Reducing unnecessary testing in the emergency department: The case for INR and aPTT

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CLINICIAN'S CAPSULE

What is known about the topic?
Rising costs of emergency department care are multifactorial but have been attributed to over-testing and over-treating in the emergency department.

What did this study ask?
Can uncoupling coagulation testing, disseminating an online educational module, and implementing an ongoing clinical decision support system tool reduce coagulation testing and associated costs in the emergency department?

What did this study find?
This pre-post staged intervention study found a 45% relative decrease in the rate of coagulation with an associated decrease in costs without any signal of patient harm.

Why does this study matter to clinicians?
Emergency physicians should continue to focus on identifying low-value tests and treatments as effective interventions exist to improve the value of emergency care.

ABSTRACT

Objective: Routine coagulation testing is rarely indicated in the emergency department. Our goal is to determine the combined effects of uncoupling routine coagulation testing (i.e., international normalized ratio [INR]; activated partial thromboplastin time [aPTT]), disseminating an educational module, and implementing a clinical decision support system (CDSS) on coagulation testing rates in two academic emergency departments.

Methods: A prospective pre-post study of INR-aPTT uncoupling, educational module distribution, and CDSS implementation in two academic emergency departments. All patients ages 18 years and older undergoing evaluation and treatment during the period of August 1, 2015, to November 30, 2017, were included. Primary outcome was coagulation testing utilization during the emergency department encounter. Secondary outcomes included associated costs, frequency of downstream testing, and frequency of blood transfusions.

Results: Uncoupling INR-aPTT testing combined with educational module distribution and CDSS implementation resulted in significantly decreased coupled INR-aPTT testing, with significantly increased selective INR and aPTT testing. Overall, the aggregate rate of coagulation testing declined for both INR and aPTT testing (48 tests/100 patients/day to 26 tests/100 patients/day). There was a significant decrease in associated daily costs (median cost per day: $1048.32 v. $601.68), realizing estimated annual savings of $163,023 Canadian dollars (CAD). There was no signal of increased downstream testing or patient blood product requirements.

Conclusion: Compared to baseline practice patterns, our multimodal initiative significantly decreased coagulation testing, with meaningful cost savings and without evidence of patient harm. Clinicians and administrators now have a growing toolkit to target the plethora of low-value tests and treatments in emergency medicine.

RÉSUMÉ

Contexte: Les épreuves courantes de la coagulation sont rarement indiquées au service des urgences. L'étude visait à déterminer les effets cumulés de la dissociation des épreuves courantes de la coagulation (rapport international normalisé [RIN], temps de thromboplastine partielle activée [TTPa]), de la diffusion d'un module de formation et de la mise en œuvre d'un système d'aide à la décision clinique (SADC) sur les taux d'épreuve de la coagulation dans deux services des urgences (SU) universitaires.

Méthode: Il s'agit d'une étude prospective, de type avant-après, sur la dissociation du RIN et du TTPa, la distribution d'un module de formation et la mise sur pied d'un SADC dans deux SU universitaires. Ont été inclus dans l'étude tous les patients de 18 ans et plus, qui avaient fait l'objet d'évaluation et de traitement, du 1er août 2015 au 30 novembre 2017. Le principal critère d'évaluation était le recours aux épreuves de la coagulation durant le séjour au SU; les critères

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secondaires d'évaluation comprenaient les coûts engendrés par les examens de laboratoire, la fréquence des épreuves effectuées en aval et la fréquence des transfusions de sang.
Résultats: La dissociation du RIN et du TTPa, alliée à la distribution du module de formation et à la mise sur pied du SADC, a conduit à une diminution significative du nombre de RIN-TTPa demandés conjointement, accompagnée d'une hausse significative du nombre de RIN et de TTPa demandés séparément. Dans l'ensemble, le taux d'épreuve de la coagulation a diminué tant pour le RIN que pour le TTPa (48 épreuves/100 patients/jour à 26 épreuves/100 patients/jour). Il s'en est suivi une diminution significative des coûts quotidiens engendrés par les examens de laboratoire (coût médian par jour : 1048,32 $ contre 601,68 $), ce qui a permis de réaliser des économies d'environ 163 023 $ CA par année. Enfin, aucun indice ne laissait croire à une augmentation du nombre d'épreuves de la coagulation effectuées en aval ou de demandes de produits sanguins.
Interprétation: Comparativement aux pratiques courantes initiales, l'initiative à l'étude, composée de différents volets, a permis de diminuer sensiblement le nombre d'épreuves de la coagulation, ce qui s'est traduit par des économies de coûts importantes, et ce, sans signe de préjudice pour les patients. Les cliniciens et les administrateurs disposent maintenant d'une trousse en évolution, qui permet de cibler toute la panoplie d'épreuves et de traitements de peu de valeur en médecine d'urgence.

