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Reducing Unnecessary Phlebotomy Testing Using a Clinical Decision Support System

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Abstract

Background: Overuse of phlebotomy testing offers little to improve patient outcomes. Reducing unnecessary phlebotomy tests can cut costs without compromising quality.

Purpose: To determine the effectiveness of a clinical decision support system (CDSS) on reducing unnecessary type and screen tests, estimate the cost saved by the CDSS implementation, and describe the unnecessary ordering practices by provider type.

Methods: Our study used a separate-sample pretest posttest design at a mid-Atlantic academic medical center to examine the number of unnecessary type and screen tests three months before and after CDSS implementation. A CDSS was embedded in our electronic health record. The CDSS appears when a type and screen is ordered informing the provider of the date and time the current test expires. Cost savings was estimated using time-driven activity-based costing. Pre-intervention (801 tests) and post-intervention (801 tests) periods were used to describe ordering practices by provider type.

Results: There were a total of 26,206 pre- and 25,053 post-intervention specimens. Significantly fewer unnecessary type and screen tests were ordered after the intervention (12.3%, n=3,073) than before (14.1%, n=3,691; $p<0.001$). The results demonstrated an estimated yearly savings of $142,612 after CDSS implementation. The majority of the tests were ordered by physicians (85.3% before and 83.1% after the intervention) compared to advanced practice nurses and physician assistants.

Conclusions: Our study demonstrated that a CDSS impacted a variety of provider types, reduced unnecessary phlebotomy tests, and decrease annual costs. Interventions such as education, audits, and feedback are recommended to further reduce unnecessary ordering practices.

Problem Statement

Type and screen testing is used to determine blood compatibility and to identify clinically significant antibodies affecting blood transfusion compatibility. Our blood bank laboratory observed type and screen tests were often unnecessarily ordered in our organization. Type and screen tests are active for three days from the date the specimen is collected, yet many patients receive orders for repeat testing well in advance of the sample's expiration without any medical need.

Throughout health care unnecessary testing is time consuming for patients and staff, labor intensive, and does not contribute to improved outcomes (Attali et al., 2006; Konger et al., 2016; Krasowski et al., 2015, Mafi et al., 2017)). It is estimated that $65 billion is spent to perform over 4 billion laboratory tests each year in the United States (Alexander, 2012). Low-cost, high-frequency tests are ordered recurrently, unnecessarily, and contribute to the high cost of health care.

Background

Overutilization has been cited as the most significant contributor to the high cost of healthcare in America (Emanuel & Fuchs, 2008) and is not consistent with the Institute of Medicine's aims to make healthcare safe, effective, efficient, timely, and patient-centered. The American Board of Internal Medicine launched Choosing Wisely, a national campaign in 2012 to address unnecessary testing (American Board of Internal Medicine Foundation. Choosing Wisely, n.d.).

Unnecessary phlebotomy testing is defined as "tests that are ordered but not indicated," (Zhi, Ding, Theisen-Toupal, Whelan, and Arnaout, 2013, p.e78962). Unnecessary phlebotomy

testing can cause patient discomfort and lead to hospital-acquired anemia and the need for possible blood transfusion (Koch et al., 2015; Thavendiranathan, Baggai, Ebidia, Detsky, & Choudhry, 2005). Unnecessary testing is ineffective because it does not provide valuable information for provider decision-making. Factors leading to unnecessary testing include: multiple providers ordering for the same patient, differing levels of provider training and experience, ordering incorrect testing, use of recurring orders that are not reviewed for necessity, and tests ordered before a clinical change could occur (Konger et al., 2016).

It is estimated that 4-6 billion laboratory and pathology tests (Wians & Gill, 2013; Zhi, Ding, Theisen-Toupal, Whelan, & Arnaout, 2013) occur each year accounting for 4% of annual healthcare costs (Hanson & Plumhoff, 2012). As a value-based system in healthcare continues to evolve, providers and healthcare organizations need to explore opportunities to reduce non-value-added care without compromising quality. Ensuring that the correct test is ordered for the correct patient at the correct time is challenging for the following reasons: traditional routine ordering practices, defensive medicine to avoid possible litigation, ease of ordering lab work over the effort to investigate the need for a repeated test, habitual ordering, and lack of awareness of cost and patient impact of testing redundancy (Attali et al., 2006; Bourgault, 2018; Konger et al., 2016; Thakkar et al., 2015). In addition, many providers are uncertain when a type and screen test will expire, and do not want to be forced to accept uncrossmatched blood for a transfusion due to an expired specimen.

