type="checkbox"/>
7. Verbal reminders to physicians from bedside nurses	<input type="checkbox"/>	<input type="checkbox"/>
8. Pre-set orders	<input type="checkbox"/>	<input type="checkbox"/>
9. Computerized physician order entry & reminders	<input type="checkbox"/>	<input type="checkbox"/>
10. Web-based practice reminders	<input type="checkbox"/>	<input type="checkbox"/>
11. Daily goals checklist	<input type="checkbox"/>	<input type="checkbox"/>
12. Audit & feedback of prescription rates	<input type="checkbox"/>	<input type="checkbox"/>
13. A quality improvement team to focus on practice change	<input type="checkbox"/>	<input type="checkbox"/>
14. Participation in a quality improvement network	<input type="checkbox"/>	<input type="checkbox"/>
15. A local clinical leader to champion the practice	<input type="checkbox"/>	<input type="checkbox"/>
16. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>
17. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>

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3 15. Finally, please provide any additional comments in the text box below.  
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16 draws and/or to receive the study results.  
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- 19  Yes, I would like my name entered in the coffee card draws.  
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21  Yes, I would like to receive the results from this study.  
22  
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25 My email address is:  
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27  
28 N.B. E-mail addresses will be kept confidential and will not be used to contact you for any  
29 reason other than those noted above.  
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36 ---End of Survey ---  
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39  
40 **Thank you for helping us improve care!**  
41  
42

43 **Please return completed surveys to:**  
44

45 Dr. Tom Stelfox  
46 Department of Critical Care Medicine  
47 Foothills Medical Centre  
48

49 **OR**

45 Rebecca Brundin-Mather  
46 Ward of the 21<sup>st</sup> Century  
47 GD01 Teaching, Research, Wellness Bldg  
48 University of Calgary, 3280 Hospital Dr NW  
49 Calgary, AB T2N 4Z6  
50  
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**Supplemental Digital Content 3.** Intensive care unit patient characteristics for the study period (January 1, 2014-December 31, 2014)

<b>Demographic variable</b>	<b>Population (N=6,946)</b>	<b>Adoption cohort 70.7% (N=4,931)</b>	<b>De-adoption cohort 93.1% (N=6,467)</b>
Age, median (IQR)	60 (46-71)	61 (47-71)	61 (46-71)
Female	41.6 (2,888)	43.3 (2,134)	41.8 (2,703)
Comorbidities			
AIDS	0.6 (42)	0.7 (33)	0.5 (35)
Chronic dialysis	3.5 (240)	3.8 (186)	3.5 (225)
Chronic heart failure	6.4 (444)	7.4 (364)	6.5 (419)
Cirrhosis	5.9 (407)	6.0 (294)	0.0 (0)
Diabetes	19.7 (1,366)	21.6 (1,065)	19.9 (1,284)
Hepatic failure	3.9 (269)	4.1 (203)	0.0 (0)
Immune suppression	8.5 (589)	9.4 (463)	8.2 (532)
Leukemia or multiple myeloma	1.3 (88)	1.4 (69)	1.3 (86)
Lymphoma	1.1 (77)	1.2 (61)	1.2 (75)
Metastatic cancer	3.9 (272)	4.1 (203)	4.1 (262)
Respiratory insufficiency	12.0 (833)	14.6 (722)	12.5 (810)
Any comorbidity	44.6 (3,100)	49.3 (2,431)	40.6 (2,625)
Admitted from			
Emergency department	36.6 (2,540)	36.7 (1,808)	36.5 (2,358)
Operating / recovery room	21.9 (1,520)	18.3 (902)	22.2 (1,437)
Hospital ward	26.7 (1,858)	28.1 (1,386)	26.3 (1,702)
Other hospital	10.4 (722)	11.9 (589)	10.5 (677)
Other location	4.3 (300)	4.9 (243)	4.5 (288)
Unknown	0.1 (6)	0.1 (3)	0.1 (5)
Admission type			

Elective surgery	9.4 (655)	8.1 (399)	9.5 (614)
Emergent surgery	16.8 (1,170)	13.8 (681)	17.3 (1,120)
No surgery	73.1 (5,078)	78.1 (3,851)	72.5 (4,690)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
Reason for ICU admission			
Medical	59.9 (4,163)	69.4 (3,420)	58.7 (3,797)
Surgical	25.8 (1,789)	24.1 (1,190)	26.2 (1,696)
Neurological	9.3 (649)	4.1 (200)	9.8 (632)
Trauma	4.3 (302)	2.5 (121)	4.6 (299)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
APACHE II Score on ICU admission, median (IQR)	19 (14-26)	20 (15-26)	19 (14-25)
Glasgow Coma Scale score on ICU admission, median (IQR)	14 (11-15)	14 (11-15)	14 (11-15)
Intubation	65.5 (4,553)	66.2 (3,264)	64.9 (4,195)
Invasive ventilation	68.3 (4,747)	68.8 (3,393)	67.8 (4,387)
Duration, median hours (IQR)	51 (18-133)	62 (25-143)	50 (18-132)
Non-invasive ventilation	13.1 (913)	16.2 (798)	13.6 (878)
Duration, median hours (IQR)	24 (8-63)	28 (9-68)	24 (6-65)
ICU length of stay, median days (IQR)	3.7 (1.8-7.7)	4.3 (2.4-8.3)	3.7 (1.8-7.6)
Hospital length of stay, median days (IQR)	13.3 (6.1-29.5)	13.9 (6.8-30.0)	13.2 (6.1-29.3)
ICU mortality	14.1 (981)	12.2 (601)	12.9 (837)
Hospital mortality	21.0 (1,462)	19.9 (979)	19.5 (1,260)

**Abbreviations:** **AIDS**=autoimmune deficiency syndrome, **APACHE II**=Acute Physiology and Chronic Health Evaluation II, **ICU**=intensive care unit, **IQR**=interquartile range,

**Supplemental Digital Content 4.** Association between demographic and site-level factors, and adoption and de-adoption

	Adoption cohort OR (95% CI)*	De-adoption cohort OR (95% CI)**
Age	NS <sup>†</sup>	0.999 (0.999-1.00)
Female	NS <sup>†</sup>	NS <sup>†</sup>
Any comorbidity	NS <sup>†</sup>	NS <sup>†</sup>
Admission type		
Elective surgery	1.00 (reference group)	1.00 (reference group)
Emergent surgery	1.19 (0.92-1.53)	0.92 (0.88-0.95)
No surgery	1.34 (1.08-1.66)	1.02 (0.98-1.05)
APACHE II Score on ICU admission	0.958 (0.951-0.965)	0.989 (0.988-0.990)
Site		
C1	1.00 (reference group)	1.00 (reference group)
C2	1.32 (1.07-1.64)	0.96 (0.92-1.00)
C3	1.13 (0.89-1.46)	0.98 (0.94-1.03)
C4	1.48 (1.15-1.90)	0.98 (0.93-1.02)
E1	2.12 (1.66-2.73)	0.90 (0.86-0.95)
E2	0.86 (0.71-1.05)	0.90 (0.87-0.92)
E3	7.26 (5.46-9.65)	0.92 (0.87-0.97)
E4	0.76 (0.63-0.92)	0.88 (0.85-0.91)
E5	1.61 (1.23-2.10)	0.75 (0.72-0.79)

*Footnote:* all “C” sites indicate ICU in Calgary and all “E” sites indicate ICU in Edmonton

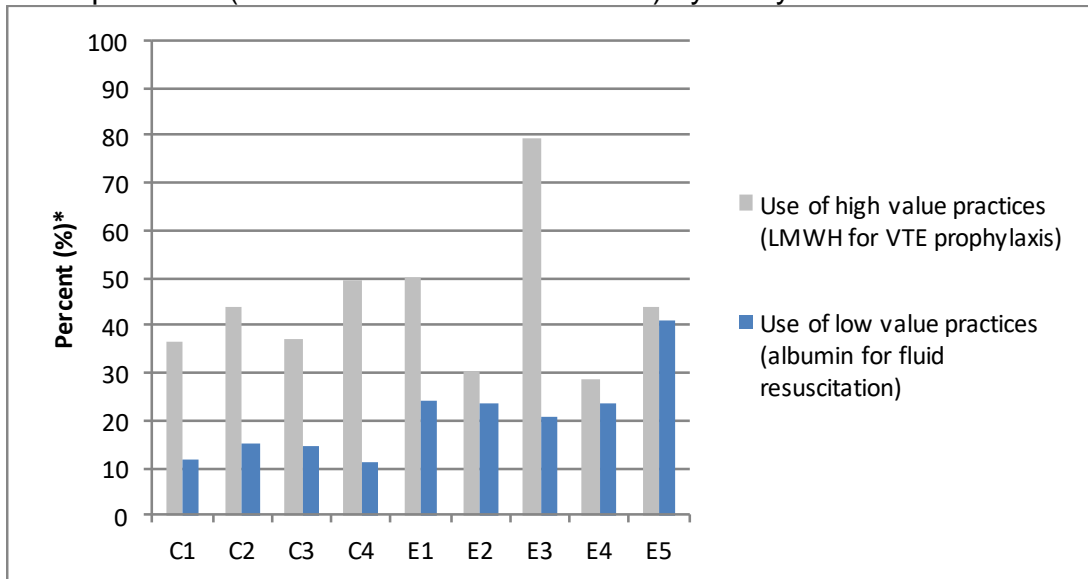
\*Used a multivariable generalized estimating equations (GEEs) logistic regression model with exchangeable correlation structure given daily measurements (clustering by patient); appropriate use considered “use of LMWH”

\*\*Used standard multivariable logistic regression model given single measurement per patient; “appropriate use” considered “not using albumin”

<sup>†</sup>NS = non-significant, removed from model



**Supplemental Digital Content 5.** The use of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and the use of low value practices (albumin for fluid resuscitation) by study intensive care unit



*Footnote:* all "C" sites indicate ICU in Calgary and all "E" sites indicate ICU in Edmonton

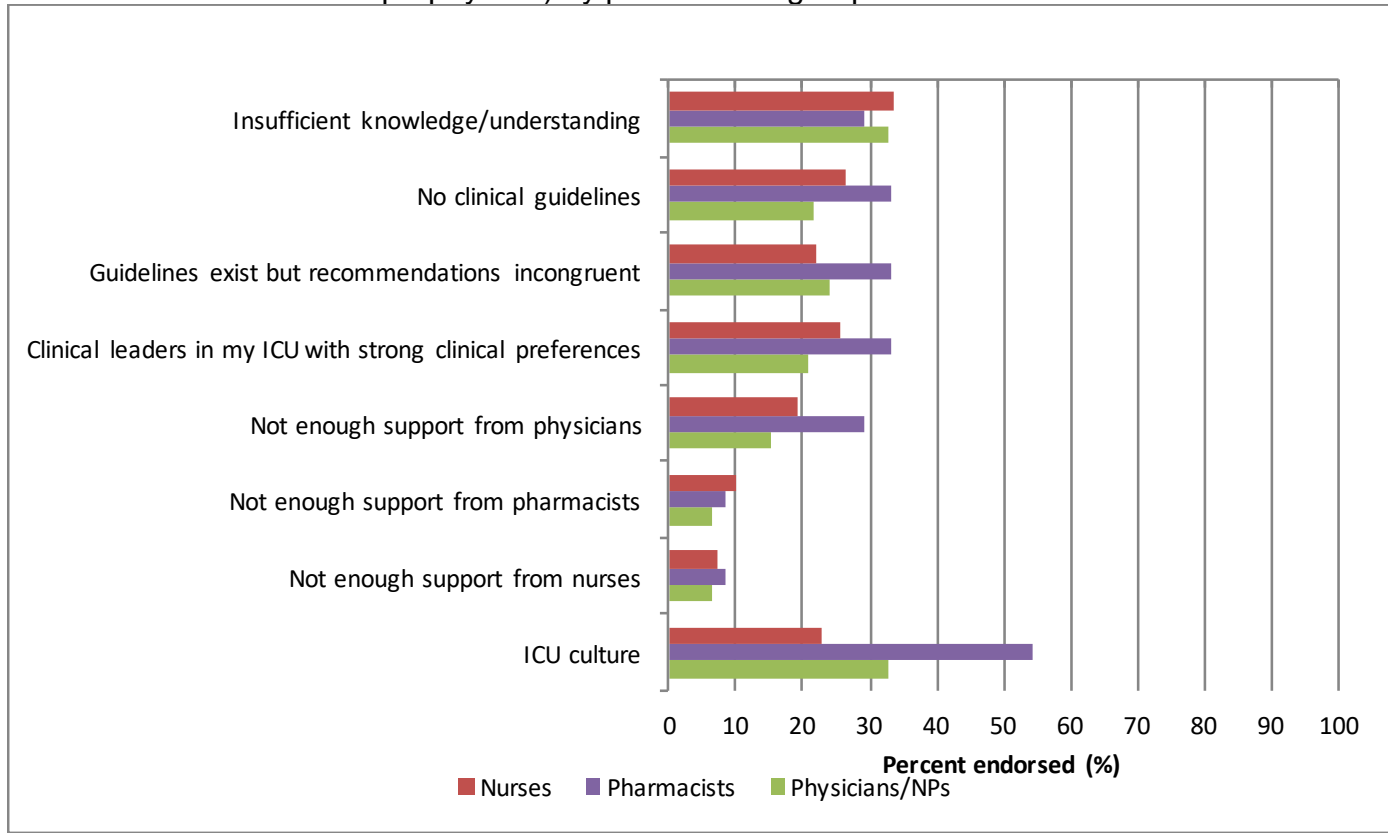
\*% of patient-days for VTE prophylaxis and % of patients for albumin

**Supplemental Digital Content 6. Survey participant characteristics**

<b>Professional group</b>	<b>% (N)</b>
Attending physician	24.7 (64)
Fellow	6.2 (16)
Resident	12.4 (32)
Nurse practitioner	5.0 (13)
Nurse manager / charge nurse	10.0 (26)
Nurse educator	8.5 (22)
Bedside nurse	23.9 (62)
Pharmacist	9.3 (24)
<b>Years worked in ICU</b>	<b>Median (IQR)</b>
Attending physician	14.0 (9.8-22.0)
Clinical fellow	1.8 (1.0-2.3)
Resident	0.3 (0.1-1.0)
Nurse practitioner	15.0 (9.0-20.0)
Nurse manager / charge nurse	11.5 (7.3-18.8)
Nurse educator	19.0 (10.3-21.5)
Bedside nurse	7.5 (2.5-12.0)
Pharmacist	5.3 (3.0-10.8)
<b>Years worked in healthcare</b>	<b>Median (IQR)</b>
Attending physician	19.0 (14.8-25.3)
Clinical fellow	8.0 (7.0-9.5)
Resident	3.0 (2.0-5.1)
Nurse practitioner	15.0 (12.0-25.0)
Nurse manager / charge nurse	16.5 (12.5-24.0)
Nurse educator	21.0 (13.0-26.0)
Bedside nurse	10.0 (6.0-16.0)
Pharmacist	10.5 (6.1-14.3)

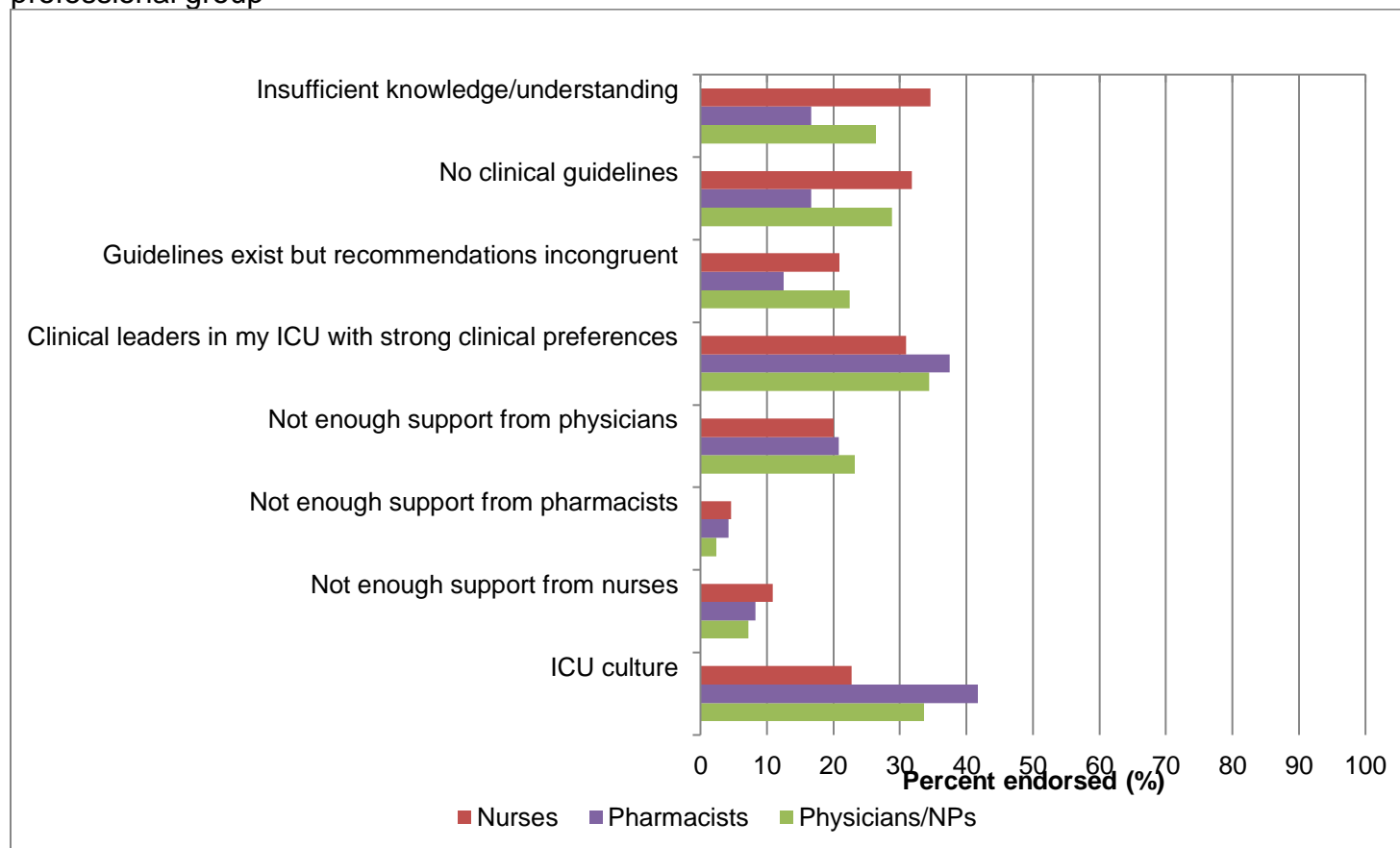
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**Supplemental Digital Content 7.** Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) by professional group



Abbreviations: ICU=intensive care unit, NP=nurse practitioner

**Supplemental Digital Content 8.** Barriers to the de-adoption of low value practices (albumin for fluid resuscitation) by professional group



Abbreviations: **ICU**=intensive care unit, **NP**=nurse practitioner

# Reporting checklist for quality improvement study.

Based on the SQUIRE guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the SQUIRE reporting guidelines, and cite them as:

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	Reporting Item	Page Number
	<a href="#">#1</a> Indicate that the manuscript concerns an initiative to improve healthcare (broadly defined to include the quality, safety, effectiveness, patientcenteredness, timeliness, cost, efficiency, and equity of healthcare)	1
	<a href="#">#02a</a> Provide adequate information to aid in searching and indexing	3
	<a href="#">#02b</a> Summarize all key information from various sections of the text using the abstract format of the intended publication or a structured summary such as: background, local problem, methods, interventions, results, conclusions	2 & 3
Problem description	<a href="#">#3</a> Nature and significance of the local problem	5
Available knowledge	<a href="#">#4</a> Summary of what is currently known about the problem, including relevant previous studies	4 & 5
Rationale	<a href="#">#5</a> Informal or formal frameworks, models, concepts, and / or theories used to explain the problem, any reasons or	5 & 6

		assumptions that were used to develop the intervention(s), and reasons why the intervention(s) was expected to work	
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4	Specific aims	<a href="#">#6</a> Purpose of the project and of this report	5 & 6
5			
6	Context	<a href="#">#7</a> Contextual elements considered important at the outset of introducing the intervention(s)	6
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10	Intervention(s)	<a href="#">#08a</a> Description of the intervention(s) in sufficient detail that others could reproduce it	N/A
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14		<a href="#">#08b</a> Specifics of the team involved in the work	10
15			
16	Study of the Intervention(s)	<a href="#">#09a</a> Approach chosen for assessing the impact of the intervention(s)	8-11
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20		<a href="#">#09b</a> Approach used to establish whether the observed outcomes were due to the intervention(s)	8-11
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24	Measures	<a href="#">#10a</a> Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions, and their validity and reliability	7,8,10
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29		<a href="#">#10b</a> Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency, and cost	7-10
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34		<a href="#">#10c</a> Methods employed for assessing completeness and accuracy of data	7-11
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38	Analysis	<a href="#">#11a</a> Qualitative and quantitative methods used to draw inferences from the data	8-11
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42		<a href="#">#11b</a> Methods for understanding variation within the data, including the effects of time as a variable	8-11
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46	Ethical considerations	<a href="#">#12</a> Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest	11
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51		<a href="#">#13a</a> Initial steps of the intervention(s) and their evolution over time (e.g., time-line diagram, flow chart, or table), including modifications made to the intervention during the project	N/A
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56		<a href="#">#13b</a> Details of the process measures and outcome	8-11
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1		<a href="#">#13c</a>	Contextual elements that interacted with the intervention(s)	7-11
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3		<a href="#">#13d</a>	Observed associations between outcomes, interventions, and	11-17
4			relevant contextual elements	
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7		<a href="#">#13e</a>	Unintended consequences such as unexpected benefits,	18-20
8			problems, failures, or costs associated with the intervention(s).	
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11		<a href="#">#13f</a>	Details about missing data	8-11
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13	Summary	<a href="#">#14a</a>	Key findings, including relevance to the rationale and specific	21
14			aims	
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17		<a href="#">#14b</a>	Particular strengths of the project	18-21
18				
19	Interpretation	<a href="#">#15a</a>	Nature of the association between the intervention(s) and the	18-21
20			outcomes	
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23		<a href="#">#15b</a>	Comparison of results with findings from other publications	18-21
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25		<a href="#">#15c</a>	Impact of the project on people and systems	18-21
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27		<a href="#">#15d</a>	Reasons for any differences between observed and anticipated	18-21
28			outcomes, including the influence of context	
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31		<a href="#">#15e</a>	Costs and strategic trade-offs, including opportunity costs	18-21
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34	Limitations	<a href="#">#16a</a>	Limits to the generalizability of the work	21-22
35				
36		<a href="#">#16b</a>	Factors that might have limited internal validity such as	21-22
37			confounding, bias, or imprecision in the design, methods,	
38			measurement, or analysis	
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41		<a href="#">#16c</a>	Efforts made to minimize and adjust for limitations	21-22
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44	Conclusion	<a href="#">#17a</a>	Usefulness of the work	22
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46		<a href="#">#17b</a>	Sustainability	22
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48		<a href="#">#17c</a>	Potential for spread to other contexts	21-22
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50		<a href="#">#17d</a>	Implications for practice and for further study in the field	18-22
51				
52		<a href="#">#17e</a>	Suggested next steps	18-22
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55	Funding	<a href="#">#18</a>	Sources of funding that supported this work. Role, if any, of the	22 & 23
56			funding organization in the design, implementation,	
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interpretation, and reporting

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# BMJ Open

## Barriers and facilitators to adopting high value practices and de-adopting low value practices in the Intensive Care Unit: A multi method study

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<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Intensive care, Evidence based practice
Keywords:	Quality Improvement, Healthcare System, Under-use and Over-use, Appropriateness, Intensive Care

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Manuscripts

**Title:** Barriers and facilitators to adopting high value practices and de-adopting low value practices in the Intensive Care Unit: A multi method study

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**Word Count:** Manuscript=3,368; Abstract=239

**References:** 47

**Figures and tables:** 3 figures, 2 table

## ABSTRACT

**Objective:** To compare and contrast illustrative examples of the adoption of high value practices and the de-adoption of low value practices.