Keywords: Costing, efficiency, emergency medicine, laboratory medicine

INTRODUCTION

As the total sum of healthcare expenditures continues to climb, a climate of fiscal restraint has emerged to slow health spending relative to Canada's economic growth, making prudent use of existing resources of the utmost importance.[1] In emergency departments (EDs) across the country, costs of care continue to rise.[2] Drivers of this increase are multifactorial and are commonly attributed to over-testing and over-treating as a result of medico-legal motivations, lack of adherence to practice guidelines, and lack of cost awareness.[2,3,4]

The pervasiveness of over-testing and over-treating has inspired educational strategies such as the Choosing Wisely™ campaign, which calls on specialty societies to identify tests and treatments that are overused and do not provide meaningful benefit to patients.[3] Using a modified Delphi consensus process, Schuur et al. generated an extensive list of tests and treatments that are of little value to the emergency encounter.[5] This list, among others, was subsequently modified and adopted by the American College of Emergency Physicians and the Canadian Association of Emergency Physicians.[6,7] However, despite widespread support, little progress has been made in the way of reducing low-value practices.[8]

One recommendation published by Schuur et al. advised against the routine use of coagulation testing (i.e., international normalized ratio [INR]; activated partial thromboplastin time [aPTT]) in the ED in the absence of hemorrhage or suspected coagulopathy.[5] As there were over 59,000 INR and aPTT studies completed in our two academic EDs in 2014, our goal is to enhance physician awareness and utilization of this low-value intervention (Richard Bak, MLT. E-mail communication regarding INR and aPTT testing in the ED [2015]). Accordingly, the purpose of our study is to determine the combined effects of uncoupling coagulation testing, disseminating an online educational module, and implementing an ongoing clinical decision support system (CDSS) tool on ED coagulation testing utilization and associated costs.

METHODS

Study design and setting

A prospective pre-post study included all patients presenting to the adult EDs of London Health Sciences Centre's Victoria Hospital (tertiary trauma centre) and University Hospital (tertiary centre) between August 1, 2015, and November 30, 2017 (~120,000 visits annually). During this time, our ED was staffed by physicians and residents who could independently order testing, nurses who could enact medical directives, and medical students who required staff approval to place orders. This study was carried out according to a pre-specified protocol that was approved by the London Health Sciences Centre Research Ethics Board.

Population

All patients ages 18 years and older undergoing evaluation (i.e., triage to disposition) at Victoria Hospital or

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University Hospital's adult ED during the study period were eligible for study inclusion. For patients with multiple eligible visits, each encounter was a unique data point. Throughout the study period, patients were provided standard care at the discretion of the emergency physician.

Intervention

At baseline (August 1, 2015–January 31, 2016), coagulation testing in our computerized provider order entry (CPOE) system included a coupled INR-aPTT orderable on a "quick order" entry page (i.e., an easily accessible and convenient selection of commonly ordered tests and treatments), but also selective INR and aPTT orderables that each provider would have to search for to select. The coupled INR-aPTT orderable was included and pre-selected in several order sets (e.g., chest pain order set, trauma order set) as per local policies. To better evaluate the effects of our intervention, default contents of order sets were not modified over the course of the study.

During the uncoupling phase (March 17, 2016 – July 24, 2016), the options available on the quick order entry page were modified to include coupled INR-aPTT, as well as selective INR and aPTT testing. In order sets, coupled INR-aPTT and selective INR and aPTT testing were offered, but only the coupled INR-aPTT orderable was pre-selected to maintain order set defaults. Providers were not notified of these changes. This phase was complicated by several logistic and technical difficulties, resulting in the exclusion of 43 days (February 1, 2016 – March 16, 2016) from the analysis.