To promote appropriate, evidence-based test ordering, clinical decision support systems (CDSSs) with specific patient information are embedded in the electronic health record (EHR). By filling a knowledge gap at the time of ordering, CDSS is known to improve adherence to ordering guidelines and reduce both direct and consequential costs of overutilization (Delvaux et

al., 2017). Adoption of CDSSs has been successful in reducing unnecessary radiologic imaging, overutilization of antibiotics, and *Clostridium dificile* testing (Blackmore et al., 2011; Forrest et al., 2014; White et al., 2017).

Purpose

The purpose of our study was to determine the effectiveness of a CDSS in decreasing the number of unnecessary type and screen tests. We also estimated the cost of unnecessary tests before and after implementation of the CDSS and described the unnecessary ordering practices by provider type. Our long-term purpose was to improve phlebotomy ordering practices by all provider types to reduce unnecessary testing and overutilization.

Methods

Research Design, Sample, Setting

We used a separate-sample pretest posttest design, approved as an expedited review by the Institutional Review Board (IRB00175556) at our large academic medical center in the Mid-Atlantic region. The design was chosen to determine the effect of a CDSS had on unnecessary type and screen ordering practices.

Our Transfusion Medicine laboratory processes approximately 8,000 type and screen specimens from inpatient and outpatient locations each month. Among 49 inpatient care units, 30 units use phlebotomists to draw the majority of specimens and 19 units use nurses to draw the specimens. Specimens rejected for not meeting acceptable specimen criteria were excluded. Reasons for excluding specimens were: labeling errors, collection errors, handling errors, contaminated specimen, or incorrect test requested. All 49 inpatient units were included in the review of provider ordering practices that included physicians, advanced practice nurses (APRNs), and physician assistants (PAs).

Study Sample Size

The total number of appropriate and unnecessary type and screen tests was collected for three months before and three months after implementation of the CDSS. To estimate cost, we used the total number of unnecessary type and screens from both the pre- and post-CDSS implementation data collection periods. To describe the type of providers and ordering practices, we systematically selected 801 unnecessary type and screen specimens from the three month pre-CDSS (267 samples x 3 months = 801) and the three month post-CDSS (267 samples x 3 months = 801) for a total of 1,602 specimens.

Clinical Decision Support System

CDSSs are EHR applications that use specific patient information to assist health care professionals in decision-making to improve care. Current literature has not assessed the effects of a CDSS before and after implementation when applied specifically to type and screen tests.

Our department of Pathology's informatics team developed the CDSS to assist providers to make decisions about type and screen testing. Evidence in the literature demonstrates reduced test ordering when a CDSS is embedded in the computerized physician order entry (CPOE) system (Algaze et al., 2016; Delvaux et al., 2017; Konger et al., 2016; Procop et al., 2015). The CDSS for type and screen ordering is similar to other systems used in our CPOE system designed to encourage best ordering practices. Our CDSS was embedded in our CPOE system and appears each time a provider initiates a type and screen order. It informs the provider of the blood type if one is on file, date and time the current test expires, and the date and time of the most recent test (Figure 1).

The CDSS is strictly an informative system and does not block ordering of the test. Orders may be placed as a one-time test, STAT, routine laboratory collection, or the order may

be cancelled. The Pathology informatics team conducted internal testing to confirm the CDSS appeared when type and screen tests were ordered. No training or notification of the CDSS was offered to the providers prior to implementation.

Instrumentation/Measurements/Procedures

To determine the effectiveness of the CDSS on type and screen tests ordered, the total numbers of both appropriately and unnecessarily ordered tests were collected over three months pre-CDSS implementation and three months post-CDSS implementation. The same three calendar months were used for the pre-intervention period (March 1 to May 31, 2017) and the post-intervention period (March 1 to May 31, 2018). The total number of type and screen tests performed each month was captured in an aggregate report from the laboratory information system. Next, the pathology informatics team, using information from the CPOE system, the laboratory information system, and transfusion management software system, created a detailed spreadsheet to capture the data. Unnecessary tests were identified as those tests ordered if the specimen was collected before the previous specimen expired.