**Design:** 1) Retrospective, population-based audit of low molecular weight heparin (LMWH) for venous thromboembolism (VTE) prophylaxis (high value practice) and albumin for fluid resuscitation (low value practice) and 2) Cross-sectional survey of healthcare providers.

**Setting:** Data were collected from nine adult medical-surgical ICUs in two large Canadian cities. Patients are managed in these ICUs by a group of multi-professional and multi-disciplinary healthcare providers.

**Participants:** Participants included 6946 ICU admissions and 309 healthcare providers from the same ICUs.

**Main Outcome Measures:** 1) The use of LMWH for VTE prophylaxis (percent ICU days) and albumin for fluid resuscitation (percent of patients); and 2) provider knowledge of evidence underpinning these practices, and barriers and facilitators to adopt and de-adopt these practices.

**Results:** LMWH was administered on 38.7% of ICU days, and 20.0% of patients received albumin.

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3 Most participants had knowledge of evidence underpinning VTE prophylaxis and fluid  
4 resuscitation (59.1% and 84.2%, respectively). Providers perceived these practices to  
5 be followed. The most commonly reported barrier to adoption was insufficient  
6 knowledge/understanding (32.8%), and to de-adoption was clinical leader preferences  
7 (33.2%). On-site education was the most commonly identified facilitator for adoption  
8 and de-adoption (67.8% and 68.6%, respectively).  
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19 **Conclusions:** Despite knowledge of and self-reported adherence to best practices,  
20 the audit demonstrated opportunity to improve. Provider-reported barriers and  
21 facilitators to adoption and de-adoption are broadly similar.  
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28 **KEY WORDS:** Intensive Care; Appropriateness, Under-use and Over-use; Healthcare  
29 System; Quality Improvement  
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### 33 **STRENGTHS & LIMITATIONS**

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36 • A strength of this study is the use of mixed-methods to comprehensively  
37 compare adoption of high value practices and de-adoption of low value  
38 practices in the ICU.  
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42 • Another strength is the use of population-based data to capture current clinical  
43 practices.  
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- 46  
47 • The survey used to assess barriers and facilitators of the two illustrative  
48 practices was derived from a validated survey instrument. It was simple and  
49 designed to garner a representative perspective from all provider professions  
50 and therefore captured key concepts, but not granular data.  
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- Our study provides several insights into similarities and differences between adoption of high value practices and de-adoption of low value practices.

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## INTRODUCTION

Optimizing the quality of care<sup>1</sup> is of particular importance in the intensive care unit (ICU) due to the acuity of patient illness and substantial resources required to care for these patients. However, practice change (adopting high value practices or de-adopting low value practices) is slow with some evidence suggesting it can take well over a decade.<sup>2</sup> To minimize the latency for change, it is important to find ways to improve the implementation of evidence-based practices.

A growing body of evidence has evaluated barriers and facilitators for adopting high value practices (effective at improving outcomes).<sup>3-6</sup> Substantially less is known about the barriers and facilitators for de-adopting low value practices (ineffective at improving outcomes or harmful), and how they compare to those for adopting high value practices.<sup>7,8</sup> De-adoption, also known by several other terms such as disinvestment and de-implementation,<sup>7</sup> is the discontinuation of a practice that has been previously adopted.<sup>9</sup> Some have suggested that the adoption of high value practices and de-adoption of low value practices involves similar processes and common facilitators and barriers;<sup>10,11</sup> however, others suggest that the two are clearly distinct.<sup>8,12</sup> There has been limited comparative evaluation of adoption and de-adoption and this is an important knowledge gap given the growing number of initiatives aimed at de-adopting low value practices.<sup>13-16</sup>

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3 The objective of this study was to describe illustrative example practices of the  
4 adoption of a high value practice (use of low molecular weight heparin [LMWH]  
5 instead of unfractionated heparin [UFH] for venous thromboembolism prophylaxis  
6 [VTE] and the de-adoption of a low value practice (albumin for fluid resuscitation) in  
7 the ICU. The results of this study prompted a subsequent implementation study to  
8 improve these two practices. The audit data identified important opportunities to  
9 improve clinical care, and the perceived barriers and facilitators identified in the  
10 survey were used to inform the development of interventions.  
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## 24 **METHODS**

### 25 **Study design**

26 This multi-method observational study included: 1) a retrospective cohort study of  
27 patients admitted to ICUs to describe current VTE prophylaxis and fluid resuscitation  
28 practices, and 2) a cross-sectional survey of ICU healthcare providers to examine:  
29 knowledge of evidence underpinning these two practices, and perceived barriers and  
30 facilitators to adopt LMWH for VTE prophylaxis and de-adopt albumin for fluid  
31 resuscitation.  
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### 44 **Setting**

45 All data were collected from nine adult medical-surgical ICUs in the two largest cities  
46 in a Canadian province (population of 4.1 million). A single health services provider is  
47 responsible for the provision of all hospital-based care in the province and uses a  
48 single formulary across all ICUs (clinical practices may differ between cities and sites).  
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3 ICU patients are managed by a multi-disciplinary and multi-professional group of  
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5 healthcare providers, including (but not limited to): physicians, medical trainees  
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7 (clinical fellows and residents), nurse practitioners (NPs with prescribing privileges),  
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9 pharmacists, and nurses (managers, educators, bedside).  
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## 14 **Audit of current practices**

### 15 **Participants**

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19 We included patients admitted to nine adult medical-surgical ICUs between January 1,  
20  
21 2014 and December 31, 2014. For analyses, patients were grouped into two cohorts.  
22

23  
24 1) The adoption cohort consisted of patients without a contraindication for  
25  
26 pharmacological VTE prophylaxis where according to international and local  
27  
28 guidelines LMWH should be prescribed.<sup>17-21</sup> Contraindications to pharmacological  
29  
30 prophylaxis included a diagnosis potentially associated with a high risk of bleeding  
31  
32 (Supplemental Content 1), daily assessed platelet count  $<50 \times 10^9/L$ ,  $INR \geq 2$ ,  $PTT \geq 55$   
33  
34 seconds, or receipt of therapeutic anti-coagulation.  
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38 2) The de-adoption cohort consisted of patients without an indication for use of  
39  
40 albumin for fluid resuscitation and where according to the current evidence-base  
41  
42 albumin should not be used for fluid resuscitation.<sup>22-25</sup> Potential indications for albumin  
43  
44 included documented liver disease (cirrhosis or hepatic failure), or receipt of plasma  
45  
46 exchange.<sup>26-29</sup> The two study cohorts were drawn from the same patient population  
47  
48 and patients satisfying both sets of clinical indications were included in both cohorts.  
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### 51 **Data source**



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3 All nine ICUs employ a shared integrated, prospective, clinical information system that  
4 captures and delivers multimodal patient data (demographic, clinical, outcome) in real  
5 time to the bedside (eCritical MetaVision, iMDsoft, MetaVision), and is also a  
6 repository and clinical analytics system that stores these data (eCritical TRACER) to  
7 support quality improvement and clinical research. eCritical TRACER was used to  
8 extract all data.  
9

### 19 Variables

20 Patient and ICU demographic variables included age, sex, comorbidities, admission  
21 type, disease severity (APACHE II score), ICU and hospital length of stay, ICU and  
22 hospital mortality. Data abstracted included: 1) type of VTE prophylaxis (mechanical  
23 included antiembolic stockings and sequential compression devices, and  
24 pharmacological included unfractionated heparin [UFH] and LMWH), 2) ICU day that  
25 VTE prophylaxis was administered, 3) if the patient received albumin, 4) quantity  
26 (units) of albumin, and 5) ICU day that albumin was administered. An ICU day was  
27 defined as any portion of a day between 07:00 and 06:59, recognizing that follow-up  
28 time on admission day and discharge day may be less than 24 hours.  
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### 44 Data analysis

45 Descriptive statistics (means with standard deviations [SD], medians with interquartile  
46 ranges [IQR], frequencies with proportions) were used to describe the two cohorts.  
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48 The proportion of admissions and ICU days with LMWH, UFH, and mechanical VTE  
49 prophylaxis by ICU and ICU day; and with any albumin administration by ICU and  
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3 patient were calculated to describe current clinical practices. The unit of analysis for  
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5 our outcome for the adoption cohort (LMWH use) was patient days because VTE  
6  
7 prophylaxis is a routine clinical practice that should be performed on a daily basis.  
8  
9  
10 Conversely, the unit of analysis for our outcome for the de-adoption cohort (albumin  
11  
12 use) was per patient because fluid resuscitation is a sporadic event that is not part of  
13  
14 routine daily patient care.  
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18  
19 To examine potential associations between patient demographic and sites, and the  
20  
21 use of the high value practice (LMWH) a multivariable generalized estimating  
22  
23 equations (GEEs) logistic regression model with exchangeable correlation structure  
24  
25 given daily measurements (clustering by patient) was used. To examine potential  
26  
27 associations between demographic and site-level factors, and the use of the low value  
28  
29 practice (albumin) a multivariable logistic regression model given a single  
30  
31 measurement per patient was used.  
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### 38 **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting** 39 **albumin for fluid resuscitation** 40

#### 41 Survey development 42

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44 The survey was modeled after previous work on adoption of LMWH for VTE  
45  
46 prophylaxis,<sup>30</sup> and refined to include questions regarding fluid resuscitation. Because  
47  
48 research around barriers and facilitators of de-adopting low value practices is in its  
49  
50 infancy<sup>31</sup> the evidence of barriers and facilitators for adopting high value practices was  
51  
52 employed.  
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5 The survey was divided into four sections: participant demographic information,  
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7 knowledge of the current evidence underpinning the best practices, and perceptions  
8  
9 of barriers and facilitators to the use of the two illustrative examples of best practices  
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11 (Supplemental Content 2).  
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16  
17 The survey was pilot tested in two phases: Phase 1) Seven providers completed the  
18  
19 survey and identified unnecessary, missing, or poorly worded items. The survey was  
20  
21 modified and pilot tested with 12 additional ICU providers (1 attending physician, 2  
22  
23 residents, 1 clinical fellow, 1 nurse practitioner, 1 nurse manager/charge nurse, 1  
24  
25 nurse educator, 2 bedside nurses, and 3 pharmacists). Phase 2) Providers completed  
26  
27 the survey twice (7-10 days apart) and an additional brief questionnaire to rate the  
28  
29 clinical sensibility of the survey. Test-retest reliability of the survey demonstrated a  
30  
31 mean intraclass correlation coefficient (ICC) of 0.66 (SD 0.47) for continuous  
32  
33 responses and a mean proportion of agreement of 0.86 (SD 0.10) for categorical  
34  
35 responses. The low ICC for continuous responses is due to low variability in  
36  
37 responses for questions relating to knowledge of best practices. The participants  
38  
39 agreed that the survey had face validity (100%), content validity (92%), clarity (92%),  
40  
41 utility (100%), discriminability (75%), and minimal redundancy (100%).  
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## 49 Participants

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51 Healthcare providers (as described in Setting) that cared for patients in the nine ICUs  
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53 were invited by email to participate in the study. Invitations to participate were sent to  
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3 healthcare providers by the principal investigators or by a local clinical leader and  
4 included a link to the electronic survey (Fluid Survey) or were provided a paper copy if  
5 requested. Weekly reminders were sent for three weeks. Providers that responded to  
6 the survey were offered entry into a draw for one of three \$20 coffee gift cards.  
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## 14 Data Analysis

15 We used descriptive statistics to describe demographic features of participants,  
16 knowledge of best practices, perceived barriers to adopting high value practices and  
17 de-adopting low value practices, perceived facilitators to encourage adopting high  
18 value practices and de-adopting low value practices. Barriers and facilitators to the  
19 use of best practices were described overall, and by professional group. Professions  
20 were categorized into three groups for analysis: 1) Physicians/NPs (those who  
21 prescribe), 2) Nurses (those who administer), and 3) Pharmacists (those who advise  
22 prescribers). Chi-squared tests were used to test for statistical significance between  
23 groups.  
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## 40 Patient and public involvement

41 Patient and family representatives were members of a committee that identified and  
42 prioritized research questions for improving the care of critically ill patients.<sup>32</sup> LMWH  
43 for VTE prophylaxis and de-adopting albumin for fluid resuscitation were two of the  
44 research questions identified by this committee. Patients were not involved in the  
45 design, the recruitment and conduct of this study. The results of this study have been  
46 disseminated to patient and family advisors through oral presentations.  
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## Ethical considerations

This study was approved by the University of Calgary Conjoint Health Research Ethics Board (REB14-0992 and REB15-2147) and the University of Alberta Research Ethics Board (Pro00056709 and Pro00060650).

## RESULTS

### Audit of current practices

There were 6,946 ICU admissions during the study period, from 6,299 unique patients. Patient characteristics are presented in Supplemental Content 3.

The adoption cohort consisted of 4,931 admissions (71.0% of all admissions) without a contraindication to pharmacological VTE prophylaxis, and the de-adoption cohort consisted of 6,467 admissions (93.1%) without a potential indication for albumin (Supplemental Content 4).

During the ICU stay LMWH was given on 38.7% of ICU days, UFH on 45.3% of ICU days and mechanical prophylaxis (exclusive of pharmacological prophylaxis) on 7.7% of ICU days. The type of VTE prophylaxis administered varied throughout patients' ICU stay; administration of mechanical devices and UFH decreased over the course of the ICU stay while administration of LMWH increased (Supplemental Content 5).

6,804 units of albumin were administered to 20.0% of the 6,467 admissions without documented liver disease or receipt of plasma exchange. Among those receiving at least 1 unit of albumin, the median number of units per patient was 3 (IQR=1.0-6.0). Albumin was administered on 6.5% of ICU days.

When controlling for demographic and site-level factors, the odds of receiving LMWH for VTE prophylaxis and not receiving albumin for fluid resuscitation were significantly lower for those patients with higher severity of illness (APACHE II score). The odds of receiving LMWH for VTE prophylaxis were significantly higher for patients with non-surgical admissions compared to those with elective surgical admissions (odds ratio = 1.34 (95% confidence interval 1.08-1.66); Table 1). There were significant differences in the odds of using LMWH for VTE prophylaxis, and not using albumin for fluid resuscitation across ICUs (Supplemental Content 6), and when controlling for patient-level factors some of these differences persisted especially with regards to the use of LMWH for VTE prophylaxis (Table 1).

**Table 1.** Association between patient demographic and sites, and the use of LMWH for VTE prophylaxis and not using albumin for fluid resuscitation

	<b>Appropriate VTE prophylaxis OR (95% CI)*</b>	<b>Appropriate fluid resuscitation OR (95% CI)**</b>
Age	NS <sup>†</sup>	0.999 (0.999-1.00)
Female	NS <sup>†</sup>	NS <sup>†</sup>
Any comorbidity	NS <sup>†</sup>	NS <sup>†</sup>
Admission type		
Elective surgery	1.00 (reference group)	1.00 (reference group)
Emergent surgery	1.19 (0.92-1.53)	0.92 (0.88-0.95)
No surgery	1.34 (1.08-1.66)	1.02 (0.98-1.05)
APACHE II Score (ICU admission)	0.958 (0.951-0.965)	0.989 (0.988-0.990)
Site		
C1	1.00 (reference group)	1.00 (reference group)

C2	1.32 (1.07-1.64)	0.96 (0.92-1.00)
C3	1.13 (0.89-1.46)	0.98 (0.94-1.03)
C4	1.48 (1.15-1.90)	0.98 (0.93-1.02)
E1	2.12 (1.66-2.73)	0.90 (0.86-0.95)
E2	0.86 (0.71-1.05)	0.90 (0.87-0.92)
E3	7.26 (5.46-9.65)	0.92 (0.87-0.97)
E4	0.76 (0.63-0.92)	0.88 (0.85-0.91)
E5	1.61 (1.23-2.10)	0.75 (0.72-0.79)

*Footnote:* all “C” sites indicate ICU in Calgary and all “E” sites indicate ICU in Edmonton

\*multivariable generalized estimating equations (GEEs) logistic regression model with exchangeable correlation structure given daily measurements (clustering by patient); “appropriate” considered *use of LMWH*

\*\*standard multivariable logistic regression model given single measurement per patient; “appropriate” considered *not using albumin*

†NS = non-significant, removed from model

## **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid resuscitation**

### Participants

83.8% (259 of 309) of participants responded; physicians/NPs (48.3%), nurses (42.5%), and pharmacists (9.3%). Participants worked in healthcare for a median of 13 years (IQR=7.1-20.0) and in critical care for a median of 8 years (IQR=3.0-15.0; Supplemental Content 7).

### Knowledge of evidence

Most participants reported that LMWH was most effective at preventing deep vein thrombosis and pulmonary embolism; and that crystalloids were most effective for fluid resuscitation (Table 2). Perceptions regarding the effectiveness of VTE prophylaxis varied by professional group, as did perceptions regarding the risks of harm (Table 2).

Perceptions regarding effectiveness of albumin for fluid resuscitation and risks of

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2  
3 harm associated with each form of fluid resuscitation did not vary by professional  
4  
5 group but perceptions regarding the risk of fluid overload did (Table 2).  
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7  
8 It was perceived that both best practices were being followed in the ICUs where the  
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10 participants practiced (Table 2).  
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**Table 2.** Knowledge of best practices for VTE prophylaxis and fluid resuscitation

Survey question	% (N)			
	Overall N=259	Physicians/NPs 48.3% (N= 125)	Nurses 42.5% (N= 110)	Pharmacists 9.3% (N= 24)
What form(s) of prophylaxis is/are most effective at preventing deep vein thrombosis?*				
LMWH only	59.1 (153)	63.2 (79)	51.8 (57)	70.8 (17)
UFH only	4.3 (11)	2.4 (3)	7.3 (8)	0.0 (0)
LMWH & UFH	16.2 (42)	24.0 (30)	5.5 (6)	25.0 (6)
Mechanical only	1.9 (5)	0.0 (0)	4.6 (5)	0.0 (0)
(LMWH or UFH) and Mechanical	15.1 (39)	8.0 (10)	25.5 (28)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
What form(s) of prophylaxis is/are most effective at preventing pulmonary embolism? *				
LMWH only	56.8 (147)	72.0 (90)	33.6 (37)	83.3 (20)
UFH only	18.2 (47)	1.6 (2)	40.9 (45)	0.0 (0)
LMWH & UFH	12.7 (33)	20.8 (26)	3.6 (4)	12.5 (3)
Mechanical only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
(LMWH or UFH) & Mechanical	8.5 (22)	3.2 (4)	15.5 (17)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
Which form(s) of prophylaxis is/are most cost effective?*				
LMWH only	51.0 (132)	70.4 (88)	22.7 (25)	79.2 (19)
UFH only	15.4 (40)	12.8 (16)	20.0 (22)	8.3 (2)
LMWH & UFH	4.3 (11)	5.6 (7)	0.9 (1)	12.5 (3)
Mechanical only	10.0 (26)	4.8 (6)	18.2 (20)	0.0 (0)
(LMWH or UFH) & Mechanical	2.7 (7)	0.0 (0)	6.4 (7)	0.0 (0)
Unsure only	16.6 (43)	6.4 (8)	31.8 (35)	0.0 (0)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of bleeding?†				
LMWH only	57.5 (149)	47.2 (59)	69.1 (76)	58.3 (14)
UFH only	24.7 (64)	32.8 (41)	18.2 (20)	12.5 (3)
LMWH & UFH	5.0 (13)	6.4 (8)	0.0 (0)	20.8 (5)
Unsure only	12.7 (33)	13.6 (17)	12.7 (14)	8.3 (2)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of heparin induced thrombocytopenia?*				

	LMWH only	86.1 (223)	94.4 (118)	74.6 (82)	95.8 (23)
	UFH only	6.6 (17)	3.2 (4)	11.8 (13)	0.0 (0)
	LMWH & UFH	0.4 (1)	0.0 (0)	0.0 (0)	4.2 (1)
	Unsure only	7.0 (18)	2.4 (3)	13.6 (15)	0.0 (0)
To what extent do you think best practices are followed for preventing DVT/PE in your ICU? 0=never and 7=always, Median (IQR)					
		6 (5-6)	6 (5-6)	6 (6-7)	6 (5-6)
<b>Survey question</b>	<b>Overall N=259</b>	<b>Physicians/NPs 48.3% (N= 125)</b>	<b>Nurses 42.5% (N= 110)</b>	<b>Pharmacists 9.3% (N= 24)</b>	
What form(s) of IV fluids is/are most effective for fluid resuscitation? ‡					
	Albumin only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
	Crystalloids only	84.2 (218)	83.2 (104)	82.7 (91)	95.8 (23)
	Albumin & Crystalloids	8.5 (22)	9.6 (12)	9.1 (10)	0.0 (0)
	Unsure only	3.9 (10)	4.8 (6)	2.7 (3)	4.2 (1)
Which form(s) of IV resuscitation fluids are most cost effective? ‡					
	Albumin only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
	Crystalloids only	94.6 (245)	94.4 (118)	95.5 (105)	91.7 (22)
	Albumin & Crystalloids	0.4 (1)	0.8 (1)	0.0 (0)	0.0 (0)
	Unsure only	4.6 (12)	4.8 (6)	3.6 (4)	8.3 (2)
Which form(s) of IV resuscitation fluids has the lowest risk of fluid overload? *					
	Albumin only	47.1 (122)	32.8 (41)	69.1 (76)	20.8 (5)
	Crystalloids only	29.7 (77)	36.8 (46)	23.6 (26)	20.8 (5)
	Albumin & Crystalloids	1.9 (5)	3.2 (4)	0.0 (0)	4.2 (1)
	Unsure only	21.2 (55)	27.2 (34)	7.3 (8)	54.2 (13)
Which form(s) of IV resuscitation fluids has the lowest risk of infectious disease? ‡					
	Albumin only	2.7 (7)	1.6 (2)	4.6 (5)	0.0 (0)
	Crystalloids only	86.5 (224)	87.2 (109)	87.3 (96)	79.2 (19)
	Albumin & Crystalloids	0.8 (2)	0.8 (1)	0.9 (1)	0.0 (0)
	Unsure only	10.0 (26)	10.4 (13)	7.3 (8)	20.8 (5)

To what extent do you think best practices are followed for prescribing fluid boluses in your ICU?

0=never and 7=always; Median (IQR)

	6 (5-6)	5 (5-6)	6 (5-6)	5 (5-6)
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<sup>1</sup>The order of the survey items are as presented in this table.