In the intervention phase (July 25, 2016 – January 31, 2017), the quick order entry page and order sets were modified to only include selective INR and aPTT testing. Subsequently, providers were instructed on coagulation testing indications and costs via an online educational module (available at https://youtu.be/YyOcX1mvjTs).[9] This module was provided by email to all physicians and nursing staff, and to all house staff on an ongoing basis in their orientation package. After a two-month, phase-in period, a CDSS tool was activated in the CPOE system to remind providers of the indications and costs for INR and aPTT testing whenever coagulation testing was ordered (see Figure 1).[9] A provider would then acknowledge the alert (i.e., click "OK") and independently choose to discontinue testing or proceed to sign-off on the order, as per usual based on their clinical judgement. There were no similar alerts in our computerized order-entry system, otherwise.

To explore the stability of our outcomes, an extended observation phase (February 1, 2017–November 30, 2017) was included. Otherwise, no significant changes occurred in our ED or CPOE system during the study period.

Outcome measures

All health records of study participants were reviewed to determine the impact of our adjustments on coagulation testing. The primary outcome was the rate of INR, aPTT, and coupled INR-aPTT testing (i.e., median number of tests/100 patients/day). Secondary outcomes included the rate of serum electrolyte testing (i.e., control testing), associated costs (i.e., median daily cost, overall cost reduction), frequency of downstream INR and/or aPTT testing, and frequency of blood product transfusion (packed red blood cells, fresh frozen plasma, and/or prothrombin complex concentrate) following an ED encounter for those without ED coagulation testing.

In evaluating costs associated with laboratory testing, the Ministry of Health and Long-Term Care's Schedule of Benefits was used to determine the labour, management, and supplies (LMS) consumed to perform any given test in Ontario, Canada.[10] As such, each test was assigned a number of LMS units based on the intensity of resource utilization, each of which was equivalent to $0.517 Canadian dollars (CAD). An INR test (Schedule of Benefits Code: L445) costs 12 LMS units (i.e., $6.20 CAD), whereas an aPTT test (Schedule of Benefits Code: L462) costs 14 LMS units (i.e., $7.24 CAD). These values were used to calculate the cost effects of the intervention.

Notably, all interventions are designed and implemented using existing hospital equipment and personnel and, therefore, incurred no additional variable costs. Furthermore, our measurements do not account for variable costs, such as the specialized laboratory tubes required for coagulation testing, nor the personnel time required to update the ED's CPOE system and produce educational materials.

Data analysis

Descriptive statistics are calculated for the number of days, patients, and each type of coagulation test in each study phase. Testing rates are calculated as the number