Using the time-driven activity-based costing (TDABC) model (Kaplan & Anderson, 2004), the estimated cost before and after the intervention was determined as a sum of the direct cost and the labor cost (Table 1) for all unnecessarily ordered tests. Direct costs are the materials and equipment needed to perform a single test. Our direct costs were $1.86/ test. Cost of the laboratory instruments was not included because our vendor agreement waives equipment and service fees. Labor cost is the time it takes an employee to perform a single type and screen test including drawing the blood and processing the specimen. Labor cost is estimated by using the employee's average hourly salary divided by 60 to achieve the labor cost per minute then

multiplied by the number of minutes it takes to perform the test (K. Lee, personal communication, March 26, 2018).

To account for nurse versus phlebotomist drawing the blood, labor costs were determined using phlebotomists' mean hourly salary ($18.52) for 30 (61%) patient care units and nurses' mean hourly salary ($36.18) for 19 (39%) patient care units for both pre- and post-CDSS implementation.

To study unnecessary test ordering by different provider types, we used the spreadsheet created by the pathology informatics team that identified unnecessarily ordered tests. Systematic sampling was used to select 801 specimens each from the pre- and post-intervention periods. The remaining specimens were deleted. The provider name was used to determine the ordering provider type (i.e., physician, APRN, PA). Coding of specimen date for pre- or post-intervention and ordering provider type took place once the sample data were abstracted.

One member of the research team was responsible for all data collection and entered all data into a data collection spreadsheet. An internal reviewer validated the accuracy of data entry for 11% of the pre- and 11% of the post-implementation sample data after the medical record numbers, order numbers, specimen numbers, and provider names were deleted to de-identify the data. Systematic sampling was used to select the specimens included for the check on data entry accuracy and all data points were identified as accurate.

Data Analysis Plan

The data were uploaded to IBM Statistical Package for the Social Sciences (SPSS) for analysis. To evaluate the total number of unnecessarily ordered type and screens, a sum of all unnecessary tests for the three-months before and after the CDSS intervention was divided by the total number of orders for each time period to achieve the percentage of unnecessary tests. To

determine the difference between the pre- and post-CDSS ordering, a chi-square test was calculated with a level of significance set at 0.05.

Cost estimates were determined for all unnecessarily ordered type and screen tests during the pre-intervention and post-intervention periods. The pre- and post-intervention estimates were each multiplied by four to estimate the yearly cost savings.

To describe the unnecessary type and screen tests ordered by physicians, APRNs, and PAs, we compared a number of unnecessary specimens for the pre-intervention and the post-intervention time periods.

Results

There were a total of 26,206 pre- and 25,053 post-intervention specimens. Significantly fewer unnecessary type and screen tests were ordered after the CDSS intervention (12.3%, n=3,073) than before (14.1%, n=3,691; $p<0.001$; Table 2) demonstrating a 16.7% reduction.

A TDABC model estimate was calculated to determine the dollars saved per year with the implementation of a CDSS for type and screen tests. The estimated annual cost of unnecessary type and screen tests pre-CDSS was $851,744 versus $709,132 post-CDSS implementation. The reduced number of unnecessary type and screen tests after implementation of the CDSS resulted in an estimated yearly savings of $142,612 in combined direct and labor costs compared to the pre-CDSS period.

We also evaluated the ordering practices of unnecessary type and screen tests by provider type before versus after implementation of the CDSS. Physicians were the largest group of providers employed at our medical center both pre-intervention (n=2,218, 75%) and post-intervention (n=2,071, 72%). The number of APRNs employed increased by 1.92% in the post-intervention period (n=570, 20%) compared to the pre-intervention (n=534, 18%) while the

number of PAs employed remained essentially the same in the pre (n=211, 7%) and post groups (n=217, 8%). Of the providers employed by the medical center who actually wrote type and screen orders, the majority of the tests were ordered by physicians (85.3% before and 83.1% after the intervention) compared to APRNs and PAs (Table 3). Fewer unnecessary type and screen tests were ordered by physicians and PAs (-2.2%, -1.5% respectively) after the intervention than before while APRN type and screen ordering increased by 3.6%.