<sup>2</sup>Evidence suggests the efficacy of LMWH for deep vein thrombosis is similar to or better than UFH.<sup>18,19,33,34</sup> Evidence suggests that LMWH is more efficacious than UFH for preventing pulmonary embolism, has a lower incidence of heparin induced thrombocytopenia, and a similar or lower risk of bleeding.<sup>18,19,33,34</sup>

<sup>3</sup>Evidence suggests that LMWH is more cost effective than UFH.<sup>18</sup>

<sup>4</sup>Evidence suggests that albumin and crystalloids are similarly effective for fluid resuscitation.<sup>21, 24, 25, 26</sup> Evidence suggests that albumin has a higher risk of infectious disease transmission than crystalloids and is less cost-effective than crystalloids.

**Abbreviations:** **IQR** = interquartile range (p25 - p75), **LMWH** = low molecular weight heparin, **N** = number, **NP** = nurse practitioner, **UFH** = unfractionated heparin, \* = responses varied by professional group (p<0.001), † = responses varied by professional group (p=0.01), ‡ = responses did not vary by professional group (p>0.05)

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5 Barriers to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
6 resuscitation  
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10 Barriers to adoption and de-adoption were reported by 65.2% and 64.9% of  
11 respondents, respectively. The most commonly reported perceived barriers to  
12 adopting LMWH for VTE prophylaxis were insufficient knowledge or understanding,  
13 ICU culture, and no clinical guidelines (Figure 1). The most commonly reported  
14 barriers to de-adopting albumin for fluid resuscitation were a strong clinical preference  
15 of the local clinical leaders in the ICUs, ICU culture, and insufficient knowledge or  
16 understanding (Figure 1). Reported barriers differed between professional groups for  
17 both adoption (Figure 2a) and de-adoption (Figure 2b).  
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31 Facilitators to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
32 resuscitation  
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35 On site education and pre-set orders were perceived to be the most commonly  
36 reported facilitator of both adoption and de-adoption (Figure 3). Verbal reminders  
37 from pharmacists to physicians was commonly reported as a perceived facilitator for  
38 adopting LMMH for VTE prophylaxis. A local leader championing the practice was  
39 commonly reported as a perceived facilitator for de-adopting albumin for fluid  
40 resuscitation (Figure 3). There was no variability by professional group.  
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## 51 **DISCUSSION**

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3 The present study identified opportunities to improve the use of best practices for VTE  
4 prophylaxis (adopting the high value practice of LMWH) and fluid resuscitation (de-  
5 adopting the low value practice of albumin). Our audit data demonstrated that current  
6 practice does not reflect providers' understanding of the evidence for these practices.  
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8 The use of the best practice for these two illustrative examples were less likely for  
9 patients with greater severity of illness and varied across institutions. The perceived  
10 barriers and facilitators to adoption and de-adoption were broadly similar.  
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21 Are de-adoption and adoption just the flip-side of the same coin? There is substantial  
22 literature describing the adoption of high value practices, but much less is known  
23 about de-adoption of low value practices.<sup>7</sup> Science can inform clinical practice through  
24 discovery resulting in adoption of a new practice, replacement resulting in a practice  
25 update, and reversal resulting in de-adoption of an existing practice. It is only recently  
26 that the last concept, de-adopting low value practices, has been debated in journals  
27 and by professional societies.<sup>13,14,16</sup> The practical implication is that there is limited  
28 evidence to inform whether the barriers and facilitators for adoption and de-adoption  
29 are similar or sufficiently distinct to warrant different approaches.<sup>8,10-12</sup> Our study adds  
30 to the limited evidence base by suggesting that culture or organizational factors,  
31 provider characteristics, and patient characteristics are perceived to be important  
32 barriers and facilitators that may play broadly similar roles in adoption and de-  
33 adoption.<sup>10,11</sup>  
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3 Knowledge translation (KT) interventions are strategies to improve the synthesis,  
4 dissemination, exchange, and application of evidence to improve health.<sup>4</sup> KT  
5 interventions tailored to the specific barriers and facilitators of an innovation and the  
6 local context are more likely to effect change.<sup>4,5</sup> Our study provides insight into the  
7 perceived barriers and facilitators of adopting high value practices (LMWH for VTE  
8 prophylaxis) and de-adopting low value practices (albumin for fluid resuscitation)  
9 within ICUs, which should be taken into consideration when designing KT  
10 interventions. Interestingly, despite knowledge of the evidence underlying the  
11 illustrative example practices, providers perceived insufficient knowledge or  
12 understanding to be a barrier and perceived education to be a facilitator to both  
13 adopting high value practices and de-adopting low value practices. These barriers and  
14 facilitators are consistent with a systematic review that suggests the most effective KT  
15 interventions in the ICU employ a combination of education and protocols.<sup>35</sup> While  
16 consistent with previous KT studies, this finding is paradoxical. It is possible that while  
17 knowledgeable, providers' confidence in applying their knowledge clinically was low  
18 and they believed education to be the intervention needed to improve their confidence  
19 in applying their knowledge. Furthermore, confidence in applying new evidence in  
20 clinical practice may be particularly challenging in the care of severely ill patients.  
21 This hypothesis is supported by two of our findings: 1) the use of LMWH for VTE  
22 prophylaxis and not using albumin for fluid resuscitation was inversely associated with  
23 severity of patient illness and 2) the use of LMWH and not using albumin increased as  
24 the patient became more stable (over ICU stay). Potential hypotheses to explain these  
25 observations include that clinicians may employ conservative decision-making (use  
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3 more familiar practices) or unintendedly neglect to use best practices when caring for  
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5 sicker patients, but this need further exploration. The implications are that KT  
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7 interventions should consider clinician heuristics that are likely to be influenced by the  
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9 nature and severity of patient illness.  
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15 Our study suggests that factors other than knowledge may contribute to the  
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17 successful adoption of high value practices and de-adoption of low value practices,  
18  
19 which includes culture, providers, and the innovation. These factors have previously  
20  
21 been identified within the context of the ICU.<sup>36-42</sup> ICU culture and local clinical leader  
22  
23 preferences were among the most commonly endorsed barriers to adopting high  
24  
25 value practices and de-adopting low value practices in this study and in our study.  
26  
27 This is highlighted by the variation in the use of LMWH between ICUs, even when  
28  
29 patient level factors were taken into consideration. Interestingly, this finding was less  
30  
31 pronounced for de-adoption, which has been previously reported.<sup>8</sup> Culture, also  
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33 referred to as organizational context, is a frequently cited barrier to evidence-based  
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35 medicine and can have a profound effect on clinical practice.<sup>6,43</sup> However, few studies  
36  
37 have systematically evaluated the effect of culture on adopting high value practices  
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39 and de-adopting low value practices, and implementation studies infrequently account  
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41 for the effect of culture on their practice change interventions.<sup>44</sup> Similarly, the  
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43 professional role of the provider is not often contextualized but may be important (e.g.,  
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45 should pharmacists and nurses be targeted in KT interventions designed to change  
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47 the prescribing patterns of physicians and if so how?).<sup>45</sup> This may be especially  
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3 relevant as healthcare delivery becomes increasingly multi-professional and team-  
4 based as illustrated in our setting (ICU).  
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10 The characteristics of innovations themselves may influence change in clinical  
11 practice. Evidence suggests that if the innovation being adopted is congruent with  
12 clinical practice beliefs it can facilitate adoption.<sup>6</sup> Furthermore, the quality, quantity,  
13 and stability of available evidence to support the adoption or de-adoption of an  
14 innovation is likely important.<sup>46</sup> Although most providers in our study were aware of  
15 the evidence to support the adoption of LMWH for VTE prophylaxis and de-adoption  
16 of albumin for fluid resuscitation, they may not have perceived the evidence to be  
17 sufficient to warrant practice change. A growing awareness of challenges with  
18 reproducing scientific evidence and clinician experience with practice reversals<sup>42</sup> may  
19 result in more conservative provider behavior and slower practice change in response  
20 to new evidence. The suboptimal prescribing practices observed in our study likely  
21 represent a combination of all these factors.  
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40 One limitation of this study is that the survey used was imperfect. The results of the  
41 self-reported survey reflect perceived modifiers of practice among providers rather  
42 than factors shown to influence practice patterns as identified in observational  
43 studies.<sup>47</sup> The survey was purposefully designed to be simple and accessible to  
44 garner a representative perspective from all provider professions and therefore  
45 captured key concepts, but not granular data. Nevertheless, the survey has been  
46 successfully used for a similar purpose by others;<sup>30</sup> was reliable and reported to have  
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3 good clinical sensibility. Alternative methodologies such as qualitative analyses of  
4 semi-structured interviews may have allowed for more in depth exploration of barriers  
5 and facilitators to adopting LMWH and de-adopting albumin. Finally, while this study  
6 was a provincial and multi-site it was constrained to ICUs, which should be taken into  
7 consideration when interpreting our findings beyond this setting.  
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17 In conclusion, our study provides several insights into similarities and differences  
18 between adoption of high value practices and de-adoption of low value practices. Both  
19 adoption and de-adoption of the illustrative example practices did not reflect  
20 healthcare providers' knowledge of the evidence. The use of best practices for both  
21 illustrative examples practices were less likely for patients with greater severity of  
22 illness and varied across institutions. We found that perceived barriers and facilitators  
23 are more similar than different between adoption and de-adoption, which suggests  
24 existing behavior change frameworks for adopting high value practices may also be  
25 applicable for de-adopting low value practices.  
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## **DISCLOSURE OF CONFLICT OF INTERESTS**

The authors declare that they have no competing interests.

## **DATA SHARING STATEMENT**

Data will be available if accepted.

## **AUTHORS' CONTRIBUTIONS**

Dr. Sauro contributed to the design and conceptualization of the study; analysis and interpretation of the data, drafting and revising the manuscript and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Bagshaw contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Niven contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

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3 Dr. Soo contributed to the analysis and interpretation of the data, providing feedback  
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5 on the manuscript and gave approval of the final version of the manuscript. No  
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7 conflicts of interest to declare.  
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12 Ms. Brundin-Mather contributed to the interpretation of the data, providing feedback  
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14 on the manuscript, and gave approval of the final version of the manuscript. No  
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16 conflicts of interest to declare.  
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21 Dr. Parsons Leigh contributed to the design and conceptualization of the study,  
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23 interpretation of the data, providing feedback on the manuscript, and gave approval of  
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25 the final version of the manuscript. No conflicts of interest to declare.  
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31 Dr. Cook contributed to the design and conceptualization of the study, interpretation of  
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33 the data, providing feedback on the manuscript, and gave approval of the final version  
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35 of the manuscript. No conflicts of interest to declare.  
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40 Dr. Stelfox contributed to the design and conceptualization of the study, interpretation  
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42 of the data, providing feedback on the manuscript, and gave approval of the final  
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44 version of the manuscript. No conflicts of interest to declare.  
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4 **Figure 1.** Barriers to the adoption of high value practices (low molecular weight  
5 heparin for venous thromboembolism prophylaxis) and de-adoption of low value  
6 practices (albumin for fluid resuscitation)  
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13 *Abbreviations:* ICU: intensive care unit  
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4 **Figure 2a.** Barriers to the adoption of high value practices (low molecular weight  
5 heparin for venous thromboembolism prophylaxis) by professional group.  
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10 **Figure 2b.** Barriers to the de-adoption of low value practices (albumin for fluid  
11 resuscitation) by professional group  
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16 *Abbreviations:* **ICU**=intensive care unit, **NP**=nurse practitioner  
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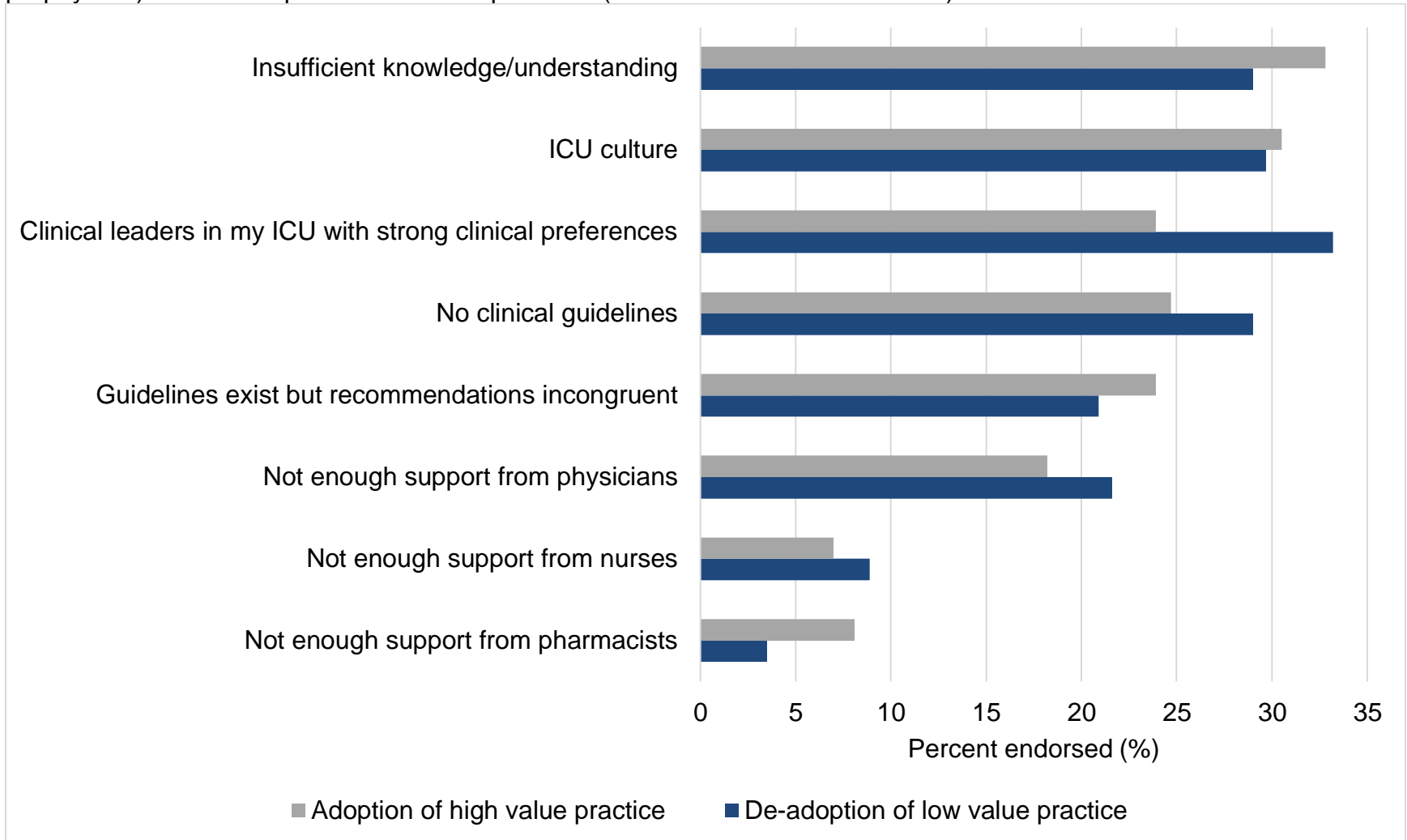


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4 **Figure 3.** Facilitators to the adoption of high value practices (low molecular  
5 weight heparin for venous thromboembolism prophylaxis) and de-adoption of low  
6 value practices (albumin for fluid resuscitation)  
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16 *Abbreviation:* **MD**=medical doctor, **QI**=quality improvement  
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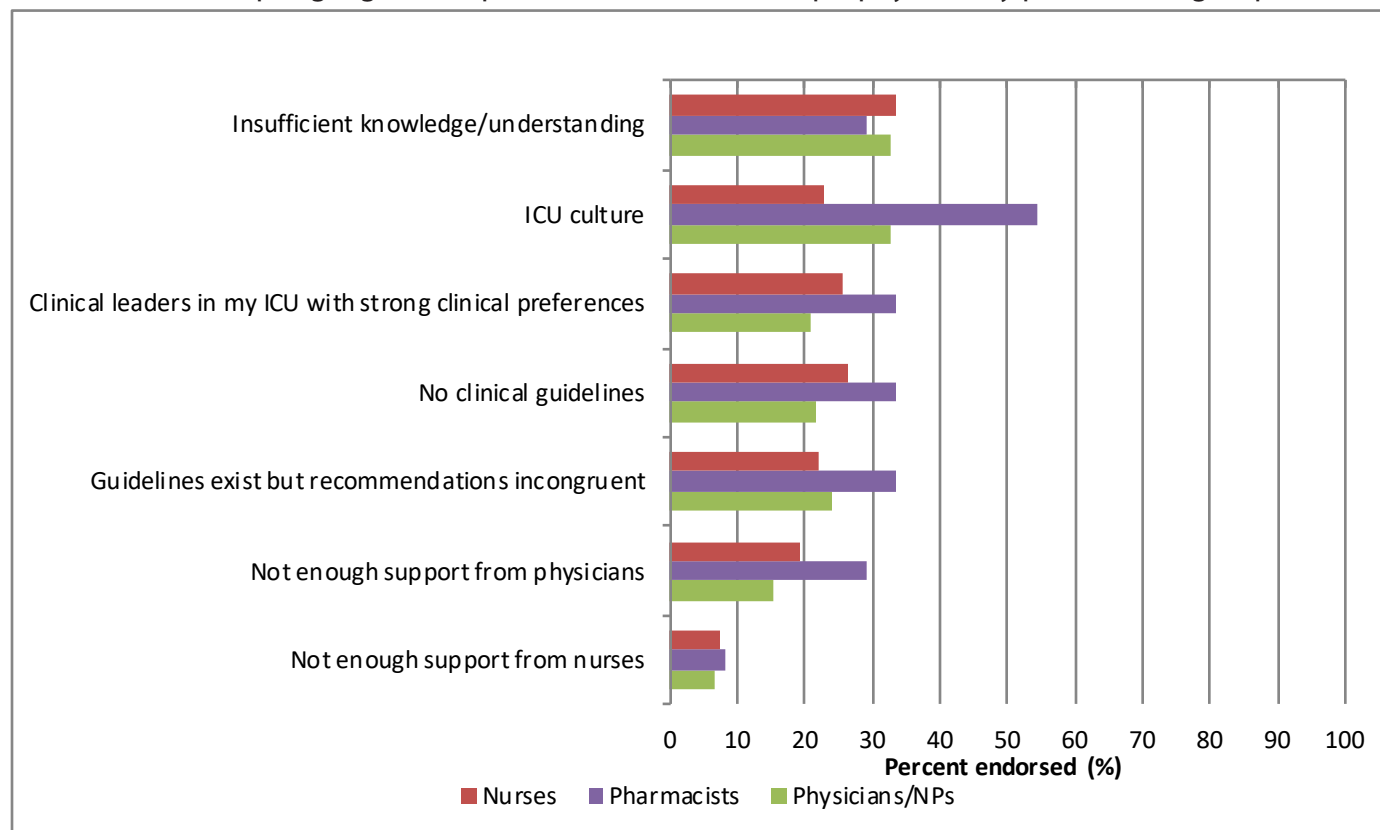
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**Figure 1.** Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)

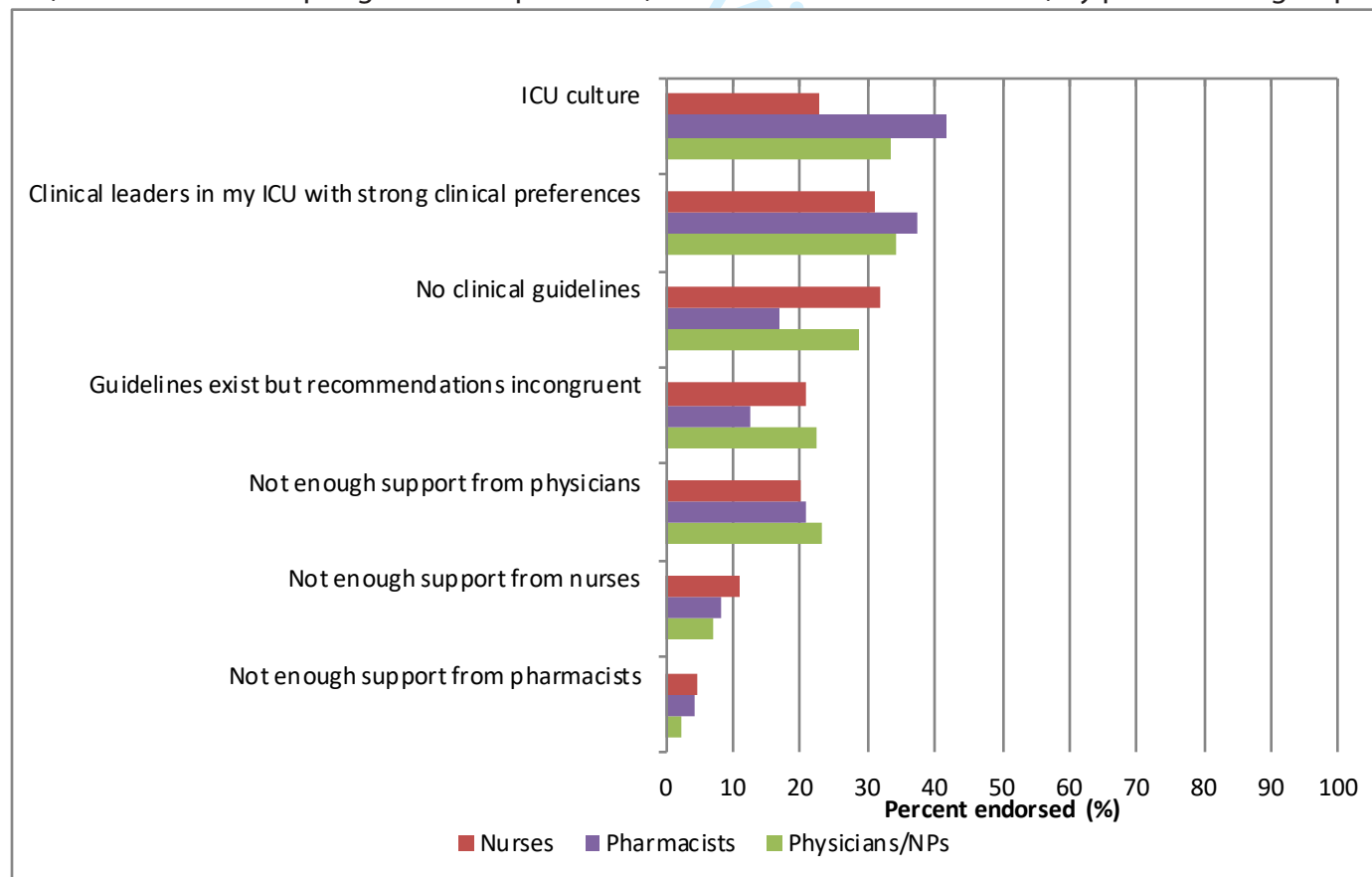


**Figure 2.** Barriers to adopting high value practices and de-adopting low value practices by profession

2.a) Barriers to adopting high value practices (LMWH for VTE prophylaxis) by professional group