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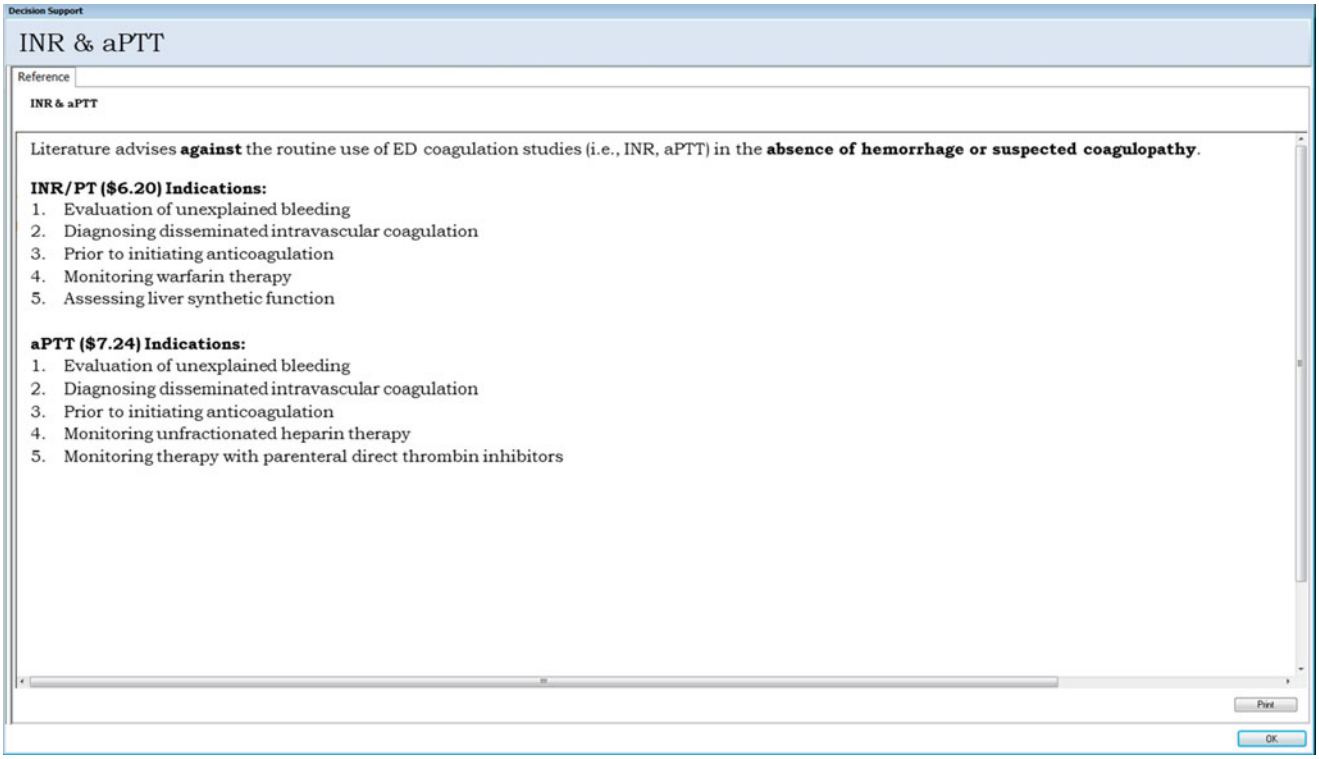

Figure 1. Clinical decision support system alert.

of tests per 100 ED visits per day and are evaluated for individual orderables (i.e., INR-aPTT, INR, or aPTT), as well as in aggregate (i.e., INR and aPTT). Variables are examined to determine a normal or non-normal distribution using the Shapiro–Wilk test. The Hodges–Lehmann estimate is used to determine 95% confidence intervals (CIs) for the differences in testing rates and costs between phases. All values are reported as median ± interquartile range (IQR) or mean ± 95% CI, where appropriate. All data are collected in password-protected Microsoft Excel spreadsheets (Microsoft Corporation, Redmond, WA) and imported into SPSS, Version 23.0 (IBM Corporation, Armonk, NY) for statistical analysis.

RESULTS

The study included 272,870 ED visits of patients who were evaluated in Victoria Hospital's and University Hospital's adult EDs and incurred 93,128 coagulation tests over the course of the study (coupled INR-aPTT: 27,061; INR: 21,272; aPTT: 17,734; Table 1).

Testing frequency

The median and aggregate numbers of coagulation testing throughout the various phases are shown in Figure 2 and Table 2. Over the course of the study, there were no significant changes in the testing rate of serum electrolytes. With uncoupling, the median rate of coupled INR-aPTT testing decreased (change: -13 tests/100 patients/day), with an associated increase in the median rate of selective INR (change: +11 tests/100 patients/day) and aPTT testing (change: +10 tests/100 patients/day).

Following the distribution of the educational module, small decreases were observed in the median rate of coupled INR-aPTT testing (change: -2 tests/100 patients/day), selective INR testing (change: -1 tests/100 patients/day), and aPTT testing (change: -2 tests/100 patients/day).