Discussion

Our study demonstrated that a CDSS appearing at the time of type and screen test ordering is an effective strategy to reduce the overall number of unnecessarily ordered tests. Our findings are in agreement with previous studies that leveraged CDSS as a means to reduce unnecessary phlebotomy testing (Algaze et al., 2016; Breen et al., 2018; Eaton et al., 2017; Kim, Dzik, Dighe, & Lweandowski, 2011; Krasowski et al., 2015; Procop et al., 2015). A common theme in the previous literature on this matter was that reductions to laboratory ordering practices requires the use of CDSSs in addition to other interventions. The most effective reductions of unnecessary ordering involved combinations of CDSS implementation, education, auditing, and feedback (Bindraban et al., 2018; Breen et al., 2018; Delvaux et al., 2017; Eaton et al., 2017; Khalifa & Khalid, 2014). However, similar to Najafi, Cucian, Poerre, and Khanna (2018), we achieved a statistically significant reduction in unnecessary ordering practices by implementing the CDSS alone. Part of our success may be attributed to the familiarity of our providers with using CDSSs and alerts within the EHR. Our CDSS had the desired characteristics of providing the right information at the time of decision-making, to the right people, and in the right format (HealthIT.gov, n.d.). Despite the reduction in unnecessary tests ordered after the CDSS implementation, the number of unnecessary tests remains unacceptably

high. Ordering practices may have undergone a greater change had implementation been augmented with organizational goals, education, auditing, and feedback.

Comparing pre- and post-intervention estimated cost of unnecessary type and screens using the TDABC model, we found a yearly savings of $142,612. While several studies have reported cost savings associated with the use of CDSS, we believe we are the first to apply the TDABC model to reduced phlebotomy testing and were encouraged by the extent of the annual cost savings achieved for a low-cost, high-frequency test.

Other studies have established a cost savings after implementing CDSSs that encourage best practice laboratory testing (Algaze et al., 2016; Eaton et al., 2017; Procop et al., 2015; Sadowski, Lane, Wood, Robinson, & Kim, 2017). Our study supported the existing literature and provides a unique estimation of cost that encompasses direct and indirect costs rather than using administrative charges or reimbursement fee schedules. Because implementation of the type and screen CDSS in our EHR was not an additional expense on top of vendor fees, any amount of cost savings was a benefit for our patients and organization.

Low-cost, high-frequency tests have been shown to be used more often and account for a greater percentage of overall healthcare costs than high-priced tests (Mafi et al., 2017). Lack of a national policy on unnecessary ordering practices combined with existing quality measures that evaluate for underuse rather than overuse may influence a provider's decision to order tests unnecessarily. Unnecessary ordering occurs among both private and publicly insured patients (Charlesworth, Meath, Schwartz, & McConnell, 2016) suggesting that all populations could achieve waste reduction with the use of CDSS.

Although we found that all provider types ordered unnecessary type and screen tests, there is more work is required to improve appropriate utilization. We noted mixed results of

ordering practices by provider type after CDSS implementation (physicians 83.1%, APRN 10%, PA 6.9%: Table 3). After evaluating the number of unnecessary tests for each provider type pre- and post-CDSS implementation, we can speculate the increase in APRN unnecessary orders after the intervention may have been attributed to an increased number of APRNs employed before and after the intervention (pre- 534, post- 570). However, because we did not collect data on the total number of providers who actually ordered type and screen tests or the number of orders written by each provider for multiple patients, we could not perform inferential statistics to further evaluate the data. While we were unable to find literature specifically about phlebotomy test ordering by provider type, current literature did not clearly identify one provider type exercising more appropriate test ordering than another (Carryer, Askew, Hodge, Miller, & Gibbons, 2011; Hughes, Jiang, & Duszak, 2015; Mafi, Wee, Davis, & Landon, 2016; Winchester et al., 2014). CDSSs can alter actions at the time of ordering but it is not known if they contribute to changing ordering habits or attitudes (Delvaux et al., 2017).