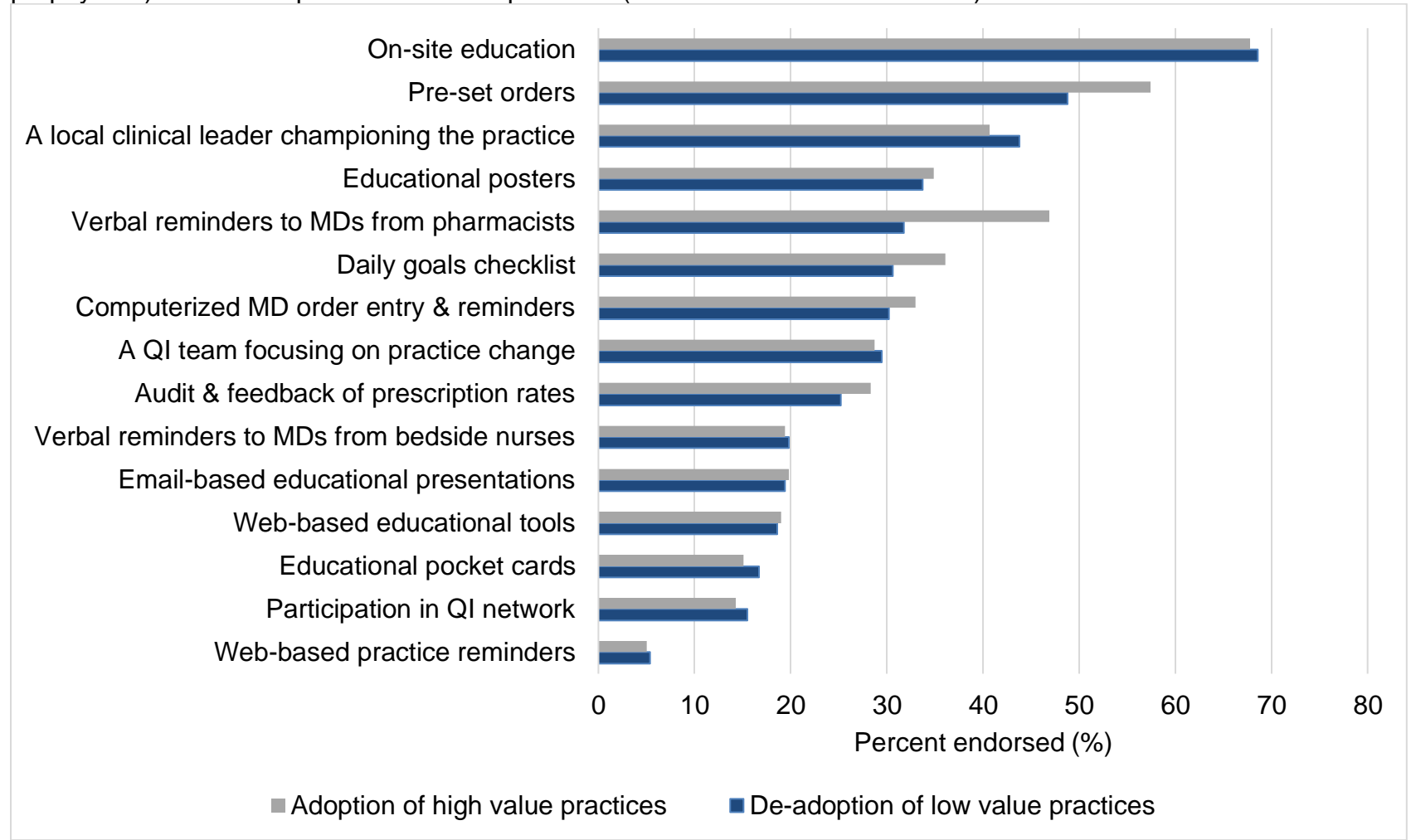


2.b) Barriers to de-adopting low value practices (albumin for fluid resuscitation) by professional group



Abbreviations: ICU=intensive care unit; NP=nurse practitioner; LMWH=low molecular weight heparin; VTE=venous thromboembolism

**Figure 3.** Facilitators to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)



Abbreviation: MD=medical doctor, QI=quality improvement

**Supplemental Content 1.** List of diagnoses with a potential contraindication to receive pharmacological venous thromboembolism prophylaxis or indication for therapeutic anticoagulation\*

Arteriovenous malformation, surgery for
Embolus, pulmonary
GI Vascular insufficiency
Grafts, removal of infected vascular
Neoplasm, neurologic
Neoplasm-cranial, surgery for (excluding transphenoidal)
Neoplasm-spinal cord surgery or other related procedures
Neurologic surgery, other
Subarachnoid hemorrhage/intracranial aneurysm
Subarachnoid hemorrhage/intracranial aneurysm, surgery for
Thrombosis, vascular (deep vein)
Transphenoidal surgery
Ulcer disease, peptic
Abdomen only trauma
Abdomen only trauma, surgery for
Abdomen/extremity trauma
Abdomen/extremity trauma, surgery for
Abdomen/face trauma
Abdomen/face trauma, surgery for
Abdomen/multiple trauma
Abdomen/multiple trauma, surgery for
Abdomen/pelvis trauma, surgery for
Abscess/infection-cranial, surgery for
Anastomosis, vascular
Aneurysm, abdominal aortic
Aneurysm, abdominal aortic; with dissection
Aneurysm, abdominal aortic; with rupture
Aneurysm, dissecting aortic
Aneurysm, thoracic aortic
Aneurysm, thoracic aortic; with dissection
Aneurysm, thoracic aortic; with rupture
Aneurysm/pseudoaneurysm, other
Aneurysms, repair of other (except ventricular)
Biopsy, brain
Bleeding, GI from esophageal varices/portal hypertension
Bleeding, GI-location unknown
Bleeding, lower GI
Bleeding, upper GI
Bleeding-lower GI, surgery for
Bleeding-other GI, surgery for
Bleeding-upper GI, surgery for

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3	Burr hole placement
4	CABG alone, coronary artery bypass grafting
5	CVA, cerebrovascular accident/stroke
6	Chest/abdomen trauma
7	Chest/abdomen trauma, surgery for
8	Chest/abdomen trauma, surgery for
9	Chest/extremity trauma
10	Chest/extremity trauma, surgery for
11	Chest/extremity trauma, surgery for
12	Chest/face trauma
13	Chest/face trauma, surgery for
14	Chest/face trauma, surgery for
15	Chest/multiple trauma
16	Chest/multiple trauma, surgery for
17	Chest/multiple trauma, surgery for
18	Chest/pelvis trauma
19	Chest/pelvis trauma, surgery for
20	Chest/pelvis trauma, surgery for
21	Chest/spinal trauma
22	Chest/spinal trauma, surgery for
23	Chest/spinal trauma, surgery for
24	Chest/thorax only trauma
25	Chest/thorax only trauma, surgery for
26	Chest/thorax only trauma, surgery for
27	Coagulopathy
28	Complications of prev. peripheral vasc. surgery, surgery for (i.e.ligation of bleeder, exploration and evacuation of hematoma, debridement, pseudoaneurysms, clots, fistula, etc.)
29	Complications of previous GI surgery; surgery for (anastomotic leak, bleeding, abscess, infection, dehiscence, etc.)
30	Complications of previous spinal cord surgery, surgery for
31	Cranioplasty and complications from previous craniotomies
32	Cranioplasty and complications from previous craniotomies
33	Head (CNS) only trauma
34	Head (CNS) only trauma, surgery for
35	Head (CNS) only trauma, surgery for
36	Head/abdomen trauma
37	Head/abdomen trauma, surgery for
38	Head/abdomen trauma, surgery for
39	Head/chest trauma
40	Head/chest trauma, surgery for
41	Head/chest trauma, surgery for
42	Head/extremity trauma
43	Head/extremity trauma, surgery for
44	Head/extremity trauma, surgery for
45	Head/face trauma
46	Head/face trauma, surgery for
47	Head/face trauma, surgery for
48	Head/multiple trauma
49	Head/multiple trauma, surgery for
50	Head/multiple trauma, surgery for
51	Head/pelvis trauma
52	Head/pelvis trauma, surgery for
53	Head/pelvis trauma, surgery for
54	Head/spinal trauma
55	Head/spinal trauma, surgery for
56	Head/spinal trauma, surgery for
57	Hematoma, epidural
58	Hematoma, epidural, surgery for
59	Hematoma, epidural, surgery for
60	Hematoma, subdural
	Hematoma, subdural, surgery for

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3	Hematomas
4	Hemorrhage (for gastrointestinal bleeding GI-see GI system) (for trauma see
5	Trauma)
6	Hemorrhage, intra/retroperitoneal
7	Hemorrhage, postpartum (female only)
8	Hemorrhage/hematoma, intracranial
9	Hemorrhage/hematoma-intracranial, surgery for
10	Hemorrhage/hemoptysis, pulmonary
11	Hemothorax
12	Pelvis/extremity trauma
13	Pelvis/extremity trauma, surgery for
14	Pelvis/face trauma
15	Pelvis/hip only trauma, surgery for
16	Pelvis/multiple trauma, surgery for
17	Pelvis/spinal trauma
18	Pericardial effusion/tamponade
19	Renal bleeding
20	Spinal cord only trauma, surgery for
21	Spinal cord surgery, other
22	Stereotactic procedure
23	Subarachnoid hemorrhage/arteriovenous malformation
24	Tamponade, pericardial
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*\*Footnote:* The primary diagnoses were reviewed independently by two ICU physicians (HTS, DJN). The two ICU physicians provided their judgment to establish a conservative list of primary diagnoses in order to exclude patients that may have a contraindication for pharmacological VTE prophylaxis based on bleeding risk and an indication for therapeutic anticoagulation. Discrepancies were resolved by discussion.



## Adopting Best Practices in DVT/PE Prophylaxis and Fluid Resuscitation in Critical Care

[http://fluidsurveys.com/s/ECG\\_facilitators\\_barriers\\_survey/](http://fluidsurveys.com/s/ECG_facilitators_barriers_survey/)

### Informed Consent

This survey is to identify and evaluate barriers to, and facilitators of, best practices in:

1. Deep Vein Thrombosis (DVT) / Pulmonary Embolism (PE) prophylaxis for medical-surgical ICU patients, and
2. Fluid Resuscitation for medical-surgical ICU patients *without* liver disease, bacterial peritonitis, hepatorenal syndrome or therapeutic paracentesis.

**This survey is not about trauma, neurosurgery or cardiac surgery patients.** Survey responses will be used to develop interventions to facilitate the adoption of best practices in Alberta ICUs.

You are being asked to take part in this survey because you are a healthcare professional working in adult critical care in Alberta. Our survey can be answered in approximately **5 minutes**. There are no direct benefits and/or risks to your participation.

Survey respondents can choose to have their name entered into a draw for \$20 Starbucks gift cards (one name will be drawn per week; non-winners will remain in the draw each week).

Your participation in this survey is voluntary and you are free to stop at any time. Your responses will be kept confidential. Your de-identified data will be stored in a password-protected database, and responses will only be presented in aggregate. The survey has peer-reviewed funding and has received ethics approval from the University of Calgary. **Your decision to complete and submit this survey will indicate your consent to participate.** Should you decide to withdraw your participation before submitting the survey, your data will be deleted.

If you have questions about this survey or your participation, please contact:

Rebecca Brundin-Mather, Research Coordinator, at [brundin@ucalgary.ca](mailto:brundin@ucalgary.ca).

If you have questions about your rights as a participant, you may contact the University of Calgary Conjoint Research Ethics Board at (403) 220-7990. This office is not affiliated with the study team.

Thank you in advance for taking the time to complete the survey!

Kind regards,

Tom Stelfox, MD, PhD, FRCPC

Intensive Care Physician

Scientific Director, AHS, Critical Care Strategic Clinical Network

I agree to participate in this survey       I do **NOT** wish to participate in this survey (online-version)



## Demographics

### 1. What is your professional group?

- ICU physician       Nurse Clinician       Pharmacist  
 ICU resident       Nurse Educator       Other: \_\_\_\_\_  
 ICU fellow       Bedside Nurse

### 2. Approximately how many years have you worked in:

Health care       Critical care

### 3. In which hospital(s) do you primarily work? (Select all that apply)

- Chinook Regional Hospital  
 Foothills Medical Centre  
 Grand Prairie QE II Hospital  
 Grey Nuns Hospital  
 Medicine Hat Regional Hospital  
 Misericordia Hospital  
 Northern Lights Regional Health Centre  
 Peter Lougheed Centre  
 Red Deer Regional Hospital  
 Rockyview General Hospital  
 Royal Alexander Hospital  
 South Health Campus  
 Sturgeon Community Hospital  
 University of Alberta Hospital

## DVT/PE Prevention

We are interested in your perceptions of the different forms of prophylaxes commonly used to prevent Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE) in medical-surgical ICU patients (not trauma, neurosurgery or cardiac surgery patients). Common prophylaxes include:

- Low molecular weight heparin (**LMWH** e.g., Enoxaparin, Dalteparin, Tinzaparin)
- Unfractionated heparin (**UFH**, regular Heparin)
- **Mechanical** prophylaxis (i.e., sequential compression devices)

We appreciate that practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

4. Which form(s) of prophylaxis is/are most effective at preventing:

	LMWH	UFH	Mechanical	Unsure
Deep Vein Thrombosis (DVT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pulmonary Embolism (PE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Which form(s) of prophylaxis is/are most cost-effective?

LMWH	UFH	Mechanical	Unsure
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Which form(s) of *pharmacological* prophylaxis has/have the lowest risk of:

	LMWH	UFH	Unsure
Bleeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heparin Induced Thrombocytopenia (HIT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. To what extent do you think best practices for preventing DVT/PE are followed in your ICU (i.e., the patient receives the right prophylaxis with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>	<b>Sometimes</b>			<b>Always</b>			

**Intravenous Fluid Resuscitation**

We are now interested in your perceptions of the different types of intravenous fluids commonly used for fluid resuscitation (i.e., fluid boluses) in the ICU for medical-surgical patients, **excluding** patients with liver disease, bacterial peritonitis, or undergoing therapeutic paracentesis as they may have different fluid needs. Common resuscitation fluids include:

- **Human Albumin** (Albumin 5% or Albumin 25%)
- **Crystalloid solutions** (e.g., normal saline, ringers lactate, and plasma-lyte)

Again, we appreciate that clinical practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

8. Which form(s) of IV resuscitation fluid is/are most effective for resuscitation?

Albumin                       Crystalloids                       Unsure

9. Which form(s) of IV resuscitation fluid(s) is/are most cost-effective?

Albumin                       Crystalloids                       Unsure

10. Which form(s) of IV resuscitation fluid(s) has/have the lowest risk of:

	Albumin	Crystalloids	Unsure
Fluid overload (peripheral / pulmonary)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Contracting an infectious disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. To what extent do you think *best practices* for prescribing fluid boluses are followed **in your ICU** (i.e., the patient receives the right fluid with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>			<b>Sometimes</b>			<b>Always</b>	

### **Barriers to Best Practices**

A number of ICU or 'systems' factors have been identified as potential barriers to best practices. We are interested in what you think are barriers **in your ICU** to prescribing:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

12. Which of the following factors are current barriers in your ICU to prescribing...

	<b>LMWH over UFH</b>		<b>Crystalloids over Albumin</b>	
	<b>Current Barrier</b>	Unsure	<b>Current Barrier</b>	Unsure
An ICU culture with an unclear or slow process for practice change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from physicians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from nurses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from pharmacists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clinical leaders in my ICU with strong clinical preferences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No clinical guidelines or orders sets in my ICU to guide the practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guidelines exist in my ICU, but they do not recommend LMWH over UFH / crystalloids over albumin	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Insufficient knowledge/understanding the evidence base for the practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>None</b> of the above factors are current barriers in my ICU to prescribing....	<input type="radio"/>		<input type="radio"/>	
Please note any other factors that may be barriers to prescribing LMWH over UFH and/or crystalloids over albumin. Specify below.				

### Strategies to Encourage Best Practices

A number of strategies have been identified as potential facilitators to changing clinical practice. We are interested in your perceptions of different strategies that have been used to encourage:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

13. Which of the following strategies are currently used in your ICU to encourage...

	LMWH over UFH	Crystalloids over Albumin
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="radio"/>	<input type="radio"/>
2. Educational posters (in the unit)	<input type="radio"/>	<input type="radio"/>
3. Educational pocket cards	<input type="radio"/>	<input type="radio"/>
4. Email-based educational presentations	<input type="radio"/>	<input type="radio"/>
5. Web-based educational tools	<input type="radio"/>	<input type="radio"/>
6. Verbal reminders to physicians from pharmacists	<input type="radio"/>	<input type="radio"/>
7. Verbal reminders to physicians from bedside nurses	<input type="radio"/>	<input type="radio"/>
8. Pre-set orders	<input type="radio"/>	<input type="radio"/>
9. Computerized physician order entry & reminders	<input type="radio"/>	<input type="radio"/>
10. Web-based practice reminders	<input type="radio"/>	<input type="radio"/>
11. Daily goals checklist	<input type="radio"/>	<input type="radio"/>
12. Audit & feedback of prescription rates	<input type="radio"/>	<input type="radio"/>
13. A quality improvement team focusing on practice change	<input type="radio"/>	<input type="radio"/>
14. Participation in a quality improvement network	<input type="radio"/>	<input type="radio"/>
15. A local clinical leader championing the practice	<input type="radio"/>	<input type="radio"/>
16. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
17. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
<b>NO</b> strategies are currently being used in my ICU encourage this practice:	<input type="radio"/>	<input type="radio"/>

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14. From the same list of strategies, please select the **5 best strategies** that you believe would work **in your ICU** to encourage:

(1) LMWH over UFH for DVT/PE prophylaxis

(2) Crystalloid solutions over Albumin for fluid resuscitation

(Select up to 5 strategies, regardless whether the strategy is used in your ICU or not)

**Select up to 5 in each column**

Strategy to change clinical practice	LMWH over UFH	Crystalloids over Albumin
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="checkbox"/>	<input type="checkbox"/>
2. Educational posters (in the unit)	<input type="checkbox"/>	<input type="checkbox"/>
3. Educational pocket cards	<input type="checkbox"/>	<input type="checkbox"/>
4. Email-based educational presentations	<input type="checkbox"/>	<input type="checkbox"/>
5. Web-based educational tools	<input type="checkbox"/>	<input type="checkbox"/>
6. Verbal reminders to physicians from pharmacists	<input type="checkbox"/>	<input type="checkbox"/>
7. Verbal reminders to physicians from bedside nurses	<input type="checkbox"/>	<input type="checkbox"/>
8. Pre-set orders	<input type="checkbox"/>	<input type="checkbox"/>
9. Computerized physician order entry & reminders	<input type="checkbox"/>	<input type="checkbox"/>
10. Web-based practice reminders	<input type="checkbox"/>	<input type="checkbox"/>
11. Daily goals checklist	<input type="checkbox"/>	<input type="checkbox"/>
12. Audit & feedback of prescription rates	<input type="checkbox"/>	<input type="checkbox"/>
13. A quality improvement team to focus on practice change	<input type="checkbox"/>	<input type="checkbox"/>
14. Participation in a quality improvement network	<input type="checkbox"/>	<input type="checkbox"/>
15. A local clinical leader to champion the practice	<input type="checkbox"/>	<input type="checkbox"/>
16. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>
17. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>

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3 15. Finally, please provide any additional comments in the text box below.  
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15 Please select the check box(es) below to have your name entered in the Starbucks coffee card  
16 draws and/or to receive the study results.  
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19  Yes, I would like my name entered in the coffee card draws.  
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28 N.B. E-mail addresses will be kept confidential and will not be used to contact you for any  
29 reason other than those noted above.  
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36 ---End of Survey ---  
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40 **Thank you for helping us improve care!**  
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43 **Please return completed surveys to:**  
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45  
46 Dr. Tom Stelfox  
47 Department of Critical Care Medicine  
48 Foothills Medical Centre  
49

OR

Rebecca Brundin-Mather  
Ward of the 21<sup>st</sup> Century  
GD01 Teaching, Research, Wellness Bldg  
University of Calgary, 3280 Hospital Dr NW  
Calgary, AB T2N 4Z6



**Supplemental Content 3.** Intensive care unit patient characteristics for the study period (January 1, 2014-December 31, 2014)

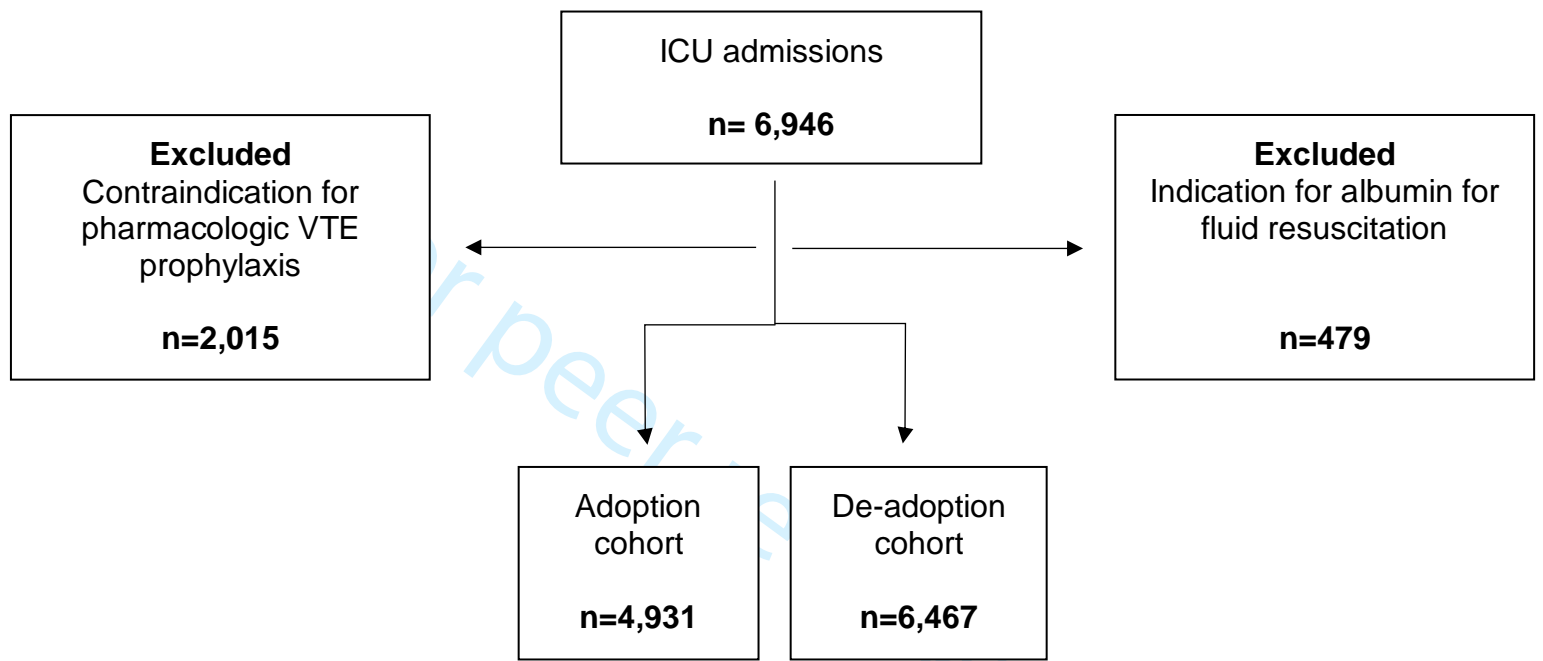
<b>Demographic variable</b>	<b>Population (N=6,946)</b>	<b>Adoption cohort 70.7% (N=4,931)</b>	<b>De-adoption cohort 93.1% (N=6,467)</b>
Age, median (IQR)	60 (46-71)	61 (47-71)	61 (46-71)
Female	41.6 (2,888)	43.3 (2,134)	41.8 (2,703)
Comorbidities			
AIDS	0.6 (42)	0.7 (33)	0.5 (35)
Chronic dialysis	3.5 (240)	3.8 (186)	3.5 (225)
Chronic heart failure	6.4 (444)	7.4 (364)	6.5 (419)
Cirrhosis	5.9 (407)	6.0 (294)	0.0 (0)
Diabetes	19.7 (1,366)	21.6 (1,065)	19.9 (1,284)
Hepatic failure	3.9 (269)	4.1 (203)	0.0 (0)
Immune suppression	8.5 (589)	9.4 (463)	8.2 (532)
Leukemia or multiple myeloma	1.3 (88)	1.4 (69)	1.3 (86)
Lymphoma	1.1 (77)	1.2 (61)	1.2 (75)
Metastatic cancer	3.9 (272)	4.1 (203)	4.1 (262)
Respiratory insufficiency	12.0 (833)	14.6 (722)	12.5 (810)
Any comorbidity	44.6 (3,100)	49.3 (2,431)	40.6 (2,625)
Admitted from			
Emergency department	36.6 (2,540)	36.7 (1,808)	36.5 (2,358)
Operating / recovery room	21.9 (1,520)	18.3 (902)	22.2 (1,437)
Hospital ward	26.7 (1,858)	28.1 (1,386)	26.3 (1,702)
Other hospital	10.4 (722)	11.9 (589)	10.5 (677)
Other location	4.3 (300)	4.9 (243)	4.5 (288)
Unknown	0.1 (6)	0.1 (3)	0.1 (5)
Admission type			