With subsequent implementation of our CDSS tool, the median rate of coupled INR-aPTT testing continued to decrease (change: -5 tests/100 patients/day) along with the median rate of aPTT testing (change: -1 tests/100 patients/day). However, the median rate of selective INR testing displayed no change (change: 0

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Table 1. Descriptive data of each study phase

	Baseline	Uncoupling	Educational intervention	Educational intervention + CDSS	Observation
Total days	184	130	57	134	303
Total patients	60,050	42,322	19,930	46,263	104,305
Median daily visits	326	326	348	342	349
Admitted to hospital (%)	10,925 (18.4%)	10,480 (18.5%)	3,387 (17.2%)	8,284 (18.2%)	19,212 (18.4%)
Median age (IQR)	48.0 [29.0–67.0]	48.00 [22.0–67.0]	48.0 [30.0–67.0]	48.0 [29.0–67.0]	49.0 [30.0–67.0]
Gender (%)					
Male	27,571 (46.6%)	26,478 (46.7%)	9,374 (47.8%)	21,097 (46.4%)	48,900 (46.9%)
Female	31,555 (53.3%)	30,208 (53.2%)	10,239 (52.2%)	24,367 (53.6%)	55,317 (53.0%)
Other	65 (0.1%)	60 (0.1%)	18 (0.1%)	37 (0.1%)	88 (0.1%)

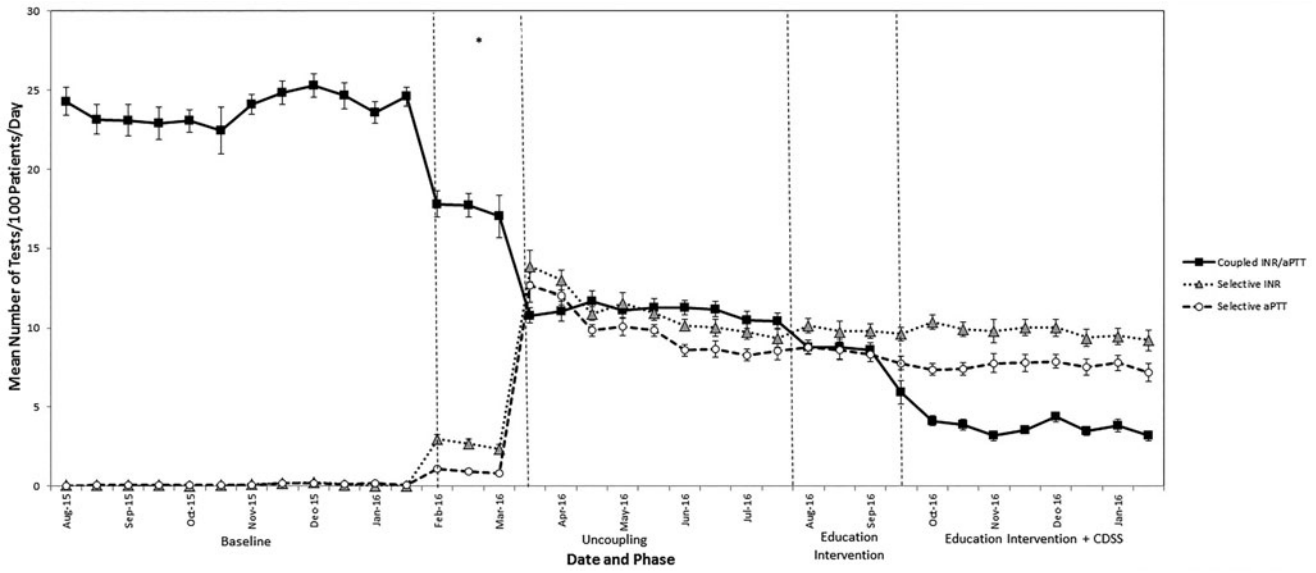

Figure 2. Rate of coupled and selective INR and aPTT tests in each study phase.
Point estimates represent the biweekly mean of the number coupled and selective INR and aPTT tests per 100 patients per day. Vertical error bars represent standard error.
*Represents an error in the computerized order entry system that did not reflect the intended study methods. This period was removed from all other analyses.