In our academic hospital setting it is well known that physician residents write the majority of patient orders. Teaching ordering best practices early in physicians' training can shape career-long habits. Learning more about ordering habits of different provider types is relevant as organizations move towards using more advanced practice clinicians and are challenged to contain costs while providing quality care.

Limitations

Our study had several limitations. First, it was conducted in a single academic institution familiar with CPOE and CDSSs. Generalizability of findings to other settings new to CPOE and CDSS is unclear. Second, results could differ in a non-academic setting where providers are no longer training and influenced by senior providers. Third, we did not differentiate ordering

practices among attending, fellow, or resident physicians. We did not account for the fact that particular providers may have ordered multiple unnecessary tests while others may have ordered one or none. Finally, we assessed the effect of a CDSS on one specific phlebotomy test. While we believe type and screen test ordering provides understanding of ordering practices and phlebotomy specimen costs, defining unnecessary ordering for other tests may be more challenging.

Implications/Recommendations for Practice, Policy, and Research

Our study illustrated the effectiveness of CDSS as a means of reducing unnecessary health care services. CPOE is widely used in a variety of health care settings and can incorporate CDSS to guide all provider types in making judicious decisions at the time of care. However, achieving greater reductions in unnecessary testing at our institution demands additional interventions including organizational support, education, audits, and feedback.

Reducing unnecessary tests requires high level organizational support and acknowledgment that it fits into an organization's strategic aim at quality care. Instituting incremental goals to reduce unnecessary low-cost, high frequency testing can establish internal quality measures reported to quality care committees and change the ordering habits of all provider types. Starting at the highest level with the Hospital Quality Improvement Council, we recommend an institutional mandate to reduce the rate of unnecessarily ordered type and screens by 2% each year for the next three years. We further recommend that departments that do not meet the target reduction goal of 2% at the end of each year be required to provide the Quality Improvement Council with a detailed action plan on how they will achieve the goal the following year. Moreover, the success of top performing departments and their improvement strategies should be highlighted in the hospital's internal newsletter.

We also recommend the appointment of champions from the departments of surgery and medicine as well as the Advanced Practice Provider Committee to disseminate test ordering practices, hold senior level providers accountable for adhering to evidence-based phlebotomy ordering, and educate new staff and trainees. We recommend that education on reducing unnecessary testing take place in formal settings such as: new-hire onboarding, annual competency training, lectures, grand rounds, daily patient rounds, and just-in-time learning opportunities.

Traditional auditing is labor intensive, but by leveraging the CPOE system using data analytics, quality improvement departments can provide data displays and analysis to identify areas for improvement. Our recommendation is to provide ongoing auditing of phlebotomy test ordering practices of individual providers to learn about individual, departmental, and organizational ordering patterns.

Until the establishment of national quality measures aimed to control the number of low-cost, high-frequency tests, each health care system must explore ways to locally identify and reduce unnecessary health services. Implementation of CDSS in combination with organizational support, education, auditing and feedback provide a ground level structure to reduce unnecessary testing. Further research is needed to determine which tests should be targeted using CDSSs without adversely affecting patient outcomes. In this era of precision healthcare, the upshot of ordering the right test, at the right time, for the right reason can reduce cost, reduce waste, and improve quality, outcomes, and satisfaction for patients.

Sustainability

Our CDSS to reduce unnecessary type and screen testing was a systems level change that will remain in our CPOE system. We believe that it will continue to reduce unnecessary type and

screen ordering but additional interventions will be instituted to achieve further substantial and sustainable reductions: strong leadership, education, performance auditing, and feedback.

Conclusions

Unnecessary testing continues in health care and contributes to excessive health spending. Phlebotomy testing is one example of how providers can reduce waste and control healthcare costs for low-cost, high-frequency tests. Our study demonstrated that CDSSs impacted a variety of provider types, reduced unnecessary phlebotomy tests, and achieved yearly cost savings.