Elective surgery	9.4 (655)	8.1 (399)	9.5 (614)
Emergent surgery	16.8 (1,170)	13.8 (681)	17.3 (1,120)
No surgery	73.1 (5,078)	78.1 (3,851)	72.5 (4,690)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
Reason for ICU admission			
Medical	59.9 (4,163)	69.4 (3,420)	58.7 (3,797)
Surgical	25.8 (1,789)	24.1 (1,190)	26.2 (1,696)
Neurological	9.3 (649)	4.1 (200)	9.8 (632)
Trauma	4.3 (302)	2.5 (121)	4.6 (299)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
APACHE II Score on ICU admission, median (IQR)	19 (14-26)	20 (15-26)	19 (14-25)
Glasgow Coma Scale score on ICU admission, median (IQR)	14 (11-15)	14 (11-15)	14 (11-15)
Intubation	65.5 (4,553)	66.2 (3,264)	64.9 (4,195)
Invasive ventilation	68.3 (4,747)	68.8 (3,393)	67.8 (4,387)
Duration, median hours (IQR)	51 (18-133)	62 (25-143)	50 (18-132)
Non-invasive ventilation	13.1 (913)	16.2 (798)	13.6 (878)
Duration, median hours (IQR)	24 (8-63)	28 (9-68)	24 (6-65)
ICU length of stay, median days (IQR)	3.7 (1.8-7.7)	4.3 (2.4-8.3)	3.7 (1.8-7.6)
Hospital length of stay, median days (IQR)	13.3 (6.1-29.5)	13.9 (6.8-30.0)	13.2 (6.1-29.3)
ICU mortality	14.1 (981)	12.2 (601)	12.9 (837)
Hospital mortality	21.0 (1,462)	19.9 (979)	19.5 (1,260)

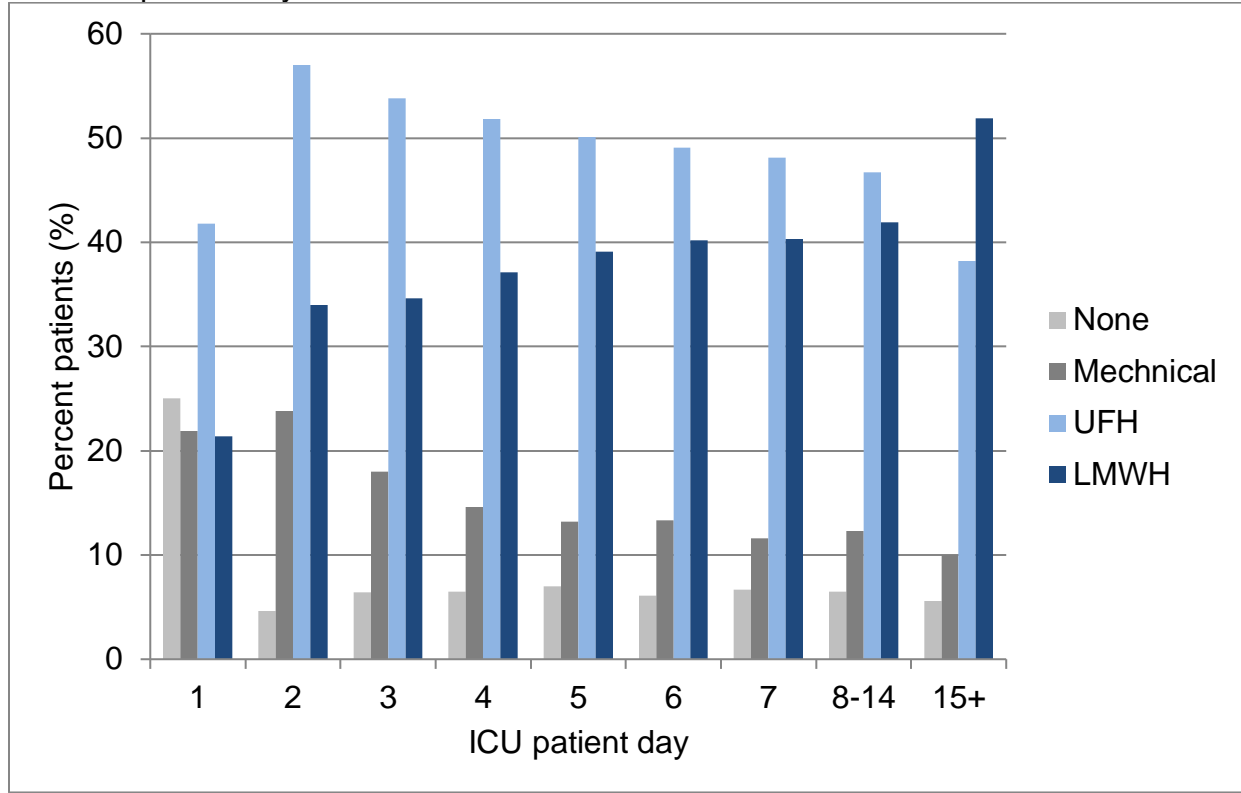
**Abbreviations:** **AIDS**=autoimmune deficiency syndrome, **APACHE II**=Acute Physiology and Chronic Health Evaluation II, **ICU**=intensive care unit, **IQR**=interquartile range,

**Supplemental Content 4. Flow of patients**



*Footnote:* Adoption cohort = Recommended to receive low molecular weight heparin for venous thromboembolism prophylaxis; de-adoption cohort = Recommended to NOT receive albumin for fluid resuscitation

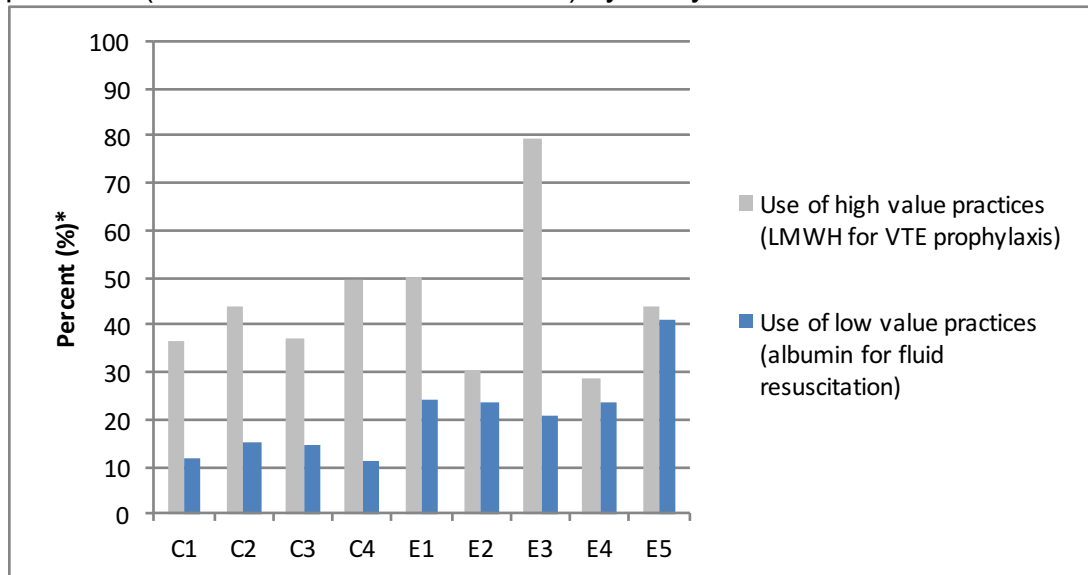
**Supplemental Content 5. Venous thromboembolism prophylaxis by intensive care unit patient day**



*Footnote:* Percent of patients may add to greater than 100% because patients may have received more than one form of venous thromboembolism prophylaxis on a given patient day.

*Abbreviation:* ICU=intensive care unit, LMWH=low molecular weight heparin, UFH=unfractionated heparin

**Supplemental Content 6.** The use of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and the use of low value practices (albumin for fluid resuscitation) by study intensive care unit



*Footnote:* all "C" sites indicate ICU in Calgary and all "E" sites indicate ICU in Edmonton

\*% of patient-days for VTE prophylaxis and % of patients for albumin

**Supplemental Content 7. Survey participant characteristics**

<b>Professional group</b>	<b>% (N)</b>
Attending physician	24.7 (64)
Fellow	6.2 (16)
Resident	12.4 (32)
Nurse practitioner	5.0 (13)
Nurse manager / charge nurse	10.0 (26)
Nurse educator	8.5 (22)
Bedside nurse	23.9 (62)
Pharmacist	9.3 (24)
<b>Years worked in ICU</b>	<b>Median (IQR)</b>
Attending physician	14.0 (9.8-22.0)
Clinical fellow	1.8 (1.0-2.3)
Resident	0.3 (0.1-1.0)
Nurse practitioner	15.0 (9.0-20.0)
Nurse manager / charge nurse	11.5 (7.3-18.8)
Nurse educator	19.0 (10.3-21.5)
Bedside nurse	7.5 (2.5-12.0)
Pharmacist	5.3 (3.0-10.8)
<b>Years worked in healthcare</b>	<b>Median (IQR)</b>
Attending physician	19.0 (14.8-25.3)
Clinical fellow	8.0 (7.0-9.5)
Resident	3.0 (2.0-5.1)
Nurse practitioner	15.0 (12.0-25.0)
Nurse manager / charge nurse	16.5 (12.5-24.0)
Nurse educator	21.0 (13.0-26.0)
Bedside nurse	10.0 (6.0-16.0)
Pharmacist	10.5 (6.1-14.3)

# BMJ Open

## Barriers and facilitators to adopting high value practices and de-adopting low value practices in Canadian Intensive Care Units: A multi method study

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<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Intensive care, Evidence based practice
Keywords:	Quality Improvement, Healthcare System, Under-use and Over-use, Appropriateness, Intensive Care

SCHOLARONE™  
Manuscripts

**Title:** Barriers and facilitators to adopting high value practices and de-adopting low value practices in Canadian Intensive Care Units: A multi method study

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**References:** 47

**Figures and tables:** 3 figures, 2 table

## ABSTRACT

**Objective:** To compare and contrast illustrative examples of the adoption of high value practices and the de-adoption of low value practices.

**Design:** 1) Retrospective, population-based audit of low molecular weight heparin (LMWH) for venous thromboembolism (VTE) prophylaxis (high value practice) and albumin for fluid resuscitation (low value practice) and 2) Cross-sectional survey of healthcare providers.

**Setting:** Data were collected from nine adult medical-surgical ICUs in two large Canadian cities. Patients are managed in these ICUs by a group of multi-professional and multi-disciplinary healthcare providers.

**Participants:** Participants included 6946 ICU admissions and 309 healthcare providers from the same ICUs.

**Main Outcome Measures:** 1) The use of LMWH for VTE prophylaxis (percent ICU days) and albumin for fluid resuscitation (percent of patients); and 2) provider knowledge of evidence underpinning these practices, and barriers and facilitators to adopt and de-adopt these practices.

**Results:** LMWH was administered on 38.7% of ICU days, and 20.0% of patients received albumin.



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3 Most participants had knowledge of evidence underpinning VTE prophylaxis and fluid  
4 resuscitation (59.1% and 84.2%, respectively). Providers perceived these practices to  
5 be followed. The most commonly reported barrier to adoption was insufficient  
6 knowledge/understanding (32.8%), and to de-adoption was clinical leader preferences  
7 (33.2%). On-site education was the most commonly identified facilitator for adoption  
8 and de-adoption (67.8% and 68.6%, respectively).  
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19 **Conclusions:** Despite knowledge of and self-reported adherence to best practices,  
20 the audit demonstrated opportunity to improve. Provider-reported barriers and  
21 facilitators to adoption and de-adoption are broadly similar.  
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28 **KEY WORDS:** Intensive Care; Appropriateness, Under-use and Over-use; Healthcare  
29 System; Quality Improvement  
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### 34 **STRENGTHS & LIMITATIONS**

- 35  
36 • A strength of this study is the use of mixed-methods to comprehensively  
37 compare adoption of high value practices and de-adoption of low value  
38 practices in the ICU.  
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42 • Another strength is the use of population-based data to capture current clinical  
43 practices.  
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47 • The survey used to assess barriers and facilitators of the two illustrative  
48 practices was derived from a validated survey instrument.  
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- The survey used was simple and designed to garner a representative perspective from all provider professions and therefore captured key concepts, but not granular data.

For peer review only

## INTRODUCTION

Optimizing the quality of care<sup>[1]</sup> is of particular importance in the intensive care unit (ICU) due to the acuity of patient illness and substantial resources required to care for these patients. However, practice change (adopting high value practices or de-adopting low value practices) can lag behind the publication of evidence hindering delivery of evidence-based practices and may be different when adopting or de-adopting practices.<sup>[2, 3]</sup> To minimize the latency for change, it is important to find ways to improve the implementation of evidence-based practices.

A growing body of evidence has evaluated barriers and facilitators for adopting high value practices (effective at improving outcomes).<sup>[4-7]</sup> Substantially less is known about the barriers and facilitators for de-adopting low value practices (ineffective at improving outcomes or harmful), and how they compare to those for adopting high value practices.<sup>[8, 9]</sup> De-adoption, also known by several other terms such as disinvestment and de-implementation,<sup>[8]</sup> is the discontinuation of a practice that has been previously adopted.<sup>[10]</sup> Some have suggested that the adoption of high value practices and de-adoption of low value practices involves similar processes and common facilitators and barriers;<sup>[11, 12]</sup> however, others suggest that the two are clearly distinct.<sup>[9, 13]</sup> There has been limited comparative evaluation of adoption and de-adoption and this is an important knowledge gap given the growing number of initiatives aimed at de-adopting low value practices.<sup>[13-16]</sup>

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3 The objective of this study was to describe illustrative example practices of the  
4 adoption of a high value practice (use of low molecular weight heparin [LMWH]  
5 instead of unfractionated heparin [UFH] for venous thromboembolism prophylaxis  
6 [VTE] and the de-adoption of a low value practice (albumin for fluid resuscitation) in  
7 the ICU. The results of this study prompted a subsequent implementation study to  
8 improve these two practices. The audit data identified important opportunities to  
9 improve clinical care, and the perceived barriers and facilitators identified in the  
10 survey were used to inform the development of interventions.  
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## 24 **METHODS**

### 25 **Study design**

26 This multi-method observational study included: 1) a retrospective cohort study of  
27 patients admitted to ICUs to describe current VTE prophylaxis and fluid resuscitation  
28 practices, and 2) a cross-sectional survey of ICU healthcare providers to examine:  
29 knowledge of evidence underpinning these two practices, and perceived barriers and  
30 facilitators to adopt LMWH for VTE prophylaxis and de-adopt albumin for fluid  
31 resuscitation.  
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### 44 **Setting**

45 All data were collected from nine adult medical-surgical ICUs in the two largest cities  
46 in a Canadian province (population of 4.1 million). A single health services provider is  
47 responsible for the provision of all hospital-based care in the province and uses a  
48 single formulary across all ICUs (clinical practices may differ between cities and sites).  
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3 ICU patients are managed by a multi-disciplinary and multi-professional group of  
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5 healthcare providers, including (but not limited to): physicians, medical trainees  
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7 (clinical fellows and residents), nurse practitioners (NPs with prescribing privileges),  
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9 pharmacists, and nurses (managers, educators, bedside).  
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## 14 **Audit of current practices**

### 15 **Participants**

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19 We included patients admitted to nine adult medical-surgical ICUs between January 1,  
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21 2014 and December 31, 2014. For analyses, patients were grouped into two cohorts.  
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24 1) The adoption cohort consisted of patients without a contraindication for  
25  
26 pharmacological VTE prophylaxis where according to international and local  
27  
28 guidelines LMWH should be prescribed.<sup>[17-21]</sup> Contraindications to pharmacological  
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30 prophylaxis included a diagnosis potentially associated with a high risk of bleeding  
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32 (Supplemental Content 1), daily assessed platelet count  $<50 \times 10^9/L$ , INR  $\geq 2$ , PTT  $\geq 55$   
33  
34 seconds, or receipt of therapeutic anti-coagulation.  
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37 2) The de-adoption cohort consisted of patients without an indication for use of  
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39 albumin for fluid resuscitation and where according to the current evidence-base  
40  
41 albumin should not be used for fluid resuscitation.<sup>[22-25]</sup> Potential indications for  
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43 albumin included documented liver disease (cirrhosis or hepatic failure), or receipt of  
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45 plasma exchange.<sup>[26-29]</sup> The two study cohorts were drawn from the same patient  
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47 population and patients satisfying both sets of clinical indications were included in  
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49 both cohorts.  
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## Data source

All nine ICUs employ a shared integrated, prospective, clinical information system that captures and delivers multimodal patient data (demographic, clinical, outcome) in real time to the bedside (eCritical MetaVision, iMDsoft, MetaVision), and is also a repository and clinical analytics system that stores these data (eCritical TRACER) to support quality improvement and clinical research. eCritical TRACER was used to extract all data.

## Variables

Patient and ICU demographic variables included age, sex, comorbidities, admission type, disease severity (APACHE II score), ICU and hospital length of stay, ICU and hospital mortality. Data abstracted included: 1) type of VTE prophylaxis (mechanical included antiembolic stockings and sequential compression devices, and pharmacological included unfractionated heparin [UFH] and LMWH), 2) ICU day that VTE prophylaxis was administered, 3) if the patient received albumin, 4) quantity (units) of albumin, and 5) ICU day that albumin was administered. An ICU day was defined as any portion of a day between 07:00 and 06:59, recognizing that follow-up time on admission day and discharge day may be less than 24 hours.

## Data analysis

Descriptive statistics (means with standard deviations [SD], medians with interquartile ranges [IQR], frequencies with proportions) were used to describe the two cohorts.

The proportion of admissions and ICU days with LMWH, UFH, and mechanical VTE

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3 prophylaxis by ICU and ICU day; and with any albumin administration by ICU and  
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5 patient were calculated to describe current clinical practices. The unit of analysis for  
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7 our outcome for the adoption cohort (LMWH use) was patient days because VTE  
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9 prophylaxis is a routine clinical practice that should be performed on a daily basis.  
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11 Conversely, the unit of analysis for our outcome for the de-adoption cohort (albumin  
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13 use) was per patient because fluid resuscitation is a sporadic event that is not part of  
14  
15 routine daily patient care.  
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22 To examine potential associations between patient demographic and sites, and the  
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24 use of the high value practice (LMWH) a multivariable generalized estimating  
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26 equations (GEEs) logistic regression model with exchangeable correlation structure  
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28 given daily measurements (clustering by patient) was used. To examine potential  
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30 associations between demographic and site-level factors, and the use of the low value  
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32 practice (albumin) a multivariable logistic regression model given a single  
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34 measurement per patient was used.  
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## 40 **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting** 41 **albumin for fluid resuscitation** 42 43

### 44 Survey development 45

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47 The survey was modeled after previous work on adoption of LMWH for VTE  
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49 prophylaxis,<sup>[30]</sup> and refined to include questions regarding fluid resuscitation. Because  
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51 research around barriers and facilitators of de-adopting low value practices is in its  
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3 infancy<sup>[31]</sup> the evidence of barriers and facilitators for adopting high value practices  
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5 was employed.  
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10 The survey was divided into four sections: participant demographic information,  
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12 knowledge of the current evidence underpinning the best practices, and perceptions  
13  
14 of barriers and facilitators to the use of the two illustrative examples of best practices  
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16 (Supplemental Content 2).  
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21 The survey was pilot tested in two phases: Phase 1) Seven providers completed the  
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23 survey and identified unnecessary, missing, or poorly worded items. The survey was  
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25 modified and pilot tested with 12 additional ICU providers (1 attending physician, 2  
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27 residents, 1 clinical fellow, 1 nurse practitioner, 1 nurse manager/charge nurse, 1  
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29 nurse educator, 2 bedside nurses, and 3 pharmacists). Phase 2) Providers completed  
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31 the survey twice (7-10 days apart) and an additional brief questionnaire to rate the  
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33 clinical sensibility of the survey. Test-retest reliability of the survey demonstrated a  
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35 mean intraclass correlation coefficient (ICC) of 0.66 (SD 0.47) for continuous  
36  
37 responses and a mean proportion of agreement of 0.86 (SD 0.10) for categorical  
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39 responses. The low ICC for continuous responses is due to low variability in  
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41 responses for questions relating to knowledge of best practices. The participants  
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43 agreed that the survey had face validity (100%), content validity (92%), clarity (92%),  
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45 utility (100%), discriminability (75%), and minimal redundancy (100%).  
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## 54 Participants

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3 Healthcare providers (as described in Setting) that cared for patients in the nine ICUs  
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5 were invited by email to participate in the study. Invitations to participate were sent to  
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7 healthcare providers by the principal investigators or by a local clinical leader and  
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9 included a link to the electronic survey (Fluid Survey) or were provided a paper copy if  
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11 requested. Weekly reminders were sent for three weeks. Providers that responded to  
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13 the survey were offered entry into a draw for one of three \$20 coffee gift cards.  
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### 19 Data Analysis

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21 We used descriptive statistics to describe demographic features of participants,  
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23 knowledge of best practices, perceived barriers to adopting high value practices and  
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25 de-adopting low value practices, perceived facilitators to encourage adopting high  
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27 value practices and de-adopting low value practices. Barriers and facilitators to the  
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29 use of best practices were described overall, and by professional group. Professions  
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31 were categorized into three groups for analysis: 1) Physicians/NPs (those who  
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33 prescribe), 2) Nurses (those who administer), and 3) Pharmacists (those who advise  
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35 prescribers). Chi-squared tests were used to test for statistical significance between  
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37 groups.  
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### 45 Patient and public involvement

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47 Patient and family representatives were members of a committee that identified and  
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49 prioritized research questions for improving the care of critically ill patients.<sup>[32]</sup> LMWH  
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51 for VTE prophylaxis and de-adopting albumin for fluid resuscitation were two of the  
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53 research questions identified by this committee. Patients were not involved in the  
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3 design, the recruitment and conduct of this study. The results of this study have been  
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5 disseminated to patient and family advisors through oral presentations.  
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### 10 **Ethical considerations**

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12 This study was approved by the University of Calgary Conjoint Health Research  
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14 Ethics Board (REB14-0992 and REB15-2147) and the University of Alberta Research  
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16 Ethics Board (Pro00056709 and Pro00060650).  
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## 21 **RESULTS**

### 22 **Audit of current practices**

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26 There were 6,946 ICU admissions during the study period, from 6,299 unique  
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28 patients. Patient characteristics are presented in Supplemental Content 3.  
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33 The adoption cohort consisted of 4,931 admissions (71.0% of all admissions) without  
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35 a contraindication to pharmacological VTE prophylaxis, and the de-adoption cohort  
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37 consisted of 6,467 admissions (93.1%) without a potential indication for albumin  
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39 (Supplemental Content 4).  
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44 During the ICU stay LMWH was given on 38.7% of ICU days, UFH on 45.3% of ICU  
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46 days and mechanical prophylaxis (exclusive of pharmacological prophylaxis) on 7.7%  
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48 of ICU days. The type of VTE prophylaxis administered varied throughout patients'  
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50 ICU stay; administration of mechanical devices and UFH decreased over the course  
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52 of the ICU stay while administration of LMWH increased (Supplemental Content 5).  
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6,804 units of albumin were administered to 20.0% of the 6,467 admissions without documented liver disease or receipt of plasma exchange. Among those receiving at least 1 unit of albumin, the median number of units per patient was 3 (IQR=1.0-6.0). Albumin was administered on 6.5% of ICU days.