Table 2. Median and aggregate number of tests/100 patients/day (IQR) in each study phase

	Baseline	Uncoupling	Educational intervention	Educational intervention + CDSS	Observation
Median rates:					
Coupled INR-aPTT	24 [22–26]	11 [10–13]	9 [8–10]	4 [3–5]	4 [3–5]
Selective INR	0 [0–0]	11 [9–13]	10 [9–11]	10 [8–11]	9 [8–11]
Selective aPTT	0 [0–0]	10 [8–11]	8 [7–10]	7 [6–9]	8 [7–9]
Serum electrolytes †	48 [45–51]	46 [44–49]	46 [43–49]	46 [42–49]	46 [43–49]
Aggregate rates ‡:					
INR testing	24	22	19	14	14
aPTT testing	24	21	17	11	12
Total aggregate rate	48	43	36	25	26

1.76% of all INR and/or aPTT orderables were requested by study investigators.
† Serum electrolytes testing rate as a non-seasonal control for ED testing rate.
‡ Aggregate rate represents the total number of tests performed, regardless of the orderable selected by the provider.

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Table 3. Median cost ($CAD) per day (IQR) for each study phase

	Baseline	Uncoupling	Educational intervention	Educational intervention + CDSS	Observation
Coupled INR-aPTT	1,048.32 [967.68–1128.96]	497.28 [416.64–540.96]	416.64 [356.16–490.56]	174.72 [134.40–204.96]	201.60 [161.28–228.48]
Selective INR	0.00 [0.00–4.65]	217.00 [186.00–260.40]	204.60 [186.00–235.60]	210.80 [179.80–241.80]	204.60 [173.60–229.40]
Selective aPTT	0.00 [0.00–5.43]	224.44 [193.67–267.88]	209.96 [181.00–253.40]	188.24 [159.28–224.44]	195.48 [166.52–231.68]
Total	1,048.32	938.72	831.2	573.76	601.68

tests/100 patients/day). During the observation phase, there was no significant changes in testing frequencies.

Overall, by uncoupling INR-aPTT testing and implementing our educational module and clinical decision support system intervention, the total aggregate rate of coagulation testing declined from 48 tests/100 patients/day to 26 tests/100 patients/day (see Table 2).

Laboratory costs

When examining associated laboratory costs, a significant reduction in median daily laboratory costs was observed with uncoupling, as well as following the implementation of our educational module and CDSS tool (Table 3). Overall, median daily cost savings were $446.64 CAD, which amount to an estimated $163,023.60 CAD annually.

Frequency of downstream coagulation testing

Among all patients who did not have any coagulation testing during their ED encounter, the frequency of coagulation testing varied by their disposition (i.e., admission, critical care, or discharged) but did not increase following implementation of our intervention regardless of the subgroup (Table 4).

Frequency of blood product administration

Furthermore, for patients without any coagulation testing during their ED encounter, the frequency of blood product administration in the subsequent 48 hours did not vary significantly throughout study phases (Table 5).

DISCUSSION

Our study examines the combined effects of uncoupling INR-aPTT testing, disseminating an educational module, and implementing a clinical decision support system tool on coagulation testing rates in two academic EDs.

During the uncoupling phase of the study (i.e., allowing providers to choose between a standard coupled test or selectively choosing INR and/or aPTT), a drastic shift towards more selective testing was observed; however, this resulted in only a small decline in aggregate testing rates. This suggests one of two possibilities: firstly, providers ordered coupled testing regardless of the system design due to a lack of an understanding of indications for such testing; or, secondly, that most coupled testing originated from order sets where coupled testing is the default. Given that order sets were not modified during

Table 4. Frequency of downstream coagulation testing

	2015		2016		2017	
Disposition	No ED testing	% Testing in 24 hours	No ED testing	% Testing in 24 hours	No ED testing	% Testing in 24 hours
Admitted as inpatient	3,597	29%	10,996	30%	12,751	28%
Admitted to intensive care or OR	82	67%	242	59%	264	56%
*Discharged**	33,765	1%	86,772	1%	87,279	1%

ED = Emergency department; OR = operating room.
*Testing included only that which was completed at the London Health Sciences Centre.