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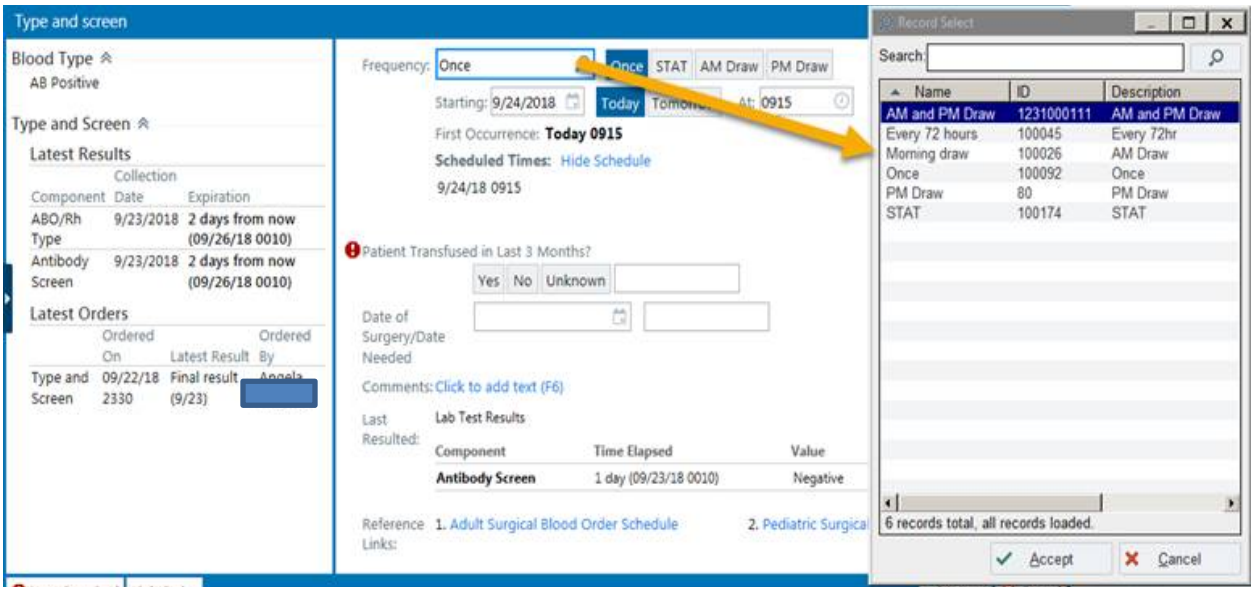

Figure 1. Clinical decision support system for type and screen test (all data and patient information are fictitious)

Table 1

Time-driven Activity-based Estimated Cost for Type and Screen Test

Direct costs			
Testing materials and reagents	$1.86/ test		
Blood bank analyzer	$185,000 x 2 analyzers + $24,700 per year service fee*		
Labor costs	Labor cost per minute based on mean hourly salary in Maryland	Estimated labor time	Number of patient care units
Nurse cost for drawing specimen	$0.43/draw	10 minutes	19
Phlebotomist cost for drawing specimen	$0.31/draw	10 minutes	30
Laboratory technologist for processing specimen	$0.31/test	120 minutes	N/A

*Not included in cost calculation; vender agreement waived equipment and service fees

Table 2

Unnecessary Type and Screen Tests Ordered Before Versus After the Implementation of a Clinical Decision Support System

	Total n (%)	Appropriate order n (%)	Unnecessary order n (%)	Statistic X^2	*p*-value
Pre-CDSS	26206 (100)	22515 (85.9)	3691 (14.1)	*36.98*	*<0.001*
Post-CDSS	25053 (100)	21980 (87.7)	3073 (12.3)		

Table 3

Unnecessary Type and Screen Tests Ordered by Provider Type Before Versus After the Implementation of a Clinical Decision Support System

	Total n (%)	Physician n (%)	APRN n (%)	PA n (%)
Pre-CDSS	801 (50)	683 (85.3)	51 (6.4)	67 (8.4)
Post-CDSS	801 (50)	666 (83.1)	80 (10)	55 (6.9)
Total	1602 (100)	1349 (84.2)	131 (8.2)	122 (7.6)

Note: We did not collect data on the total number of providers who actually wrote type and screen orders, or the number of orders written by each provider during the study period and therefore, we were unable to perform inferential statistics to further evaluate the data.