When controlling for demographic and site-level factors, the odds of receiving LMWH for VTE prophylaxis and not receiving albumin for fluid resuscitation were significantly lower for those patients with higher severity of illness (APACHE II score). The odds of receiving LMWH for VTE prophylaxis were significantly higher for patients with non-surgical admissions compared to those with elective surgical admissions (odds ratio = 1.34 (95% confidence interval 1.08-1.66); Table 1). There were significant differences in the odds of using LMWH for VTE prophylaxis, and not using albumin for fluid resuscitation across ICUs (Supplemental Content 6), and when controlling for patient-level factors some of these differences persisted especially with regards to the use of LMWH for VTE prophylaxis (Table 1).

**Table 1.** Association between patient demographic and sites, and the use of LMWH for VTE prophylaxis and not using albumin for fluid resuscitation

	<b>Appropriate VTE prophylaxis OR (95% CI)*</b>	<b>Appropriate fluid resuscitation OR (95% CI)**</b>
Age	NS <sup>†</sup>	0.999 (0.999-1.00)
Female	NS <sup>†</sup>	NS <sup>†</sup>
Any comorbidity	NS <sup>†</sup>	NS <sup>†</sup>
Admission type		
Elective surgery	1.00 (reference group)	1.00 (reference group)
Emergent surgery	1.19 (0.92-1.53)	0.92 (0.88-0.95)
No surgery	1.34 (1.08-1.66)	1.02 (0.98-1.05)
APACHE II Score (ICU admission)	0.958 (0.951-0.965)	0.989 (0.988-0.990)

Site		
C1	1.00 (reference group)	1.00 (reference group)
C2	1.32 (1.07-1.64)	0.96 (0.92-1.00)
C3	1.13 (0.89-1.46)	0.98 (0.94-1.03)
C4	1.48 (1.15-1.90)	0.98 (0.93-1.02)
E1	2.12 (1.66-2.73)	0.90 (0.86-0.95)
E2	0.86 (0.71-1.05)	0.90 (0.87-0.92)
E3	7.26 (5.46-9.65)	0.92 (0.87-0.97)
E4	0.76 (0.63-0.92)	0.88 (0.85-0.91)
E5	1.61 (1.23-2.10)	0.75 (0.72-0.79)

*Footnote:* all “C” sites indicate ICU in Calgary and all “E” sites indicate ICU in Edmonton

\*multivariable generalized estimating equations (GEEs) logistic regression model with exchangeable correlation structure given daily measurements (clustering by patient); “appropriate” considered *use of LMWH*

\*\*standard multivariable logistic regression model given single measurement per patient; “appropriate” considered *not using albumin*

†NS = non-significant, removed from model

## **Barriers and facilitators to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid resuscitation**

### Participants

83.8% (259 of 309) of participants responded; physicians/NPs (48.3%), nurses (42.5%), and pharmacists (9.3%). Participants worked in healthcare for a median of 13 years (IQR=7.1-20.0) and in critical care for a median of 8 years (IQR=3.0-15.0; Supplemental Content 7).

### Knowledge of evidence

Most participants reported that LMWH was most effective at preventing deep vein thrombosis and pulmonary embolism; and that crystalloids were most effective for fluid resuscitation (Table 2). Perceptions regarding the effectiveness of VTE prophylaxis varied by professional group, as did perceptions regarding the risks of harm (Table 2).

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3 Perceptions regarding effectiveness of albumin for fluid resuscitation and risks of  
4 harm associated with each form of fluid resuscitation did not vary by professional  
5 group but perceptions regarding the risk of fluid overload did (Table 2).  
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10 It was perceived that both best practices were being followed in the ICUs where the  
11 participants practiced (Table 2).  
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**Table 2.** Knowledge of best practices for VTE prophylaxis and fluid resuscitation

Survey question	% (N)			
	Overall N=259	Physicians/NPs 48.3% (N= 125)	Nurses 42.5% (N= 110)	Pharmacists 9.3% (N= 24)
What form(s) of prophylaxis is/are most effective at preventing deep vein thrombosis?*				
LMWH only	59.1 (153)	63.2 (79)	51.8 (57)	70.8 (17)
UFH only	4.3 (11)	2.4 (3)	7.3 (8)	0.0 (0)
LMWH & UFH	16.2 (42)	24.0 (30)	5.5 (6)	25.0 (6)
Mechanical only	1.9 (5)	0.0 (0)	4.6 (5)	0.0 (0)
(LMWH or UFH) and Mechanical	15.1 (39)	8.0 (10)	25.5 (28)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
What form(s) of prophylaxis is/are most effective at preventing pulmonary embolism? *				
LMWH only	56.8 (147)	72.0 (90)	33.6 (37)	83.3 (20)
UFH only	18.2 (47)	1.6 (2)	40.9 (45)	0.0 (0)
LMWH & UFH	12.7 (33)	20.8 (26)	3.6 (4)	12.5 (3)
Mechanical only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
(LMWH or UFH) & Mechanical	8.5 (22)	3.2 (4)	15.5 (17)	4.2 (1)
Unsure only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
Which form(s) of prophylaxis is/are most cost effective?*				
LMWH only	51.0 (132)	70.4 (88)	22.7 (25)	79.2 (19)
UFH only	15.4 (40)	12.8 (16)	20.0 (22)	8.3 (2)
LMWH & UFH	4.3 (11)	5.6 (7)	0.9 (1)	12.5 (3)
Mechanical only	10.0 (26)	4.8 (6)	18.2 (20)	0.0 (0)
(LMWH or UFH) & Mechanical	2.7 (7)	0.0 (0)	6.4 (7)	0.0 (0)
Unsure only	16.6 (43)	6.4 (8)	31.8 (35)	0.0 (0)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of bleeding?†				
LMWH only	57.5 (149)	47.2 (59)	69.1 (76)	58.3 (14)
UFH only	24.7 (64)	32.8 (41)	18.2 (20)	12.5 (3)
LMWH & UFH	5.0 (13)	6.4 (8)	0.0 (0)	20.8 (5)
Unsure only	12.7 (33)	13.6 (17)	12.7 (14)	8.3 (2)
Which form(s) of pharmacological prophylaxis has/have the lowest risk of heparin induced thrombocytopenia?*				

	LMWH only	86.1 (223)	94.4 (118)	74.6 (82)	95.8 (23)
	UFH only	6.6 (17)	3.2 (4)	11.8 (13)	0.0 (0)
	LMWH & UFH	0.4 (1)	0.0 (0)	0.0 (0)	4.2 (1)
	Unsure only	7.0 (18)	2.4 (3)	13.6 (15)	0.0 (0)
To what extent do you think best practices are followed for preventing DVT/PE in your ICU? 0=never and 7=always, Median (IQR)					
		6 (5-6)	6 (5-6)	6 (6-7)	6 (5-6)
<b>Survey question</b>	<b>Overall N=259</b>	<b>Physicians/NPs 48.3% (N= 125)</b>	<b>Nurses 42.5% (N= 110)</b>	<b>Pharmacists 9.3% (N= 24)</b>	
What form(s) of IV fluids is/are most effective for fluid resuscitation? ‡					
	Albumin only	3.5 (9)	2.4 (3)	5.5 (6)	0.0 (0)
	Crystalloids only	84.2 (218)	83.2 (104)	82.7 (91)	95.8 (23)
	Albumin & Crystalloids	8.5 (22)	9.6 (12)	9.1 (10)	0.0 (0)
	Unsure only	3.9 (10)	4.8 (6)	2.7 (3)	4.2 (1)
Which form(s) of IV resuscitation fluids are most cost effective? ‡					
	Albumin only	0.4 (1)	0.0 (0)	0.9 (1)	0.0 (0)
	Crystalloids only	94.6 (245)	94.4 (118)	95.5 (105)	91.7 (22)
	Albumin & Crystalloids	0.4 (1)	0.8 (1)	0.0 (0)	0.0 (0)
	Unsure only	4.6 (12)	4.8 (6)	3.6 (4)	8.3 (2)
Which form(s) of IV resuscitation fluids has the lowest risk of fluid overload? *					
	Albumin only	47.1 (122)	32.8 (41)	69.1 (76)	20.8 (5)
	Crystalloids only	29.7 (77)	36.8 (46)	23.6 (26)	20.8 (5)
	Albumin & Crystalloids	1.9 (5)	3.2 (4)	0.0 (0)	4.2 (1)
	Unsure only	21.2 (55)	27.2 (34)	7.3 (8)	54.2 (13)
Which form(s) of IV resuscitation fluids has the lowest risk of infectious disease? ‡					
	Albumin only	2.7 (7)	1.6 (2)	4.6 (5)	0.0 (0)
	Crystalloids only	86.5 (224)	87.2 (109)	87.3 (96)	79.2 (19)
	Albumin & Crystalloids	0.8 (2)	0.8 (1)	0.9 (1)	0.0 (0)
	Unsure only	10.0 (26)	10.4 (13)	7.3 (8)	20.8 (5)

To what extent do you think best practices are followed for prescribing fluid boluses in your ICU?

0=never and 7=always; Median (IQR)

	6 (5-6)	5 (5-6)	6 (5-6)	5 (5-6)
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<sup>1</sup>The order of the survey items are as presented in this table.

<sup>2</sup>Evidence suggests the efficacy of LMWH for deep vein thrombosis is similar to or better than UFH.<sup>[18, 19, 33, 34]</sup> Evidence suggests that LMWH is more efficacious than UFH for preventing pulmonary embolism, has a lower incidence of heparin induced thrombocytopenia, and a similar or lower risk of bleeding.<sup>[18, 19, 33, 34]</sup>

<sup>3</sup>Evidence suggests that LMWH is more cost effective than UFH.<sup>18</sup>

<sup>4</sup>Evidence suggests that albumin and crystalloids are similarly effective for fluid resuscitation.<sup>21, 24, 25, 26</sup> Evidence suggests that albumin has a higher risk of infectious disease transmission than crystalloids and is less cost-effective than crystalloids.

**Abbreviations:** **IQR** = interquartile range (p25 - p75), **LMWH** = low molecular weight heparin, **N** = number, **NP** = nurse practitioner, **UFH** = unfractionated heparin, \* = responses varied by professional group (p<0.001), † = responses varied by professional group (p=0.01), ‡ = responses did not vary by professional group (p>0.05)



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5 Barriers to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
6 resuscitation  
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10 Barriers to adoption and de-adoption were reported by 65.2% and 64.9% of  
11 respondents, respectively. The most commonly reported perceived barriers to  
12 adopting LMWH for VTE prophylaxis were insufficient knowledge or understanding,  
13 ICU culture, and no clinical guidelines (Figure 1). The most commonly reported  
14 barriers to de-adopting albumin for fluid resuscitation were a strong clinical preference  
15 of the local clinical leaders in the ICUs, ICU culture, and insufficient knowledge or  
16 understanding (Figure 1). Reported barriers differed between professional groups for  
17 both adoption (Figure 2a) and de-adoption (Figure 2b).  
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31 Facilitators to adopting LMWH for VTE prophylaxis and de-adopting albumin for fluid  
32 resuscitation  
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35 On site education and pre-set orders were perceived to be the most commonly  
36 reported facilitator of both adoption and de-adoption (Figure 3). Verbal reminders  
37 from pharmacists to physicians was commonly reported as a perceived facilitator for  
38 adopting LMMH for VTE prophylaxis. A local leader championing the practice was  
39 commonly reported as a perceived facilitator for de-adopting albumin for fluid  
40 resuscitation (Figure 3). There was no variability by professional group.  
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## 51 **DISCUSSION**

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3 The present study identified opportunities to improve the use of best practices for VTE  
4 prophylaxis (adopting the high value practice of LMWH) and fluid resuscitation (de-  
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6 adopting the low value practice of albumin). Our audit data demonstrated that current  
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8 practice does not reflect providers' understanding of the evidence for these practices.  
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11 The use of the best practice for these two illustrative examples were less likely for  
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13 patients with greater severity of illness and varied across institutions. The perceived  
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15 barriers and facilitators to adoption and de-adoption were broadly similar.  
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22 Are de-adoption and adoption just the flip-side of the same coin? There is substantial  
23  
24 literature describing the adoption of high value practices, but much less is known  
25  
26 about de-adoption of low value practices.<sup>[8]</sup> Science can inform clinical practice  
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28 through discovery resulting in adoption of a new practice, replacement resulting in a  
29  
30 practice update, and reversal resulting in de-adoption of an existing practice. It is only  
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32 recently that the last concept, de-adopting low value practices, has been debated in  
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34 journals and by professional societies.<sup>[13, 14, 16]</sup> The practical implication is that there is  
35  
36 limited evidence to inform whether the barriers and facilitators for adoption and de-  
37  
38 adoption are similar or sufficiently distinct to warrant different approaches.<sup>[9, 11-13]</sup> Our  
39  
40 study adds to the limited evidence base by suggesting that culture or organizational  
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42 factors, provider characteristics, and patient characteristics are perceived to be  
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44 important barriers and facilitators that may play broadly similar roles in adoption and  
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46 de-adoption.<sup>[11, 12]</sup>  
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3 Knowledge translation (KT) interventions are strategies to improve the synthesis,  
4 dissemination, exchange, and application of evidence to improve health.<sup>[5]</sup> KT  
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6 interventions tailored to the specific barriers and facilitators of an innovation and the  
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8 local context are more likely to effect change.<sup>[5, 6]</sup> Our study provides insight into the  
9  
10 perceived barriers and facilitators of adopting high value practices (LMWH for VTE  
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12 prophylaxis) and de-adopting low value practices (albumin for fluid resuscitation)  
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14 within ICUs, which should be taken into consideration when designing KT  
15  
16 interventions. Interestingly, despite knowledge of the evidence underlying the  
17  
18 illustrative example practices, providers perceived insufficient knowledge or  
19  
20 understanding to be a barrier and perceived education to be a facilitator to both  
21  
22 adopting high value practices and de-adopting low value practices. These barriers and  
23  
24 facilitators are consistent with a systematic review that suggests the most effective KT  
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26 interventions in the ICU employ a combination of education and protocols.<sup>[35]</sup> While  
27  
28 consistent with previous KT studies, this finding is paradoxical. It is possible that while  
29  
30 knowledgeable, providers' confidence in applying their knowledge clinically was low  
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32 and they believed education to be the intervention needed to improve their confidence  
33  
34 in applying their knowledge. Furthermore, confidence in applying new evidence in  
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36 clinical practice may be particularly challenging in the care of severely ill patients.  
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38 This hypothesis is supported by two of our findings: 1) the use of LMWH for VTE  
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40 prophylaxis and not using albumin for fluid resuscitation was inversely associated with  
41  
42 severity of patient illness and 2) the use of LMWH and not using albumin increased as  
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44 the patient became more stable (over ICU stay). Potential hypotheses to explain these  
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46 observations include that clinicians may employ conservative decision-making (use  
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3 more familiar practices) or unintentionally neglect to use best practices when caring for  
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5 sicker patients, but this need further exploration. The implications are that KT  
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7 interventions should consider clinician heuristics that are likely to be influenced by the  
8  
9 nature and severity of patient illness.  
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15 Our study suggests that factors other than knowledge may contribute to the  
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17 successful adoption of high value practices and de-adoption of low value practices,  
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19 which includes culture, providers, and the innovation. These factors have previously  
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21 been identified within the context of the ICU.<sup>[2, 36-41]</sup> ICU culture and local clinical  
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23 leader preferences were among the most commonly endorsed barriers to adopting  
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25 high value practices and de-adopting low value practices in this study and in our  
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27 study. This is highlighted by the variation in the use of LMWH between ICUs, even  
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29 when patient level factors were taken into consideration. Interestingly, this finding was  
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31 less pronounced for de-adoption, which has been previously reported.<sup>[9]</sup> Culture, also  
32  
33 referred to as organizational context, is a frequently cited barrier to evidence-based  
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35 medicine and can have a profound effect on clinical practice.<sup>[7, 42]</sup> However, few  
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37 studies have systematically evaluated the effect of culture on adopting high value  
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39 practices and de-adopting low value practices, and implementation studies  
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41 infrequently account for the effect of culture on their practice change interventions.<sup>[43]</sup>  
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43 Similarly, the professional role of the provider is not often contextualized but may be  
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45 important (e.g., should pharmacists and nurses be targeted in KT interventions  
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47 designed to change the prescribing patterns of physicians and if so how?).<sup>[44]</sup> This  
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3 may be especially relevant as healthcare delivery becomes increasingly multi-  
4 professional and team-based as illustrated in our setting (ICU).  
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10 The characteristics of innovations themselves may influence change in clinical  
11 practice. Evidence suggests that if the innovation being adopted is congruent with  
12 clinical practice beliefs it can facilitate adoption.<sup>[7]</sup> Furthermore, the quality, quantity,  
13 and stability of available evidence to support the adoption or de-adoption of an  
14 innovation is likely important.<sup>[45]</sup> Although most providers in our study were aware of  
15 the evidence to support the adoption of LMWH for VTE prophylaxis and de-adoption  
16 of albumin for fluid resuscitation, they may not have perceived the evidence to be  
17 sufficient to warrant practice change. A growing awareness of challenges with  
18 reproducing scientific evidence and clinician experience with practice reversals<sup>[2]</sup> may  
19 result in more conservative provider behavior and slower practice change in response  
20 to new evidence. The suboptimal prescribing practices observed in our study likely  
21 represent a combination of all these factors.  
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40 One limitation of this study is that the survey used was imperfect. The results of the  
41 self-reported survey reflect perceived modifiers of practice among providers rather  
42 than factors shown to influence practice patterns as identified in observational  
43 studies.<sup>[46]</sup> The survey was purposefully designed to be simple and accessible to  
44 garner a representative perspective from all provider professions and therefore  
45 captured key concepts, but not granular data. Nevertheless, the survey has been  
46 successfully used for a similar purpose by others;<sup>[30]</sup> was reliable and reported to have  
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3 good clinical sensibility. Alternative methodologies such as qualitative analyses of  
4 semi-structured interviews may have allowed for more in depth exploration of barriers  
5 and facilitators to adopting LMWH and de-adopting albumin. Finally, while this study  
6 was a provincial and multi-site it was constrained to ICUs, which should be taken into  
7 consideration when interpreting our findings beyond this setting.  
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17 In conclusion, our study provides several insights into similarities and differences  
18 between adoption of high value practices and de-adoption of low value practices. Both  
19 adoption and de-adoption of the illustrative example practices did not reflect  
20 healthcare providers' knowledge of the evidence. The use of best practices for both  
21 illustrative examples practices were less likely for patients with greater severity of  
22 illness and varied across institutions. We found that perceived barriers and facilitators  
23 are more similar than different between adoption and de-adoption, which suggests  
24 existing behavior change frameworks for adopting high value practices may also be  
25 applicable for de-adopting low value practices.  
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## DISCLOSURE OF CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

## DATA SHARING STATEMENT

Data will be provided upon request to the corresponding author ([tstelfox@ucalgary.ca](mailto:tstelfox@ucalgary.ca))

## AUTHORS' CONTRIBUTIONS

Dr. Sauro contributed to the design and conceptualization of the study; analysis and interpretation of the data, drafting and revising the manuscript and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Bagshaw contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

Dr. Niven contributed to the design and conceptualization of the study, interpretation of the data, providing feedback on the manuscript, and gave approval of the final version of the manuscript. No conflicts of interest to declare.