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Table 5. Frequency of blood product administration among patients without ED coagulation testing

Phase	No ED testing	Number (%) requiring blood products within 48 hours
Baseline	45,158	96 (0.21%)
Uncoupling	32,456	75 (0.23%)
Educational intervention	16,020	39 (0.24%)
Educational intervention + CDSS	39,451	102 (0.26%)
Observation	90,832	222 (0.24%)

CDSS = Clinical decision support system; ED = emergency department.

the uncoupling phase, we can infer that this shift to selective testing stemmed from individual providers (i.e., via order entry page). However, as there was minimal change in aggregate testing rates, we believe providers continued to order coupled testing due to a lack of an understanding of indications for coagulation testing.

At the outset of the intervention phase, the educational intervention resulted in a continued shift away from coupled testing but without a related increase in selective testing. As our CDSS used a conspicuous and contiguous reminder with content pertinent to the testing at hand, a further reduction of coupled testing and the largest decrease in aggregate coagulation testing was observed. Most importantly, the observed reduction in coagulation testing was accomplished without any signal of patient harm, as represented by the stable rate of blood product transfusions in the subsequent 48 hours throughout the course of our study.

The observed reduction in aggregate coagulation testing following the educational module and CDSS implementation is consistent with existing literature. In a systematic review of 109 studies on the ability of various interventions (i.e., educational, system-based, audit-feedback, and incentive-penalty) to reduce test utilization, Kobewka et al. found that, while all intervention categories in isolation can reduce test utilization to a certain extent, interventions using multiple strategies were typically more effective.[11] Interestingly, Kobewka et al. suggest that, unlike educational interventions, system-based interventions (i.e., CDSS) required fewer resources to sustain and typically maintained their effects beyond 1 year. This is consistent with the durability of our observed effect.

Furthermore, we see a growing body of literature with a focus on improving resource utilization in the ED. Our results are similar to those observed by Fralick et al., who safely observed a significant reduction in coagulation testing rates using a quality improvement approach.[12] However, in contrast, there are four important differences in our study. Firstly, we used an educational intervention and CDSS alert to effectively empower users in reducing inappropriate testing, which is in contrast to Fralick et al., who utilized systemic changes to reduce inappropriate testing (i.e., removing all coagulation testing from order sets; back-end uncoupling of testing). Secondly, each change that we implemented was staged to enable us to determine the effect size of each intervention. Thirdly, we monitored for downstream testing to ensure that any testing avoided during the ED encounter represented true savings for the system. Finally, we included an extended observation window to allow for confidence in the durability of our results. Despite these differences, we believe both studies highlight the value of multimodal interventions and the tremendous opportunity for improved resource utilization in emergency medicine.

Limitations

Our study has several limitations that are important to consider. Firstly, due to logistic and technical difficulties with modification of the CPOE system, it was necessary to exclude data points from February 1, 2016 – March 16, 2016 from our analysis. While this reduced the number of observations, we suspect this had little effect on our conclusions given the large sample sizes and observed stability in testing rates. Secondly, our study was conducted at a single centre with unique patient management systems and one clinical group, thereby limiting our external generalizability. However, given similar reported effects by other groups, we expect that improved resource utilization can be achieved in comparable institutions. Thirdly, our costing methodology considered only the labour, materials, and resources required to perform coagulation testing within a laboratory environment and excluded important costs, such as those of testing tubes and personnel time to update the CPOE system and produce educational materials. Fourthly, the educational intervention was disseminated to all providers via email, and, therefore, we could not reliably determine uptake rates or assess the degree of knowledge translation; as a result, we interpret any observed effect of our educational intervention with caution. Fifthly, we compared point estimates of the various phases, which is susceptible to secular trends. While a

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more robust analytic approach could include an interrupted time series design, we believe that the stability of our estimates, as demonstrated in Figure 2, lends validity to our estimates. Finally, we did not include any measure of provider satisfaction with our intervention following implementation. While there is a high risk of alert fatigue, we are reassured by the stability of our testing rates during the observation window, suggesting that our CDSS tool remains effective.

CONCLUSION

Overall, our study demonstrates that a simple, multimodal intervention is associated with a significant reduction in unnecessary coagulation testing and with substantial cost savings. Most importantly, reduction in unnecessary coagulation testing was accomplished without a signal of patient harm. To continue our pursuit of resource stewardship, further efforts will include a focus on reducing inappropriate testing originating from order sets.

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