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3 Dr. Soo contributed to the analysis and interpretation of the data, providing feedback  
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5 on the manuscript and gave approval of the final version of the manuscript. No  
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7 conflicts of interest to declare.  
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12 Ms. Brundin-Mather contributed to the interpretation of the data, providing feedback  
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14 on the manuscript, and gave approval of the final version of the manuscript. No  
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16 conflicts of interest to declare.  
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21 Dr. Parsons Leigh contributed to the design and conceptualization of the study,  
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23 interpretation of the data, providing feedback on the manuscript, and gave approval of  
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25 the final version of the manuscript. No conflicts of interest to declare.  
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30 Dr. Cook contributed to the design and conceptualization of the study, interpretation of  
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32 the data, providing feedback on the manuscript, and gave approval of the final version  
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34 of the manuscript. No conflicts of interest to declare.  
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39 Dr. Stelfox contributed to the design and conceptualization of the study, interpretation  
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41 of the data, providing feedback on the manuscript, and gave approval of the final  
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43 version of the manuscript. No conflicts of interest to declare.  
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4 **Figure 1.** Barriers to the adoption of high value practices (low molecular weight  
5 heparin for venous thromboembolism prophylaxis) and de-adoption of low value  
6 practices (albumin for fluid resuscitation)  
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13 *Abbreviations:* ICU: intensive care unit  
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4 **Figure 2a.** Barriers to the adoption of high value practices (low molecular weight  
5 heparin for venous thromboembolism prophylaxis) by professional group.  
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10 **Figure 2b.** Barriers to the de-adoption of low value practices (albumin for fluid  
11 resuscitation) by professional group  
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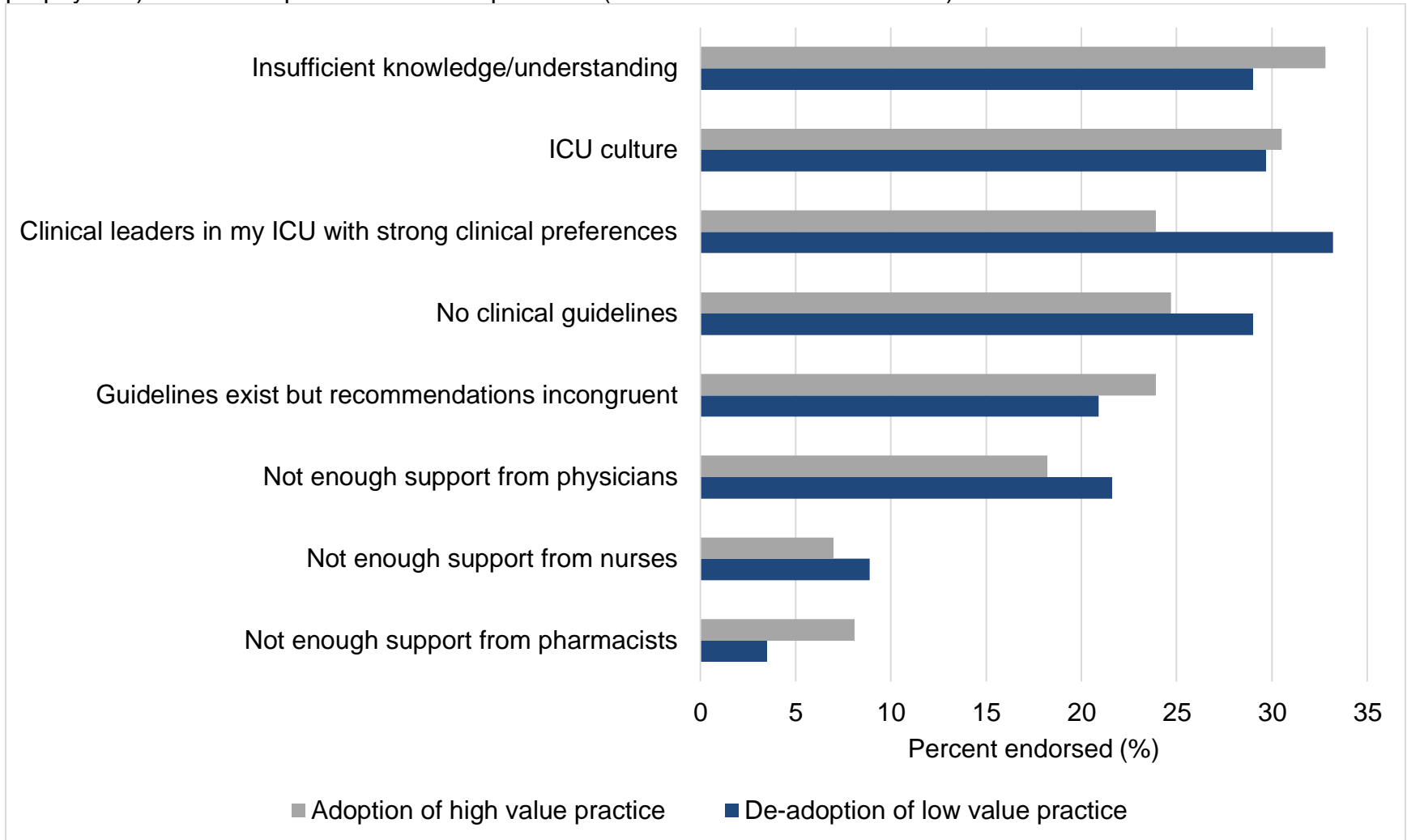
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16 *Abbreviations:* **ICU**=intensive care unit, **NP**=nurse practitioner  
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4 **Figure 3.** Facilitators to the adoption of high value practices (low molecular  
5 weight heparin for venous thromboembolism prophylaxis) and de-adoption of low  
6 value practices (albumin for fluid resuscitation)  
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16 *Abbreviation:* **MD**=medical doctor, **QI**=quality improvement  
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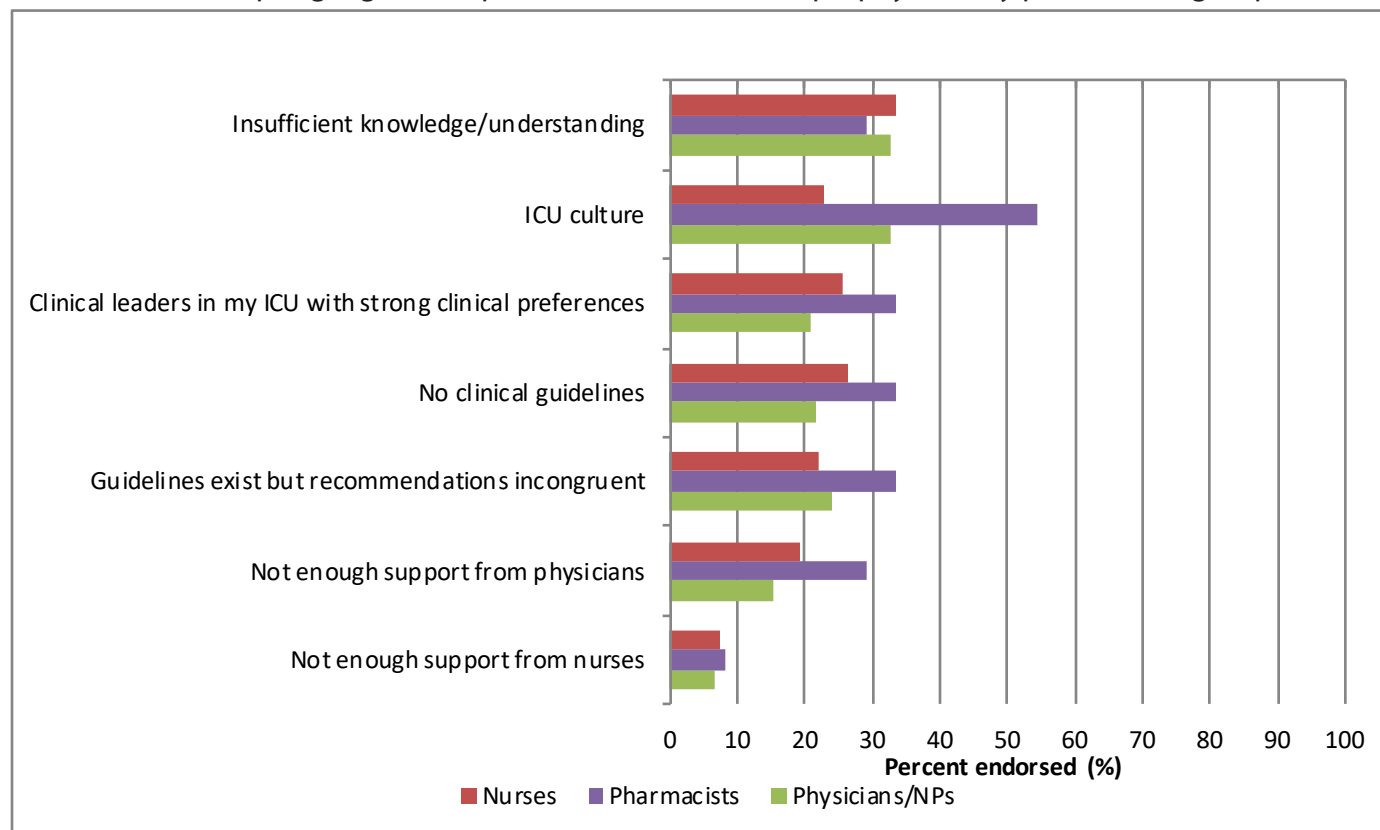
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**Figure 1.** Barriers to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)

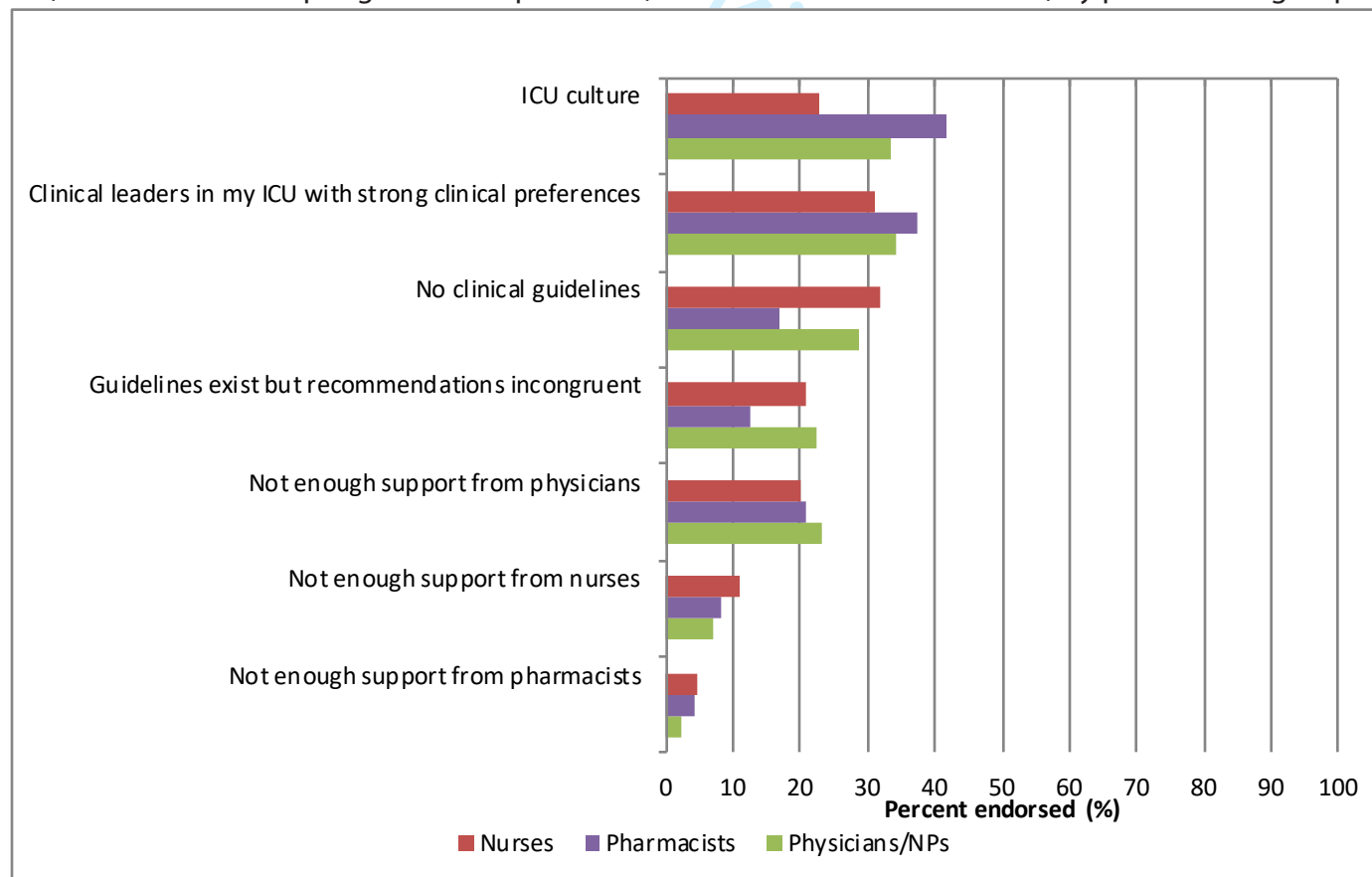


**Figure 2.** Barriers to adopting high value practices and de-adopting low value practices by profession

2.a) Barriers to adopting high value practices (LMWH for VTE prophylaxis) by professional group



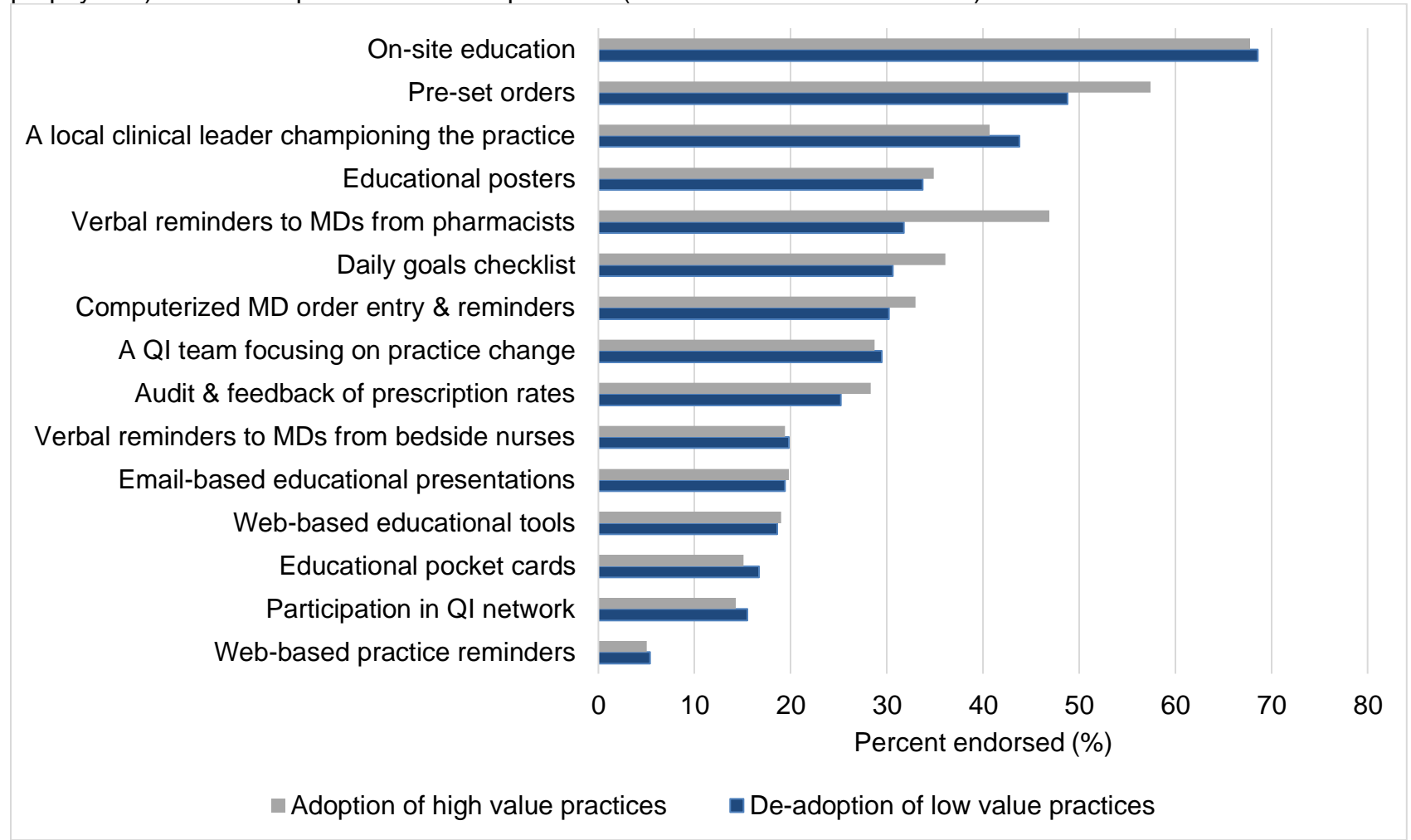
2.b) Barriers to de-adopting low value practices (albumin for fluid resuscitation) by professional group



Abbreviations: ICU=intensive care unit; NP=nurse practitioner; LMWH=low molecular weight heparin; VTE=venous thromboembolism



**Figure 3.** Facilitators to the adoption of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and de-adoption of low value practices (albumin for fluid resuscitation)



Abbreviation: MD=medical doctor, QI=quality improvement

**Supplemental Content 1.** List of diagnoses with a potential contraindication to receive pharmacological venous thromboembolism prophylaxis or indication for therapeutic anticoagulation\*

Arteriovenous malformation, surgery for
Embolus, pulmonary
GI Vascular insufficiency
Grafts, removal of infected vascular
Neoplasm, neurologic
Neoplasm-cranial, surgery for (excluding transphenoidal)
Neoplasm-spinal cord surgery or other related procedures
Neurologic surgery, other
Subarachnoid hemorrhage/intracranial aneurysm
Subarachnoid hemorrhage/intracranial aneurysm, surgery for
Thrombosis, vascular (deep vein)
Transphenoidal surgery
Ulcer disease, peptic
Abdomen only trauma
Abdomen only trauma, surgery for
Abdomen/extremity trauma
Abdomen/extremity trauma, surgery for
Abdomen/face trauma
Abdomen/face trauma, surgery for
Abdomen/multiple trauma
Abdomen/multiple trauma, surgery for
Abdomen/pelvis trauma, surgery for
Abscess/infection-cranial, surgery for
Anastomosis, vascular
Aneurysm, abdominal aortic
Aneurysm, abdominal aortic; with dissection
Aneurysm, abdominal aortic; with rupture
Aneurysm, dissecting aortic
Aneurysm, thoracic aortic
Aneurysm, thoracic aortic; with dissection
Aneurysm, thoracic aortic; with rupture
Aneurysm/pseudoaneurysm, other
Aneurysms, repair of other (except ventricular)
Biopsy, brain
Bleeding, GI from esophageal varices/portal hypertension
Bleeding, GI-location unknown
Bleeding, lower GI
Bleeding, upper GI
Bleeding-lower GI, surgery for
Bleeding-other GI, surgery for
Bleeding-upper GI, surgery for

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3	Burr hole placement
4	CABG alone, coronary artery bypass grafting
5	CVA, cerebrovascular accident/stroke
6	Chest/abdomen trauma
7	Chest/abdomen trauma, surgery for
8	Chest/abdomen trauma, surgery for
9	Chest/extremity trauma
10	Chest/extremity trauma, surgery for
11	Chest/extremity trauma, surgery for
12	Chest/face trauma
13	Chest/face trauma, surgery for
14	Chest/face trauma, surgery for
15	Chest/multiple trauma
16	Chest/multiple trauma, surgery for
17	Chest/multiple trauma, surgery for
18	Chest/pelvis trauma
19	Chest/pelvis trauma, surgery for
20	Chest/pelvis trauma, surgery for
21	Chest/spinal trauma
22	Chest/spinal trauma, surgery for
23	Chest/spinal trauma, surgery for
24	Chest/thorax only trauma
25	Chest/thorax only trauma, surgery for
26	Chest/thorax only trauma, surgery for
27	Coagulopathy
28	Complications of prev. peripheral vasc. surgery, surgery for (i.e.ligation of
29	bleeder, exploration and evacuation of hematoma, debridement,
30	pseudoaneurysms, clots, fistula, etc.)
31	Complications of previous GI surgery; surgery for (anastomotic leak, bleeding,
32	abscess, infection, dehiscence, etc.)
33	Complications of previous spinal cord surgery, surgery for
34	Cranioplasty and complications from previous craniotomies
35	Cranioplasty and complications from previous craniotomies
36	Head (CNS) only trauma
37	Head (CNS) only trauma, surgery for
38	Head (CNS) only trauma, surgery for
39	Head/abdomen trauma
40	Head/abdomen trauma, surgery for
41	Head/abdomen trauma, surgery for
42	Head/chest trauma
43	Head/chest trauma, surgery for
44	Head/chest trauma, surgery for
45	Head/extremity trauma
46	Head/extremity trauma, surgery for
47	Head/extremity trauma, surgery for
48	Head/face trauma
49	Head/face trauma, surgery for
50	Head/face trauma, surgery for
51	Head/multiple trauma
52	Head/multiple trauma, surgery for
53	Head/multiple trauma, surgery for
54	Head/pelvis trauma
55	Head/pelvis trauma, surgery for
56	Head/pelvis trauma, surgery for
57	Head/spinal trauma
58	Head/spinal trauma, surgery for
59	Head/spinal trauma, surgery for
60	Hematoma, epidural
	Hematoma, epidural, surgery for
	Hematoma, epidural, surgery for
	Hematoma, subdural
	Hematoma, subdural, surgery for
	Hematoma, subdural, surgery for

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3	Hematomas
4	Hemorrhage (for gastrointestinal bleeding GI-see GI system) (for trauma see
5	Trauma)
6	Hemorrhage, intra/retroperitoneal
7	Hemorrhage, postpartum (female only)
8	Hemorrhage/hematoma, intracranial
9	Hemorrhage/hematoma-intracranial, surgery for
10	Hemorrhage/hemoptysis, pulmonary
11	Hemothorax
12	Pelvis/extremity trauma
13	Pelvis/extremity trauma, surgery for
14	Pelvis/face trauma
15	Pelvis/hip only trauma, surgery for
16	Pelvis/multiple trauma, surgery for
17	Pelvis/spinal trauma
18	Pericardial effusion/tamponade
19	Renal bleeding
20	Spinal cord only trauma, surgery for
21	Spinal cord surgery, other
22	Stereotactic procedure
23	Subarachnoid hemorrhage/arteriovenous malformation
24	Tamponade, pericardial
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\*Footnote: The primary diagnoses were reviewed independently by two ICU physicians (HTS, DJN). The two ICU physicians provided their judgment to establish a conservative list of primary diagnoses in order to exclude patients that may have a contraindication for pharmacological VTE prophylaxis based on bleeding risk and an indication for therapeutic anticoagulation. Discrepancies were resolved by discussion.



## Adopting Best Practices in DVT/PE Prophylaxis and Fluid Resuscitation in Critical Care

[http://fluidsurveys.com/s/ECG\\_facilitators\\_barriers\\_survey/](http://fluidsurveys.com/s/ECG_facilitators_barriers_survey/)

### Informed Consent

This survey is to identify and evaluate barriers to, and facilitators of, best practices in:

1. Deep Vein Thrombosis (DVT) / Pulmonary Embolism (PE) prophylaxis for medical-surgical ICU patients, and
2. Fluid Resuscitation for medical-surgical ICU patients *without* liver disease, bacterial peritonitis, hepatorenal syndrome or therapeutic paracentesis.

**This survey is not about trauma, neurosurgery or cardiac surgery patients.** Survey responses will be used to develop interventions to facilitate the adoption of best practices in Alberta ICUs.

You are being asked to take part in this survey because you are a healthcare professional working in adult critical care in Alberta. Our survey can be answered in approximately **5 minutes**. There are no direct benefits and/or risks to your participation.

Survey respondents can choose to have their name entered into a draw for \$20 Starbucks gift cards (one name will be drawn per week; non-winners will remain in the draw each week).

Your participation in this survey is voluntary and you are free to stop at any time. Your responses will be kept confidential. Your de-identified data will be stored in a password-protected database, and responses will only be presented in aggregate. The survey has peer-reviewed funding and has received ethics approval from the University of Calgary. **Your decision to complete and submit this survey will indicate your consent to participate.** Should you decide to withdraw your participation before submitting the survey, your data will be deleted.

If you have questions about this survey or your participation, please contact:

Rebecca Brundin-Mather, Research Coordinator, at [brundin@ucalgary.ca](mailto:brundin@ucalgary.ca).

If you have questions about your rights as a participant, you may contact the University of Calgary Conjoint Research Ethics Board at (403) 220-7990. This office is not affiliated with the study team.

Thank you in advance for taking the time to complete the survey!

Kind regards,

Tom Stelfox, MD, PhD, FRCPC

Intensive Care Physician

Scientific Director, AHS, Critical Care Strategic Clinical Network

I agree to participate in this survey       I do **NOT** wish to participate in this survey (online-version)

## Demographics

### 1. What is your professional group?

- ICU physician       Nurse Clinician       Pharmacist  
 ICU resident       Nurse Educator       Other: \_\_\_\_\_  
 ICU fellow       Bedside Nurse

### 2. Approximately how many years have you worked in:

Health care       Critical care

### 3. In which hospital(s) do you primarily work? (Select all that apply)

- Chinook Regional Hospital  
 Foothills Medical Centre  
 Grand Prairie QE II Hospital  
 Grey Nuns Hospital  
 Medicine Hat Regional Hospital  
 Misericordia Hospital  
 Northern Lights Regional Health Centre  
 Peter Lougheed Centre  
 Red Deer Regional Hospital  
 Rockyview General Hospital  
 Royal Alexander Hospital  
 South Health Campus  
 Sturgeon Community Hospital  
 University of Alberta Hospital

## DVT/PE Prevention

We are interested in your perceptions of the different forms of prophylaxes commonly used to prevent Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE) in medical-surgical ICU patients (not trauma, neurosurgery or cardiac surgery patients). Common prophylaxes include:

- Low molecular weight heparin (**LMWH** e.g., Enoxaparin, Dalteparin, Tinzaparin)
- Unfractionated heparin (**UFH**, regular Heparin)
- **Mechanical** prophylaxis (i.e., sequential compression devices)

We appreciate that practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

4. Which form(s) of prophylaxis is/are most effective at preventing:

	LMWH	UFH	Mechanical	Unsure
Deep Vein Thrombosis (DVT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pulmonary Embolism (PE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Which form(s) of prophylaxis is/are most cost-effective?

LMWH	UFH	Mechanical	Unsure
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Which form(s) of *pharmacological* prophylaxis has/have the lowest risk of:

	LMWH	UFH	Unsure
Bleeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heparin Induced Thrombocytopenia (HIT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. To what extent do you think best practices for preventing DVT/PE are followed in your ICU (i.e., the patient receives the right prophylaxis with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>	<b>Sometimes</b>			<b>Always</b>			

**Intravenous Fluid Resuscitation**

We are now interested in your perceptions of the different types of intravenous fluids commonly used for fluid resuscitation (i.e., fluid boluses) in the ICU for medical-surgical patients, **excluding** patients with liver disease, bacterial peritonitis, or undergoing therapeutic paracentesis as they may have different fluid needs. Common resuscitation fluids include:

- **Human Albumin** (Albumin 5% or Albumin 25%)
- **Crystalloid solutions** (e.g., normal saline, ringers lactate, and plasma-lyte)

Again, we appreciate that clinical practices vary across units and providers. For each of the following questions, please select the **best response option** OR **options**, to the best of your knowledge (more than one response option can be selected).

8. Which form(s) of IV resuscitation fluid is/are most effective for resuscitation?

Albumin                       Crystalloids                       Unsure

9. Which form(s) of IV resuscitation fluid(s) is/are most cost-effective?

Albumin                       Crystalloids                       Unsure

10. Which form(s) of IV resuscitation fluid(s) has/have the lowest risk of:

	Albumin	Crystalloids	Unsure
Fluid overload (peripheral / pulmonary)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Contracting an infectious disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. To what extent do you think *best practices* for prescribing fluid boluses are followed **in your ICU** (i.e., the patient receives the right fluid with the right dose at the right time)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	Unsure
<b>Never</b>			<b>Sometimes</b>			<b>Always</b>	



## **Barriers to Best Practices**

A number of ICU or 'systems' factors have been identified as potential barriers to best practices. We are interested in what you think are barriers **in your ICU** to prescribing:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

12. Which of the following factors are current barriers in your ICU to prescribing...

	<b>LMWH over UFH</b>		<b>Crystalloids over Albumin</b>	
	<b>Current Barrier</b>	Unsure	<b>Current Barrier</b>	Unsure
An ICU culture with an unclear or slow process for practice change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from physicians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from nurses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not enough support from pharmacists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clinical leaders in my ICU with strong clinical preferences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No clinical guidelines or orders sets in my ICU to guide the practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guidelines exist in my ICU, but they do not recommend LMWH over UFH / crystalloids over albumin	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Insufficient knowledge/understanding the evidence base for the practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>None</b> of the above factors are current barriers in my ICU to prescribing....	<input type="radio"/>		<input type="radio"/>	
Please note any other factors that may be barriers to prescribing LMWH over UFH and/or crystalloids over albumin. Specify below.				

### **Strategies to Encourage Best Practices**

A number of strategies have been identified as potential facilitators to changing clinical practice. We are interested in your perceptions of different strategies that have been used to encourage:

1. LMWH over UFH for DVT/PE prophylaxis
2. Crystalloid solutions over Albumin for fluid resuscitation

13. Which of the following strategies are currently used in your ICU to encourage...

	<b>LMWH over UFH</b>	<b>Crystalloids over Albumin</b>
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="radio"/>	<input type="radio"/>
2. Educational posters (in the unit)	<input type="radio"/>	<input type="radio"/>
3. Educational pocket cards	<input type="radio"/>	<input type="radio"/>
4. Email-based educational presentations	<input type="radio"/>	<input type="radio"/>
5. Web-based educational tools	<input type="radio"/>	<input type="radio"/>
6. Verbal reminders to physicians from pharmacists	<input type="radio"/>	<input type="radio"/>
7. Verbal reminders to physicians from bedside nurses	<input type="radio"/>	<input type="radio"/>
8. Pre-set orders	<input type="radio"/>	<input type="radio"/>
9. Computerized physician order entry & reminders	<input type="radio"/>	<input type="radio"/>
10. Web-based practice reminders	<input type="radio"/>	<input type="radio"/>
11. Daily goals checklist	<input type="radio"/>	<input type="radio"/>
12. Audit & feedback of prescription rates	<input type="radio"/>	<input type="radio"/>
13. A quality improvement team focusing on practice change	<input type="radio"/>	<input type="radio"/>
14. Participation in a quality improvement network	<input type="radio"/>	<input type="radio"/>
15. A local clinical leader championing the practice	<input type="radio"/>	<input type="radio"/>
16. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
17. Other strategy used. Please specify:	<input type="radio"/>	<input type="radio"/>
<b>NO</b> strategies are currently being used in my ICU encourage this practice:	<input type="radio"/>	<input type="radio"/>

14. From the same list of strategies, please select the **5 best strategies** that you believe would work **in your ICU** to encourage:

(1) LMWH over UFH for DVT/PE prophylaxis

(2) Crystalloid solutions over Albumin for fluid resuscitation

(Select up to 5 strategies, regardless whether the strategy is used in your ICU or not)

**Select up to 5 in each column**

Strategy to change clinical practice	LMWH over UFH	Crystalloids over Albumin
1. On-site education (in-services, rounds, journal clubs, orientations)	<input type="checkbox"/>	<input type="checkbox"/>
2. Educational posters (in the unit)	<input type="checkbox"/>	<input type="checkbox"/>
3. Educational pocket cards	<input type="checkbox"/>	<input type="checkbox"/>
4. Email-based educational presentations	<input type="checkbox"/>	<input type="checkbox"/>
5. Web-based educational tools	<input type="checkbox"/>	<input type="checkbox"/>
6. Verbal reminders to physicians from pharmacists	<input type="checkbox"/>	<input type="checkbox"/>
7. Verbal reminders to physicians from bedside nurses	<input type="checkbox"/>	<input type="checkbox"/>
8. Pre-set orders	<input type="checkbox"/>	<input type="checkbox"/>
9. Computerized physician order entry & reminders	<input type="checkbox"/>	<input type="checkbox"/>
10. Web-based practice reminders	<input type="checkbox"/>	<input type="checkbox"/>
11. Daily goals checklist	<input type="checkbox"/>	<input type="checkbox"/>
12. Audit & feedback of prescription rates	<input type="checkbox"/>	<input type="checkbox"/>
13. A quality improvement team to focus on practice change	<input type="checkbox"/>	<input type="checkbox"/>
14. Participation in a quality improvement network	<input type="checkbox"/>	<input type="checkbox"/>
15. A local clinical leader to champion the practice	<input type="checkbox"/>	<input type="checkbox"/>
16. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>
17. Other strategy. Please specify:	<input type="checkbox"/>	<input type="checkbox"/>

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3 15. Finally, please provide any additional comments in the text box below.  
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15 Please select the check box(es) below to have your name entered in the Starbucks coffee card  
16 draws and/or to receive the study results.  
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19  Yes, I would like my name entered in the coffee card draws.  
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21  Yes, I would like to receive the results from this study.  
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25 My email address is:  
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28 N.B. E-mail addresses will be kept confidential and will not be used to contact you for any  
29 reason other than those noted above.  
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36 ---End of Survey ---  
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40 **Thank you for helping us improve care!**  
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42  
43 **Please return completed surveys to:**  
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45  
46 Dr. Tom Stelfox  
47 Department of Critical Care Medicine  
48 Foothills Medical Centre  
49

OR

Rebecca Brundin-Mather  
Ward of the 21<sup>st</sup> Century  
GD01 Teaching, Research, Wellness Bldg  
University of Calgary, 3280 Hospital Dr NW  
Calgary, AB T2N 4Z6



**Supplemental Content 3.** Intensive care unit patient characteristics for the study period (January 1, 2014-December 31, 2014)

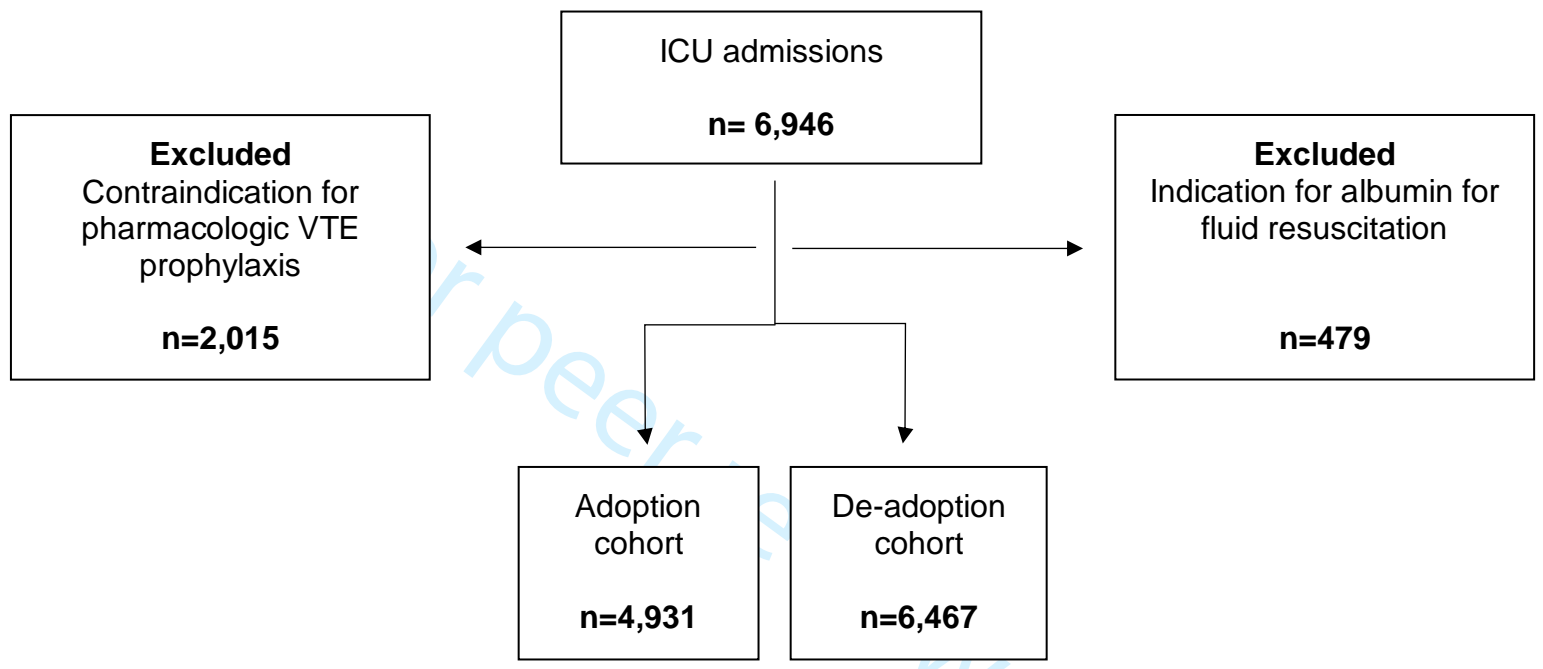
<b>Demographic variable</b>	<b>Population (N=6,946)</b>	<b>Adoption cohort 70.7% (N=4,931)</b>	<b>De-adoption cohort 93.1% (N=6,467)</b>
Age, median (IQR)	60 (46-71)	61 (47-71)	61 (46-71)
Female	41.6 (2,888)	43.3 (2,134)	41.8 (2,703)
Comorbidities			
AIDS	0.6 (42)	0.7 (33)	0.5 (35)
Chronic dialysis	3.5 (240)	3.8 (186)	3.5 (225)
Chronic heart failure	6.4 (444)	7.4 (364)	6.5 (419)
Cirrhosis	5.9 (407)	6.0 (294)	0.0 (0)
Diabetes	19.7 (1,366)	21.6 (1,065)	19.9 (1,284)
Hepatic failure	3.9 (269)	4.1 (203)	0.0 (0)
Immune suppression	8.5 (589)	9.4 (463)	8.2 (532)
Leukemia or multiple myeloma	1.3 (88)	1.4 (69)	1.3 (86)
Lymphoma	1.1 (77)	1.2 (61)	1.2 (75)
Metastatic cancer	3.9 (272)	4.1 (203)	4.1 (262)
Respiratory insufficiency	12.0 (833)	14.6 (722)	12.5 (810)
Any comorbidity	44.6 (3,100)	49.3 (2,431)	40.6 (2,625)
Admitted from			
Emergency department	36.6 (2,540)	36.7 (1,808)	36.5 (2,358)
Operating / recovery room	21.9 (1,520)	18.3 (902)	22.2 (1,437)
Hospital ward	26.7 (1,858)	28.1 (1,386)	26.3 (1,702)
Other hospital	10.4 (722)	11.9 (589)	10.5 (677)
Other location	4.3 (300)	4.9 (243)	4.5 (288)
Unknown	0.1 (6)	0.1 (3)	0.1 (5)
Admission type			

Elective surgery	9.4 (655)	8.1 (399)	9.5 (614)
Emergent surgery	16.8 (1,170)	13.8 (681)	17.3 (1,120)
No surgery	73.1 (5,078)	78.1 (3,851)	72.5 (4,690)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
Reason for ICU admission			
Medical	59.9 (4,163)	69.4 (3,420)	58.7 (3,797)
Surgical	25.8 (1,789)	24.1 (1,190)	26.2 (1,696)
Neurological	9.3 (649)	4.1 (200)	9.8 (632)
Trauma	4.3 (302)	2.5 (121)	4.6 (299)
Unknown	0.6 (43)	0.0 (0)	0.7 (43)
APACHE II Score on ICU admission, median (IQR)	19 (14-26)	20 (15-26)	19 (14-25)
Glasgow Coma Scale score on ICU admission, median (IQR)	14 (11-15)	14 (11-15)	14 (11-15)
Intubation	65.5 (4,553)	66.2 (3,264)	64.9 (4,195)
Invasive ventilation	68.3 (4,747)	68.8 (3,393)	67.8 (4,387)
Duration, median hours (IQR)	51 (18-133)	62 (25-143)	50 (18-132)
Non-invasive ventilation	13.1 (913)	16.2 (798)	13.6 (878)
Duration, median hours (IQR)	24 (8-63)	28 (9-68)	24 (6-65)
ICU length of stay, median days (IQR)	3.7 (1.8-7.7)	4.3 (2.4-8.3)	3.7 (1.8-7.6)
Hospital length of stay, median days (IQR)	13.3 (6.1-29.5)	13.9 (6.8-30.0)	13.2 (6.1-29.3)
ICU mortality	14.1 (981)	12.2 (601)	12.9 (837)
Hospital mortality	21.0 (1,462)	19.9 (979)	19.5 (1,260)

**Abbreviations:** **AIDS**=autoimmune deficiency syndrome, **APACHE II**=Acute Physiology and Chronic Health Evaluation II, **ICU**=intensive care unit, **IQR**=interquartile range,

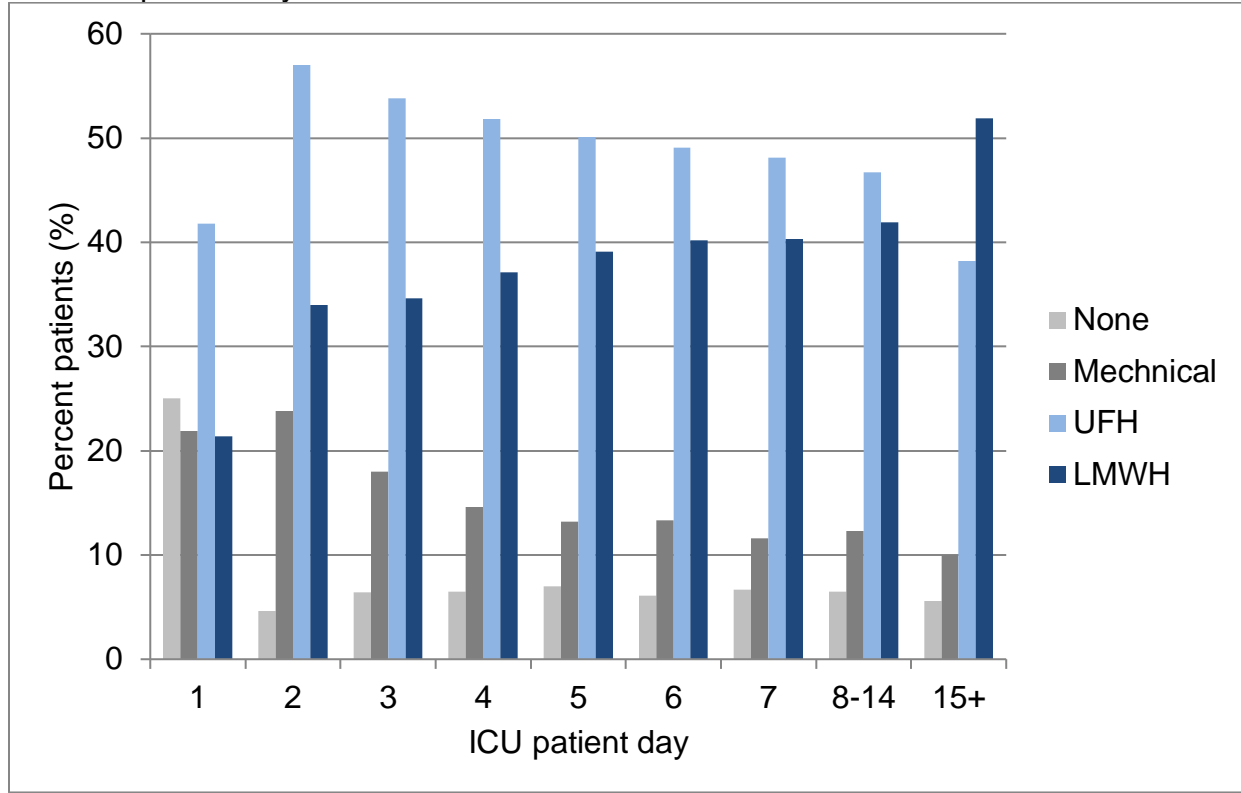
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**Supplemental Content 4. Flow of patients**



*Footnote:* Adoption cohort = Recommended to receive low molecular weight heparin for venous thromboembolism prophylaxis; de-adoption cohort = Recommended to NOT receive albumin for fluid resuscitation

**Supplemental Content 5. Venous thromboembolism prophylaxis by intensive care unit patient day**

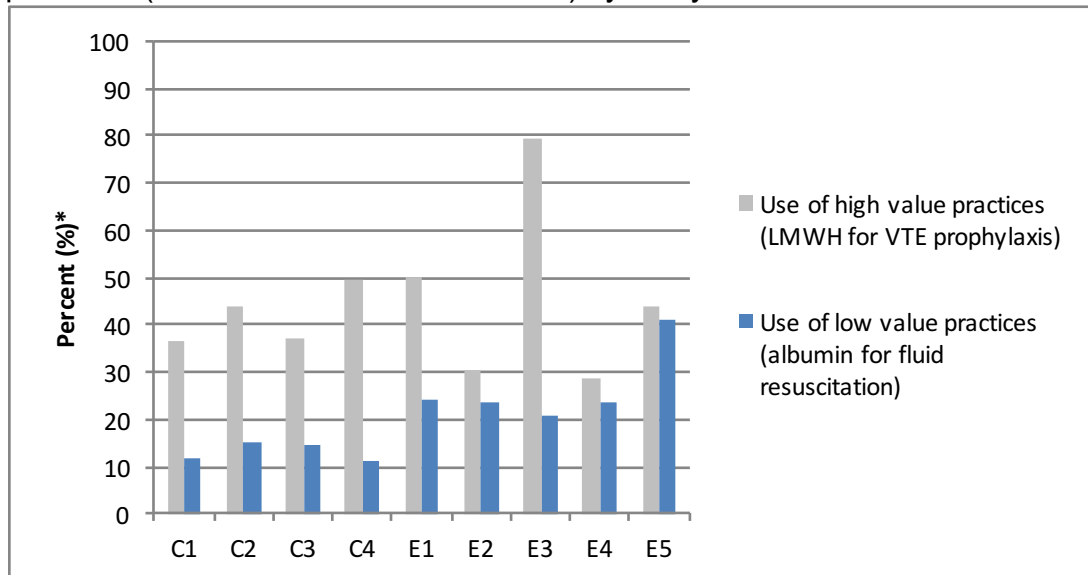


*Footnote:* Percent of patients may add to greater than 100% because patients may have received more than one form of venous thromboembolism prophylaxis on a given patient day.

*Abbreviation:* ICU=intensive care unit, LMWH=low molecular weight heparin, UFH=unfractionated heparin



**Supplemental Content 6.** The use of high value practices (low molecular weight heparin for venous thromboembolism prophylaxis) and the use of low value practices (albumin for fluid resuscitation) by study intensive care unit



*Footnote:* all "C" sites indicate ICU in Calgary and all "E" sites indicate ICU in Edmonton

\*% of patient-days for VTE prophylaxis and % of patients for albumin

**Supplemental Content 7. Survey participant characteristics**

<b>Professional group</b>	<b>% (N)</b>
Attending physician	24.7 (64)
Fellow	6.2 (16)
Resident	12.4 (32)
Nurse practitioner	5.0 (13)
Nurse manager / charge nurse	10.0 (26)
Nurse educator	8.5 (22)
Bedside nurse	23.9 (62)
Pharmacist	9.3 (24)
<b>Years worked in ICU</b>	<b>Median (IQR)</b>
Attending physician	14.0 (9.8-22.0)
Clinical fellow	1.8 (1.0-2.3)
Resident	0.3 (0.1-1.0)
Nurse practitioner	15.0 (9.0-20.0)
Nurse manager / charge nurse	11.5 (7.3-18.8)
Nurse educator	19.0 (10.3-21.5)
Bedside nurse	7.5 (2.5-12.0)
Pharmacist	5.3 (3.0-10.8)
<b>Years worked in healthcare</b>	<b>Median (IQR)</b>
Attending physician	19.0 (14.8-25.3)
Clinical fellow	8.0 (7.0-9.5)
Resident	3.0 (2.0-5.1)
Nurse practitioner	15.0 (12.0-25.0)
Nurse manager / charge nurse	16.5 (12.5-24.0)
Nurse educator	21.0 (13.0-26.0)
Bedside nurse	10.0 (6.0-16.0)
Pharmacist	10.5 (6.1-14.3)